Refined Pesticide Exposure Modeling for Endangered Species in Flowing Water Habitats

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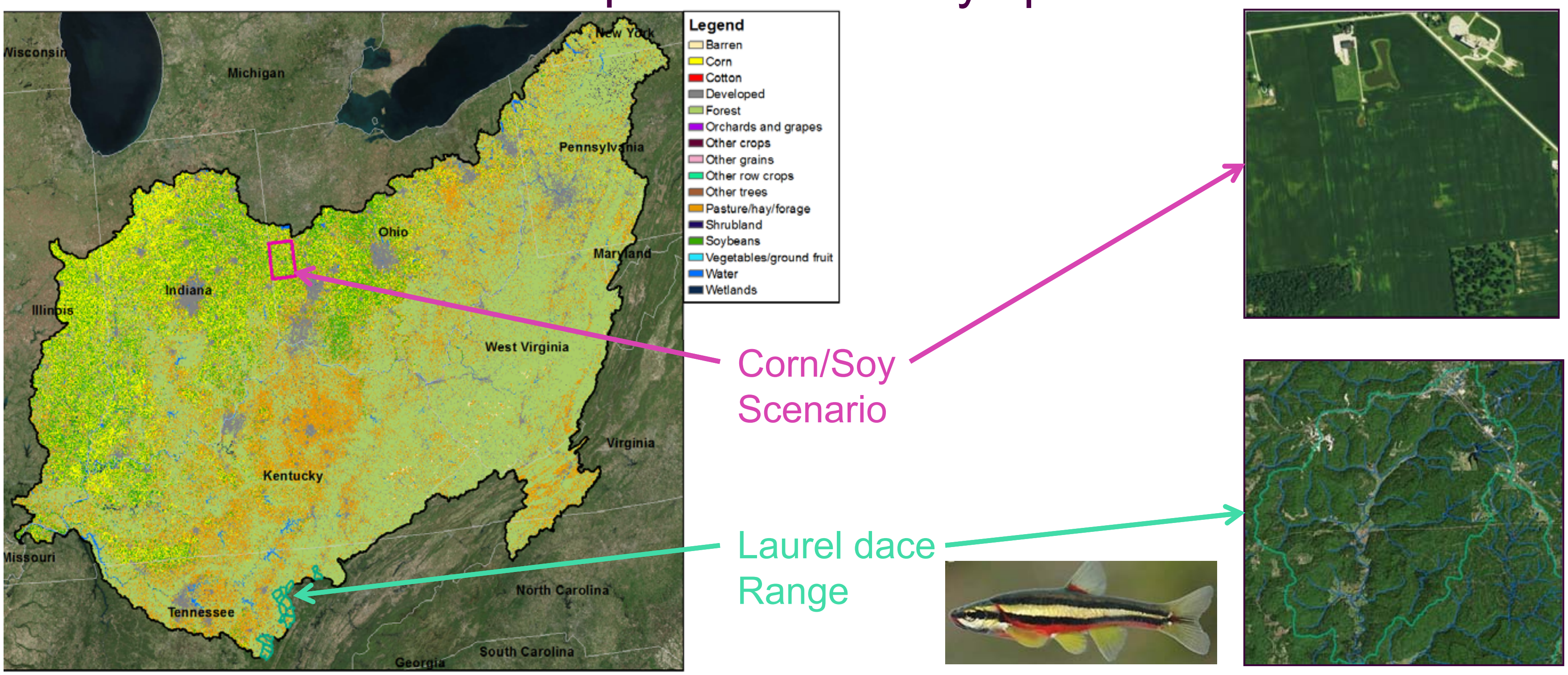
Michael Winchell[1], Naresh Pai[1], Lauren Padilla[1],Raghavan Srinivasan[2], Pat Havens[3], Jeff Giddings[4]

1. Stone Environmental, Inc.
2. Texas A&M University
3. Dow AgroSciences
4. Compliance Services International

Motivation and Objectives

National Endangered Species Assessments require the determination of pesticide expected environmental concentrations (EECs) in flowing water.

Proposed screening level modeling methods and scenarios may have little relevance to real world exposure for many species.



Objective: Develop and implement a spatially explicit flowing water modeling approach to derive species specific probabilistic exposure estimates.

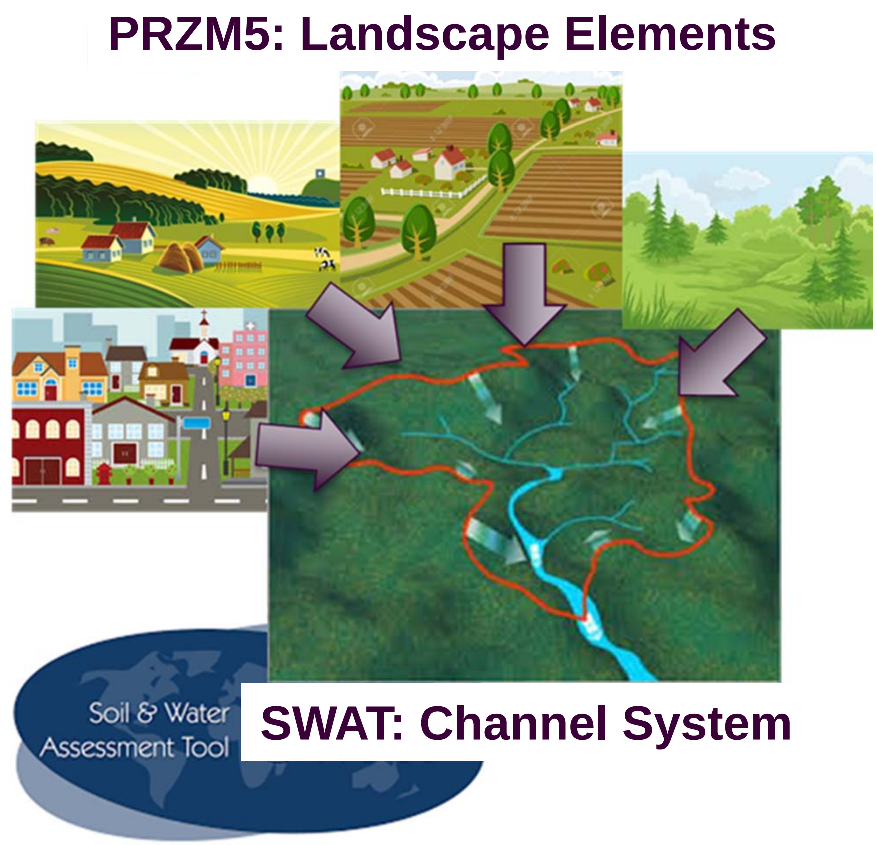
Flowing Water Modeling Approach

Requirements:

- Spatially explicit, species specific
- Account for variability in environmental conditions and agronomic practices
- Allow flexibility in refinement options (e.g., pesticide use, probabilistic inputs)

Methodology:

- Develop a spatially distributed watershed model from:
  - PRZM5 regulatory model: Landscape processes (runoff, sediment, pesticide)
  - SWAT watershed model (EPA Office of Water HAWQS): In-stream processes, downstream routing (water, sediment, pesticide), stream baseflow
- Generate species-specific exposure probability distributions



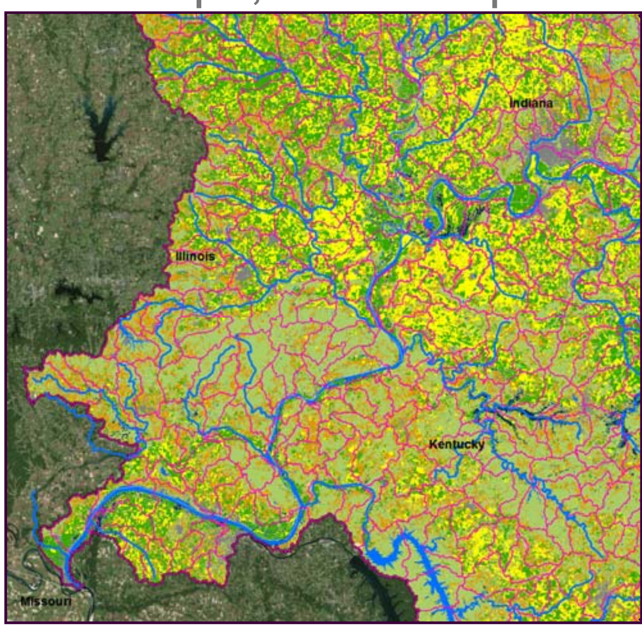
Modeling Approach Applied to Ohio River (HUC2-05)

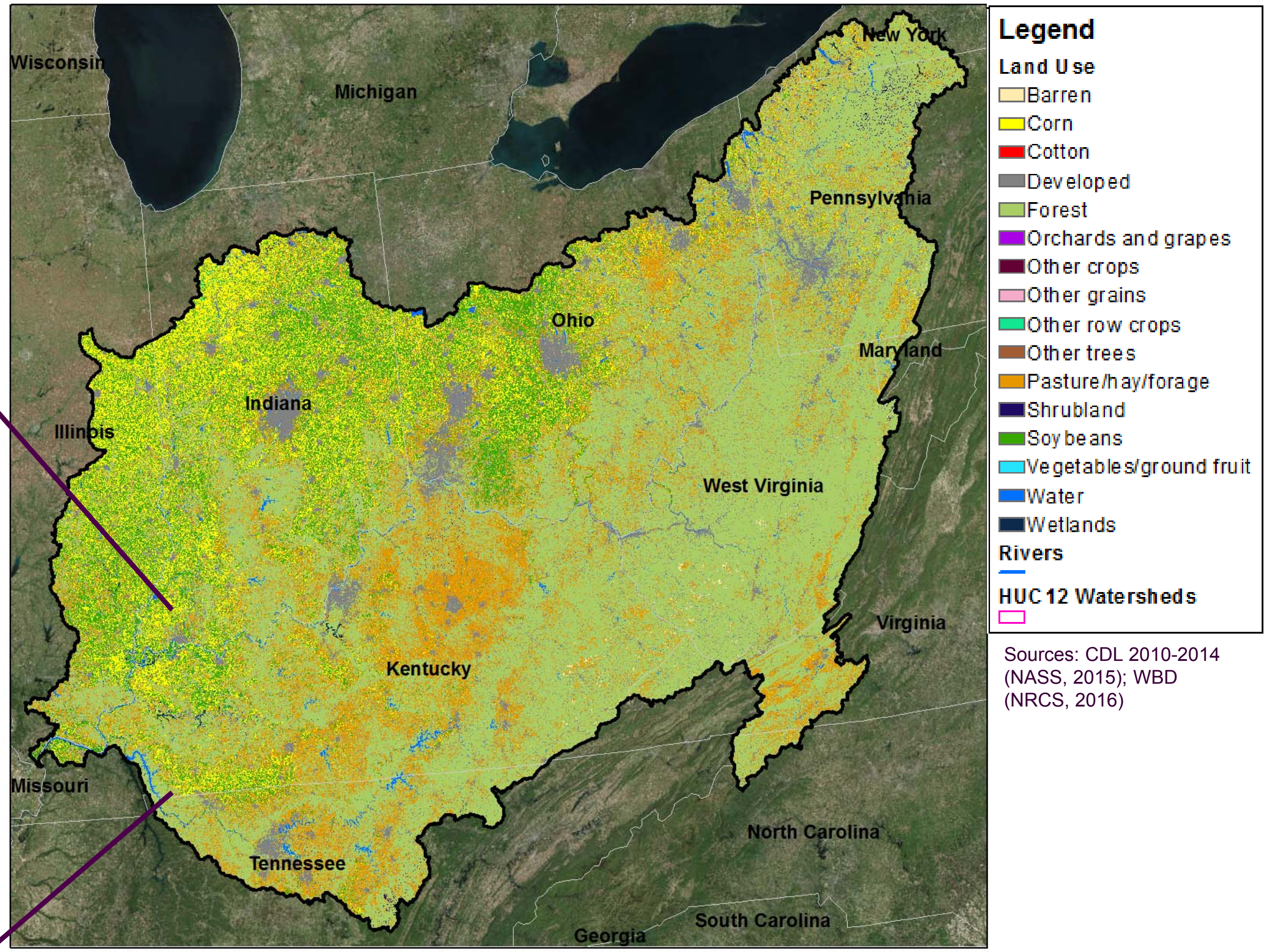
Model applied to HUC2-05 (Ohio River Basin) at HUC12 watershed scale:

- 5,277 HUC12 watersheds
- 163,000 mi^2 total drainage area

Applied for Chlorpyrifos

- Treated crops include: corn, soybean, cotton, pasture, orchards, vegetables, other grains, other row crops, other crops



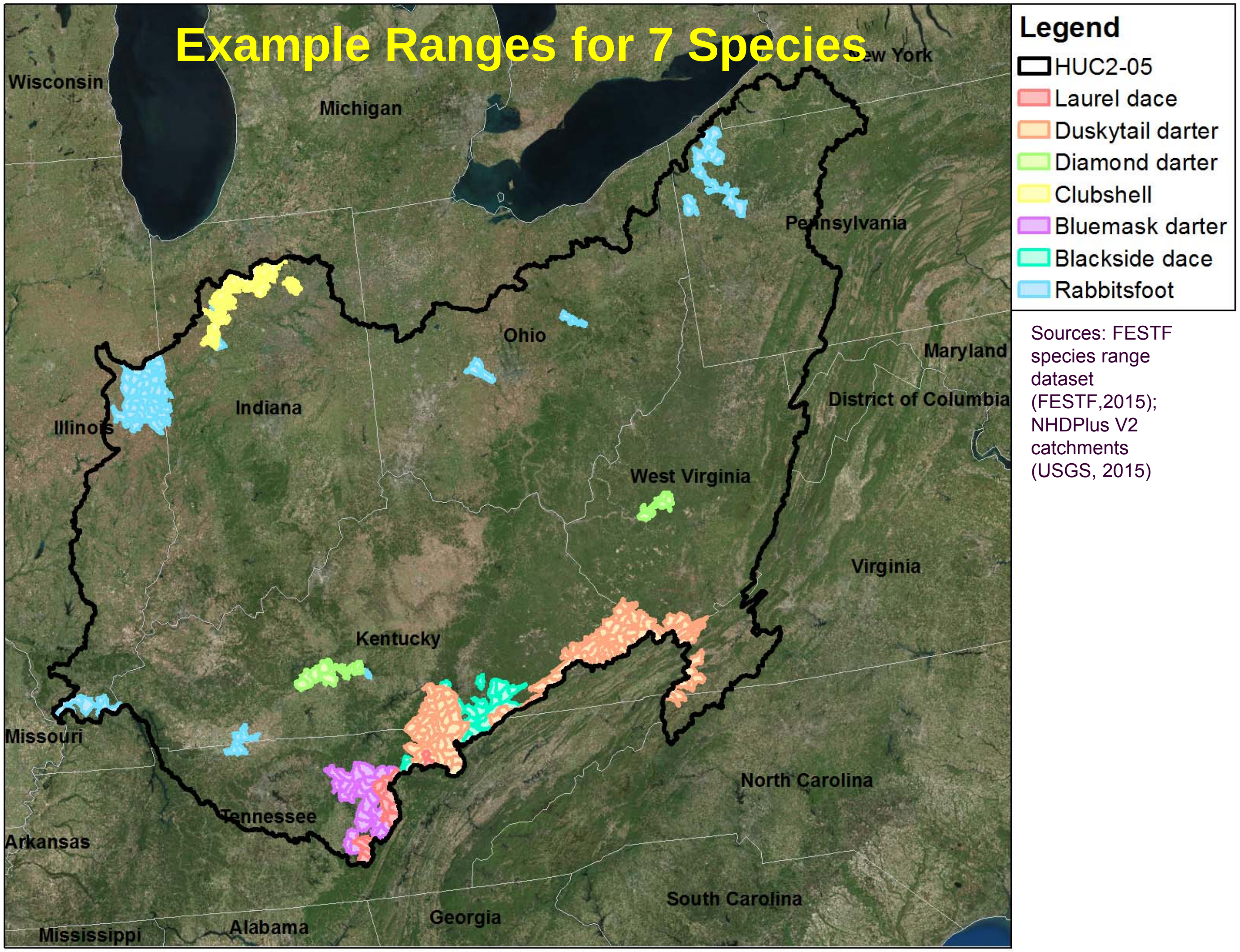


Sources: CDL 2010-2014 (NASS, 2015); WBD (NRCS, 2016)

Exposure Predictions Made for 23 Fish, Mollusks, and Crustacean Species Ranges

The EECs relevant to each species were based on the spatial intersection of HUC12 catchments and species ranges.

Taxon	Common Name
Crustaceans	Kentucky cave shrimp
Crustaceans	Nashville crayfish
Fish	Blackside dace
Fish	Bluemask (=jewel) darter
Fish	Boulder darter
Fish	Cumberland darter
Fish	Diamond darter
Fish	Duskytail darter
Fish	Laurel dace
Fish	Palezone shiner
Fish	Pallid sturgeon
Fish	Roanoke logperch
Fish	Scioto madtom
Fish	Slender chub
Fish	Spotfin chub
Mollusks	Clubshell
Mollusks	Fanshell
Mollusks	Northern riffleshell
Mollusks	Orangefoot pimpleback (pearlymussel)
Mollusks	Rabbitsfoot
Mollusks	Rayed bean
Mollusks	Sheepnose mussel
Mollusks	Snuffbox mussel

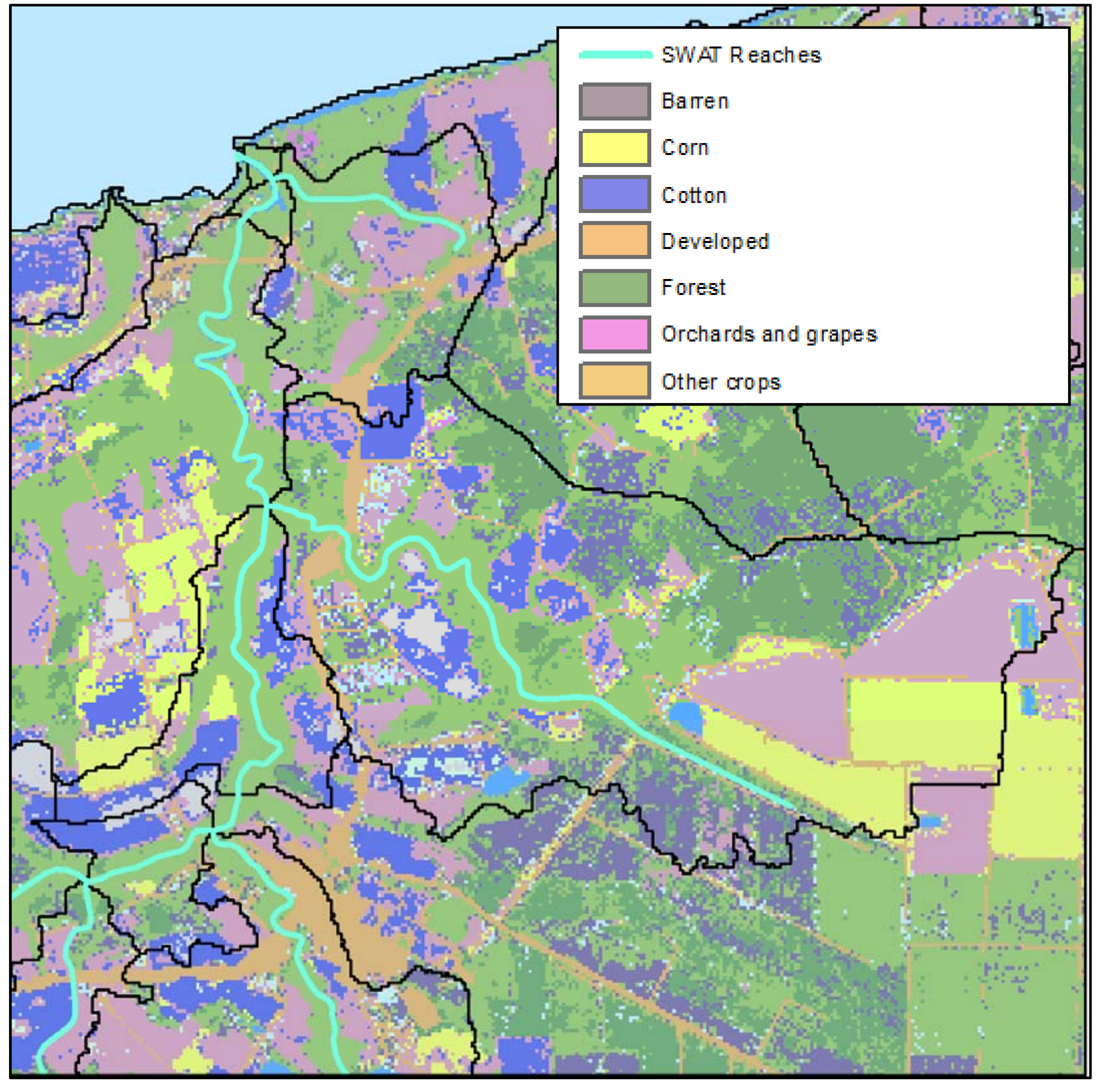


Sources: FESTF species range dataset (FESTF,2015); NHDPlus V2 catchments (USGS, 2015)

Coupling PRZM5 and SWAT for Spatially Explicit Flowing Water Modeling

Unique combinations (226,361) of land cover/soil/weather were simulated using PRZM5 to represent each of 5,277 HUC12 watersheds.

- 19 Land over/crop classes
- 343 soil classes
- 1,010 weather time series



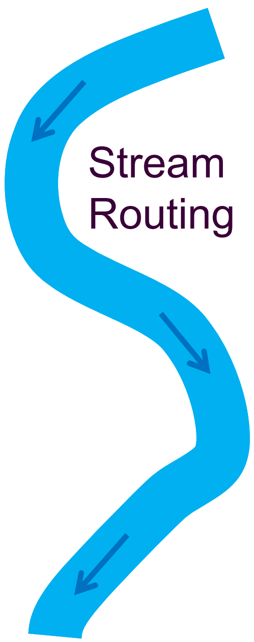
Area-weighted total runoff, sediment, and pesticide by HUC12:

Runoff, Sediment: 40% Area

Runoff, Sediment, Pesticide: 25% Area

Runoff, Sediment: 15% Area

Runoff, Sediment, Pesticide: 20% Area



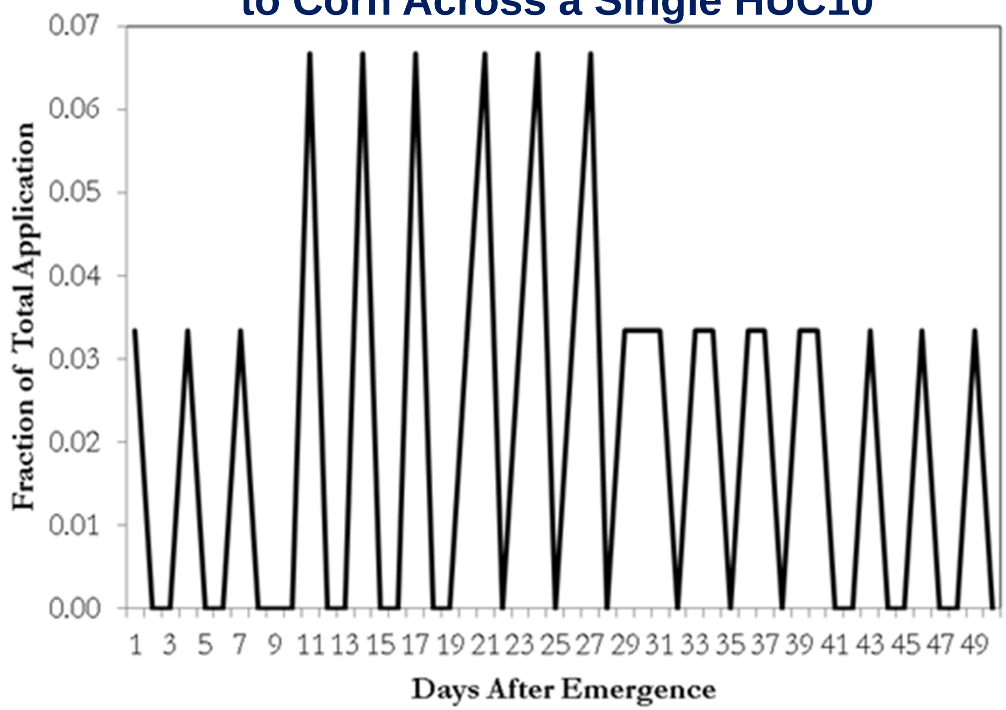
Watershed Scale Pesticide Application Approach

Typical chlorpyrifos application windows for each treated crop were derived from a literature review and calls to local ag extension agents.

For each crop in a HUC10 watershed, the earliest initial application date was randomly chosen from the window.

Depending upon the use pattern, this resulted applications occurring over 6 to 25 dates within a HUC10.

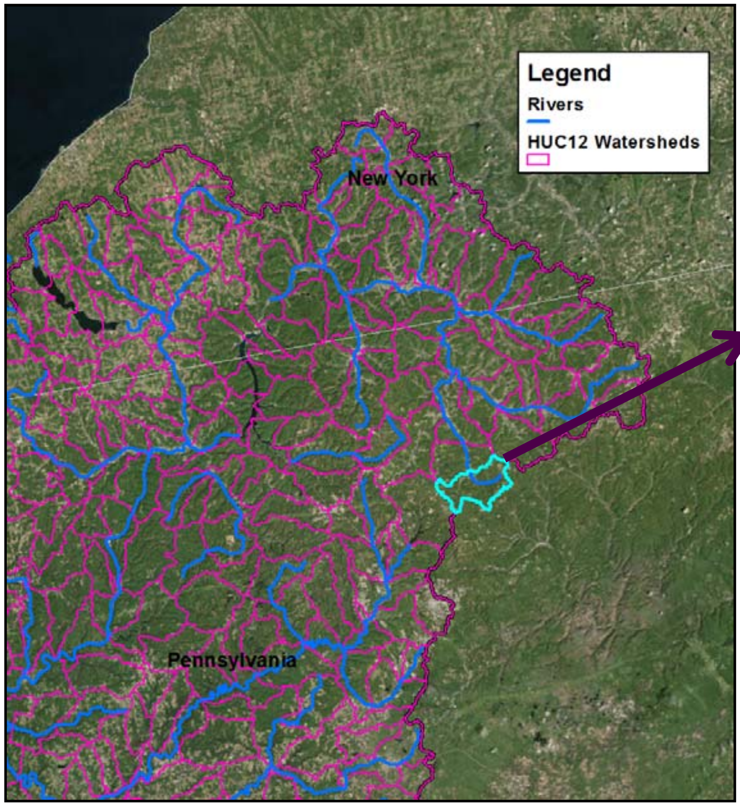
Fraction of Total Seasonal Applications to Corn Across a Single HUC10

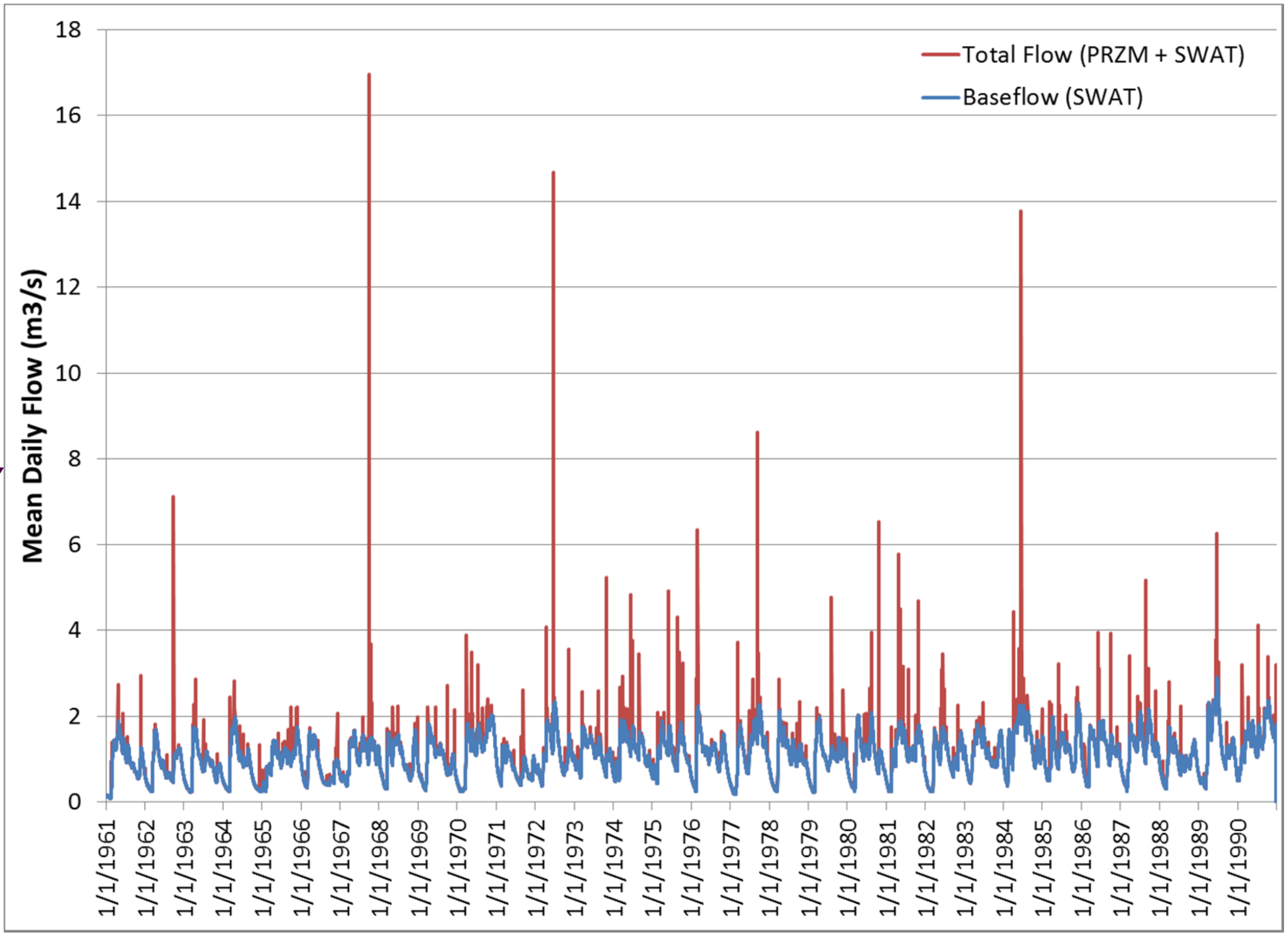


Incorporation of Daily Baseflow from HAWQS SWAT

The SWAT model simulates the entire hydrologic cycle, including daily varying subsurface baseflow contributions to streamflow.

Total daily streamflow was simulated from PRZM5 surface runoff and HAWQS SWAT baseflow.



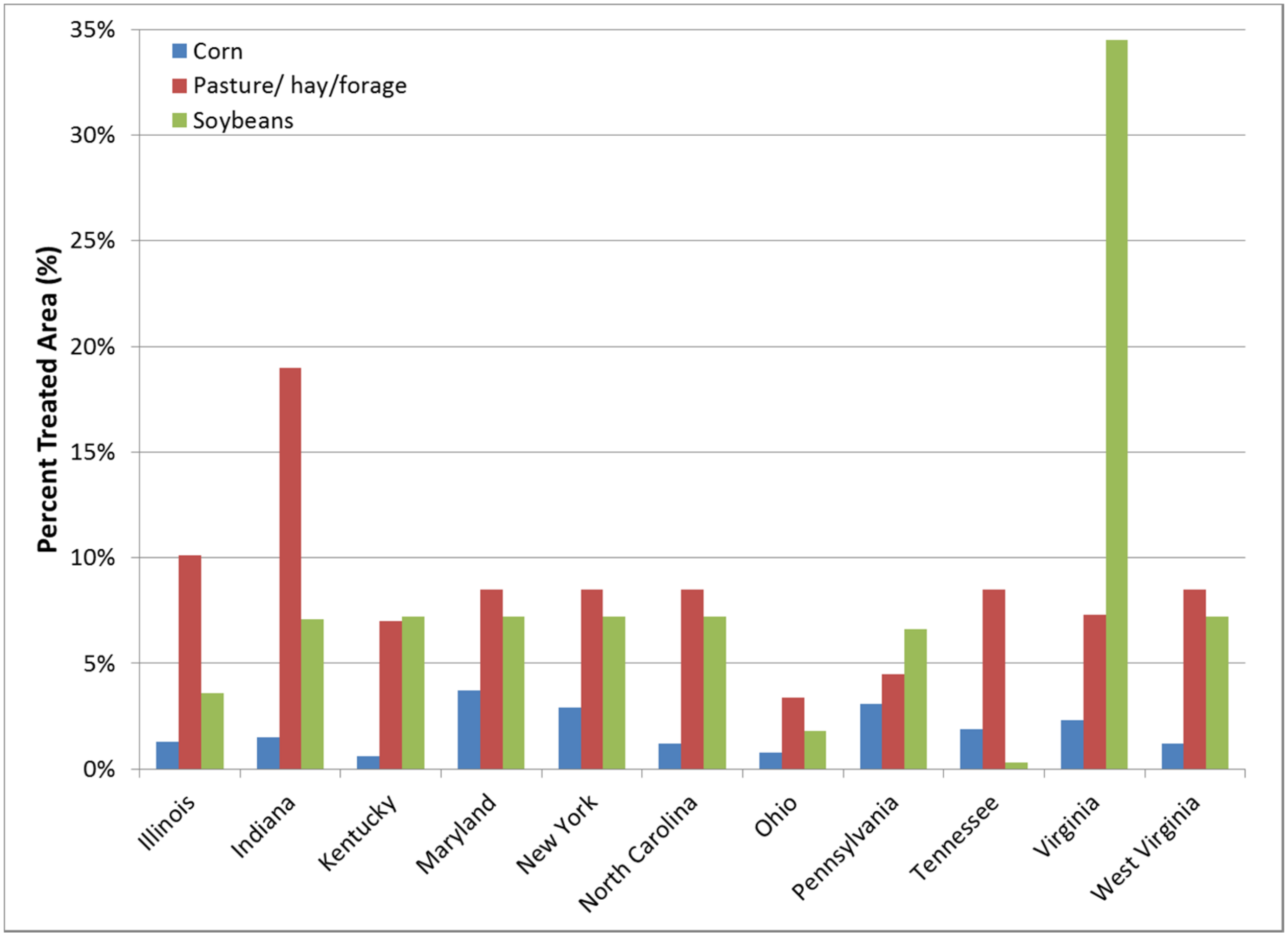


Percent Treated Area Refinement Approach

State-level use data from 2010 – 2015 was obtained from AgroTRAK and the Percent Treated Areas (PTA) was calculated by state/crop group.

The 90th percentile PTA was calculated for each crop and state.

- Corn: 0.3% - 3.7%
- Soybean: 0.3% - 34.5%
- Pasture/Hay: 3.4% -19%



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Model Simulation Approach and Uncertainty Analysis

Probability distributions of annual maximum EECs were generated for each of 5,277 HUC12 stream segments based on 8 uncertainty scenarios:

- Soil Half Life: 28.3 to 96.3 days
- Baseflow: A high and low SWAT baseflow parameterization
- Channel Routing: A high and low channel velocity parameterization

Uncertainty Scenario	Environmental Fate	Baseflow[1]	Channel Routing[2]
1	High soil half-life	Baseflow Low	Channel Velocity Hi
2	High soil half-life	Baseflow Low	Channel Velocity Low
3	Low soil half-life	Baseflow Low	Channel Velocity Hi
4	Low soil half-life	Baseflow Low	Channel Velocity Low
5	High soil half-life	Baseflow Hi	Channel Velocity Hi
6	High soil half-life	Baseflow Hi	Channel Velocity Low
7	Low soil half-life	Baseflow Hi	Channel Velocity Hi
8	Low soil half-life	Baseflow Hi	Channel Velocity Low

1. Baseflow uncertainty using two CN adjustment methods; soil moisture and plant ET
2. Channel routing uncertainty accounting for velocities based on two different Manning's n value; 0.014 and 0.05

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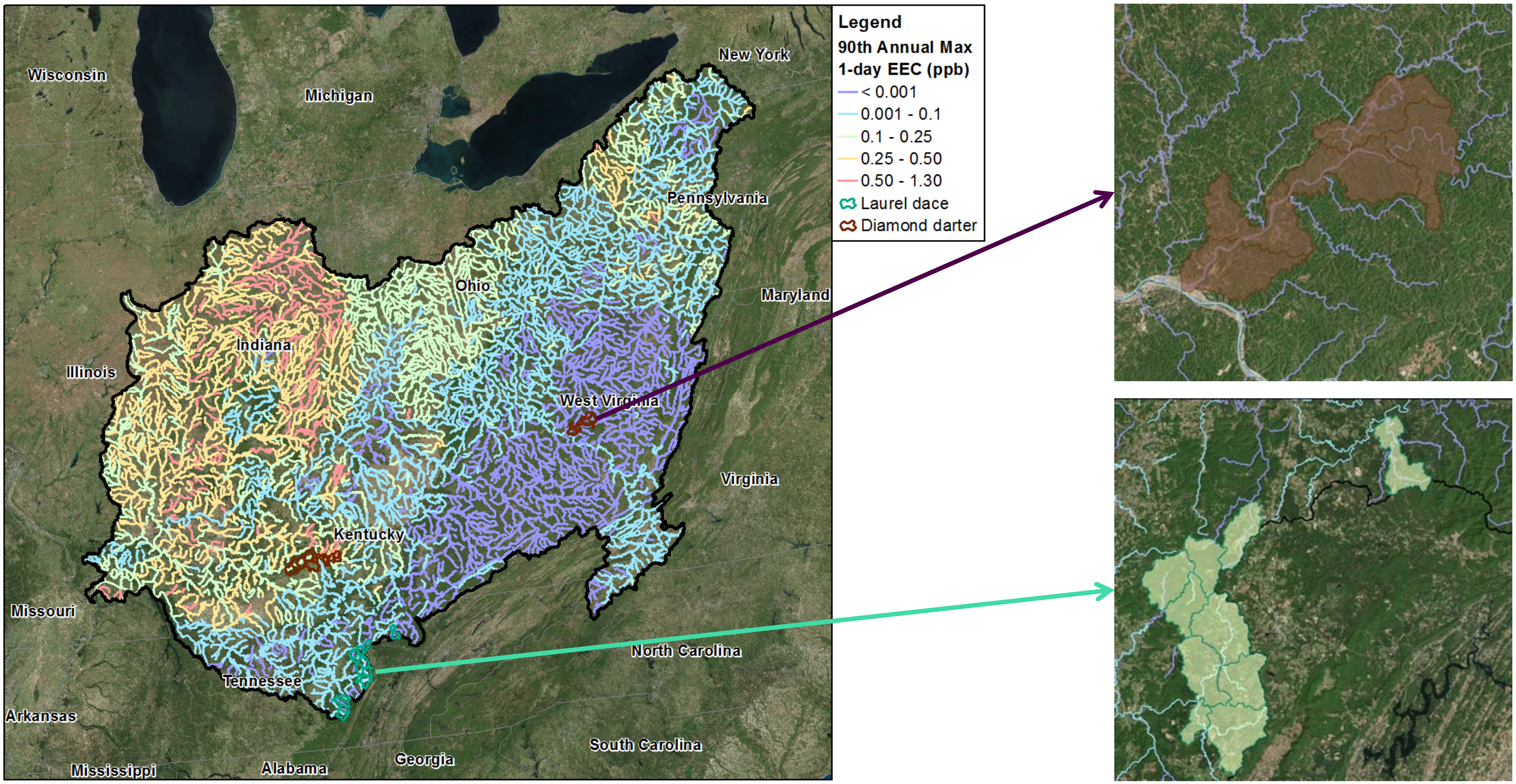
Spatial Distribution of Chlorpyrifos EECs

PRZM-SWAT simulations were run for each of the 8 uncertainty scenarios.

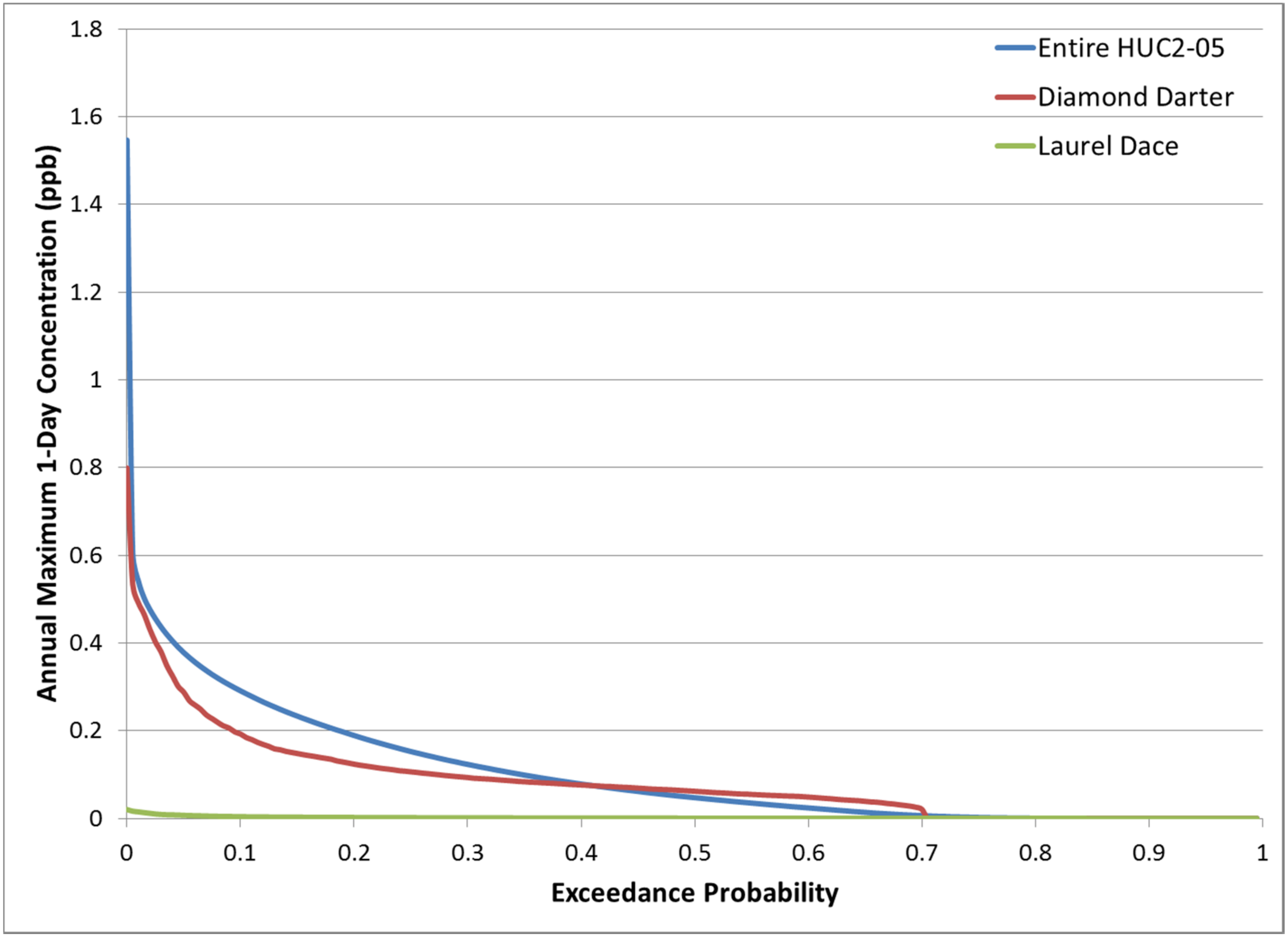
Probability distributions of EECs were generated for every HUC12 stream.

- Very high spatial variability was observed across HUC2-05
- Many species ranges had very low exposure likelihood



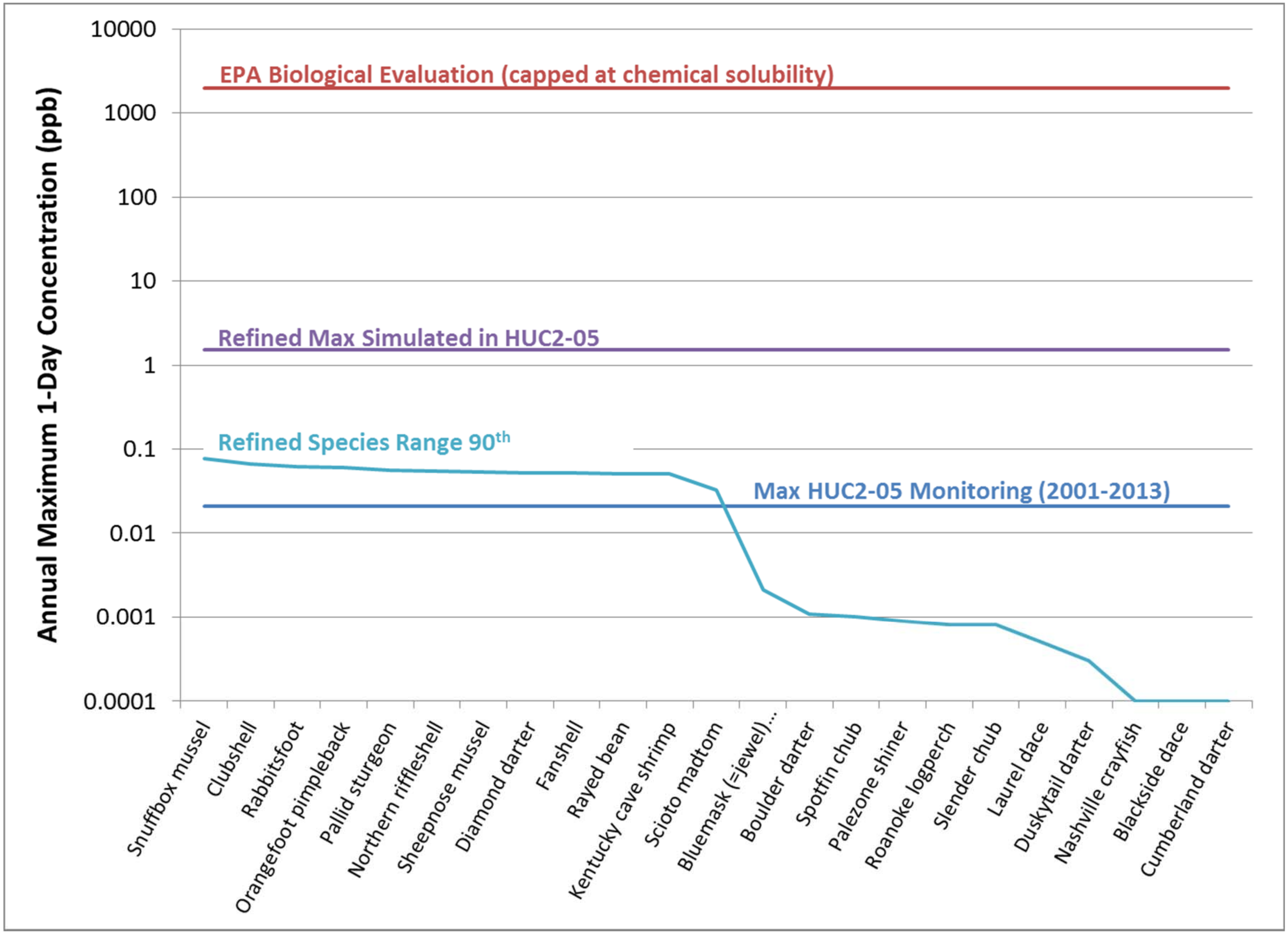
Annual Maximum Flowing Water EEC Distributions

Exposure probability for the entire HUC2, does reflect a specific species. Differences in EEC distributions between species can be significant.



Comparison of EECs with Draft Biological Evaluation

Refined EECs vary several orders of magnitude across species ranges, and are conservative relative to monitoring data.



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Summary and Conclusions

A refined modeling approach was developed to assess exposure of aquatic endangered species to pesticides in flowing water bodies.

The refined, probabilistic approach integrates the regulatory PRZM5 model with components of the SWAT watershed scale model.

- Allows for a range of possible input refinements
- Suitable for incorporating uncertainty analysis

A single regional screening level scenario may have little relevance to exposure for some endangered species.

The refined EEC distributions demonstrate the variability in exposure potential between species and the importance of these refined exposure estimates to support well-informed risk decisions.

This approach addresses many flowing water modeling recommendations identified during the June 2016 ESA Stakeholder Workshop.

Thank you.

For more information / mwinchell@stone-env.com