Probabilistic Modeling to Account for Spatial and Temporal Variability in Aquatic Pesticide Concentrations for Endangered Species Risk Assessments

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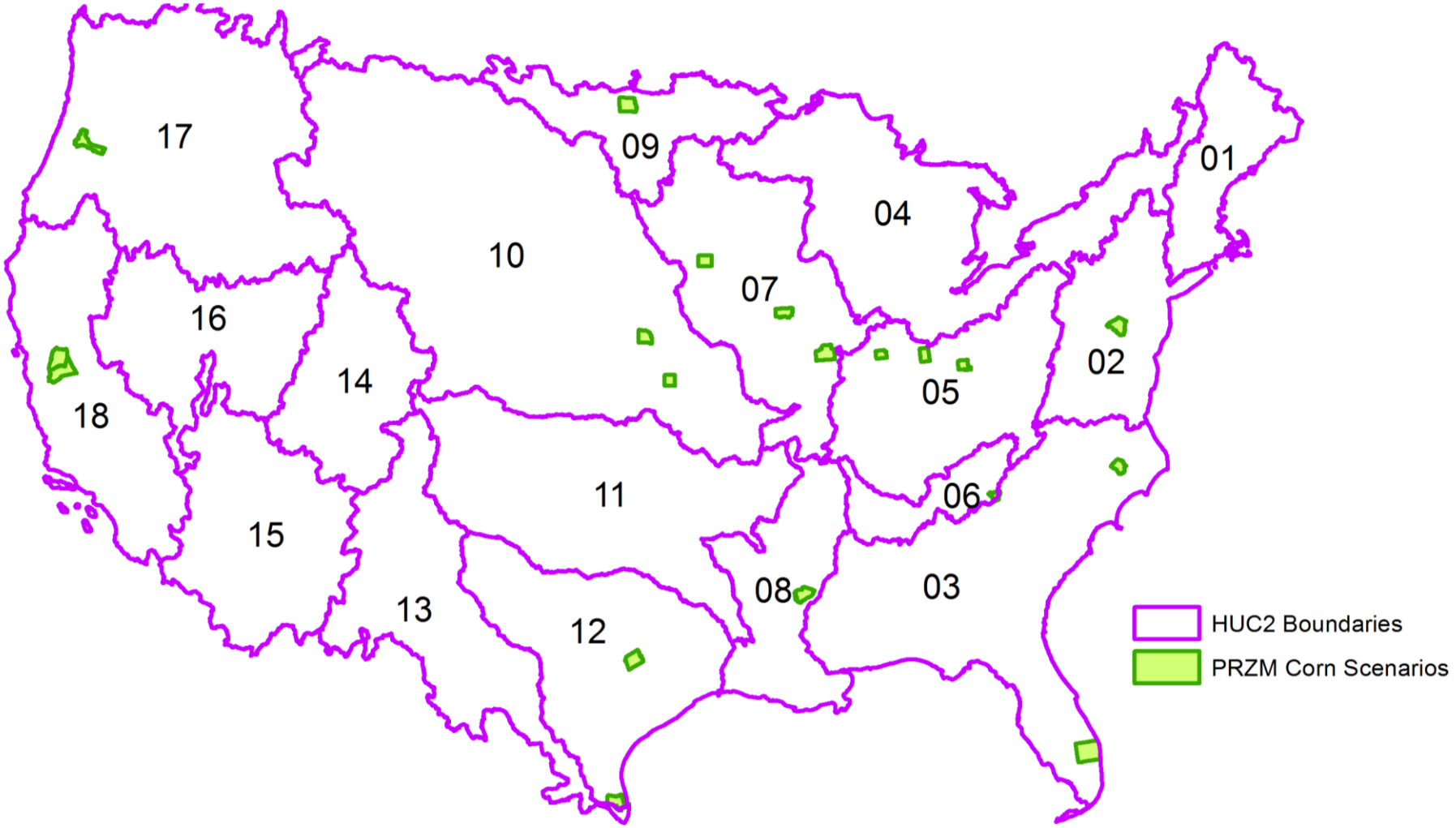
Current regulatory exposure modeling tools are deterministic, considering certain use patterns and environmental conditions.

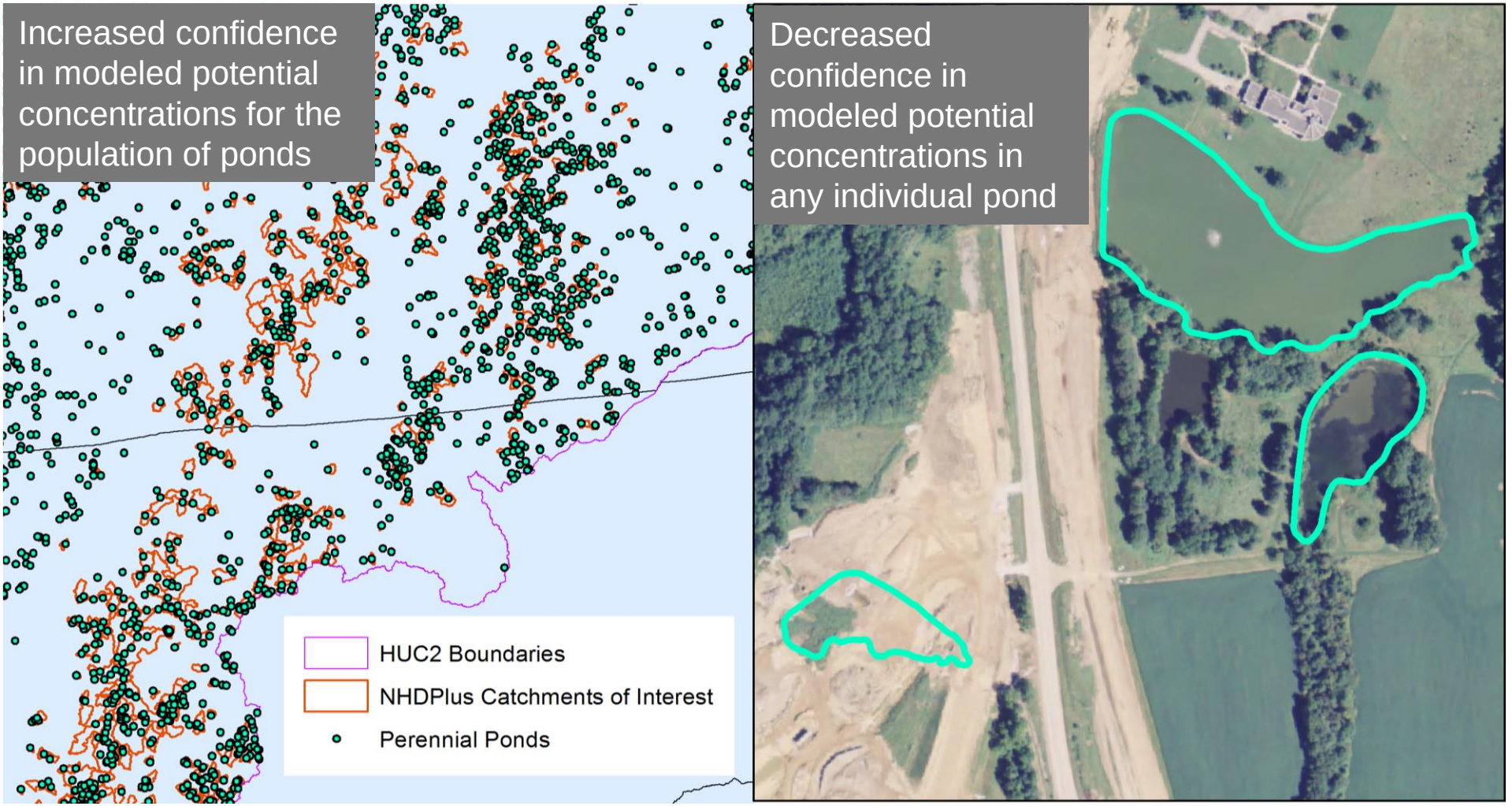
One estimate from the Surface Water Concentration Calculator (SWCC) per crop group and HUC2 for endangered species assessments



A broader, more accurate range of exposure estimates can be achieved using a probabilistic approach.

Account for uncertainty in use pattern and environmental conditions.

Probability distributions of modeled potential pesticide exposure based on conditions around a large collection of ponds reduces uncertainty compared to estimates for a single pond.



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Probabilistic SWCC Web Application

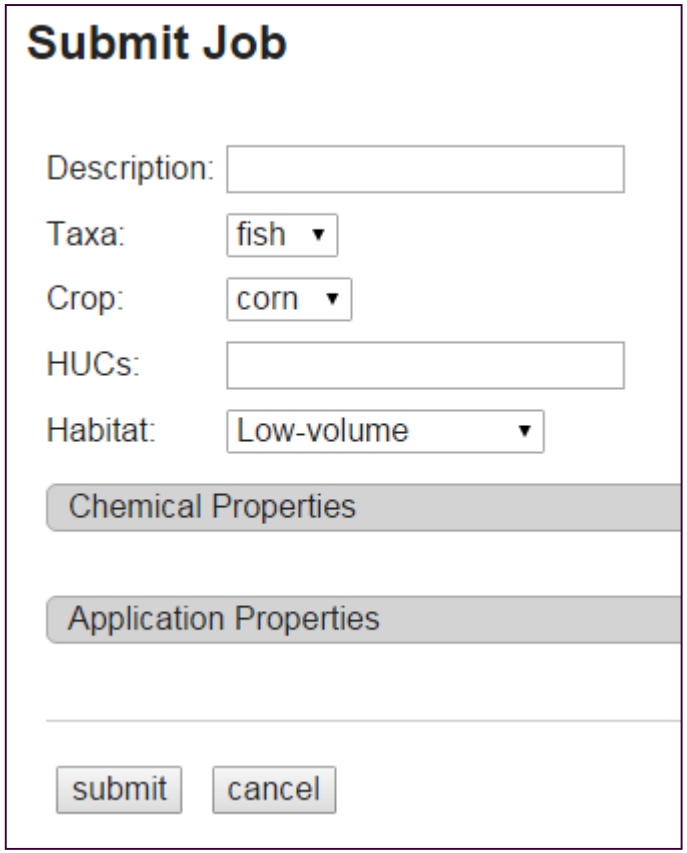
Represent SWCC model input parameters by probability distributions based on environmental and agronomic conditions in each HUC2

- Vary parameters with greatest influence on pesticide concentrations

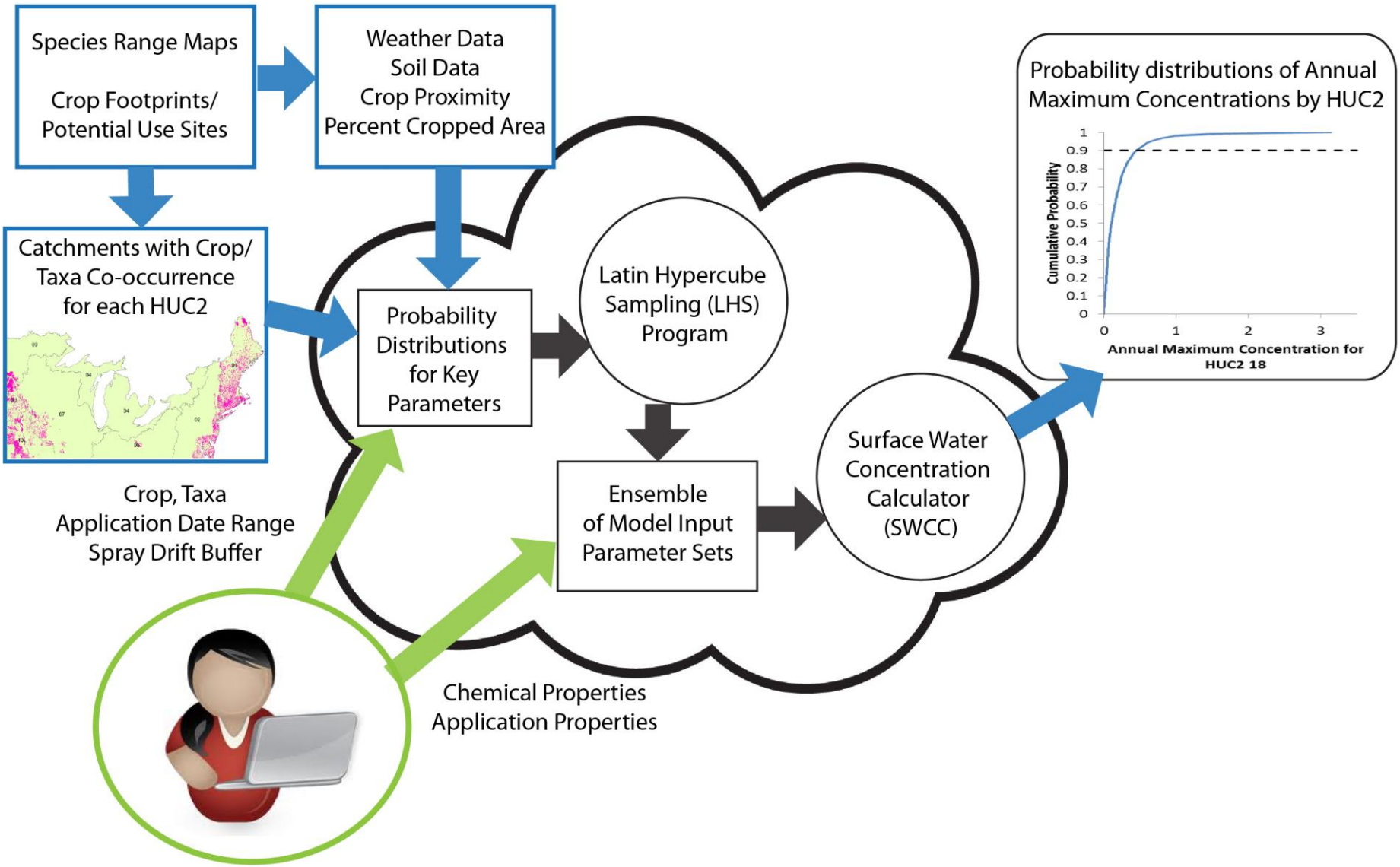
Conduct many model simulations sampling from these distributions using Latin Hypercube Sampling (LHS)

- Sandia National Laboratory program
- LHS results in better coverage of parameter space with fewer samples than Monte Carlo sampling

Results are probability distributions of pesticide concentration for each HUC2 where crop group and species habitat co-occur



Data Processing and Simulation Workflow



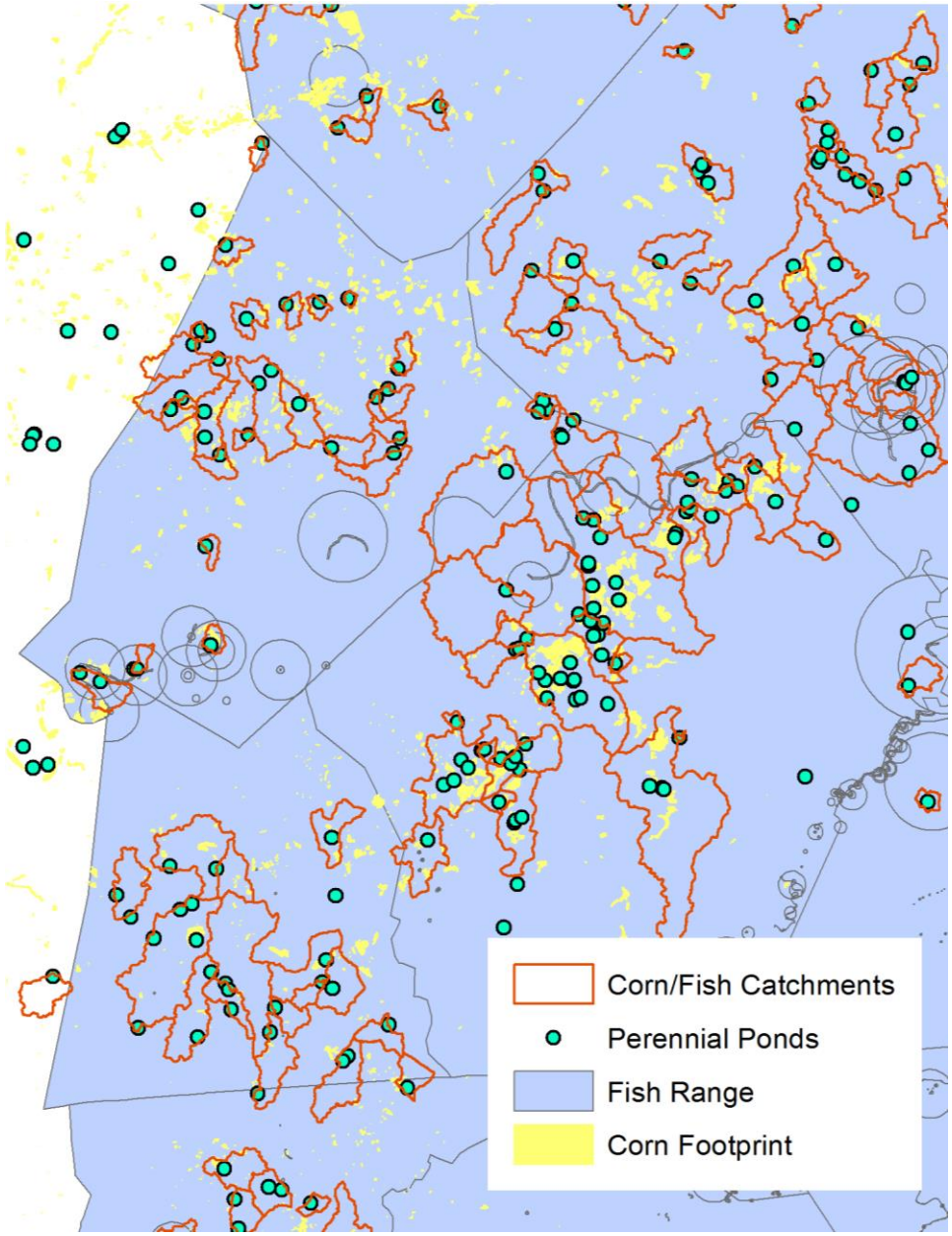
Probabilistic SWCC Web Application

Probability distributions derived for regions co-occurring with crop group and endangered species range (grouped by taxa).

All ponds in NHDPlus V2 catchments overlapped by crop and taxa habitat range included in analysis.

NHDPlus V2 water bodies of Lake/Pond type with surface area > 0.5 ha and < 5 ha evaluated.

For pilot version of App, using Corn and Fish.



App represents higher tier modeling approach for static aquatic habitats.

SWCC most appropriate for modeling static habitat bins, 5, 6, and 7.

Simulations for a submitted run are specific to a user selected habitat and HUC2.

Generic Habitat	Depth (meters)	Width (meters)	Length (meters)	Flow (m^3/s)
1 – Aquatic-associated terrestrial habitats	NA	NA	NA	NA
2- Low-flow	0.1	2	Length of field[1]	0.001
3- Moderate-flow	1	8	Length of field	1
4- High-flow	2	40	Length of field	100
5 – Low-volume	0.1	1	1	0
6- Moderate-volume	1	10	10	0
7- High-volume	2	100	100	0
8- Intertidal nearshore	0.5	50	Length of field	NA
9- Subtidal nearshore	5	200	Length of field	NA
10- Offshore marine	200	300	Length of field	NA

Probability distributions developed for most sensitive environmental and agronomic factors.

Pre-processed distributions for each crop/taxa combination

- Soil Profile
- Weather Station

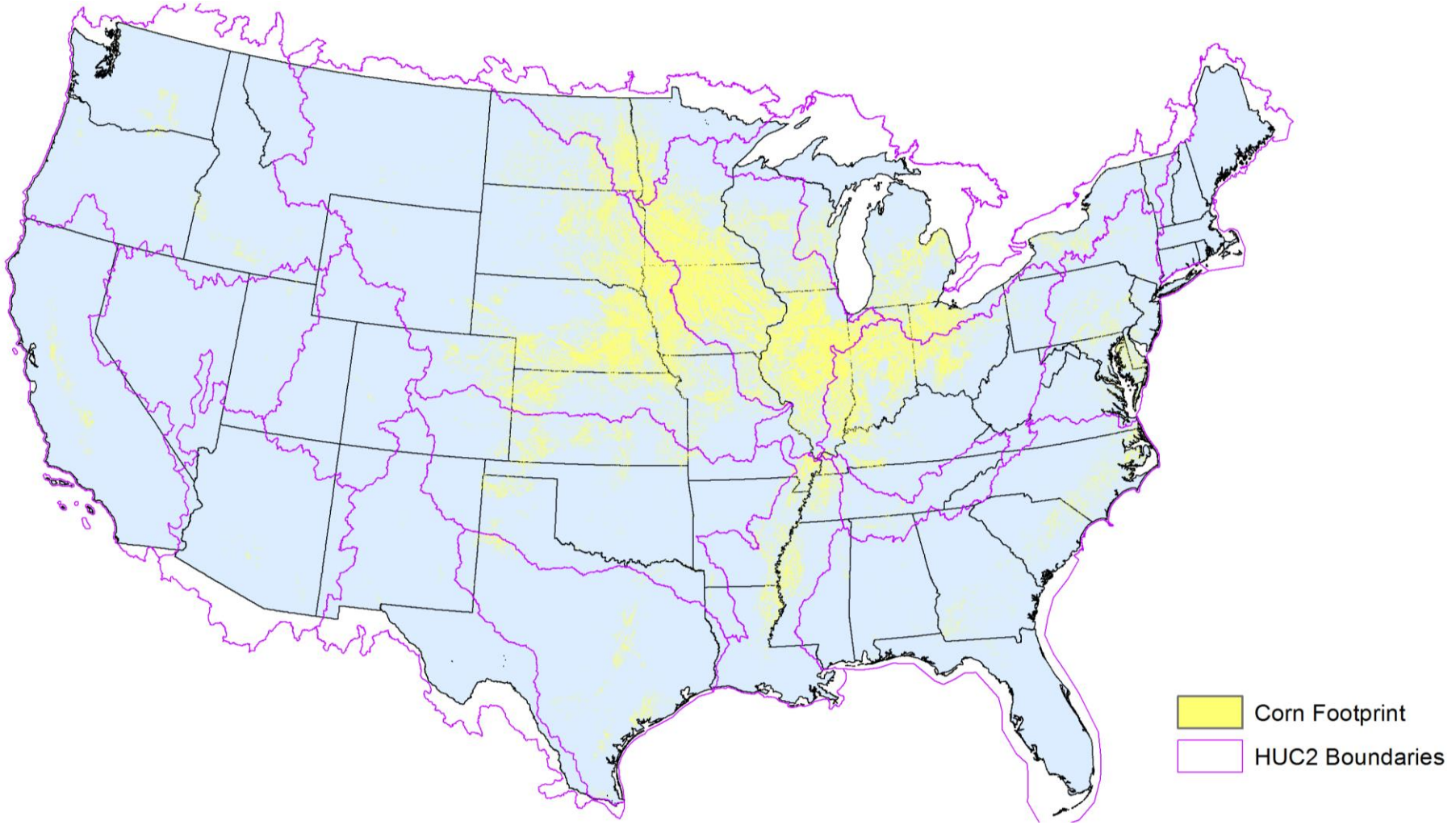
Distributions determined at run-time depending on user inputs

- Application Timing
- Drift fraction as a function of crop proximity to aquatic habitat
- Percent cropped area around aquatic habitat

Crop Footprints, Potential Use Sites

Corn crop footprint generated using the Cropland Data Layer.

- Combined all pixels with corn in any year between 2010-2014.
- Included corn classes plus other crops rotated with corn.



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Soil Profile Distributions

Evaluated all soils in NHDPlus catchments with cultivated crops.

- Include soils in catchments with both crop and taxa of interest
- Dominant soil component for each gridded SSURGO map unit

Parameters and ranges for grouping like soils			
Soil Hydrologic Group	Surface USLE K Factor	Surface Organic Carbon (%)	Land Slope (%)
A	< 0.1	< 0.5	<2
B	0.11 - 0.2	0.5 - 2	2 - 5
C	0.21 - 0.32	2 - 4	5 - 10
D	0.33 - 0.43	4 - 6	10 - 15
	0.44 - 0.64	6 - 8	>15
		> 8	

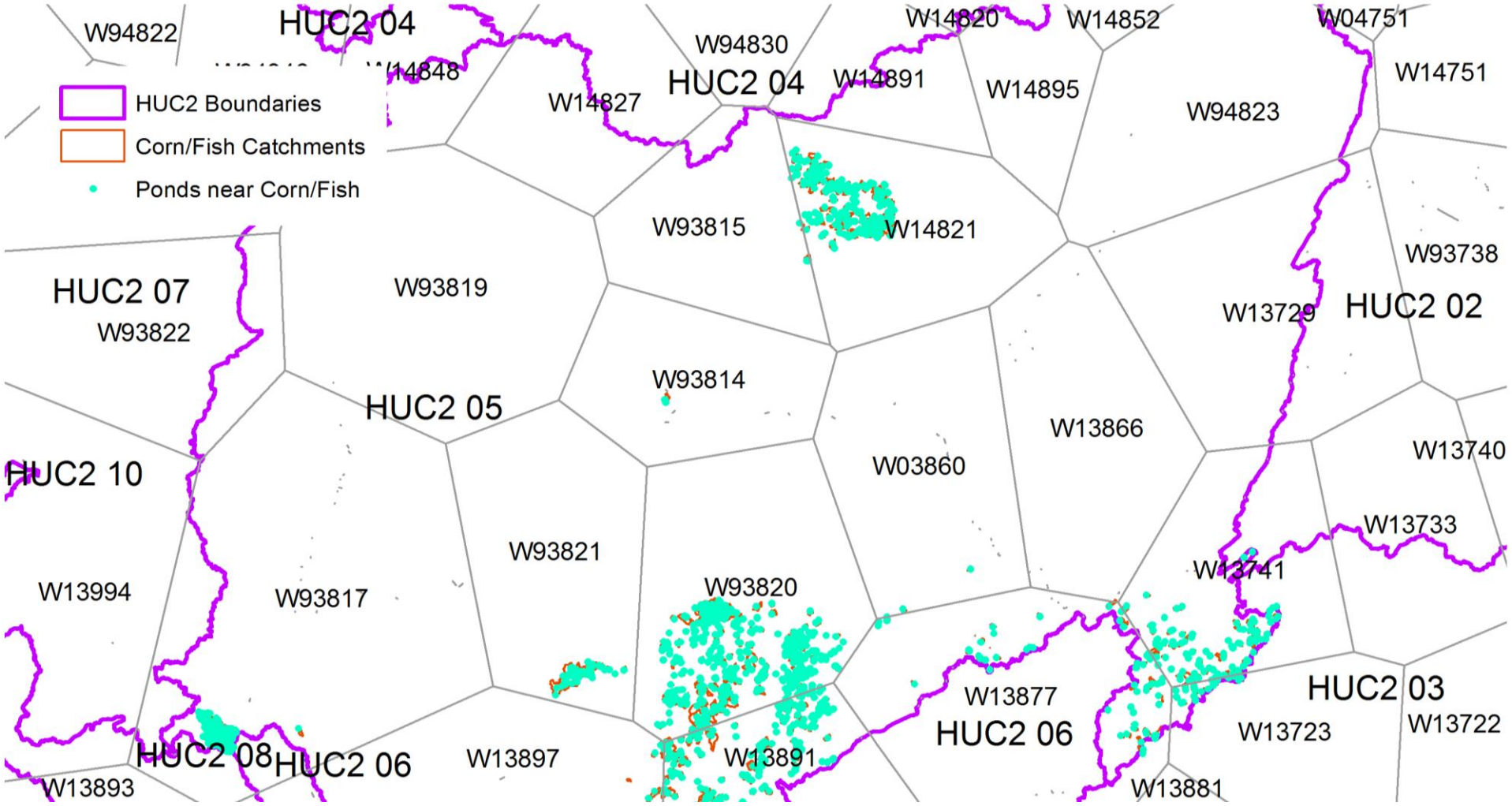
Grouped dominant components into 600 soil groups following EPA Spatial Aquatic Model approach.

- Representative component for the groups determined remaining soil input values to PRZM
- Simplified component horizons to 2 layers (0-10 cm and > 10 cm) using depth weighted averaging

Total area of the soil components in each soil group out of total area of all groups determined the likelihood of representing that group in a PRZM simulation.

Weather Station Distributions

Probability weight for each NOAA SAMSON station based on number of ponds occurring in Thiessen polygon around station



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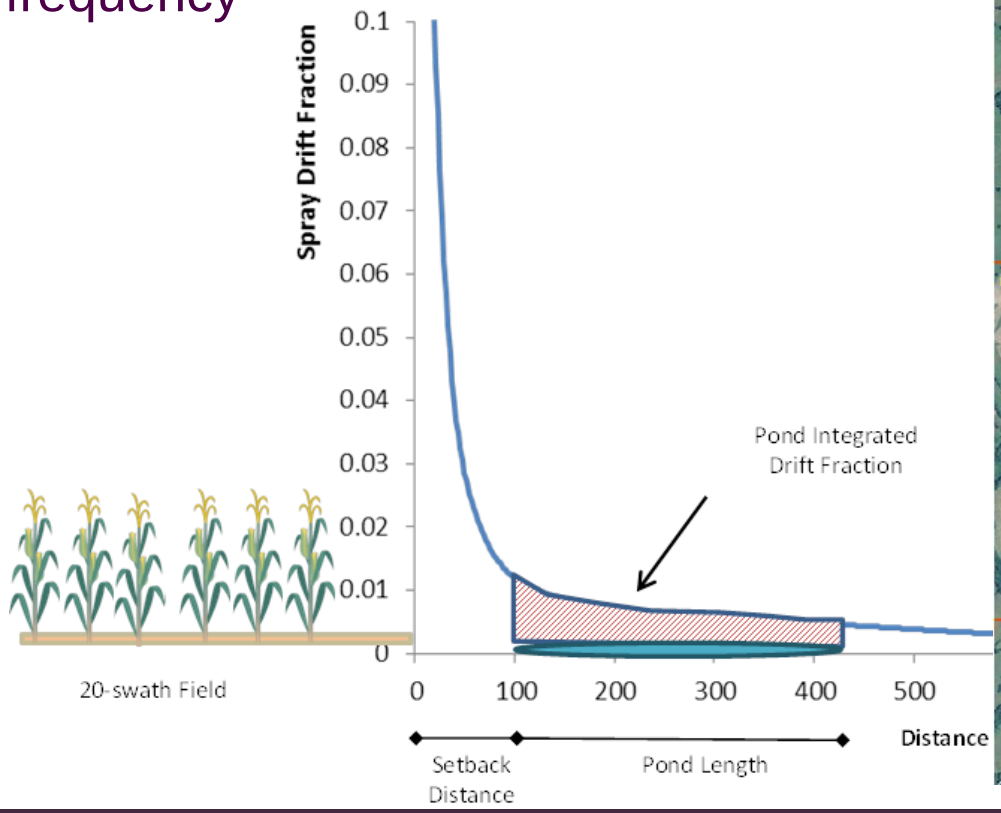
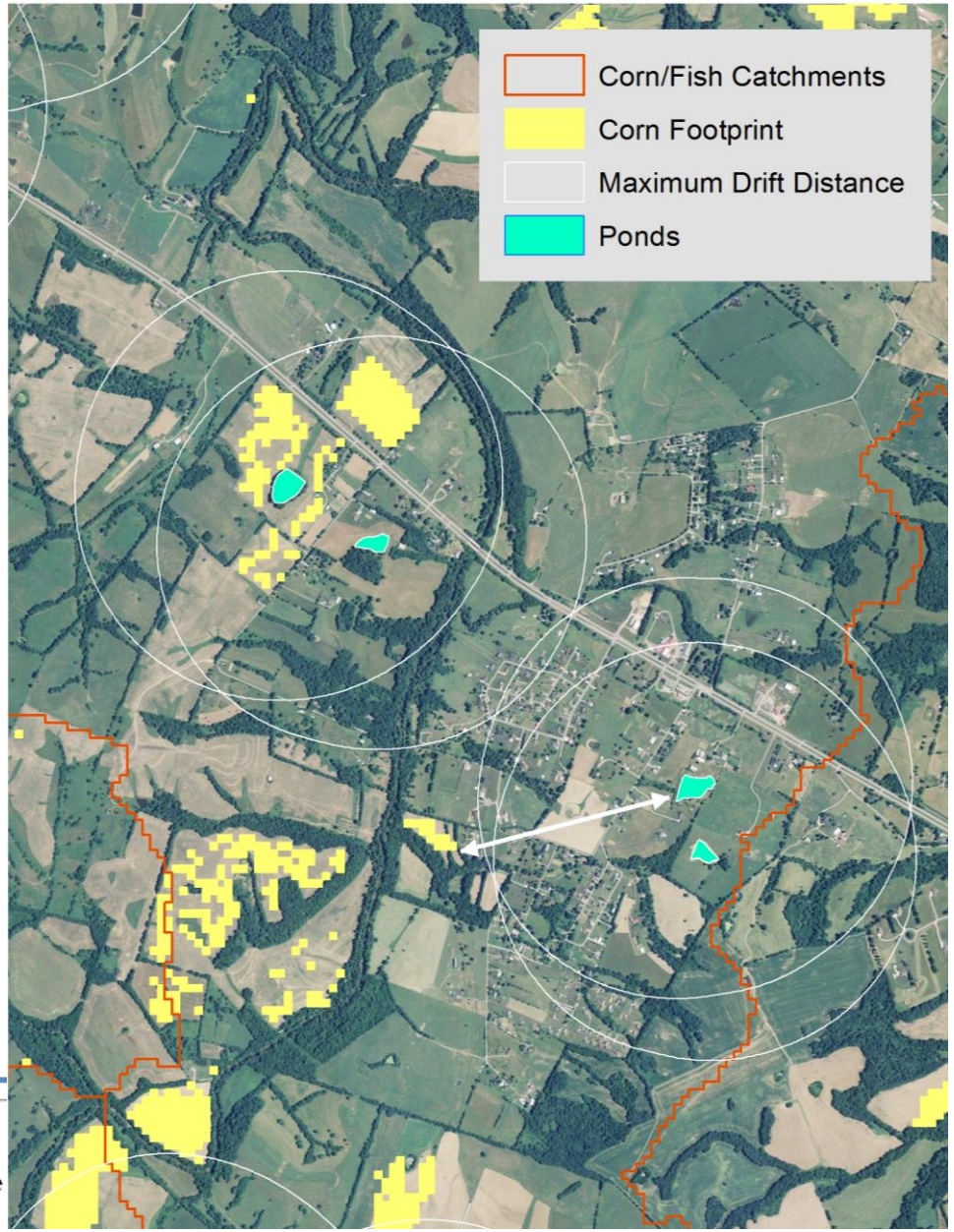
Habitat Proximity to Crop for Drift Distributions

- Proximity analysis determines distance of edge of field to water body
- Drift fraction for each pond by integrating AgDRIFT Tier I drift-distance curves over pond length
- Probability based on drift fraction frequency





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Percent Cropped Area Distributions

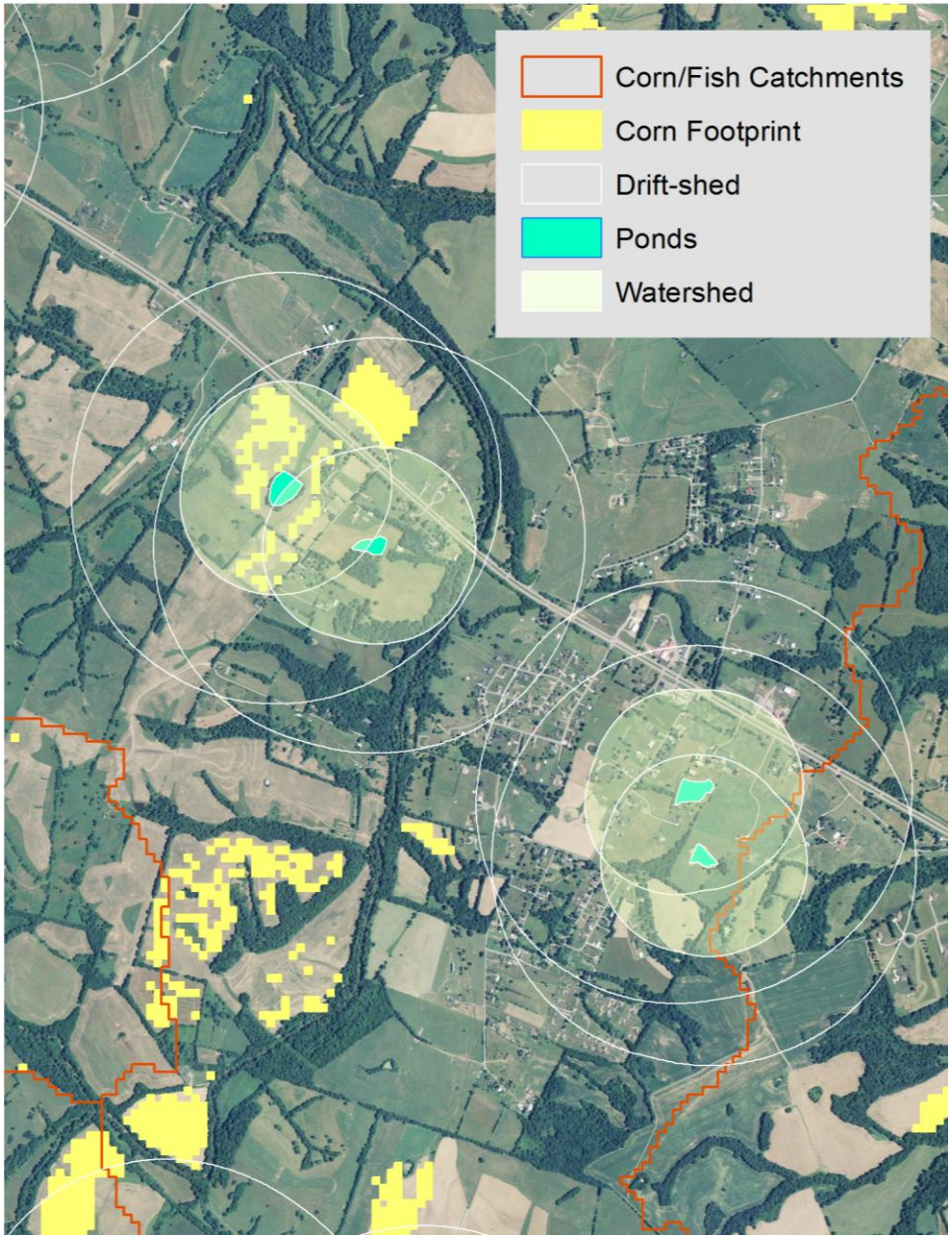
Approximate watersheds by 358.6 m buffer around ponds

Maximum of watershed or drift-shed PCA included in distribution

Only non-zero PCAs included in distribution

User can make PCA distribution more conservative by specifying minimum percentile

- e.g. 75th percentile and higher PCAs only



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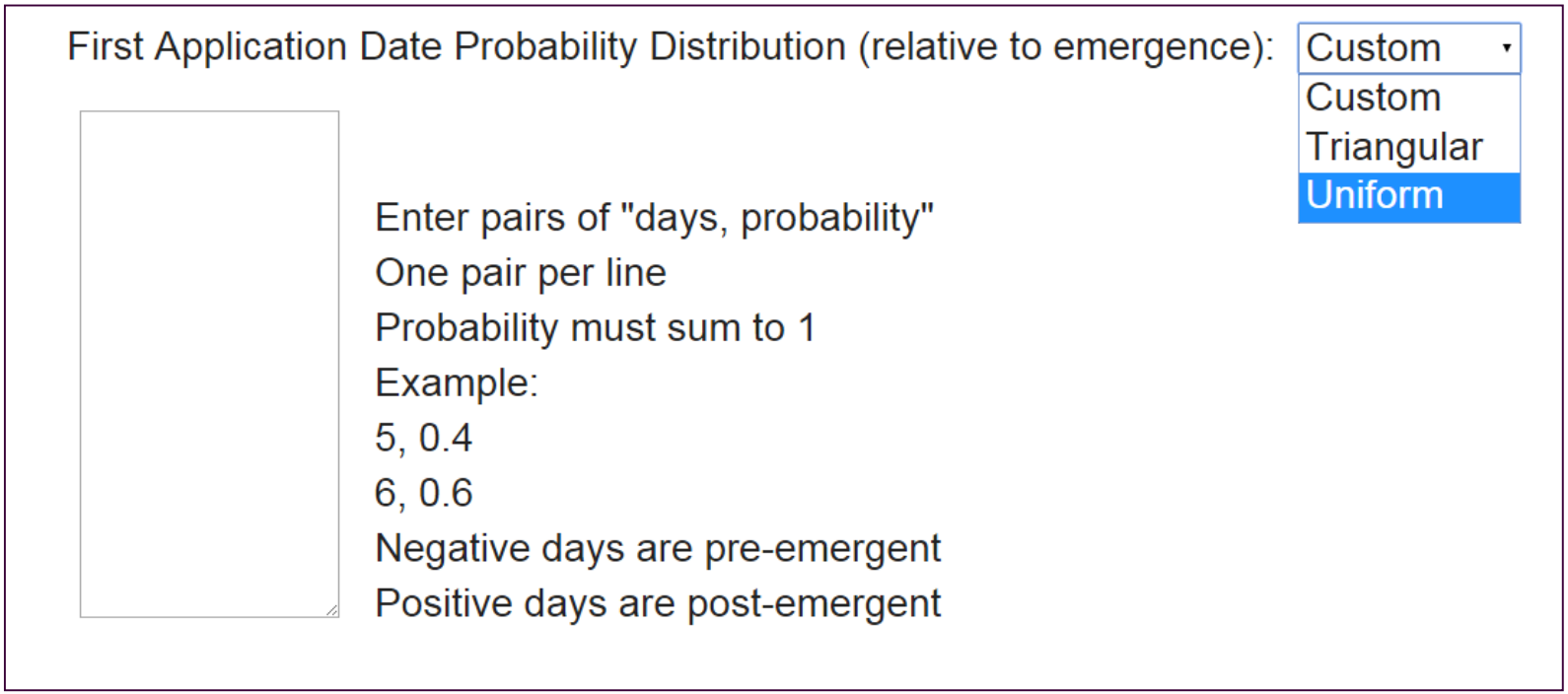
Application Timing Distribution Development

User may specify a custom distribution or have App calculate uniform or triangular distributions based on available agronomic information.

Applications are specified relative to emergence, which varies by HUC2 according to PRZM scenarios.



Additional Parameters Not Represented Probabilistically

Additional environmental parameters were derived from EPA PRZM standard scenarios:

- Emergence, Maturity, Harvest Dates
- Crop growth
- Management practices

Nearest PRZM corn scenario was used for HUC2s without a PRZM corn scenario.

Chemical properties, application information and spray drift characteristics selected by user in the App.

HUC2	HUC2 Name	PRZM Scenario
01	Northeast	PAcornSTD
02	Mid-Atlantic	PAcornSTD
03	South Atlantic	MScornSTD
04	Great Lakes	OHCornSTD
05	Ohio	OHCornSTD
06	Tennessee	NCcornWOP
07	Upper Mississippi	ILCornSTD
08	Lower Mississippi	MScornSTD
09	Souris-Red-Rainy	NDcornOP
10	Missouri	NECornStd
11	Ark-Red-White	MScornSTD
12	Texas	TXcornOP
13	Rio Grande	TXcornOP
14	Upper Colorado	CAcornOP
15	Lower Colorado	CAcornOP
16	Great Basin	CAcornOP
17	Pacific Northwest	ORswcornOP
18	California	CAcornOP

App Demonstration

http://ec2-54-208-8-206.compute-1.amazonaws.com/

Description:

Taxa: fish

Crop: corn

HUCs:

Habitat: Low-volume

Chemical Properties

Application Properties

Number of Applications per Year: 1

Days After 1st App	Rate (kg/ha)	Method	Efficiency	Depth (cm)	T-Band Fraction
0	1	Ground	0.99	4	0

Spray Drift Curve: None

Application Setback from Water (ft):

PCA Distribution Threshold (eg. 0 - entire distribution, 1 - maximum PCA, 0.5 - median and higher PCAs)

First Application Date Probability Distribution (relative to emergence): Uniform

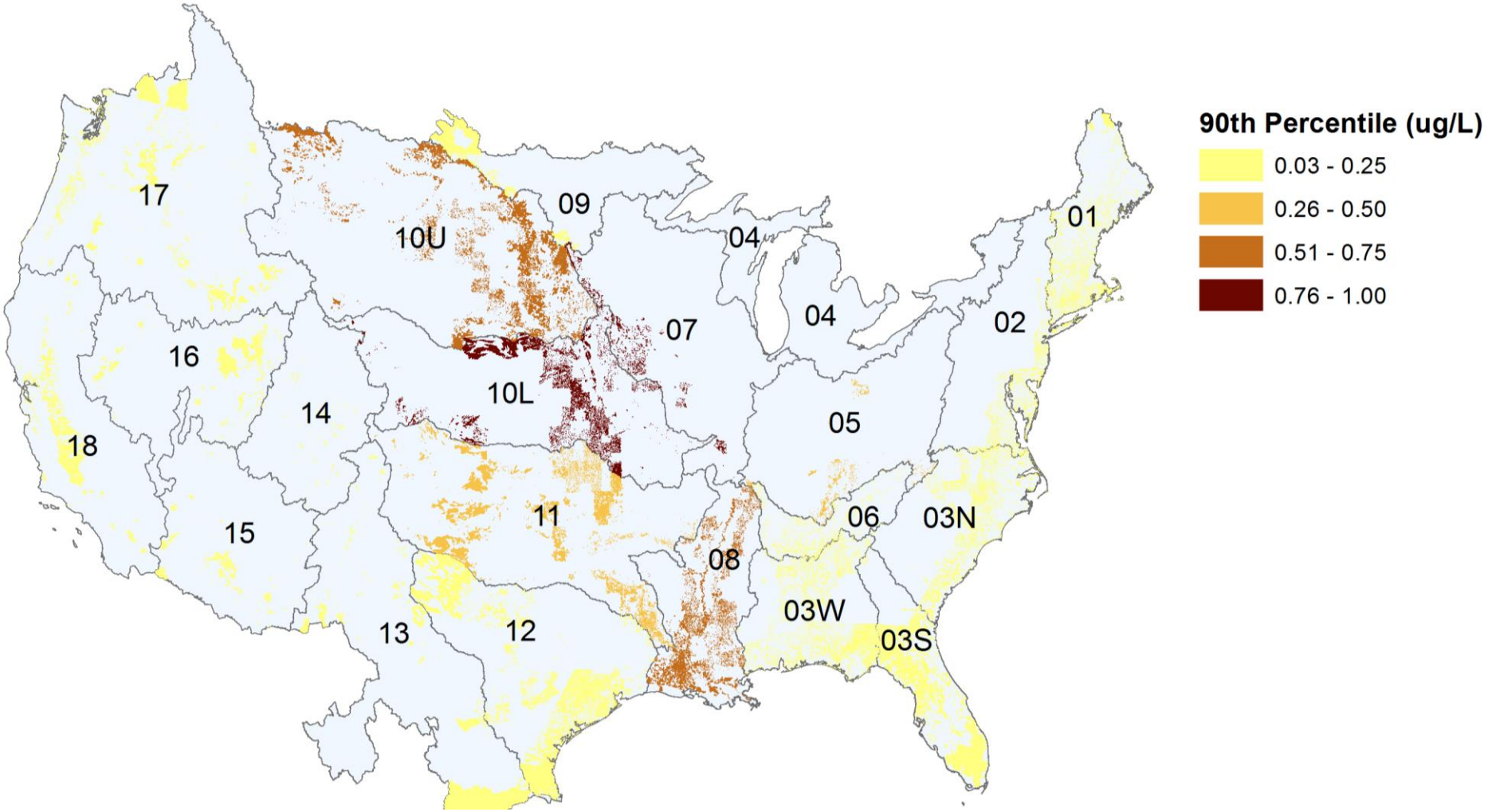
Begin:

End:

Example Results

Probability distributions returned by HUC2 which can be mapped to visualize relative vulnerability.

Estimated modeled concentrations pertain to static water bodies in catchments in the HUC2 where crop and taxa co-occur.



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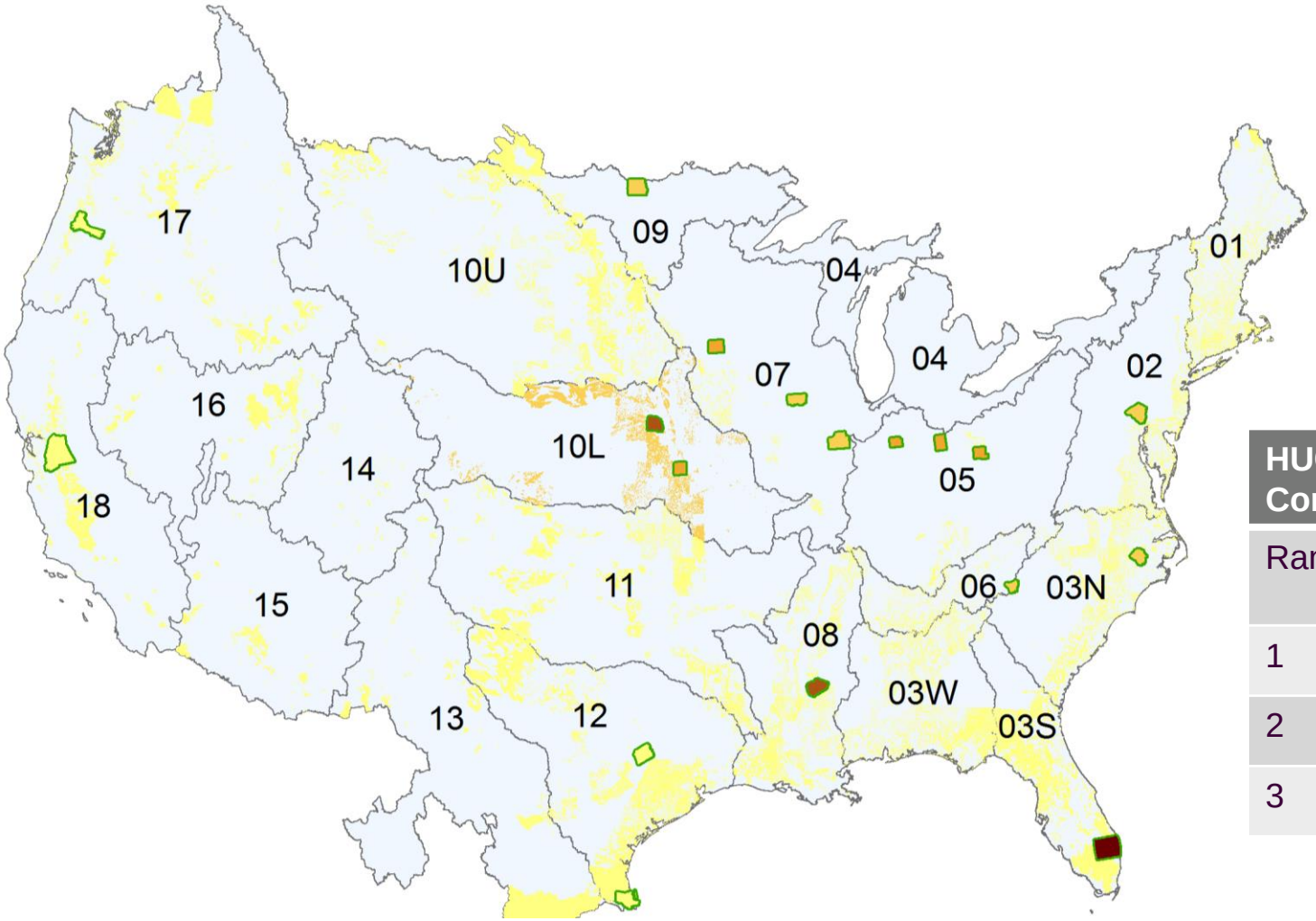
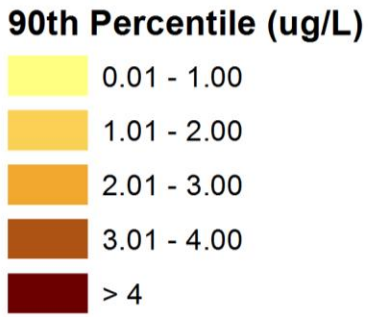
Comparison to Standard SWCC Scenarios

Estimated modeled 90th percentile annual maximum concentrations generally the same or lower for probabilistic approach and priority ranking may change.

Probabilistic results better represent conditions where crop and taxa co-occur.





HUC2s with Highest Concentrations		
Rank	Standard SWCC	Probabilistic SWCC
1	03S	10L
2	10L	07
3	08	08

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Processing Strategy for Scalability/Efficiency

Additional crops and taxa easy to add to app with spatial processing scripts and stored database queries.

Computationally expensive spatial analyses are generalized for all catchments with cultivated crops and potential aquatic habitat, and are processed only once.

Allows for crop and taxa specific analysis conducted using only queries, no further spatial processing.

- eg. Soils – one time spatial processing of soil map units and NHDPlus catchments with cultivated crop, assigned every map unit to a catchment
- Then only need catchment IDs associated with crop and taxa of interest to select map units to include in soil probability distributions

App spins up virtual linux “worker” machines to complete simulations based on estimated computational resources needed for each job. Workers self-terminate when complete.

Summary

National probabilistic SWCC modeling App enables modelers to conduct many thousands of simulations to understand the range and likelihood of pesticide exposures to aquatic species.

Useful in refining surface water exposures, including Step 2 (Not likely/likely to adversely affect) and Step 3 (No Jeopardy/Jeopardy) of the endangered species assessment process.

Web-based application provides flexibility in user inputs while managing the many simulations, facilitating reproducibility of results.

Standardized approach could be used to refine exposure distributions for other crops and taxa or even individual species habitat ranges.

Thank you.

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