STONE ENVIRONMENTAL
100% EMPLOYEE-OWNED

Probabilistic Tools for Addressing Uncertainty in Endangered Species Act Assessments

April 17, 2025

Presented by Jonnie Dunne

Stone Environmental Webinar Series

Automated Probabilistic Co-Occurrence Assessment Tool (APCOAT)

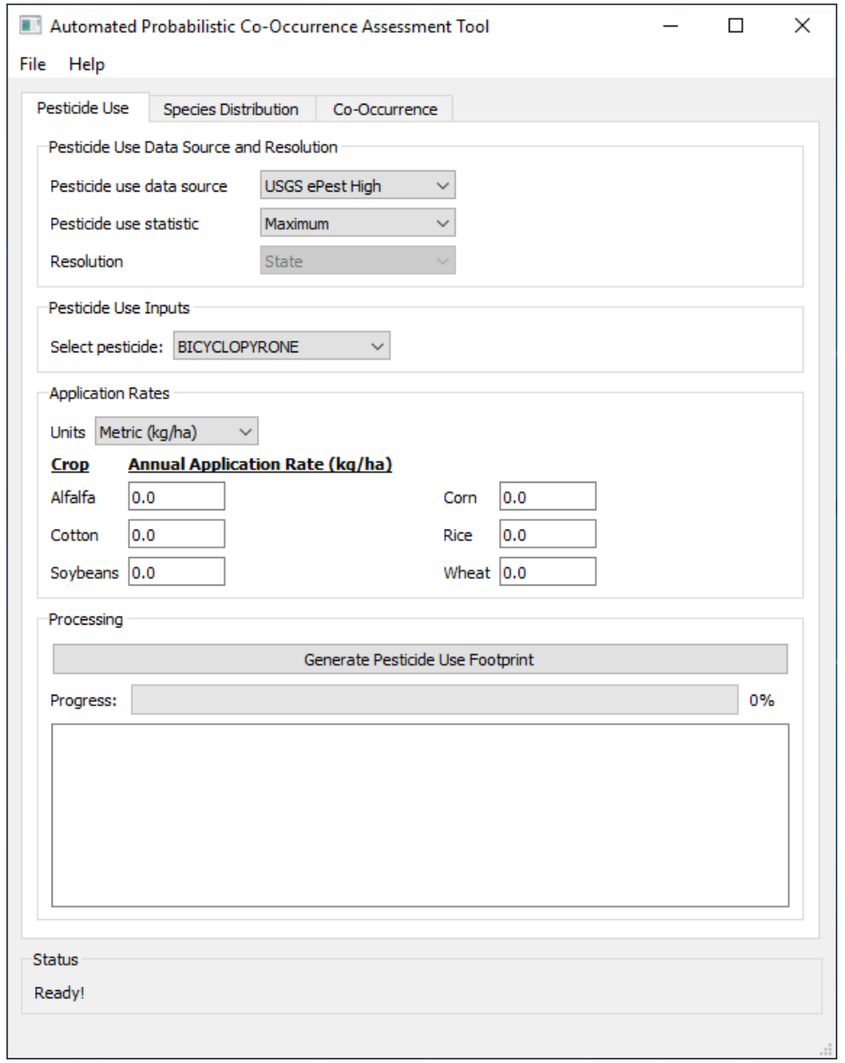
APCOAT allows for rapid probabilistic mapping of:

- Pesticide usage
- Endangered species habitat quality
- Co-occurrence between pesticide usage and habitats

Software, user guide, and case studies available for download at:

http://stone-env.com/APCOAT

Developed with support from Syngenta Crop Protection, LLC



Outline

Introduction and Background

1. APCOAT's primary functionality and intended purpose
2. Key input datasets and methods in APCOAT
3. Results of an APCOAT probabilistic co-occurrence assessment
4. How do APCOAT components advance ESAs?

Example Applications of APCOAT

1. Produce habitat quality maps for comparison to EPA PULAs
2. Incorporate refined usage analysis into co-occurrence assessments
3. Improve aquatic exposure modeling assessments

APCOAT Primary Functionality and Purpose

Co-occurrence analyses for endangered species assessments can present challenges

- 1,600+ species listed by USFWS and NMFS
- 1,000+ products registered by EPA
- Appropriate consideration of refinement opportunities and methods

Studies require best available data for

- Potential use site locations
- Pesticide usage
- Spatial distribution of species

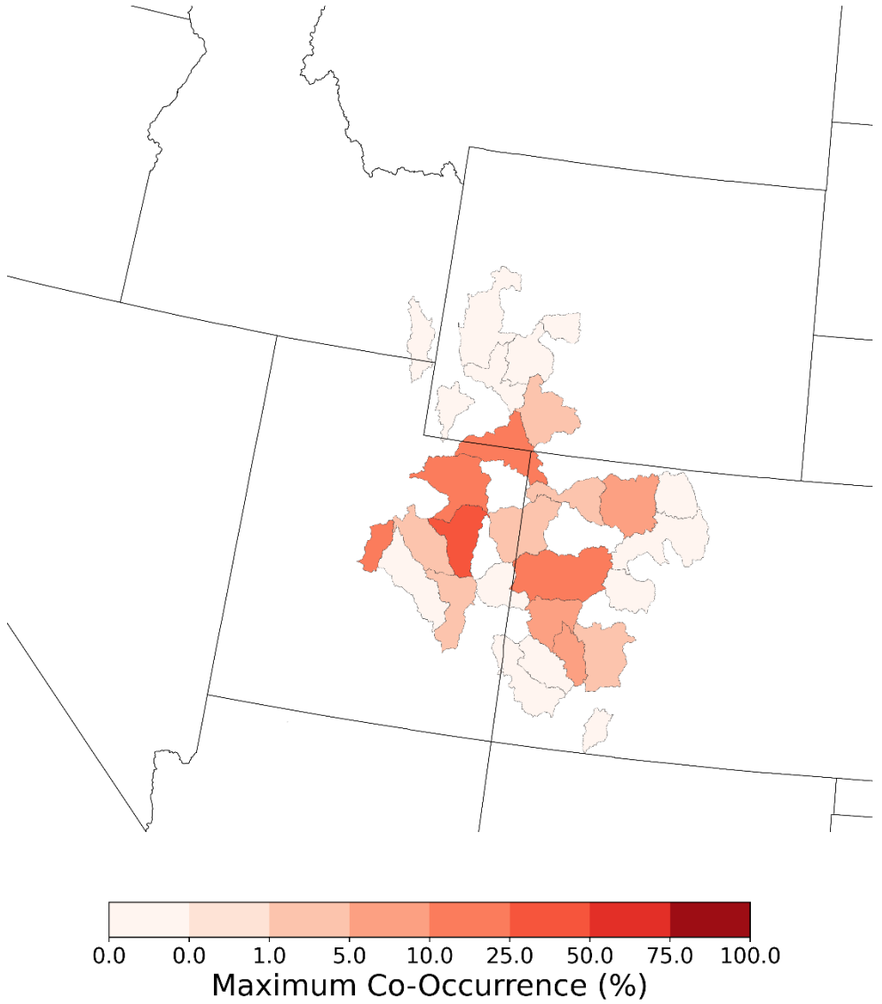
Deterministic methods assume uniformity of potential use sites and species presence and do not account for downstream flow of residues

Probabilistic refinement has been recommended to characterize variability and uncertainty in potential use sites and species distributions

APCOAT Primary Functionality and Purpose

Purpose: Improve the accuracy and efficiency of exposure likelihood characterization

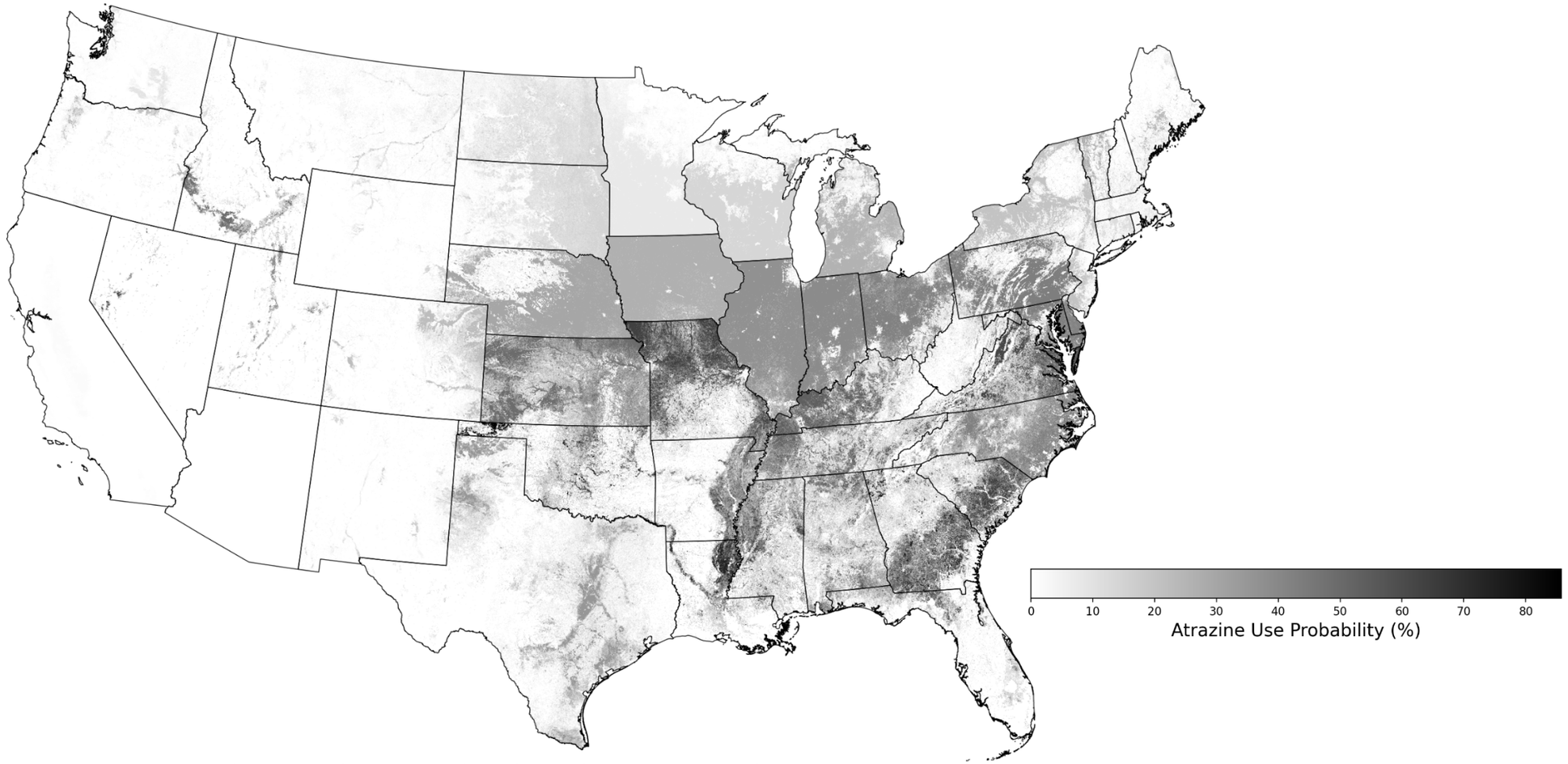
Objective: Rapid assessment of spatial co-occurrence between pesticide use sites and endangered species, using the best available data and probabilistic methods



Map showing probabilistic co-occurrence between the range of *Ptychocheilus lucius* and atrazine applications on corn, summarized at the HUC8 scale.

APCOAT Functionality – Pesticide Usage

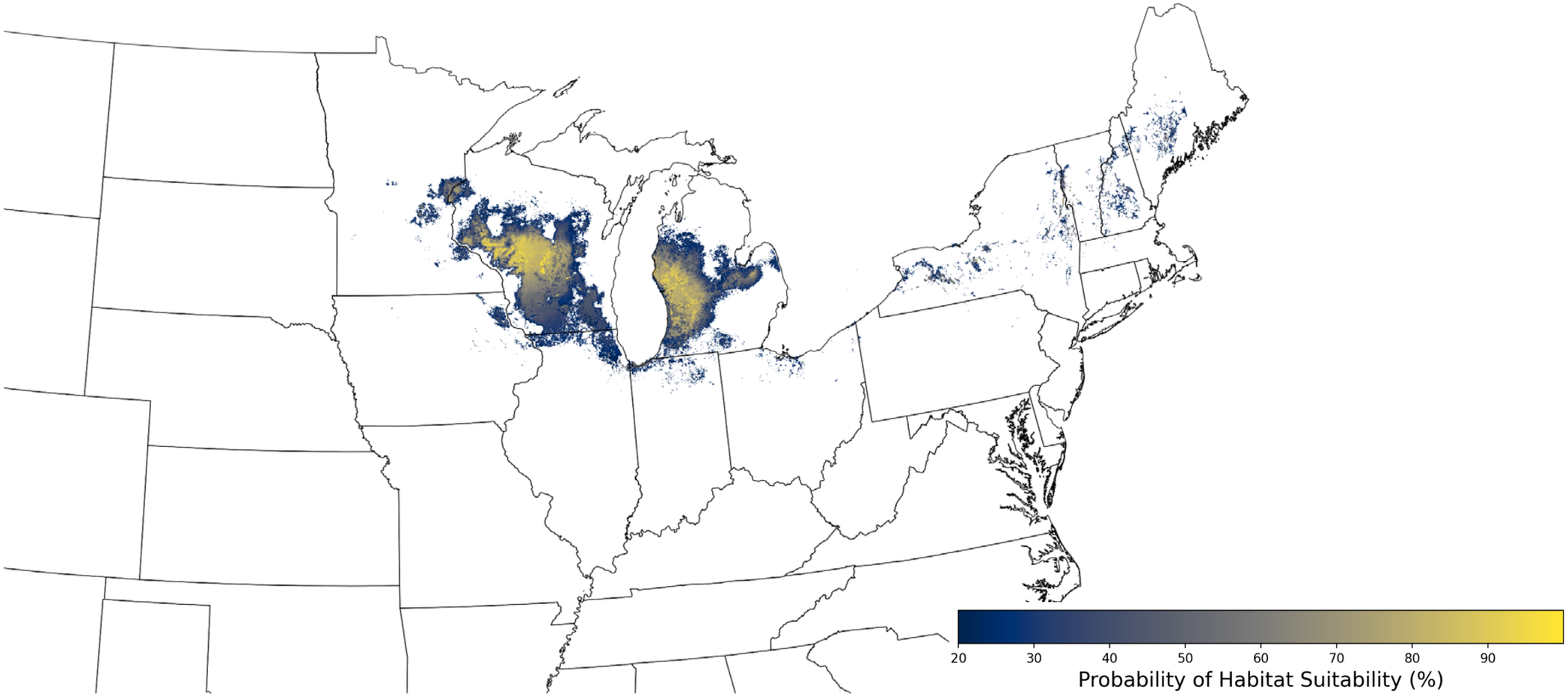
Map the probability of usage of 315 pesticides on 6 commonly grown crops



Probabilistic use footprint for atrazine applications on corn

APCOAT Functionality – Species Habitat Quality

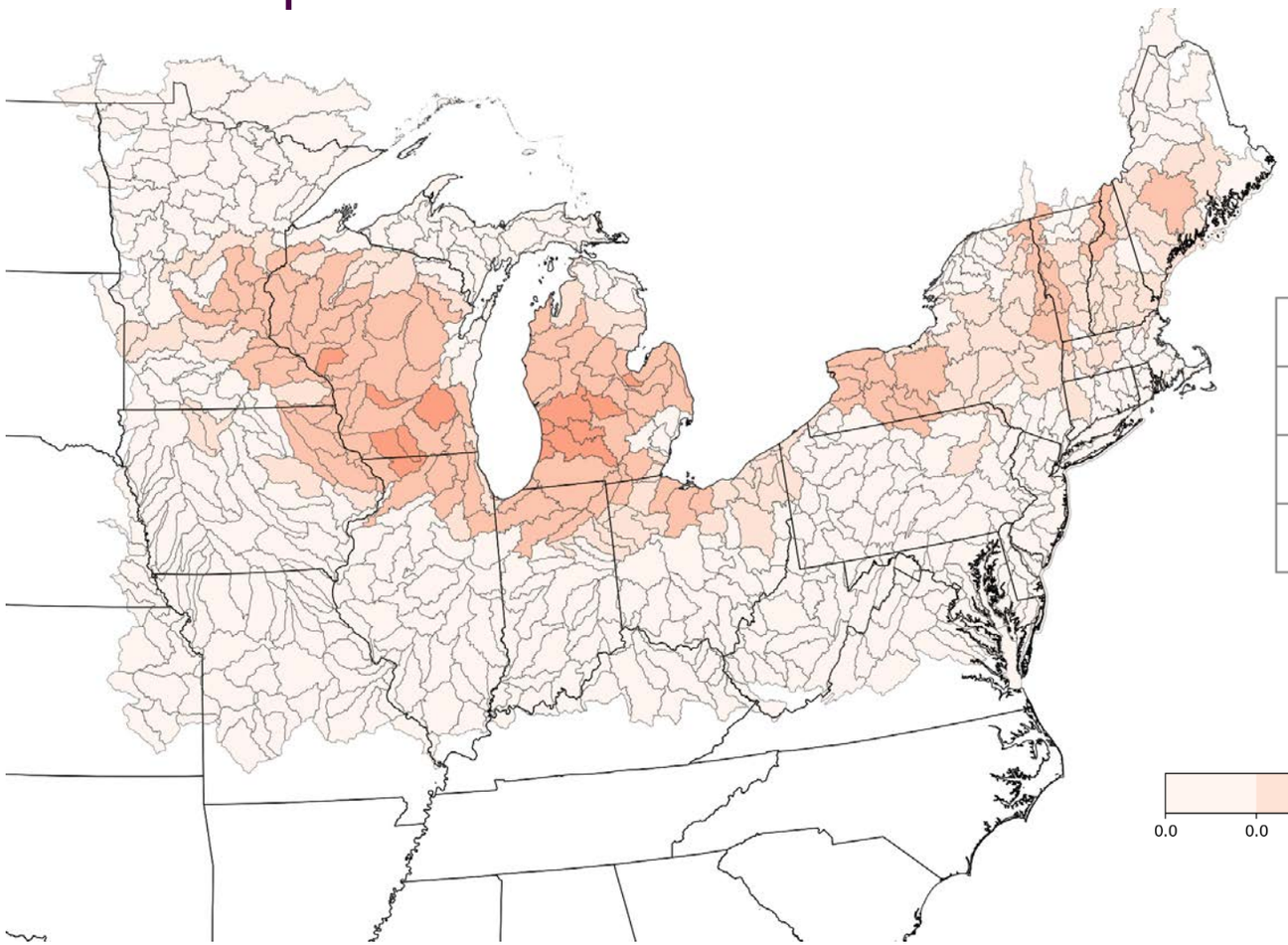
Map the probability of habitat suitability for listed species



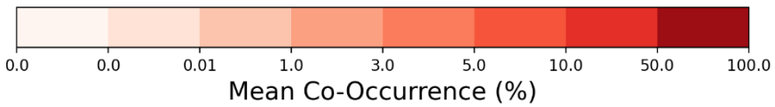
Habitat suitability map for *Lycaeides melissa samuelis*

APCOAT Functionality – Co-Occurrence Assessment

Map and summarize the probability of co-occurrence between pesticide use sites and listed species



Average co-occurrence for species range	1.51e+00%
Number of HUC8 polygons included in assessment	645
Maximum average HUC8 co-occurrence	8.24e+00%
Minimum average HUC8 co-occurrence	0.00e+00%



Co-occurrence map for *Lycaeides melissa samuelis* and atrazine applied to corn

APCOAT Datasets and Methods – Pesticide Usage

Probabilistic crop footprints for: corn, soybeans, wheat, cotton, rice, alfalfa

- Six years of Cropland Data Layer rasters per crop (30 m resolution)
- Pixel-based probability of cropping is refined to agree with:
  - Cropland Data Layer accuracy metadata
  - NASS Agricultural Survey acreage

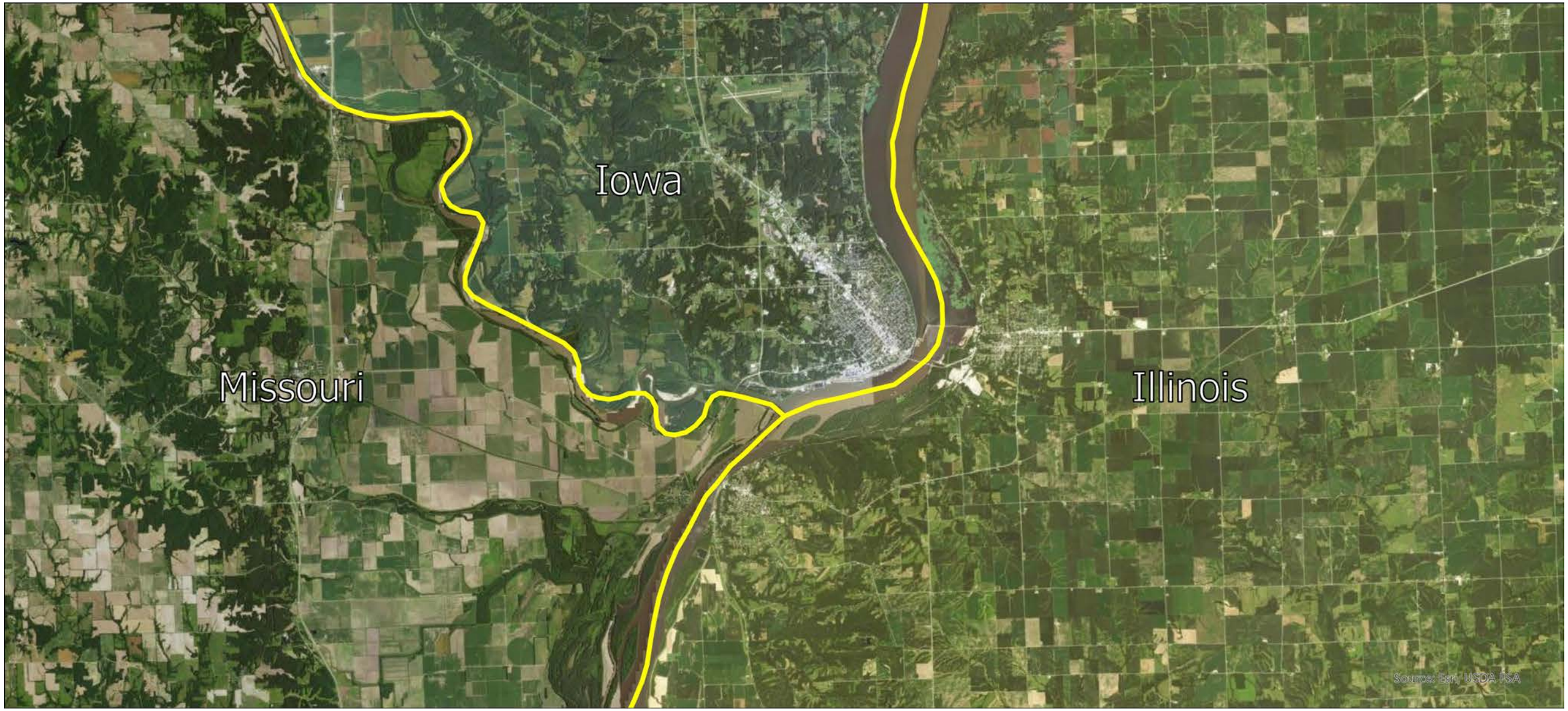
Percent Crop Treated are calculated using:

- Compiled USGS ePest usage estimates for 315 pesticides
- Acreage from Cropland Data Layer

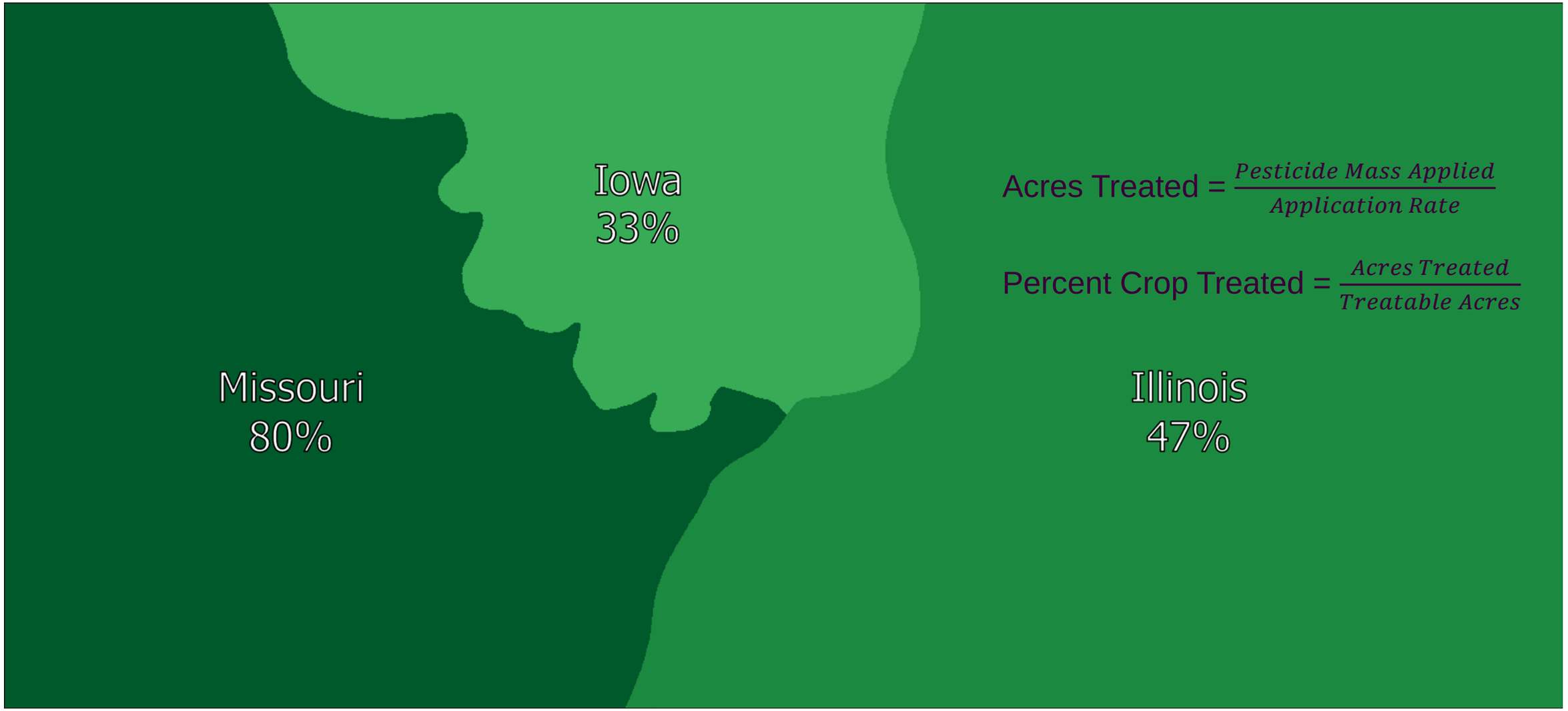
Can incorporate external pesticide usage data provided by user

Can assume all sites are treated for additional conservatism

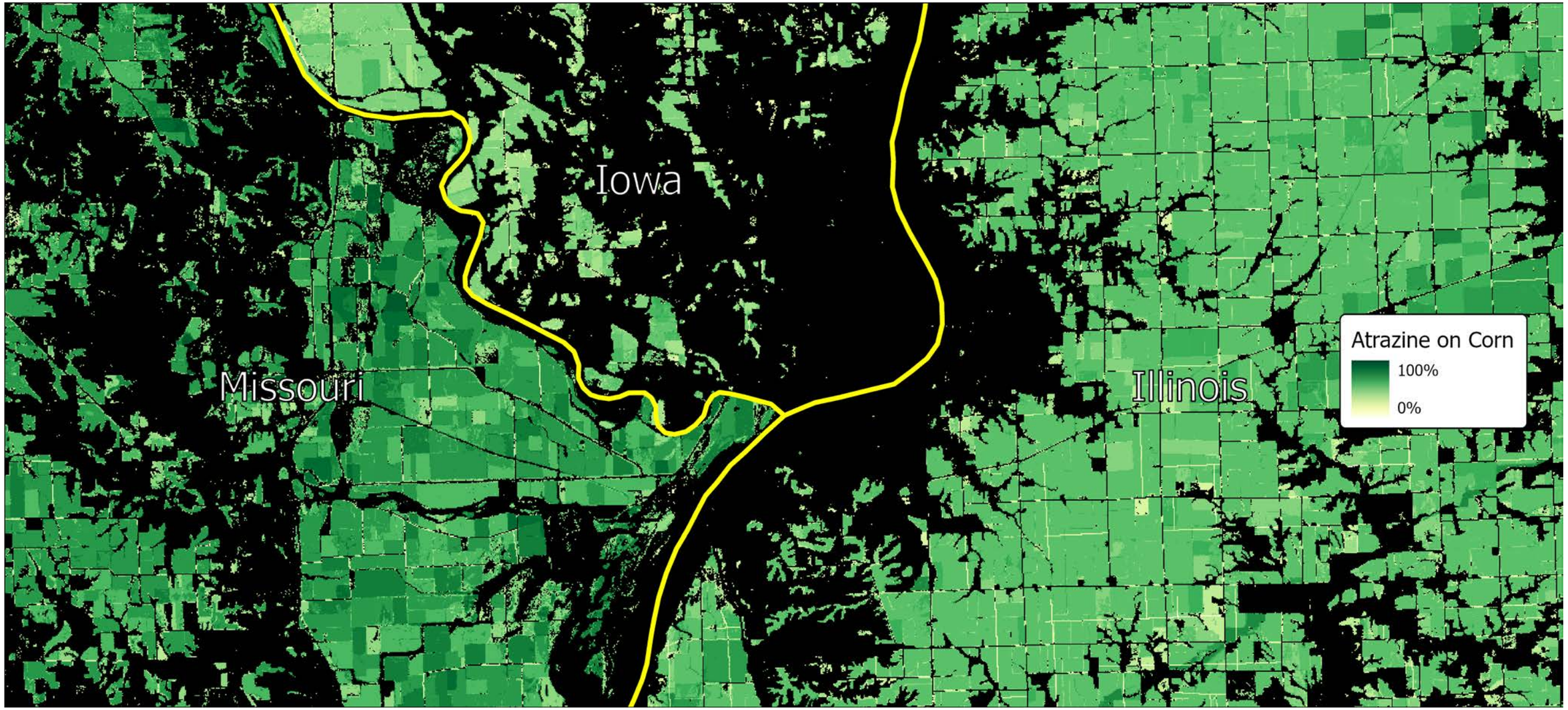
APCOAT Datasets and Methods – Pesticide Usage



APCOAT Datasets and Methods – Pesticide Usage



APCOAT Datasets and Methods – Pesticide Usage

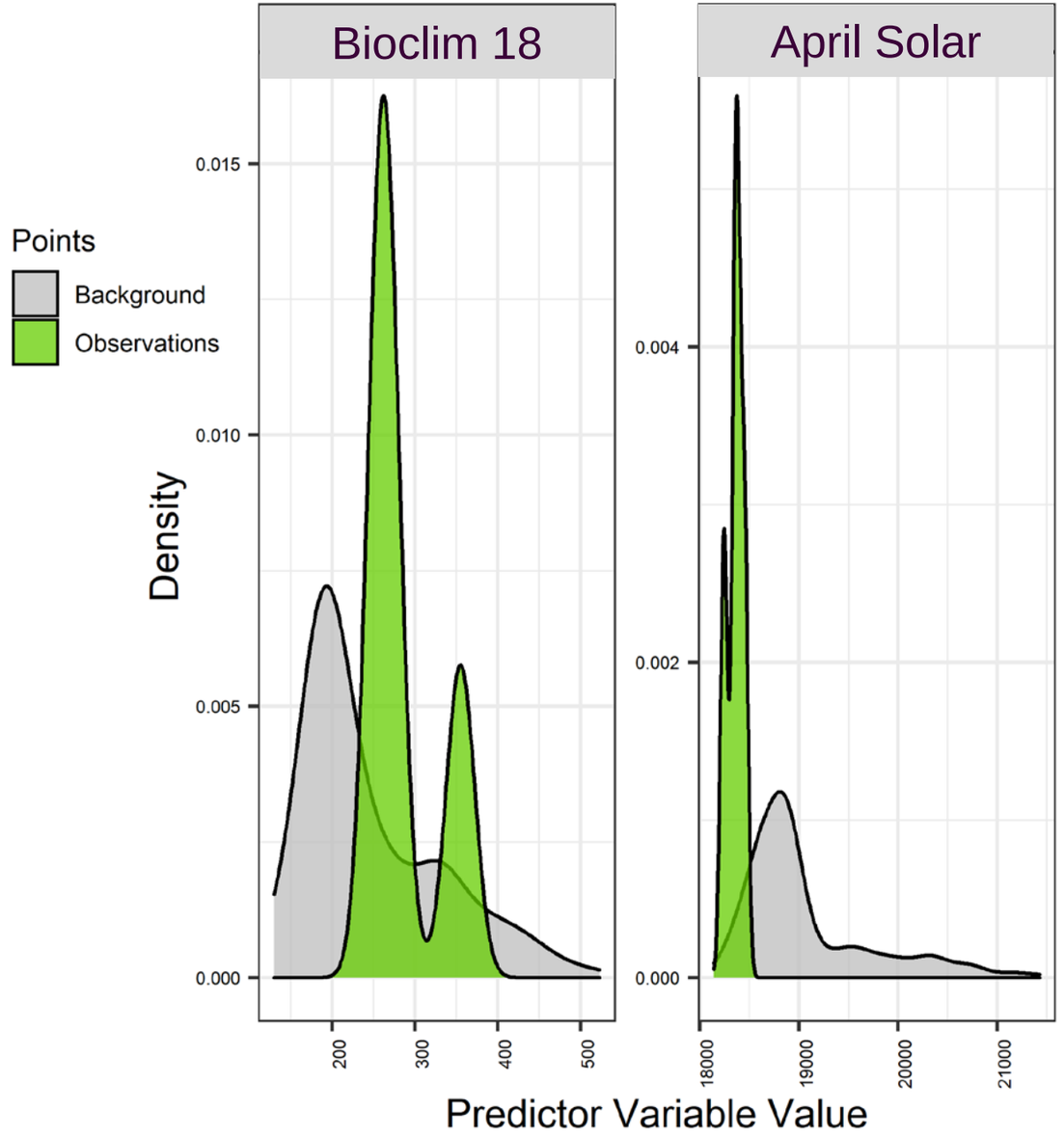


APCOAT Datasets and Methods – Habitat Quality

Each Species Habitat Model iteration models observed patterns between species locations and multiple candidate environmental datasets using Maxent

Multiple fitting functions are used for each predictor variable

Attwater's prairie chicken shows a preference (Observations) for high precipitation during warm months (Bioclim 18) and low solar radiation during April relative to the landscape (Background)

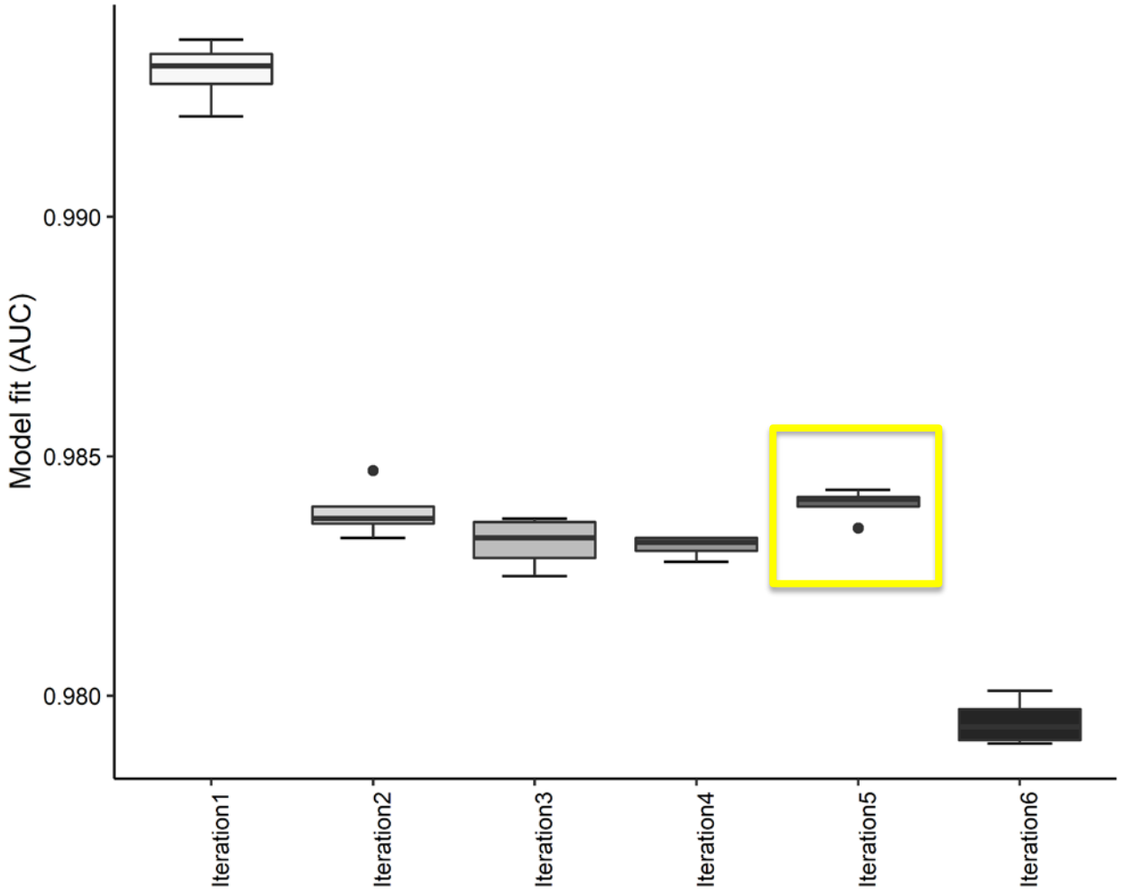


APCOAT Datasets and Methods – Habitat Quality

APCOAT iterates through drafts of Species Habitat Models to balance model fitting and model economy

In each draft the contribution of each potential explanatory variable is ranked, and low-ranking variables are removed

The final model (i.e. Iteration 5) removes as many predictor variables as possible without reducing model fitness (Iteration 6)

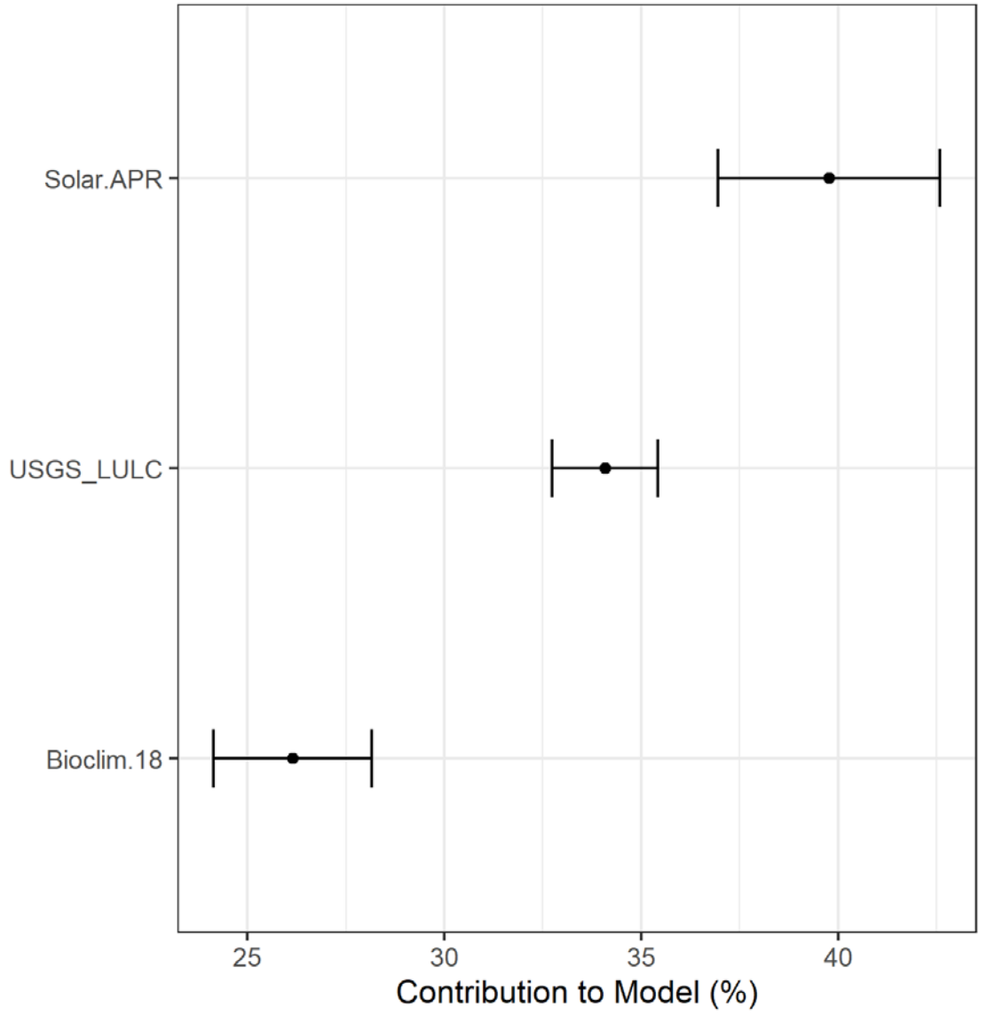


Boxplots of model fit for each iteration of *Tympanuchus cupido attwateri* distribution modeling.

APCOAT Datasets and Methods – Habitat Quality

The resulting model shows the probability that a site provides suitable habitat given multiple site characteristics

Final model fitness is evaluated using reserved location data



Plot showing the contribution of each predictor variable to the *Tympanuchus cupido attwateri* habitat model

APCOAT Datasets and Methods – Habitat Quality

Site characteristic data is packaged with APCOAT

- 35 terrestrial rasters (800 m resolution): bioclimatic, land cover, soil, topography, distance to water, vegetation
- Aquatic variables: bioclimatic, land cover, hydrologic, geologic, etc.
  - 197 stream and river variables
  - 148 pond and lake variables

Species location data must be collected

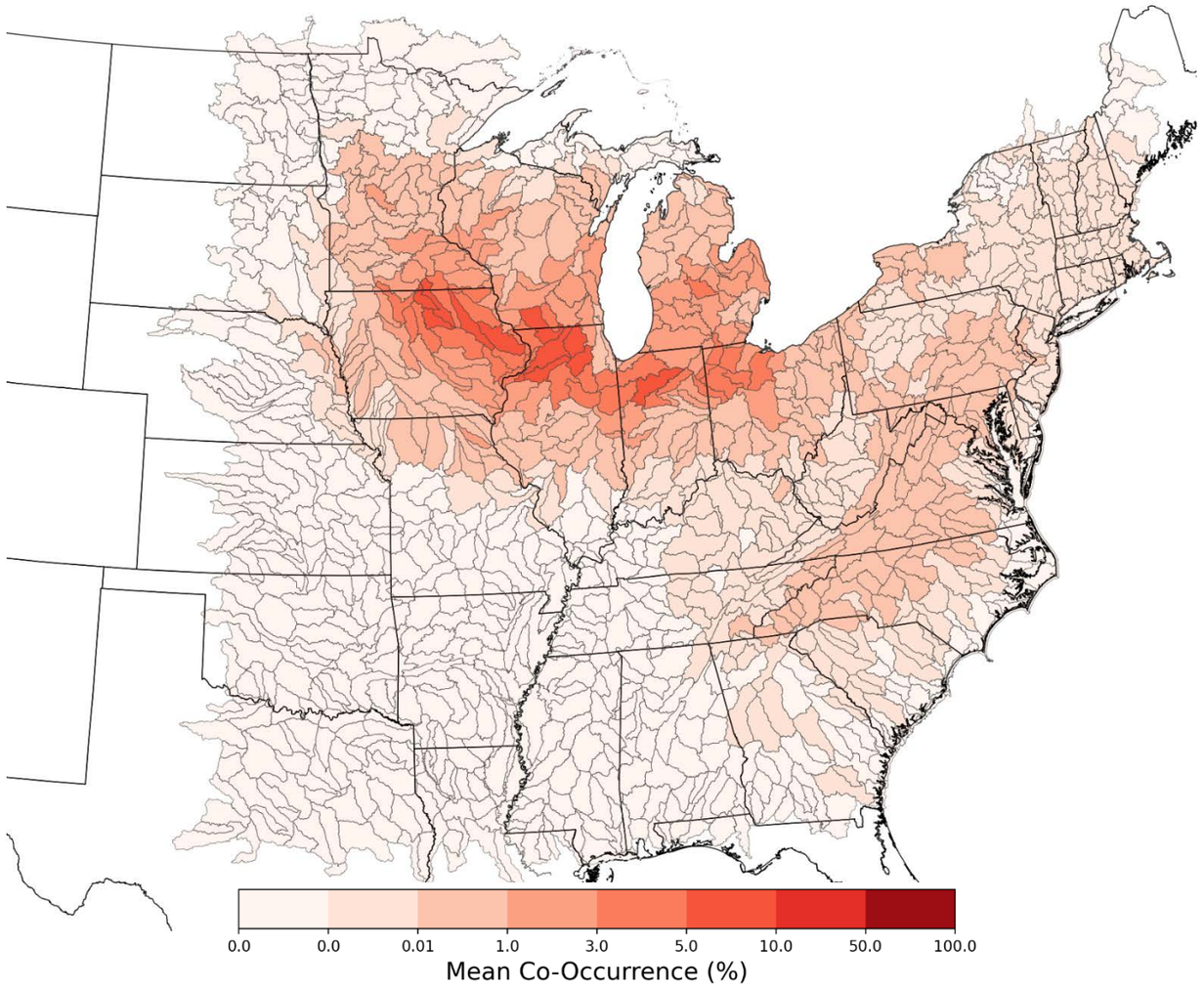
- GBIF.org - freely available batches of species occurrence records
- iNaturalist.org - individual species occurrence records, may be obscured
- NatureServe.org - Element Occurrence records available on request
- Individual state natural heritage programs

APCOAT Datasets and Methods – Co-Occurrence

For terrestrial species:

1. Species Habitat Models (SHMs) are filtered e.g. > 20%
2. SHM raster overlayed with and multiplied by usage probability raster
3. Co-occurrence raster values are averaged by zone and over entire extent

Average co-occurrence for species range	1.76e+00%
Number of HUC8 polygons included in assessment	1049
Maximum average HUC8 co-occurrence	7.35e+00%
Minimum average HUC8 co-occurrence	0.00e+00%



Co-occurrence map for *Bombus affinis* and atrazine applied to corn

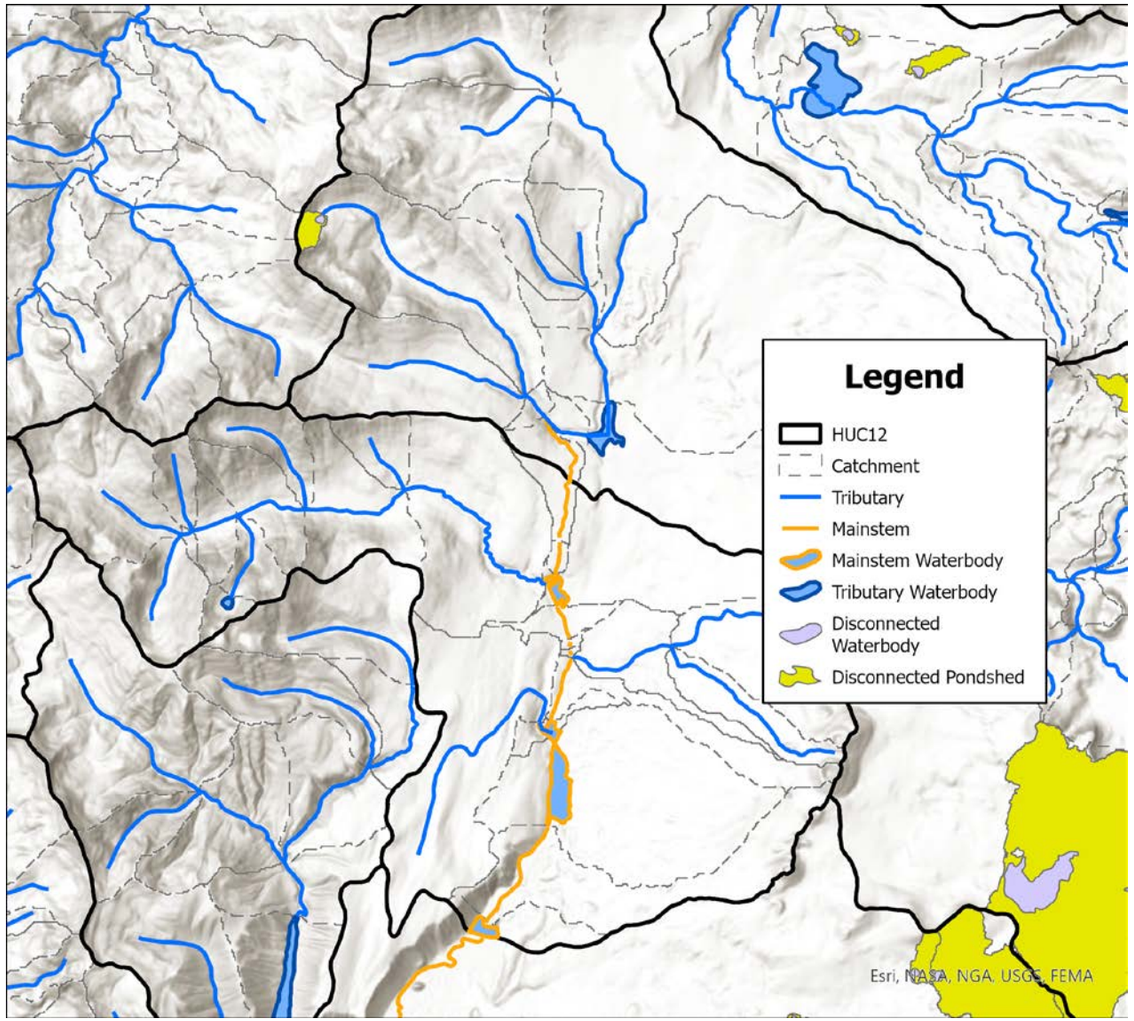
APCOAT Datasets and Methods – Co-Occurrence

Hydrologically connected features

- Use pesticide statistics from local or upstream HUC12s
  - Mainstems
  - Ponds on mainstems

Hydrologically disconnected features

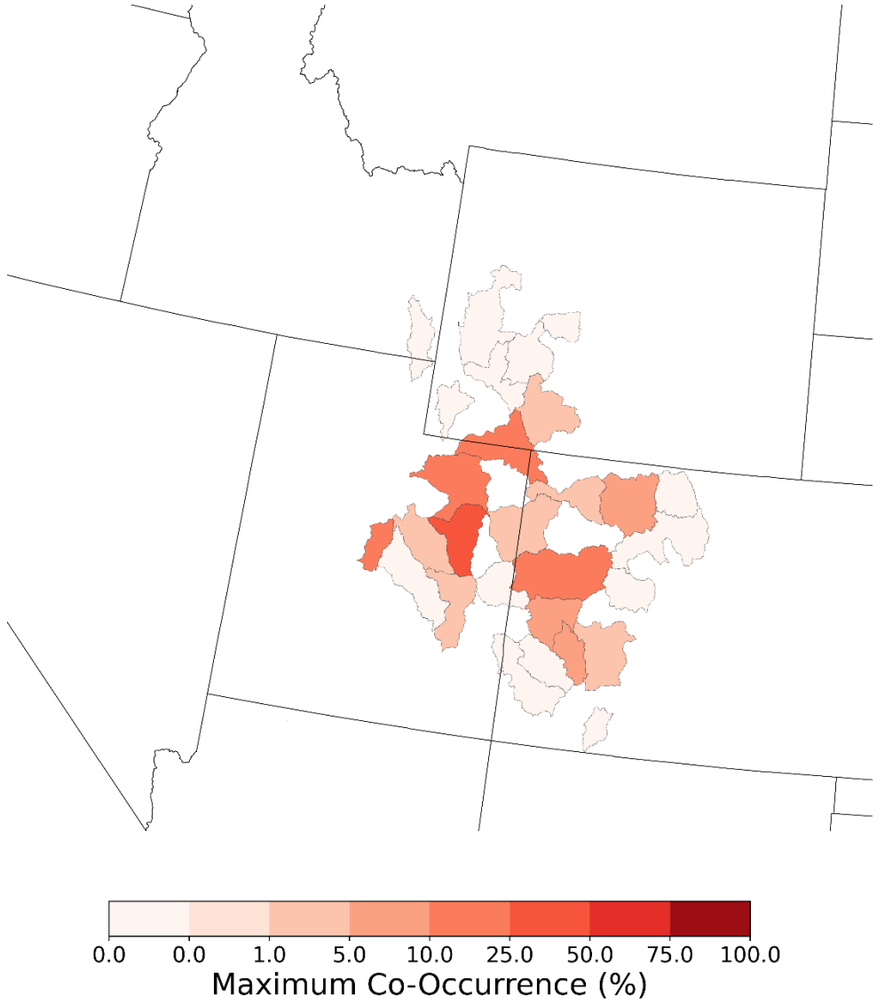
- Use pesticide statistics from local or upstream catchments
  - Tributaries
  - Ponds on tributaries
  - Disconnected ponds (use delineated pondsheds)



APCOAT Datasets and Methods – Co-Occurrence

APCOAT co-occurrence reports include results of :

- Pesticide usage modeling
- Species Habitat Model
- Spatial co-occurrence
  - Average co-occurrence over species range
  - Zonal co-occurrence statistics
  - Zonal co-occurrence map
  - Multiple flow tracing methods used for aquatic species



Map showing probabilistic co-occurrence between the range of *Ptychocheilus lucius* and atrazine applications on corn, summarized at the HUC8 scale.

APCOAT Assessment Results

Pesticide usage probability

- Statistics derived from time series of Percent Crop Treated calculations, accounting for variability in pest pressure and pesticide usage
- High resolution map (30 m) of probabilistic pesticide usage in the continental US for up to 6 crops, incorporating PCT statistics and accounting for variability in cropping practices

Habitat quality

- Report showing Species Habitat Model inputs, selected predictor variables, and diagnostic statistics
- Medium (800 m) to high resolution (30 m) map of species habitat quality reflecting uncertainty in species locations

Co-occurrence probability

- Convenient summary of species range-wide co-occurrence probability
- High resolution map of co-occurrence for use in conservation and restoration

How Can APCOAT Components Advance ESAs?

APCOAT recognizes uncertainty in all components of co-occurrence analyses and provides objective analysis to better understand species locations and usage restrictions

Pesticide Usage Modeling

- Refines mapping through more comprehensive data inputs and processing
- Could be used with existing range/critical habitat data to improve realism of deterministic overlap analyses

Species Habitat Modeling

- Leverages machine learning to maximize understanding of habitat requirements
- Provides objective analysis to better understand species locations and usage restrictions

Co-occurrence Assessment

- Automated reporting ensures transparency and consistency
- Makes the best available data and probabilistic methods easily accessible and reproducible

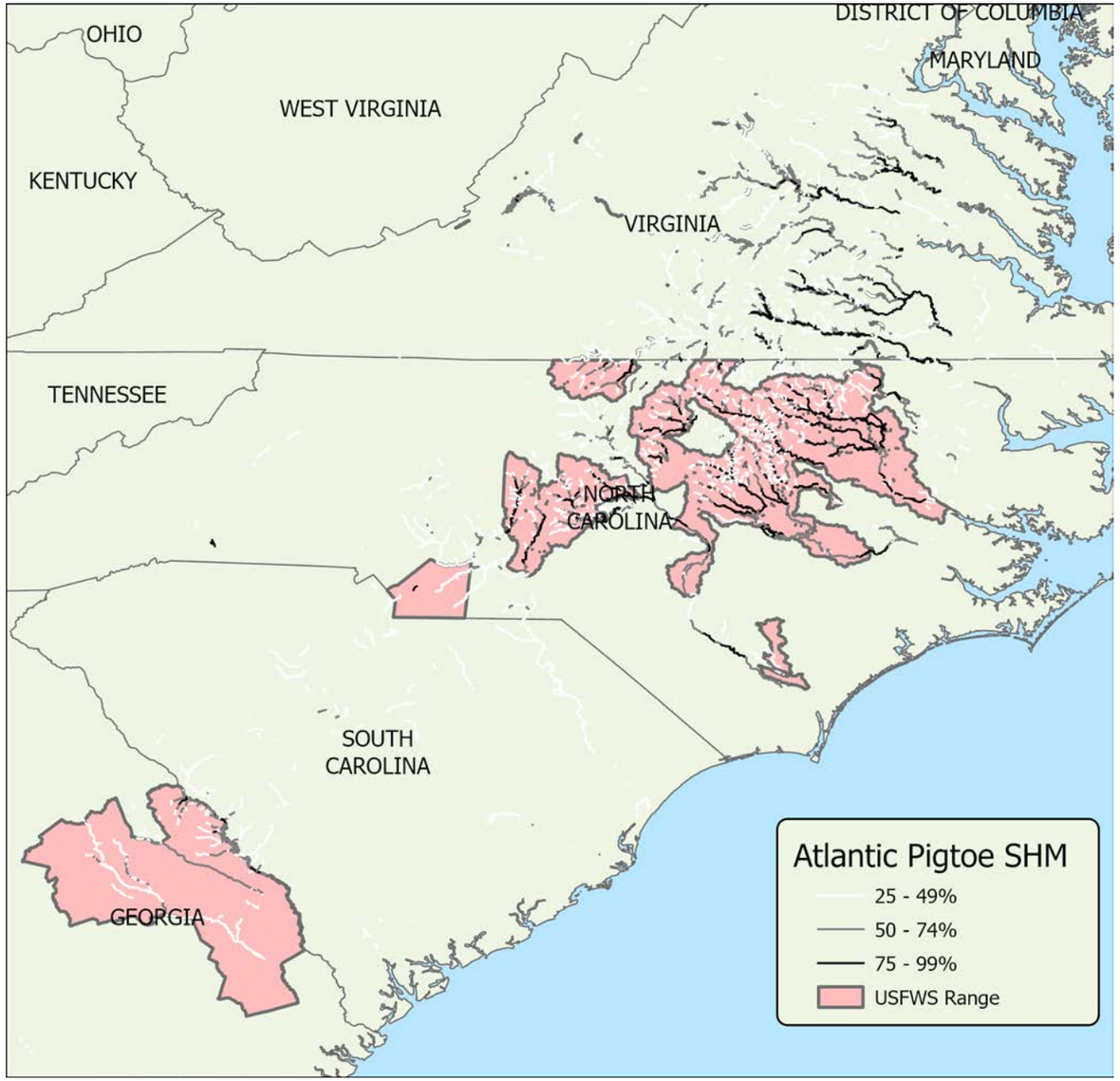
ESA Advancement – PULA Refinement and QC

Pesticide Use Limitation Areas (PULAs) are to be based on best available location data and pesticide transport

SHMs can be used as core map type for some species

SHMs could be used to identify additional potential habitat outside of recognized ranges

APCOAT methods align with FWS SOP for refining listed species ranges



ESA Advancement – Usage Analysis Refinement

Simulating field-scale application of reported usage highlights areas where pesticide is likely to be used instead of where it is potentially used

This refinement shows that deterministic crop site-based overlap analyses can be overly conservative

UDL	Offsite Transport Distance (m)	Range - Number of Species with Overlap > 5%					CH - Number of Species with Overlap > 5%				
		EPA	50th	90th	99th	Max	EPA	50th	90th	99th	Max
Corn	**0**	6	0	0	1	1	20	0	0	0	0
	30	14	0	0	3	6	1	0	0	0	0
	300	66	10	13	13	14	92	4	12	16	22

Results of a case-study comparing deterministic EPA methods for crop site-based co-occurrence analyses to probabilistic methods incorporating usage data

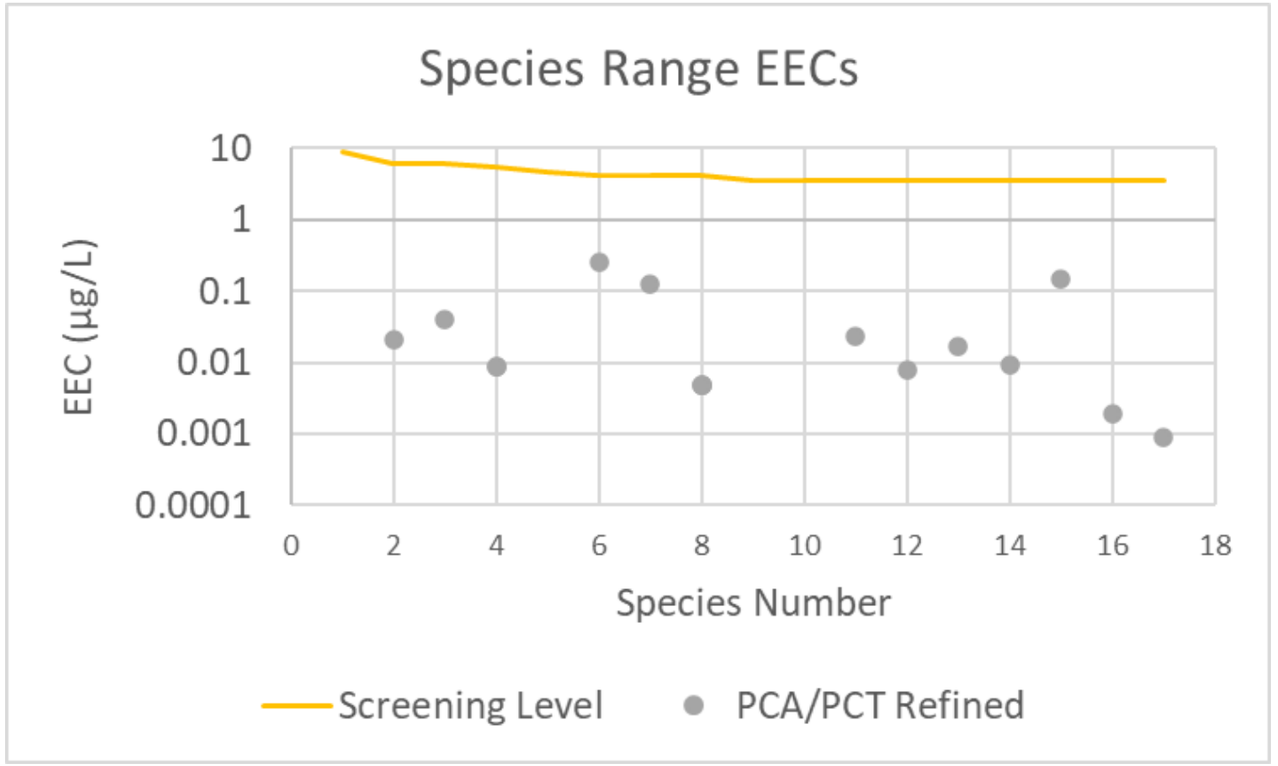
ESA Advancement – Aquatic Exposure Refinement

Incorporating usage data can refine characterization of upland pesticide usage for aquatic exposure likelihood and magnitude estimates

Conservatism can be adjusted through PCT statistic selection choice (median, 99th percentile, maximum, etc.)

High-resolution flow tracing methods can also improve realism for individual waterbody EECs

Differences in Expected Environmental Concentrations (EECs) vary by crop and pesticide



Next Steps – Future APCOAT Development

Manuscript detailing 375 species aquatic co-occurrence analyses (In press, Integrated Environmental Assessment and Management, 2025)

Pesticide usage footprint functionality will be expanded

- ~90 additional crop footprints
- Custom crop group combinations for ePest data (Vegetables & Fruit, Orchards & Grapes, Pasture and Hay, Other Crops)

Off-site Exposure Modeling

- Custom drift distance buffers
- Additive probabilities of overlapping drift buffers

Field-based usage allocation

PULA co-occurrence analyses

STONE ENVIRONMENTAL
100% EMPLOYEE-OWNED

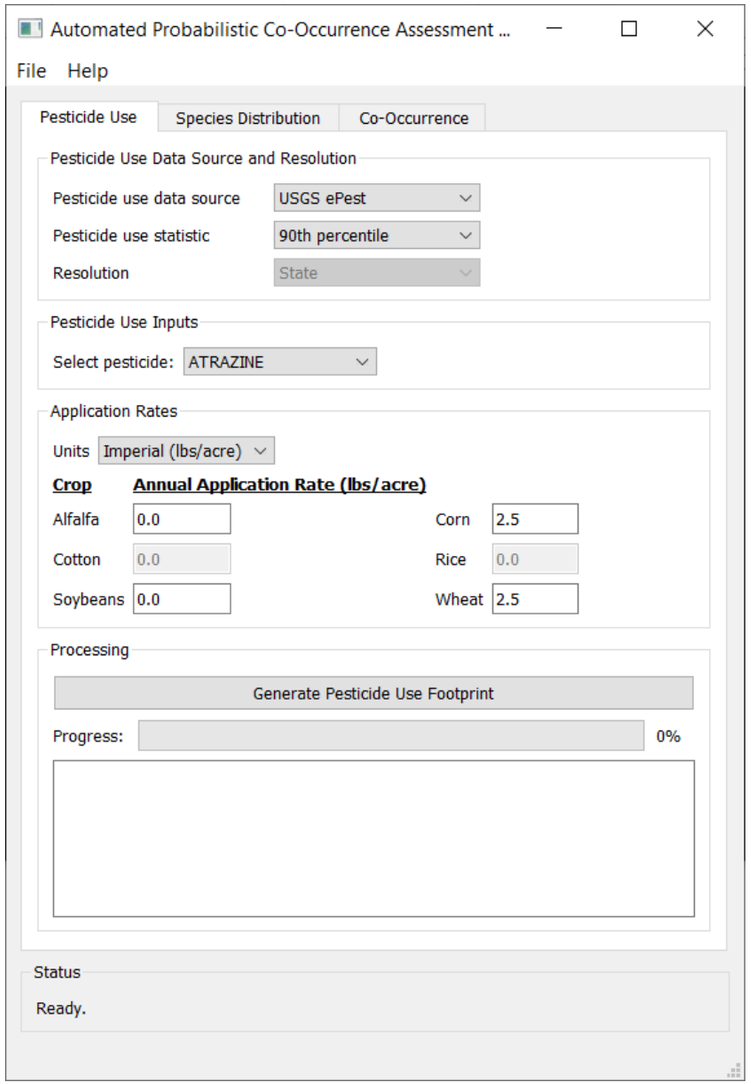
Thank you.

For more information / http://stone-env.com/APCOAT

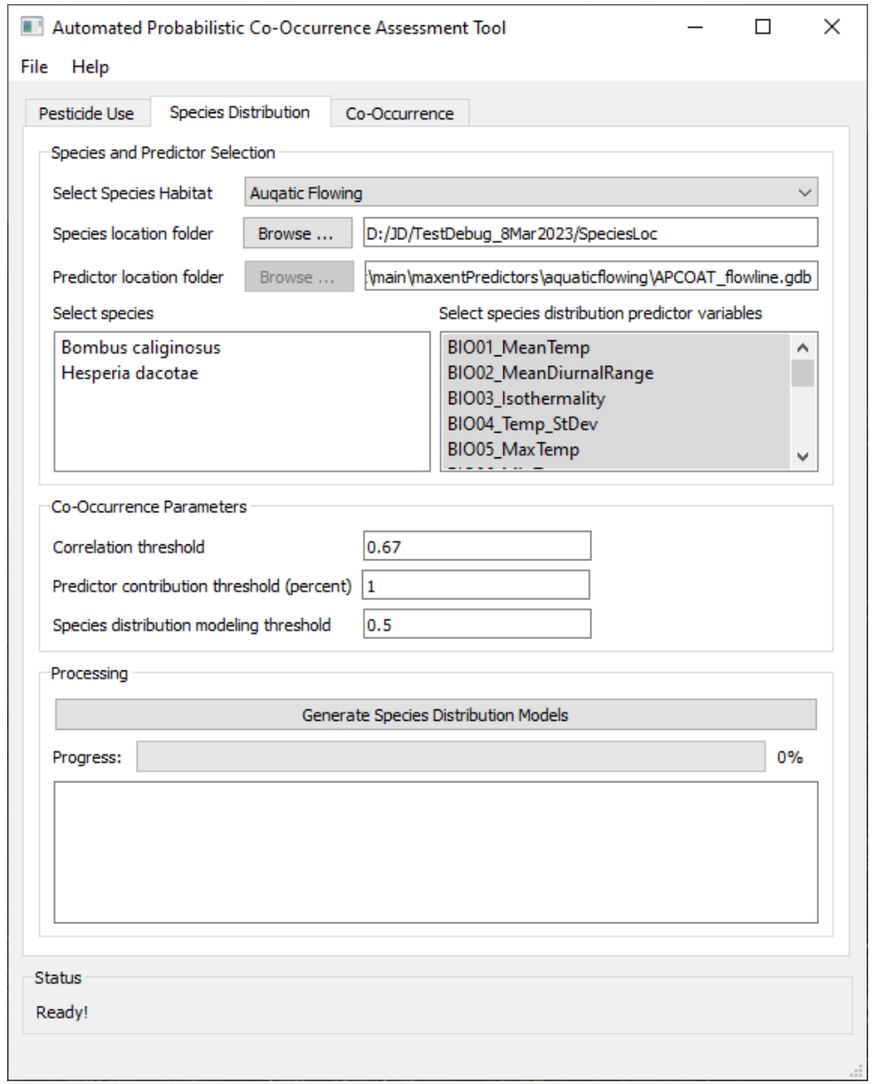
Contact / jdunne@stone-env.com
Hendrik Rathjens, Michael Winchell of Stone Environmental, Inc.
Richard Brain, Max Feken, Tony Burd of Syngenta Crop Protection, LLC

APCOAT Interface

Crop Footprint



Species Distribution Model



Co-Occurrence