Development of PRZM-GW Scenarios for Spring and Winter Wheat-Growing Areas

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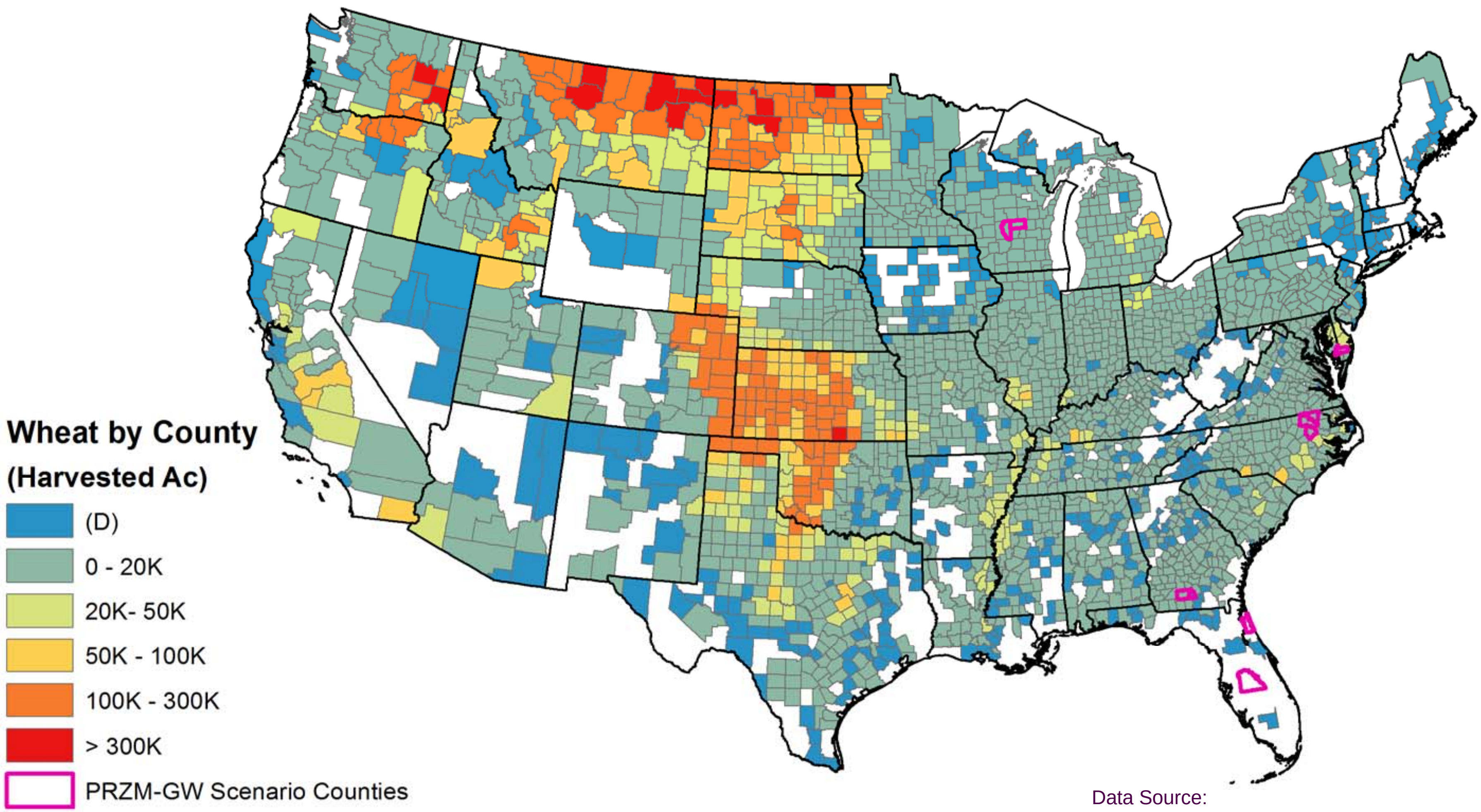
Major wheat regions of the United States are not included in EPA groundwater exposure modeling scenarios

Need to define appropriately vulnerable PRZM-GW scenarios for high-producing spring and winter wheat growing regions.



"D" refers to Agricultural Census designation for counties with wheat but with too few growers to report actual acreage

Data Source:
Wheat Acreage, NASS Census of Agriculture 2012;
PRZM-GW Counties, EPA PRZM-GW Scenario Metadata

Vulnerable PRZM-GW wheat scenarios were developed using a two step modeling approach

Step 1: Screening modeling was conducted for all wheat growing soils and weather conditions throughout the nation.

- Basis for comparison was standardized by assuming 4 m depth to shallow aquifer
- Separate analyses were conducted for spring and winter wheat
- Over 150,000 unique combinations of PRZM soil/weather/crop parameters were simulated

Step 2: Representative vulnerable model scenarios were identified from screening results and finalized with realistic aquifer depths.

- Scenario selection based on post-breakthrough average herbicide concentration predictions, wheat acreage, areas of shallow groundwater
- Aquifer depth estimated based on groundwater wells in the shallow Principal Aquifers of the United States (http://water.usgs.gov/ogw/aquifer/map.html)

Step 1: Screening modeling for spring and winter wheat sites

Wheat crop footprints generated using the Cropland Data Layer.

- Combined all pixels with wheat in any year between 2009-2013
- Included spring, winter, and durum wheat plus other crops rotated with wheat

Spatial analysis identified unique combinations of soils, weather, and state-dependent crop parameters that overlapped wheat areas.

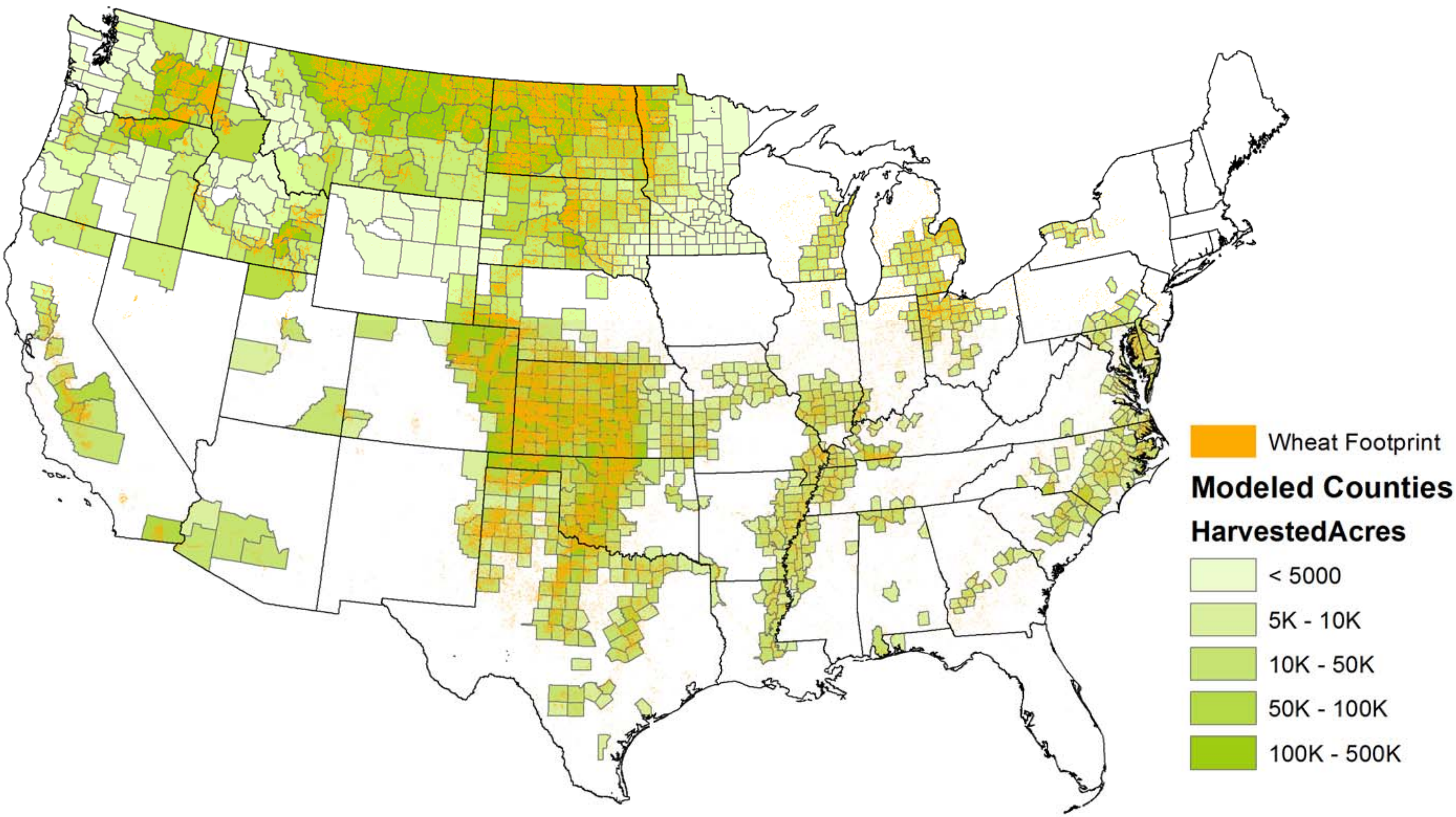
- SSURGO soils map units
- SAMSON Thiessen polygons
- State-level parameters including: emergence, maturity, harvest, application dates, GW temperature, evaporation depth, irrigation

All unique soil components were considered for independent PRZM simulations.

Spring and Winter Wheat Crop Footprint

Wheat in high priority states (MN, ND, SD, WY, MT, WA, OR, ID) plus additional counties with greater than 5000 acres wheat included in screening modeling

- County wheat acreage determined from NASS 2012 Census of Agriculture



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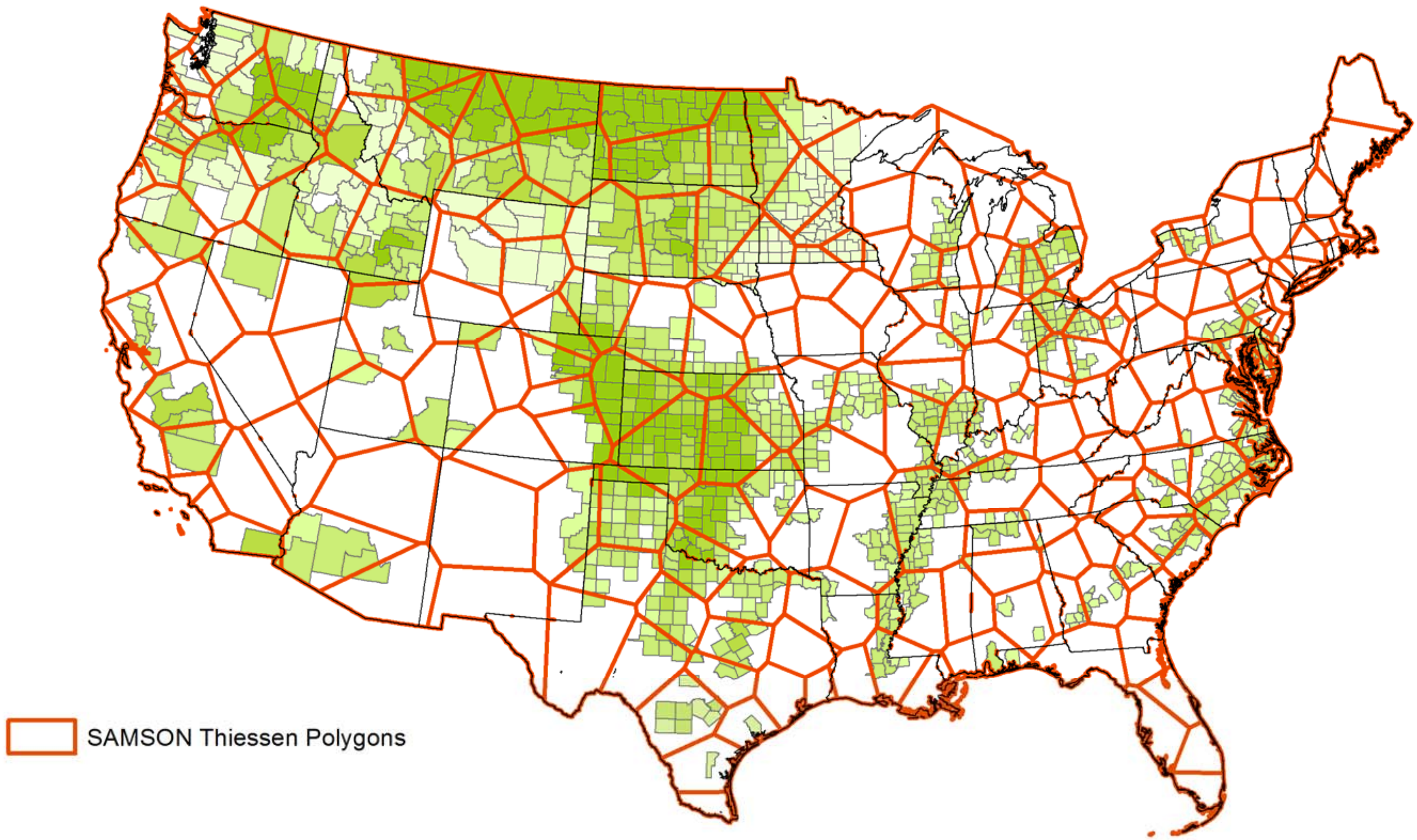
SAMSON Weather Data Layer

NOAA SAMSON Thiessen polygons were combined with soils map units and crop footprint.

Simulations used 100 year weather data for each station.



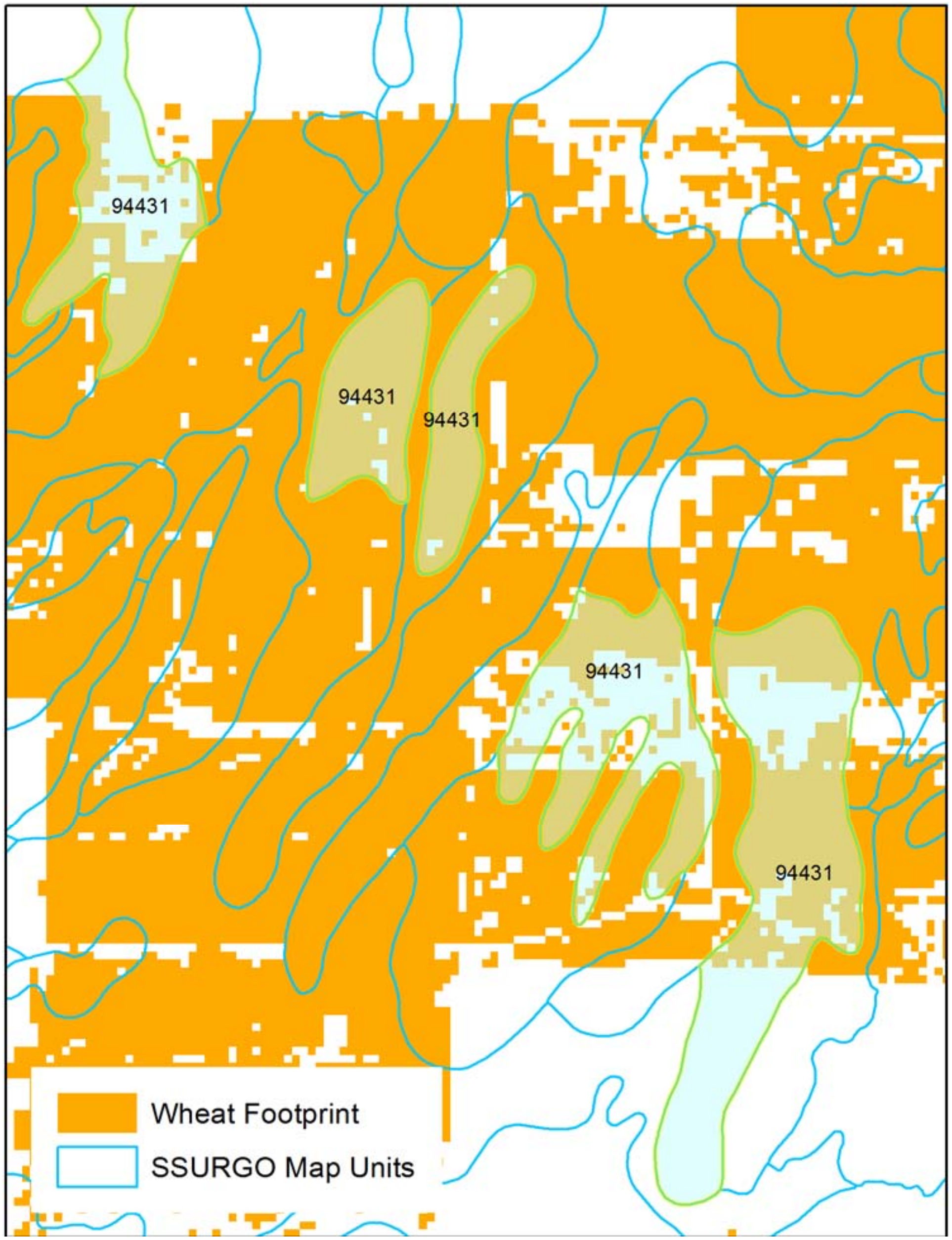
Soil Component Analysis

All soil components overlapping wheat growing areas were evaluated.

Soils with horizons at least 80 cm deep were included in modeling.

Missing data was estimated from available parameters where possible.

Map unit: 94431	**Kim-Stoneham-Larimer loams, 3 to 12 percent slopes**		
Component	Kim	Larimer	Stoneham
Component %	35	25	30
Horizons	3	4	4



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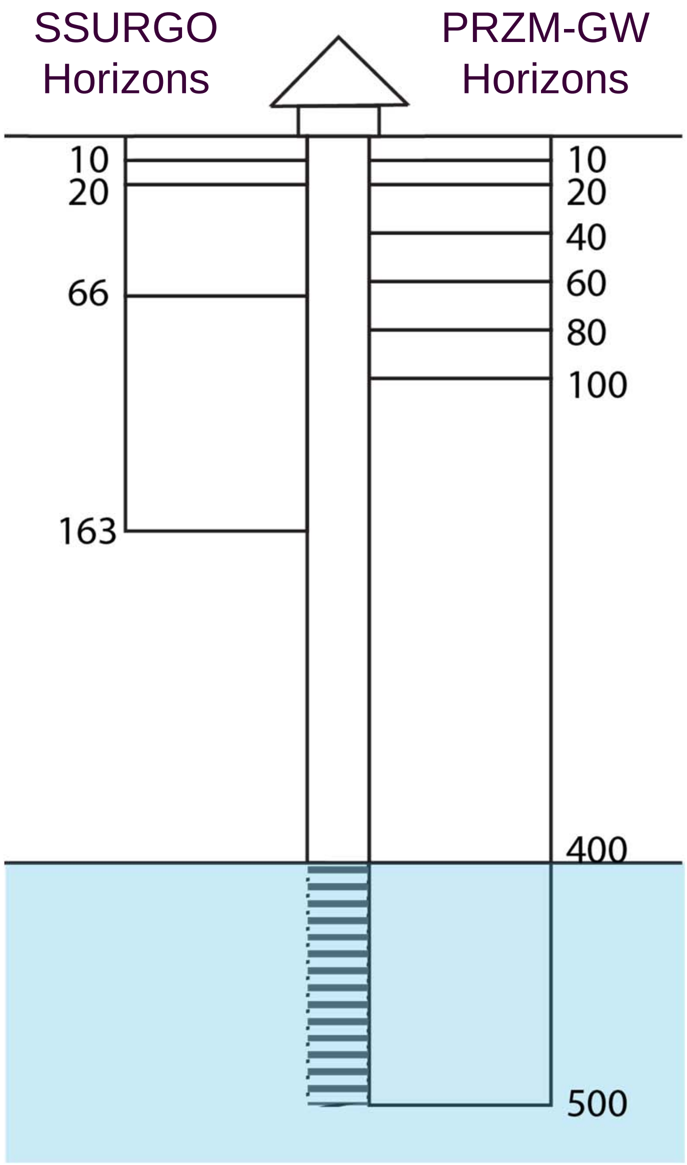
Soil Parameter Projection to Standardized Horizons

SSURGO component data was standardized to the PRZM-GW conceptual soil profile using interpolation.

Depth to water table assumed at 4 m for all screening runs with 1 m well screen.

Stoneham Horizon Data						
SSURGO Raw Data						
Horizon Depth (cm)	OC	BD	Field Cap.	Wilting Pt.	Clay %	Sand %
0-10	0.73	1.33	0.26	0.12	21	41.6
10-20	0.44	1.43	0.3	0.16	27.5	34.7
20-66	0.44	1.43	0.29	0.16	27.5	34.7
66-163	0.15	1.5	0.16	0.08	15	65.9
Standardized for PRZM-GW						
0-10	0.73	1.33	0.26	0.12	21	41.6
10-20	0.44	1.43	0.3	0.16	27.5	34.7
20-40	0.44	1.43	0.29	0.16	27.5	34.7
40-60	0.44	1.43	0.29	0.16	27.5	34.7
60-80	0.23	1.48	0.2	0.1	18.75	56.54
80-100	0.15	1.5	0.16	0.08	15	65.9
100-400	0.15	1.5	0.16	0.08	15	65.9
400-500	0.15	1.5	0.16	0.08	15	65.9



Additional PRZM Input Parameters

Additional screening-level parameters were derived from EPA PRZM standard scenarios, PRZM Manual, PRZM-GW guidance documents, and USDA reports.

Consistent with EPA scenarios, simulations were parameterized to generate negligible runoff.

Crop Parameter	Value
Minimum Evaporation Depth	varies by state
Canopy Water Holdup	0.1 cm
Root Depth	20 cm
Canopy Coverage	100%
Max Canopy Height	90 cm
Pan Evaporation Correction Factor	0.73
Snowmelt Factor	0.36
Extra Water for Leaching	0.1
Available Depletion	0.5
States with Irrigation	CA, OR (winter & spring), ID (spring only)
Maximum Irrigation Rate	5 cm/hr
Depth to Aquifer	4 m
Bottom Boundary (Groundwater) Temperature	varies by state
Albedo	0.2
Curve Number	10

Additional PRZM Input Parameters

One post-emergent foliar herbicide application per year.

Emergence, maturity, harvest dates determined from *USDA Usual Planting and Harvesting Dates for U.S. Field Crops.*

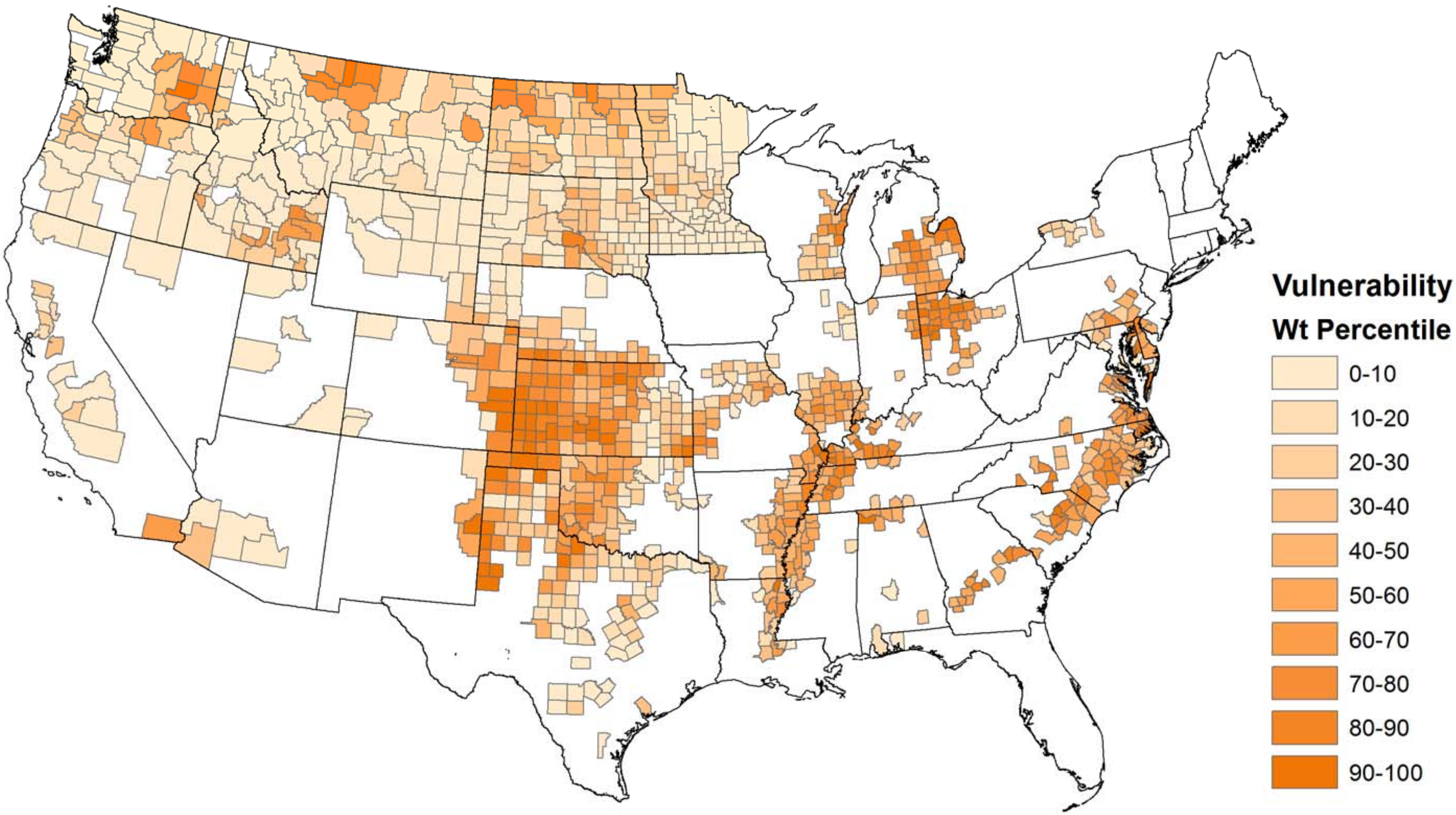
Chemical Property	Value
Chemical	Hypothetical herbicide
Hydrolysis Half Life	stable
Surface Soil Half Life	126 days
Sorption Coefficient	144.4 mL/g
Volitalization	none
Number Apps	1
Method	foliar
Rate	0.07 kg/ha
Emergence Date	spring -varies by state: plant+21/winter - Nov 1
Maturity Date	spring -varies by state: emerg+70/winter - May 12
Harvest Date	spring - varies by state: mat+11/winter - Jul 8
Application Date	post emergence

Screening-Level Vulnerability Results

Exposure varied widely with no chemical breakthrough to the water table after 100 years of simulation in some cases.

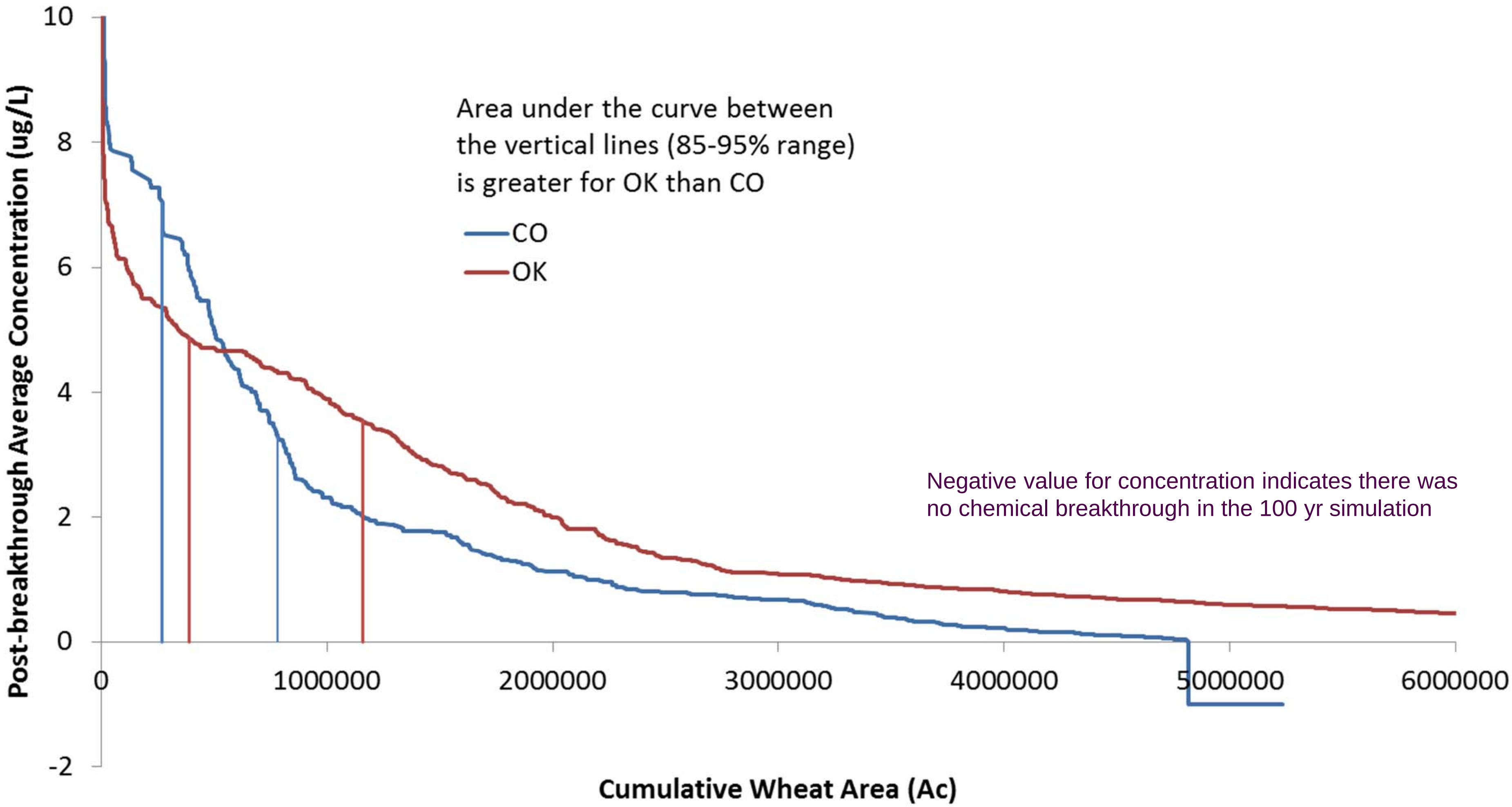
County vulnerability is a function of 90th percentile concentration and wheat area (county-90th-percentile post-breakthrough concentrations times the fraction of the county growing wheat).

Final site selection was based on component-level results; this map shows a high-level summary of screening results.



Step 2: Selection of States for Representative Scenario Development

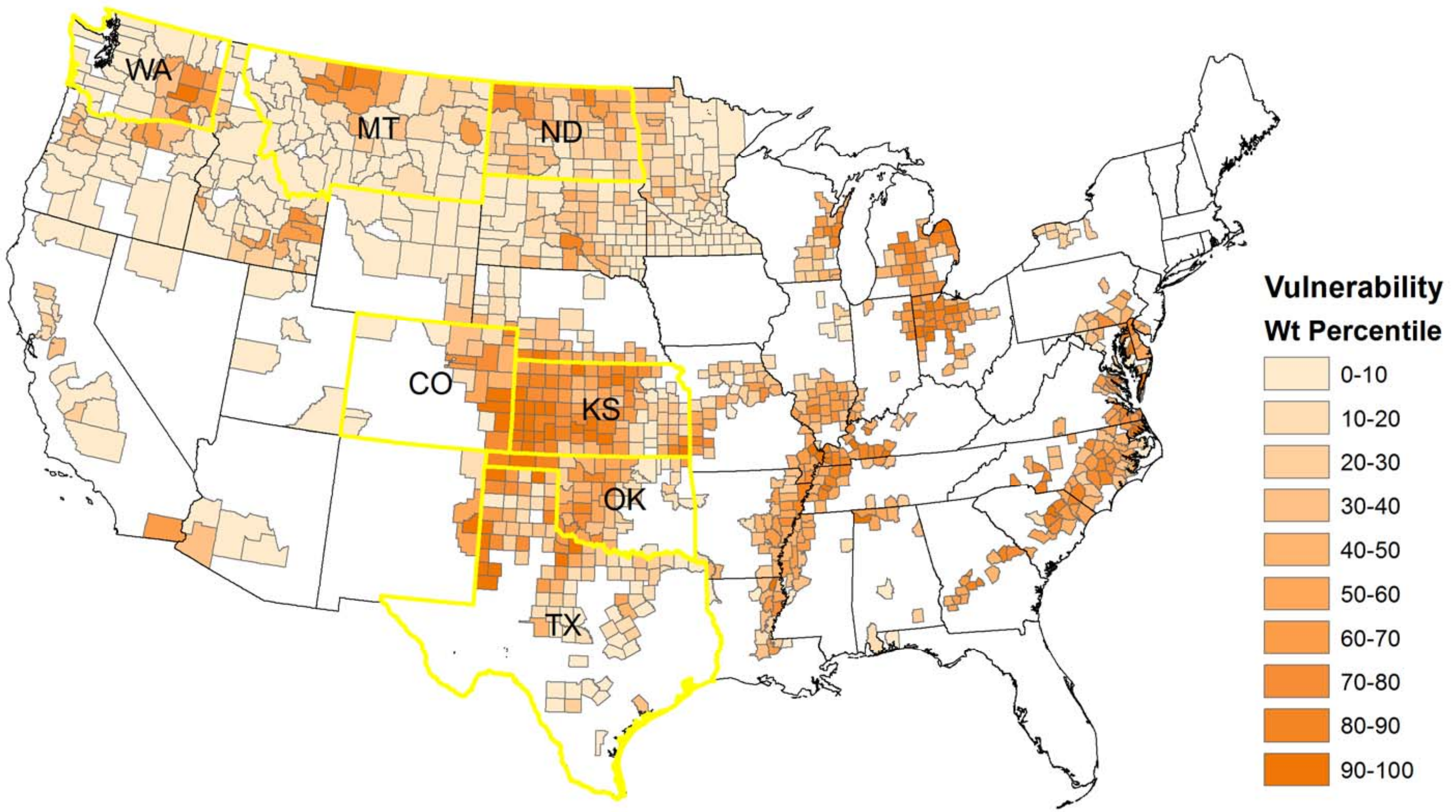
The most vulnerable states were identified as those with the highest sum of 85th-95th percentile post-breakthrough concentrations for the state times the corresponding wheat area. Wheat area has an influence in selection.



Selected States for Representative Scenario Development

Four winter and spring wheat states were selected from the top 5 vulnerable states also considering geographic diversity.

	Winter Wheat			Spring Wheat	
Rank	State	Conc.-Area Integral		State	Conc.-Area Integral
1	KS	4574498		TX	3041801
2	TX	3470817		ND	2798112
3	OK	3309084		MT	2449460
4	ND	2805845		CO	2305226
5	CO	2624213		WA	1663869



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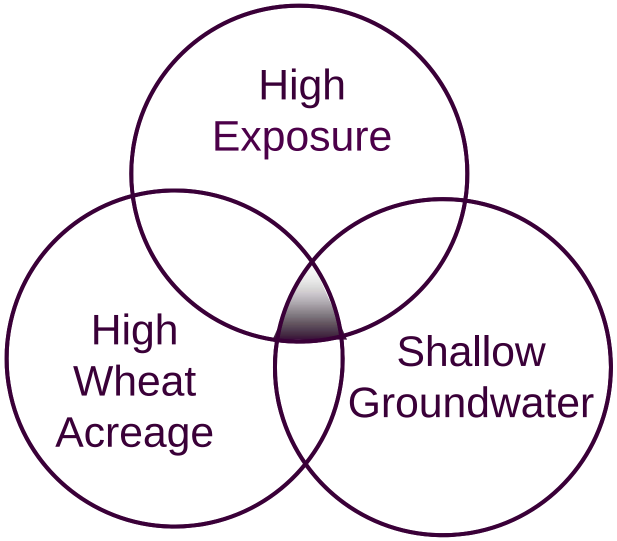
Final Site Selection for Representative Scenarios

For each of the top states identified as vulnerable (4 spring wheat, 4 winter wheat), final soil, weather, and environmental parameters were selected as the representative scenario.

The screening simulation best satisfying the following criteria formed the basis of the representative scenario:

- Post-breakthrough average screening concentrations near 90th-percentile for the state
- Near to shallow groundwater wells (corresponding to crop within the same aquifer as the shallowest wells in the state)
- Corresponding to areas of high wheat acreage

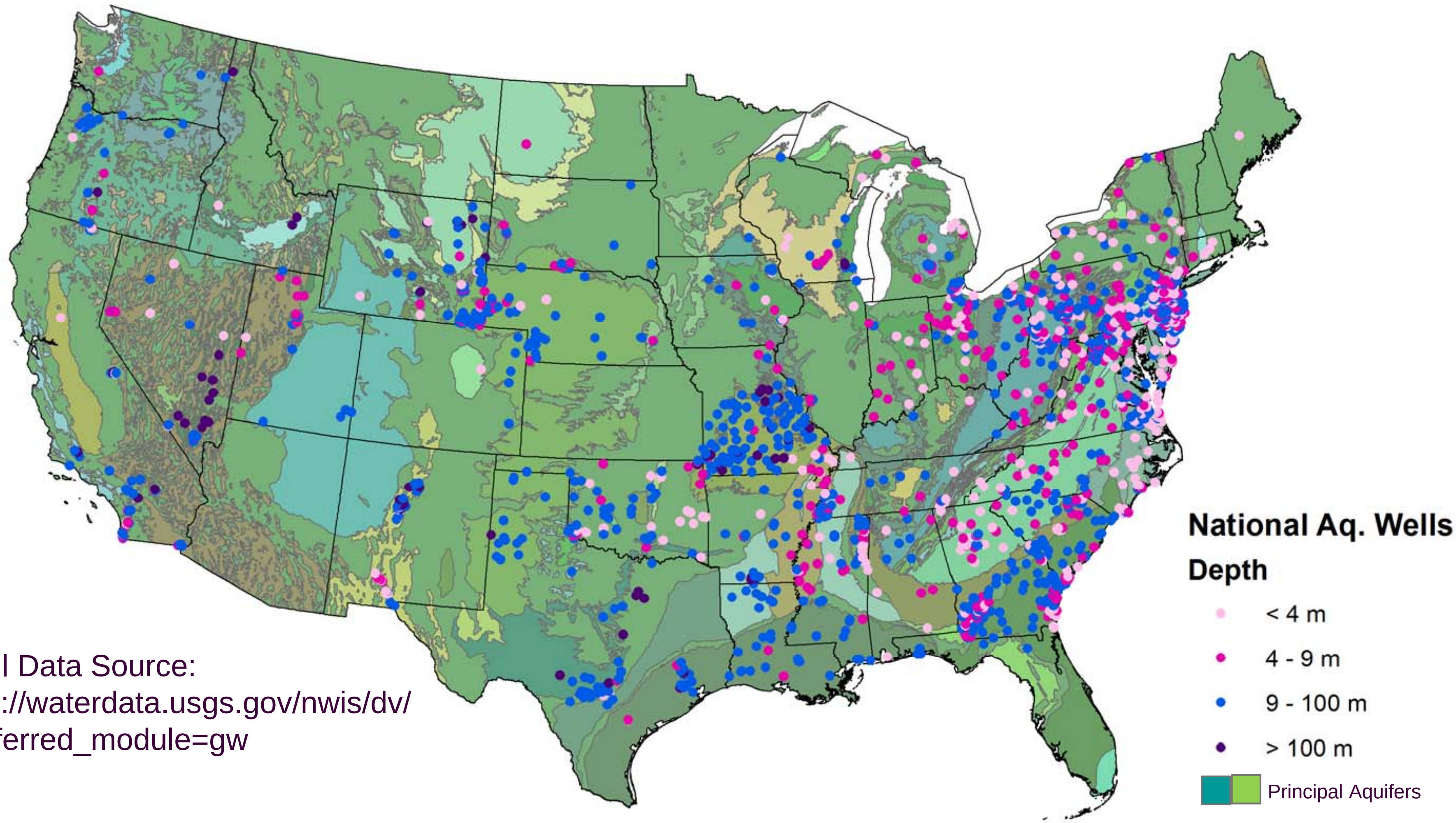


Representative scenarios were finalized by updating groundwater depth and pan evaporation to match the location.

Groundwater Depth for Wells in the Principal Shallow Aquifers of the United States

Daily groundwater depth data from long-term USGS groundwater sites corresponding to Principal Aquifers selected.

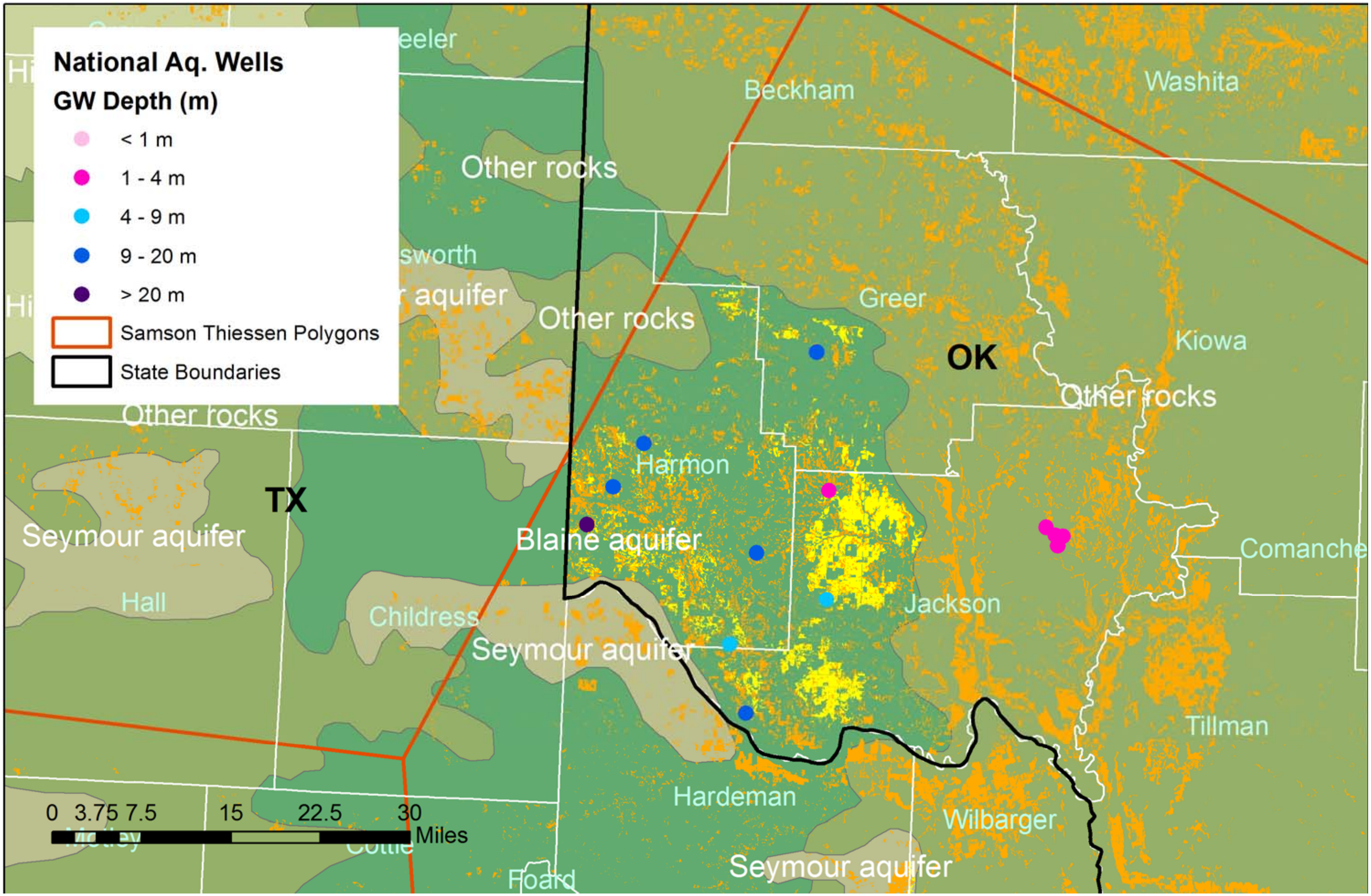
Long-term annual-average groundwater depth to land surface calculated.



Well Data Source:
http://waterdata.usgs.gov/nwis/dv/?referred_module=gw

Oklahoma Winter Wheat Representative Scenario Site

Selected Site | 85^{th}-95^{th} Percentile Wheat Footprint | Blaine Aquifer



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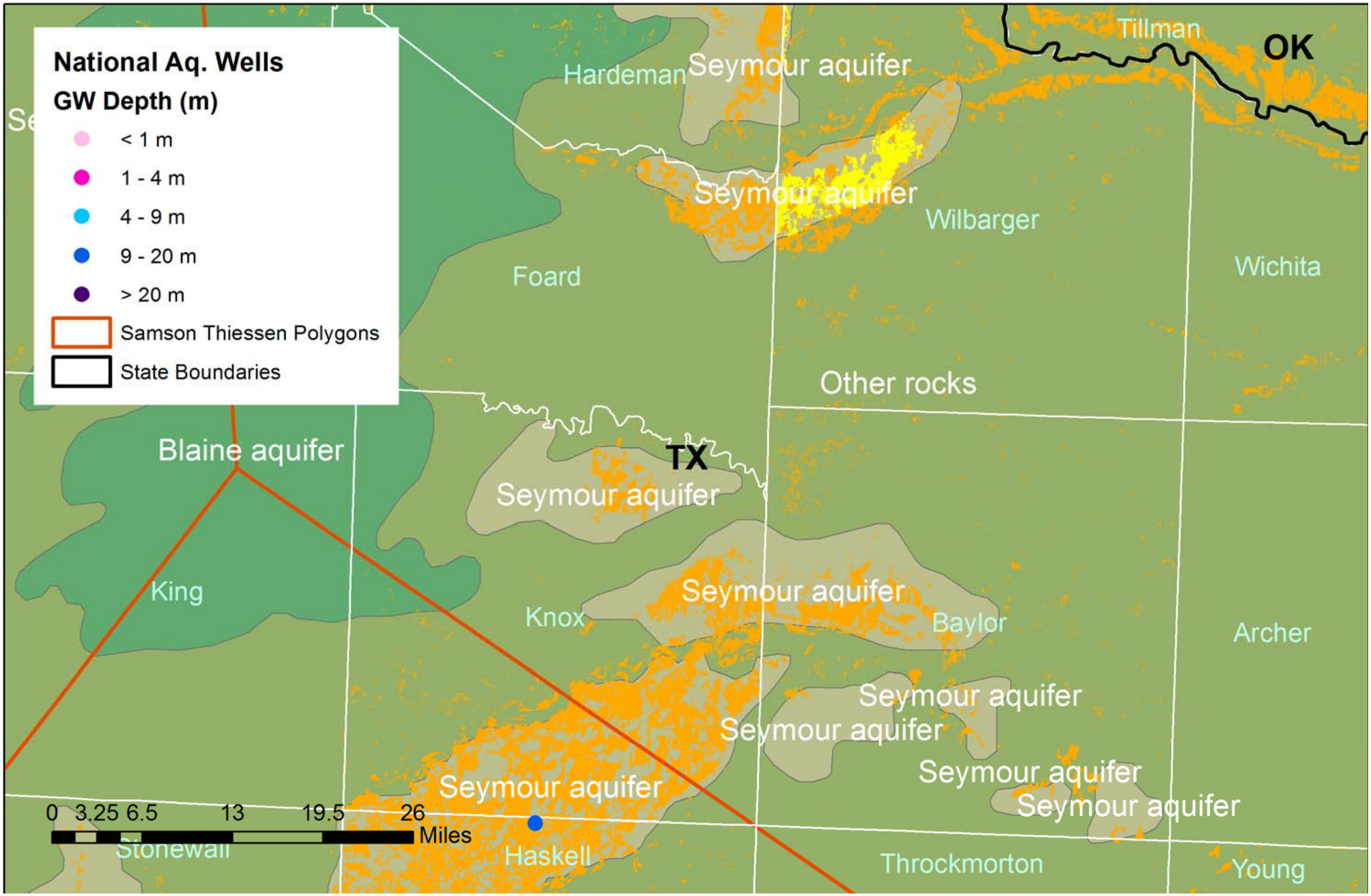
Texas Spring Wheat Representative Scenario Site

Selected Site | 85th-95th Percentile Wheat Footprint | Seymour Aquifer



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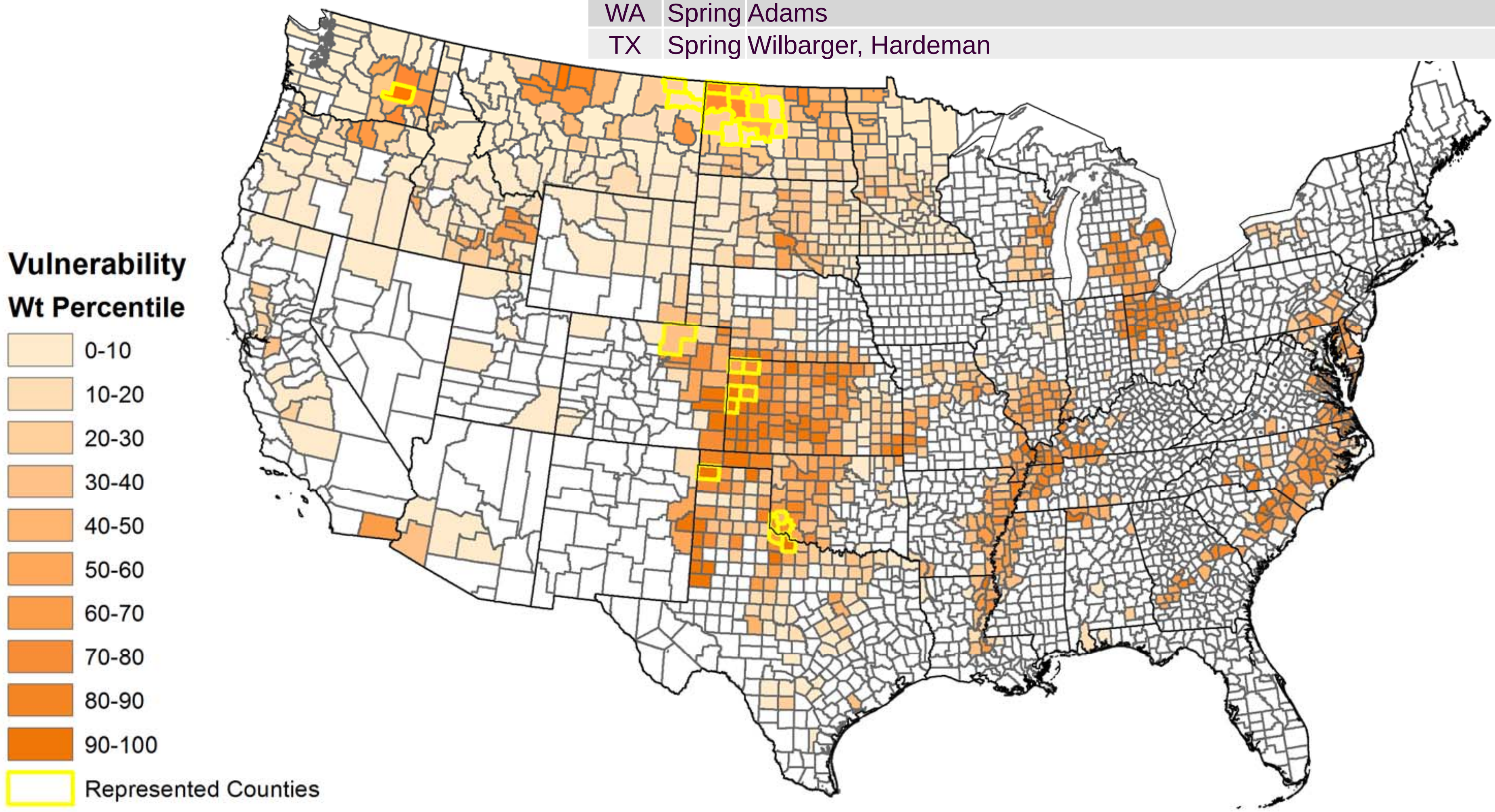
Counties Represented by Finalized PRZM-GW Wheat Scenarios

State	Crop	Counties
OK	Winter	Harmon, Greer, Jackson
TX	Winter	Dallam
KS	Winter	Cheyenne, Rawlins, Wallace, Logan, Greeley
CO	Winter	Weld
ND	Spring	Divide, Burke, Williams, Mountrial, Ward, McKenzie, Dunn, Mercer, McLean, McHenry, Renville, Sheridan
MT	Spring	Daniels, Roosevelt
WA	Spring	Adams
TX	Spring	Wilbarger, Hardeman



Finalized PRZM-GW Wheat Scenario Summary

- Post-breakthrough (PBT) concentrations for the final scenarios corresponded to sites in the upper 7th -12th percentile vulnerability for the target state.
- Groundwater depth updated to annual-average depth of the shallowest well in the aquifer corresponding to the selected site.
- Applied upper limit on depth of 9 m (PRZM-GW maximum depth of all current scenarios).
- Depth for states without long-term Principal Aquifer depth data derived from nearby state sharing the same aquifer.
- Screening and final concentrations were similar with final concentrations lower in some cases

State	Crop	Screening PBT Avg Conc. (GW 4m) (ug/L)	Upper Percentile	Area (Ac)	Local GW Depth (m)	GW Depth used in PRZM (m)	Final PBT Avg Conc. (ug/L)	Aquifer
OK	Winter	4.21	11.42	17723	11.81	9	4.14	Blaine
TX	Winter	3.25	9.18	37528	71.37	9	2.55	High Plains
KS	Winter	2.36	9.72	66234	27.22	9	1.55	High Plains
CO	Winter	4.35	11.65	13444	3.57	4	4.34	Denver Basin
ND	Spring	2.08	9.12	501217	4.93	5	2.04	Lower Tertiary
MT	Spring	2.59	9.56	14245	4.93	5	2.55	Lower Tertiary
WA	Spring	4.38	7.03	133386	11.99	9	4.30	Columbia Plateau basaltic-rock
TX	Spring	3.00	7.65	28967	12.64	9	2.98	Seymour

Comparison to PRZM-GW Standard Scenario Results

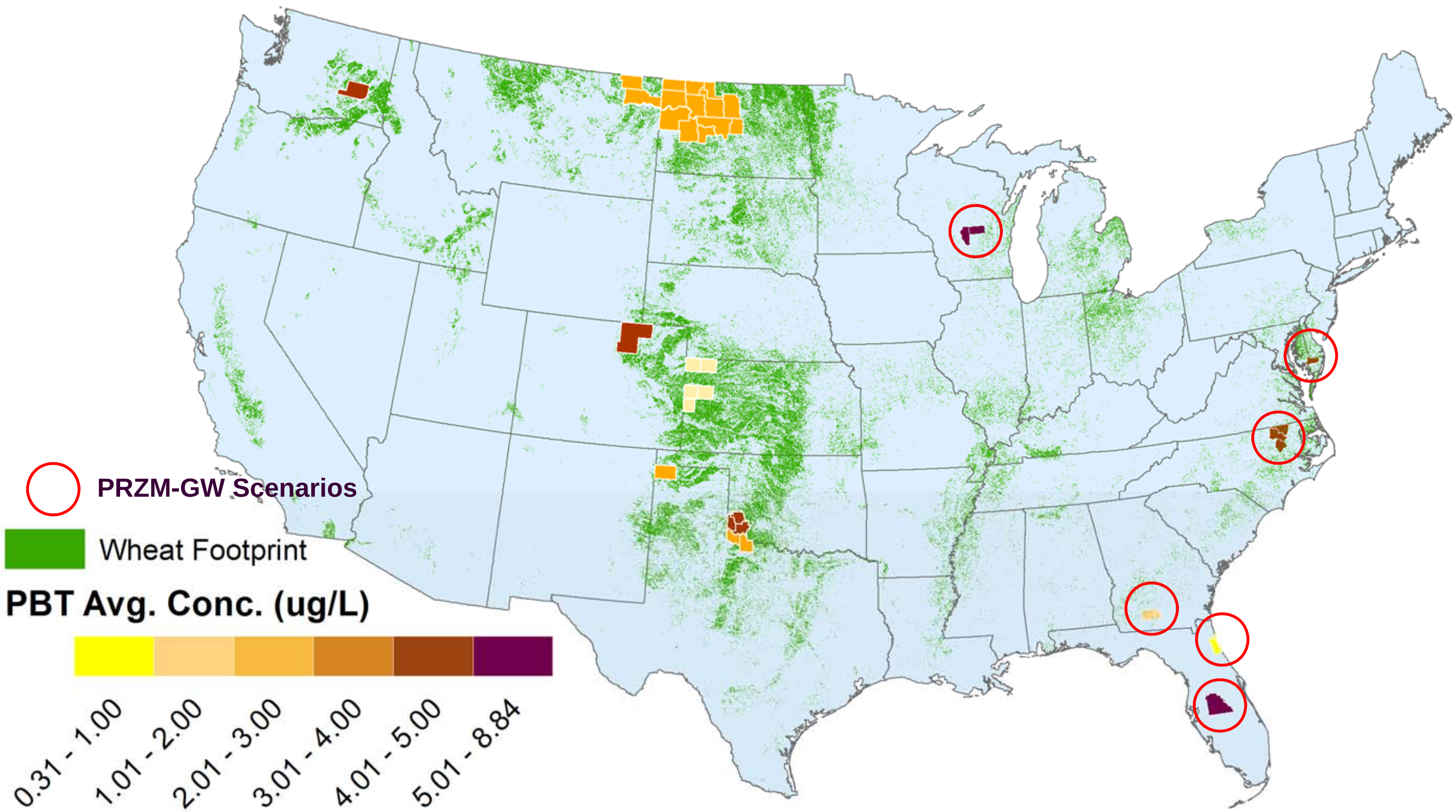
All 8 wheat scenario PBT concentrations from post-emergence application are lower than 4 of the 6 standard scenarios (FL citrus, DELMARVA, NC, and WI), but higher than FL potato and GA Peanuts.

The highest standard scenario concentration (WI Corn) is 2x higher than highest wheat scenario concentration.

State	Crop	PBT concentrations (ppb)
OK	Winter Wheat	4.14
TX	Winter Wheat	2.55
KS	Winter Wheat	1.55
CO	Winter Wheat	4.34
ND	Spring Wheat	2.04
MT	Spring Wheat	2.55
WA	Spring Wheat	4.30
TX	Spring Wheat	2.98
State	**PRZM-GW Standard Scenario**	**PBT concentrations (ppb)**
FL	Citrus	5.92
FL	Potato	0.306
GA	Coastal Peanuts	1.94
DELMARVA	Sweet Corn	4.54
NC	Coastal Cotton	4.41
WI	Corn	8.84

Comparison to PRZM-GW Standard Scenario Results

Counties represented by the new wheat scenarios and the standard scenarios mapped by post-breakthrough average concentration and compared to wheat footprint.



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Extensible Methodology

Efficient parallel processing using python scripts to run batches of simulations simultaneously,

- allows vulnerability assessment to be national in scope while maximizing the number of different environmental conditions evaluated.
- facilitates extending process to other use patterns and pesticides.
- generates reproducible results.

Recently conducted similar analysis for corn growing areas.

New wheat scenarios can be used for modeling other chemicals as used in the screening simulations.

Summary

National screening-level PRZM modeling was conducted for wheat-growing regions with resolution at the soil component level.

Sites corresponding to high post-breakthrough herbicide concentrations, high wheat acreage, and shallow groundwater were selected as representative scenarios.

Work resulted in 8 new appropriately vulnerable PRZM-GW modeling scenarios for wheat crops in regions previously excluded from EPA standard groundwater scenarios.

Concentrations predicted at EPA standard PRZM-GW scenario locations were not representative of vulnerable concentrations in major wheat regions. Concentrations at the vulnerable wheat sites were lower than most standard scenario concentrations.

The newly developed wheat scenarios for regulatory groundwater exposure assessments can be used for other chemicals.

Thank you.

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