A Probabilistic Approach to Modeling Pesticide Exposure for an Endangered Species Assessment in the California Delta

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Exposure Modeling Recommendations from NAS Report

- The National Academy of Science (NAS) report recognized that a step-wise approach to estimating pesticide exposure will be needed.

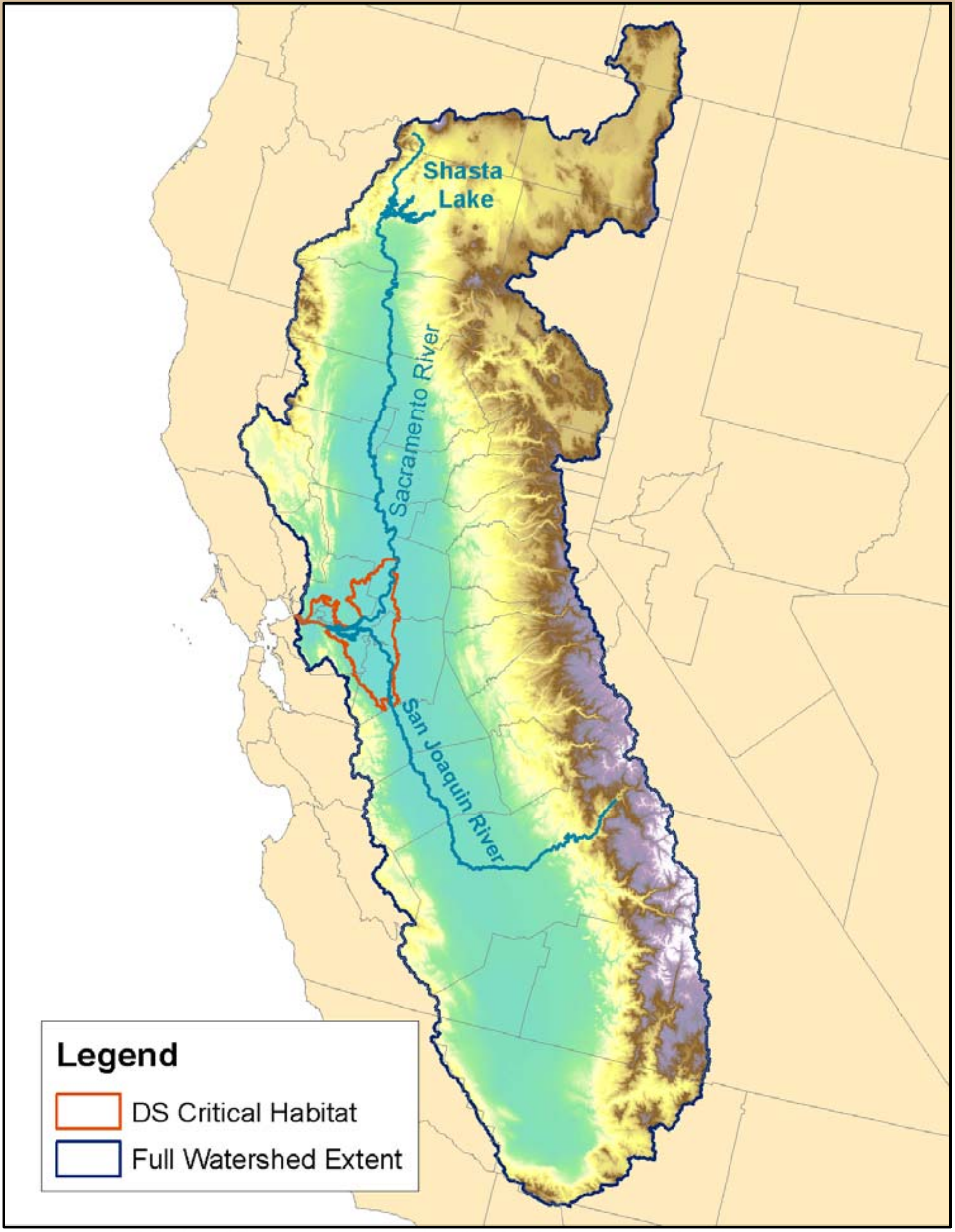
- Exposure models applied at Steps 2 and 3 will require:
  - Use of best available "authoritative" geospatial datasets
  - Estimates of spatial-temporal variations
  - Accounting for uncertainty in determining probabilistic exposure estimates

- The NAS reported identified that currently used pesticide aquatic exposure models do not provide information at the watershed scale.

- The Soil and Water Assessment Tool (SWAT) was identified by NAS as a suitable tool to model watershed scale aquatic exposure estimates which vary over spatially and temporally.

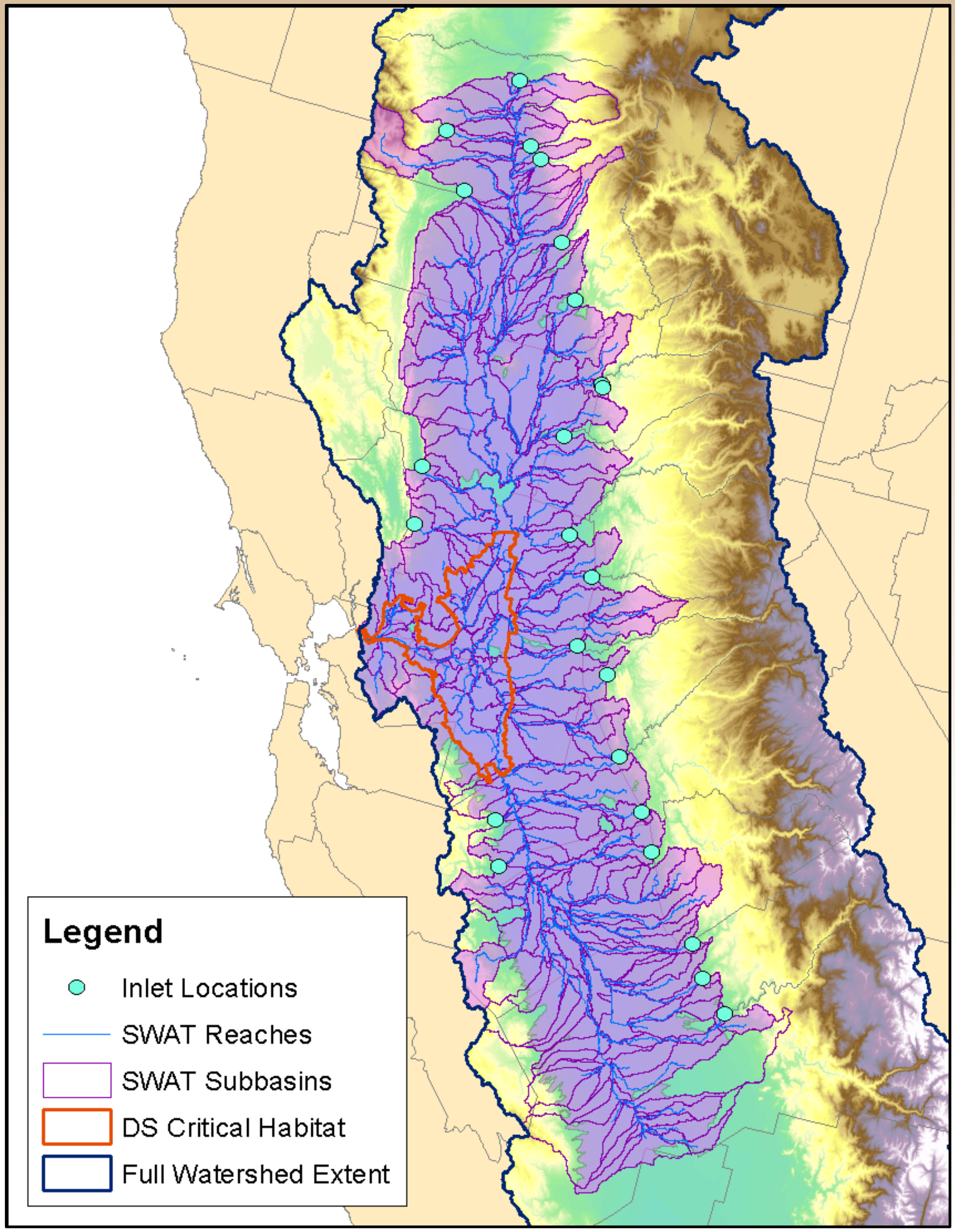
Case Study: Insecticide Exposure Assessment for the Delta Smelt

- Objective: To estimate spatially variable pesticide exposure distributions across the Delta Smelt (DS) Critical Habitat.
- Approach: Apply the SWAT model for a watershed scale assessment that:
  - Is relevant to specific species habitat
  - Utilizes best available spatial datasets
  - Accounts for uncertainties in model inputs
  - Provides probabilistic exposure estimates for use in risk characterization



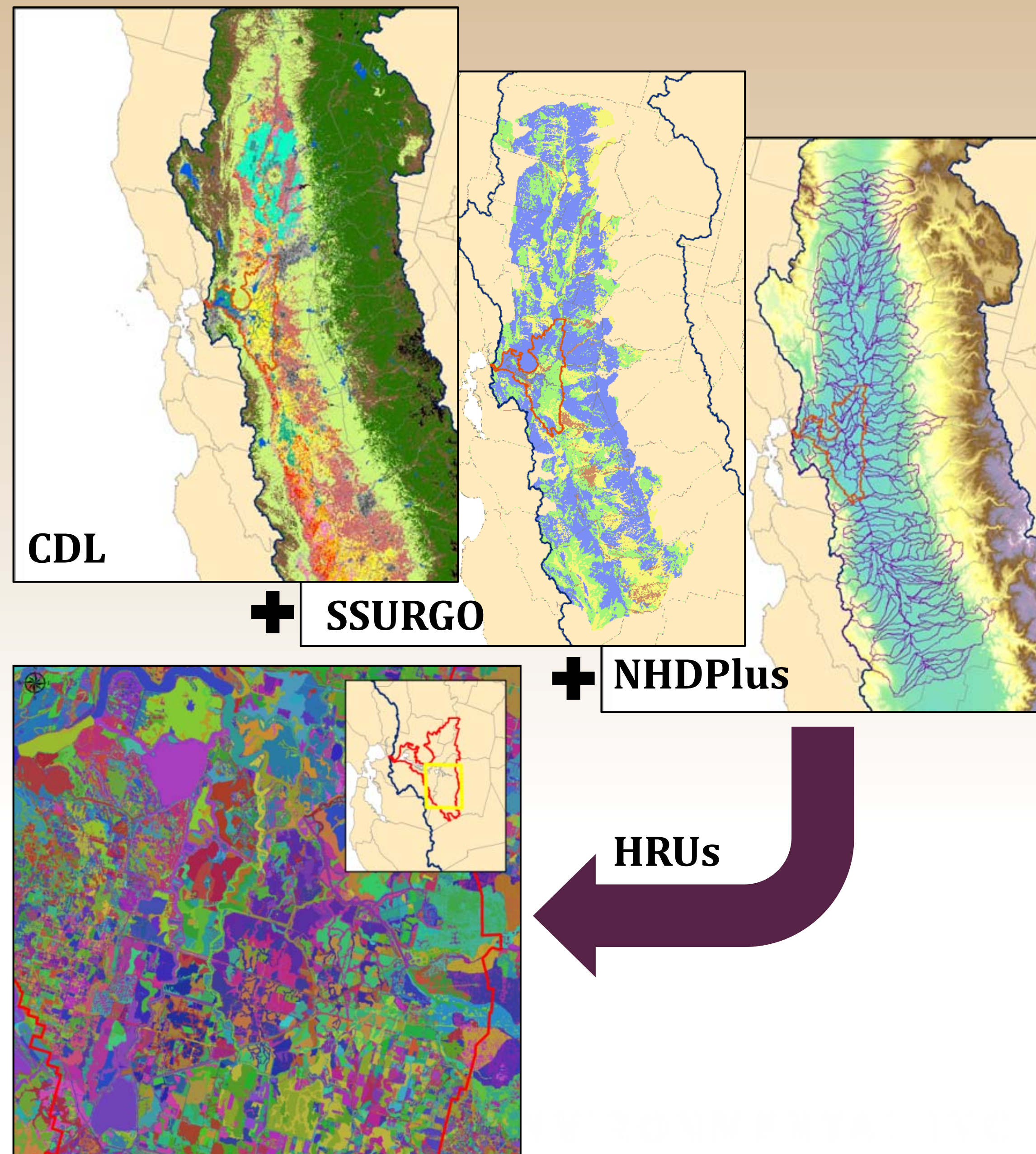
Model Development: Spatial Delineation of Watershed

- A large, diverse watershed drains through CA Delta.
- Watershed delineated into 344 sub-basins, 59 within DS Critical Habitat.
- Pesticide applied upstream of Critical Habitat is routed downstream.



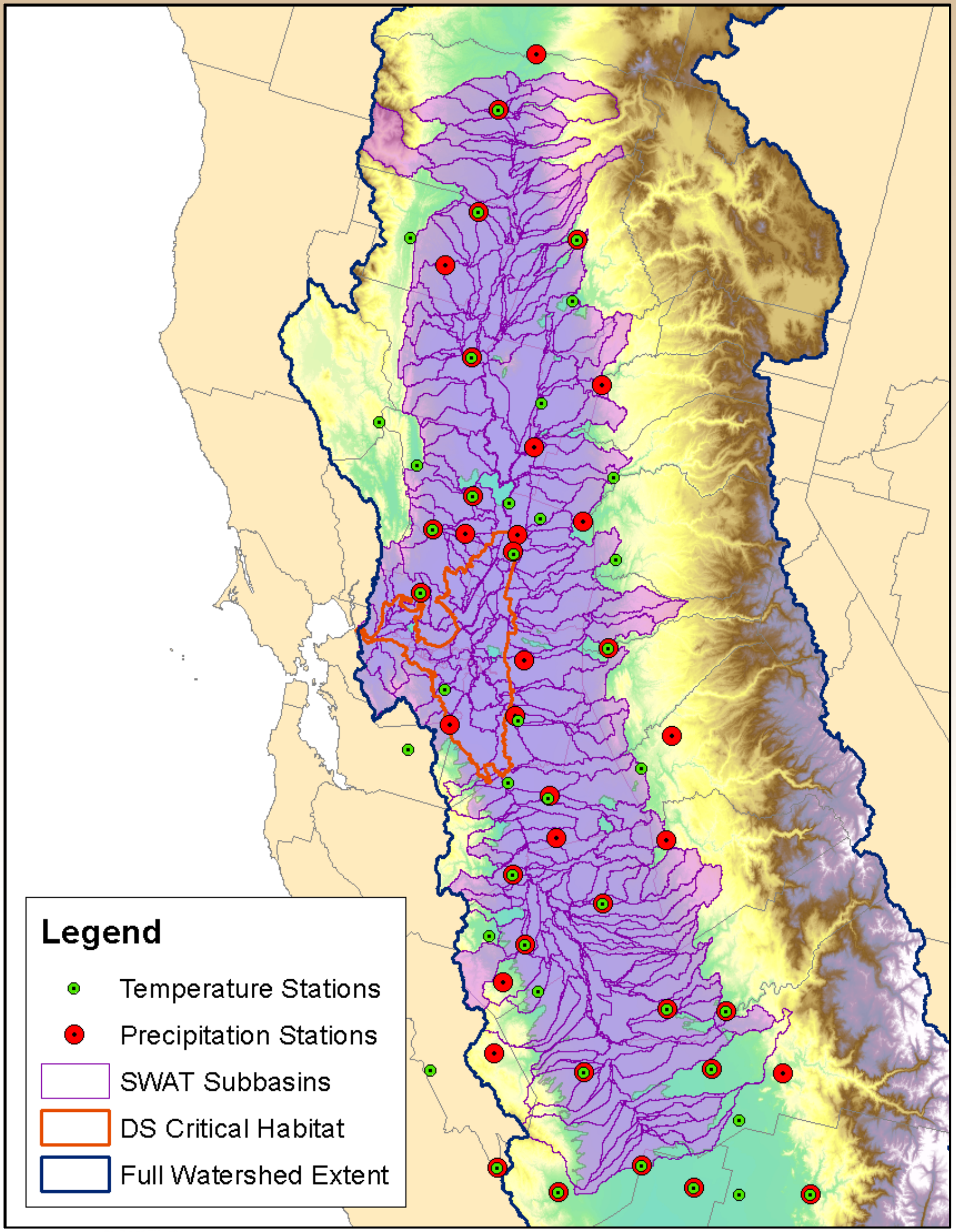
Best Available Spatial Data for Landscape Characterization

- Topography: 30-m NHDPlus V2
- Land Use Data: Cropland Data Layer (CDL)
- Soils Data: Soil Survey Geographic database, 1:24,000 scale
- Heterogeneity in landscape characteristics impacting pesticide transport is represented.



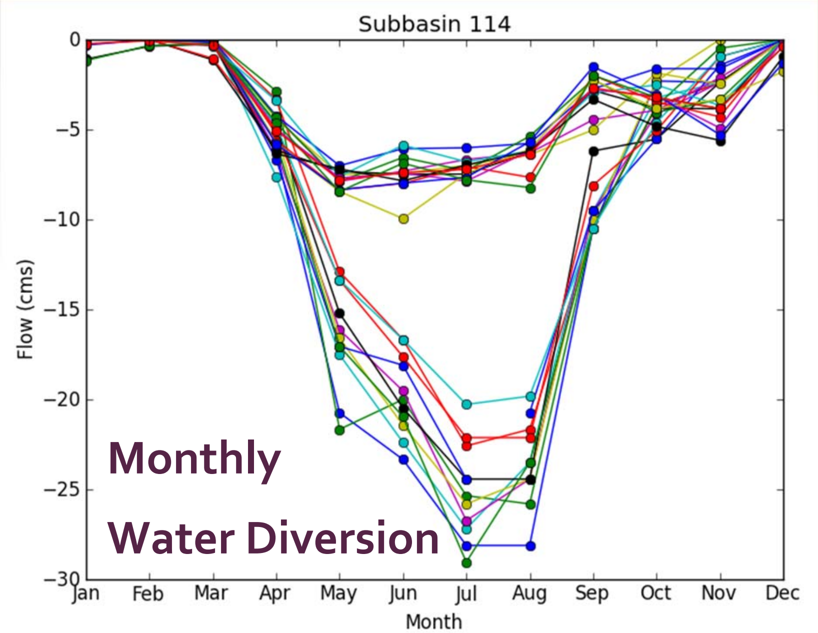
Best Available Data for Long Term Climate Characterization

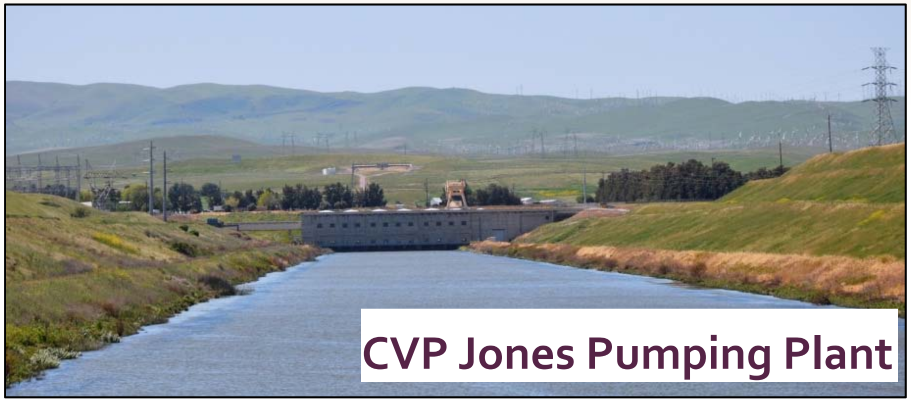
- 30 years of daily data between 1981-2010
  - 51 temperature stations
  - 48 precipitation stations with most complete records



Best Available Hydrologic Data

- Complex hydrologic system throughout the Central Valley was accounted for in the SWAT model:
  - Flow diversions
  - Flood control structures
  - Pumping plants



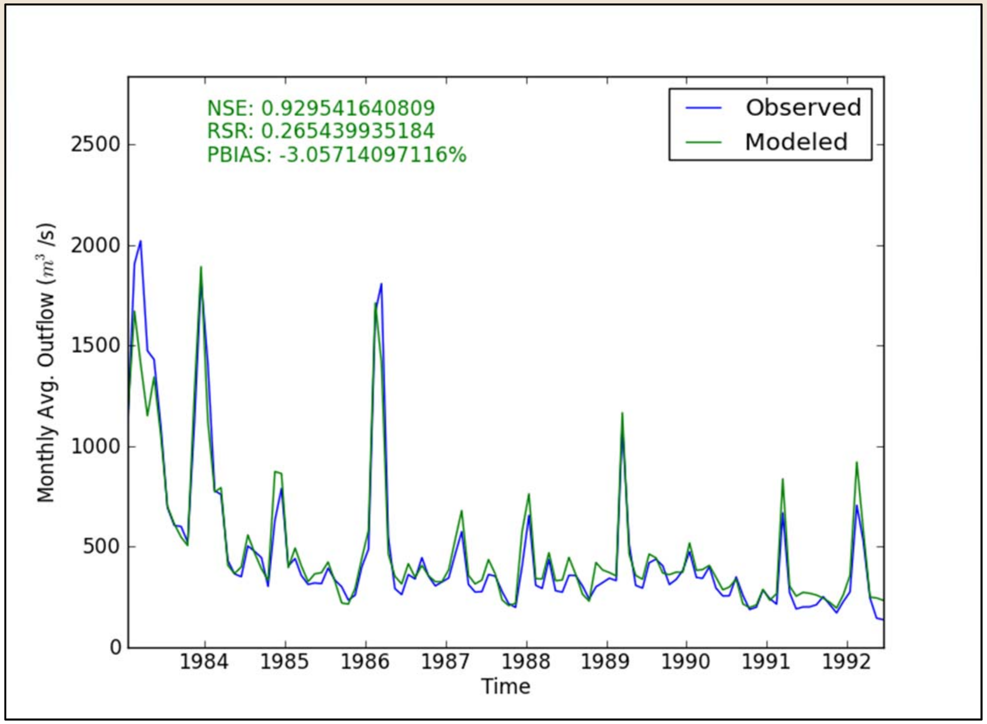


Calibration and Validation of Model with Observed Data

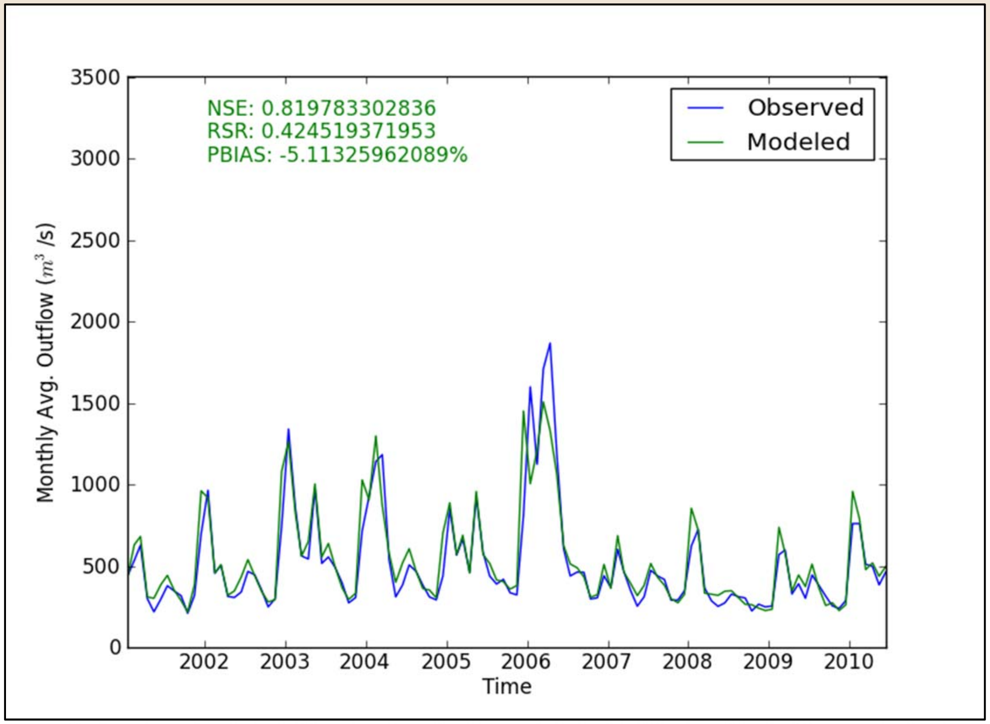
- Streamflow was calibrated at 13 locations within the watershed.

- Spatial and temporal variability in flow was well captured by the model, leading to improved pesticide concentration estimates.

Sacramento R. at Verona, Calibration

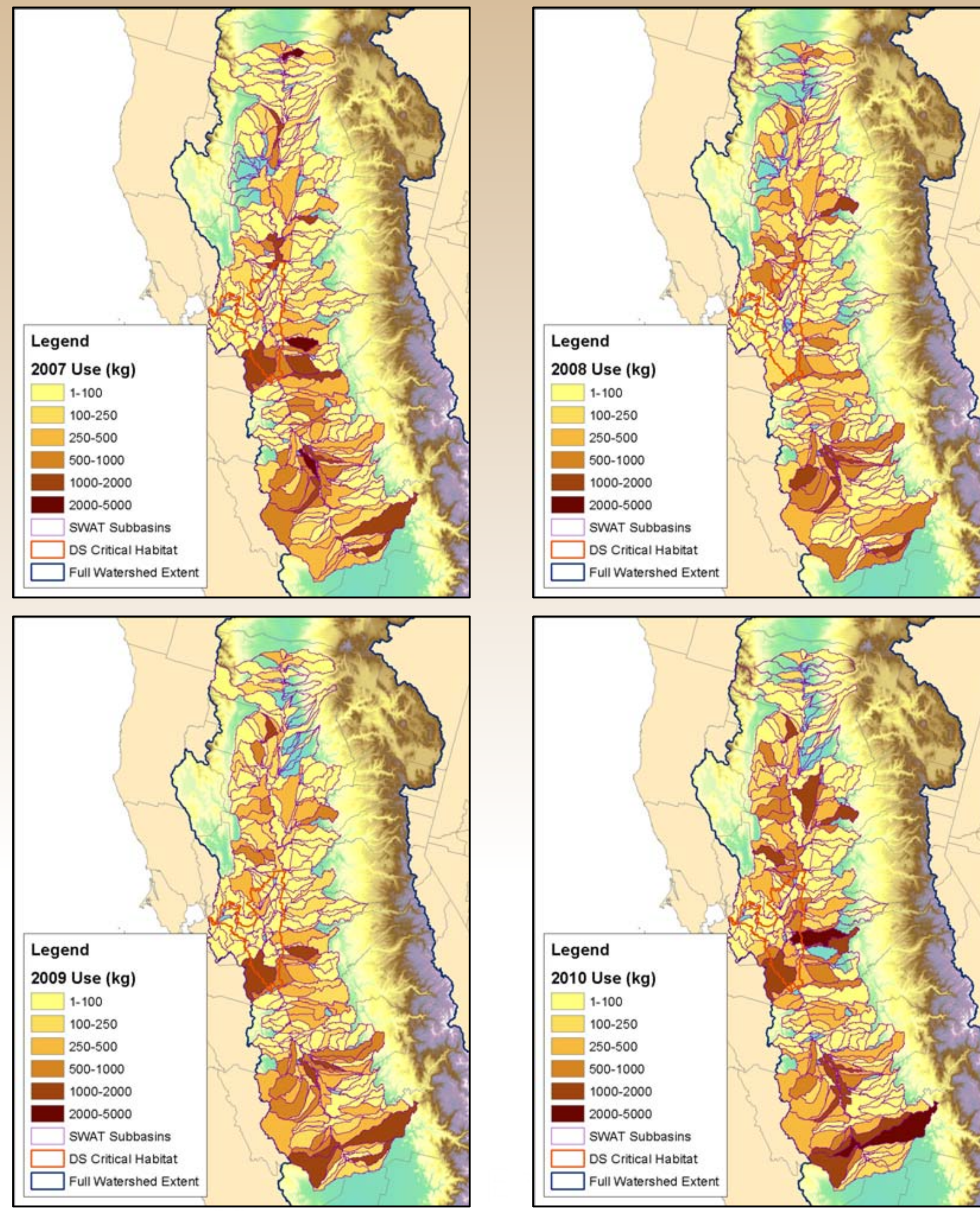


Sacramento R. at Verona, Validation



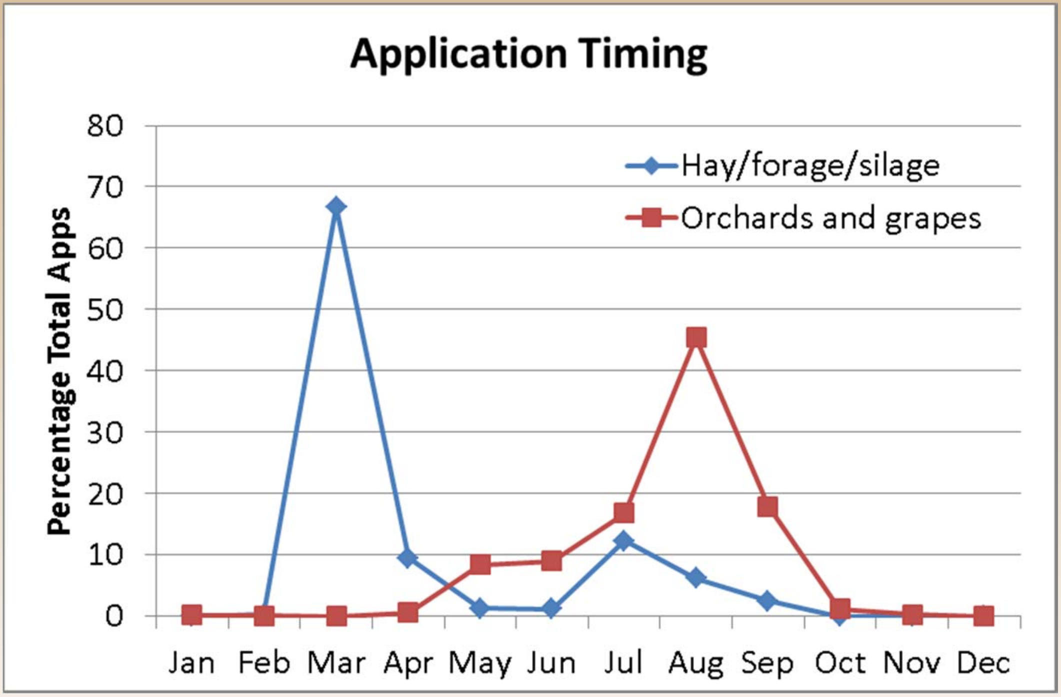
Accounting for Uncertainty in Pesticide Applications: Spatial

- Locations and amounts of pesticide applied can vary from year to year.
- Each year of pesticide use is assumed to have an equal probability of occurring.
- The annual pesticide use in a single subbasin can be met by many different combinations of field applications.

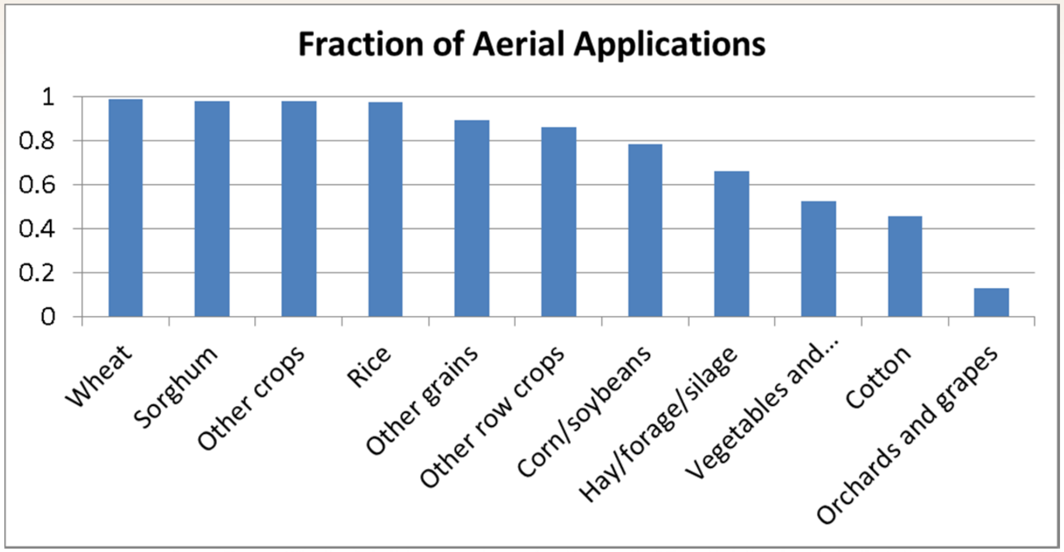


Accounting for Uncertainty in Pesticide Applications: Temporal

- Probability distributions of application timing are determined for each crop from PUR database.

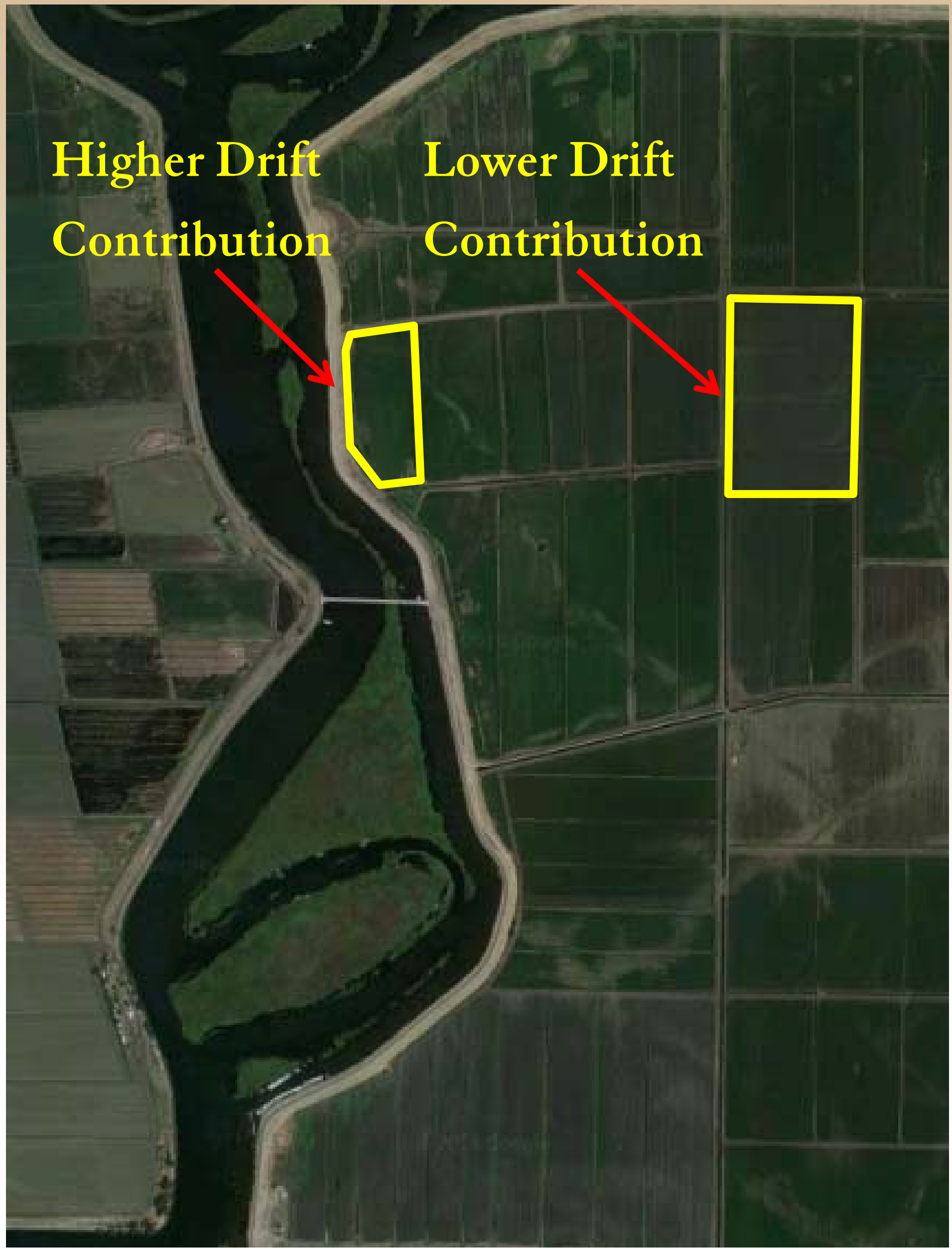


- Probability of ground and aerial application methods calculated for each crop.



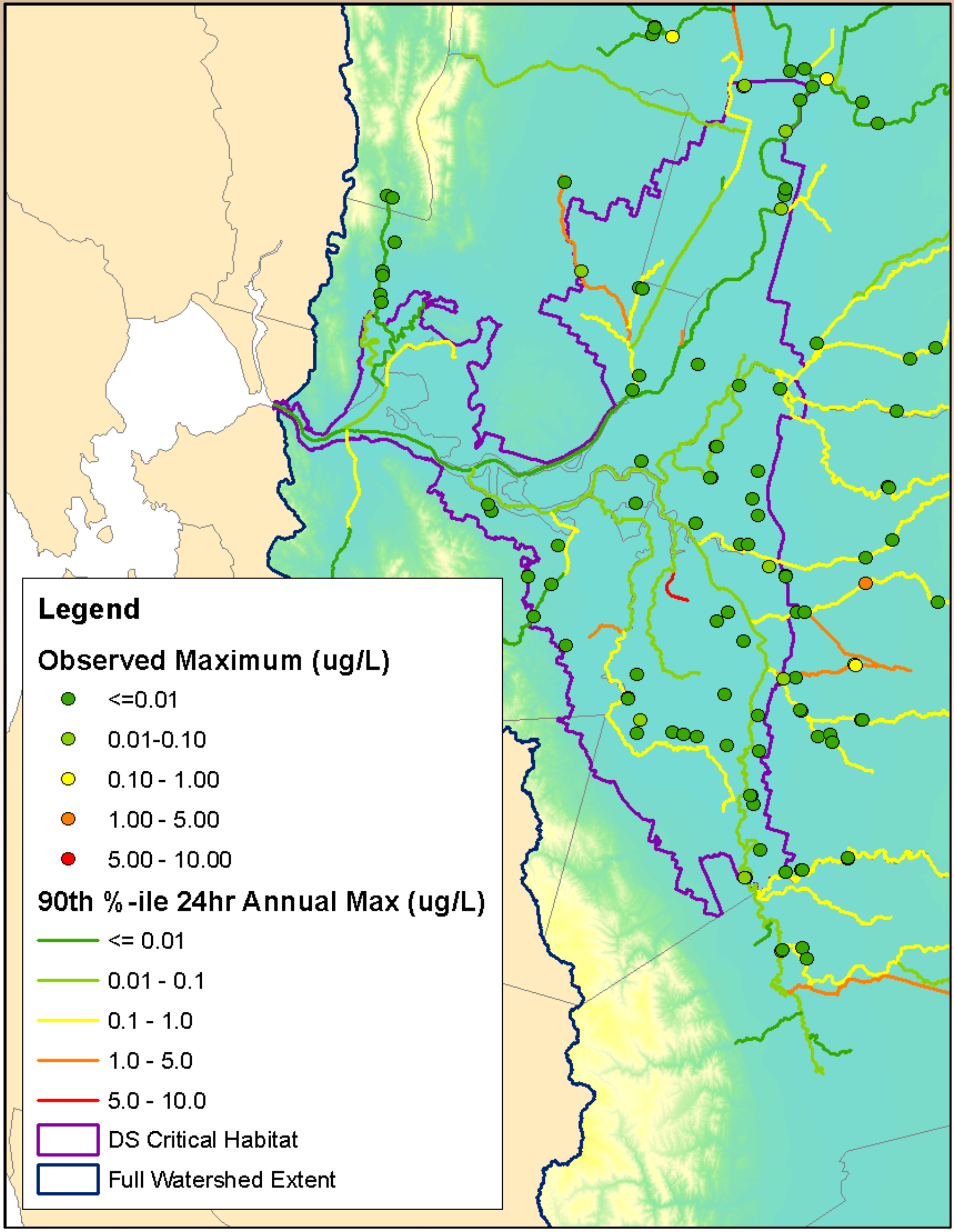
Accounting for Uncertainty in Pesticide Applications: Spray Drift

- At the watershed scale, the potential for exposure due to spray drift is highly variable.
- From a geospatial perspective, dependencies include:
  - Location and size of treated area within a subbasin
  - The proximity of treated area to a receiving water body.
- Each potentially treated area has a different maximum drift contribution.



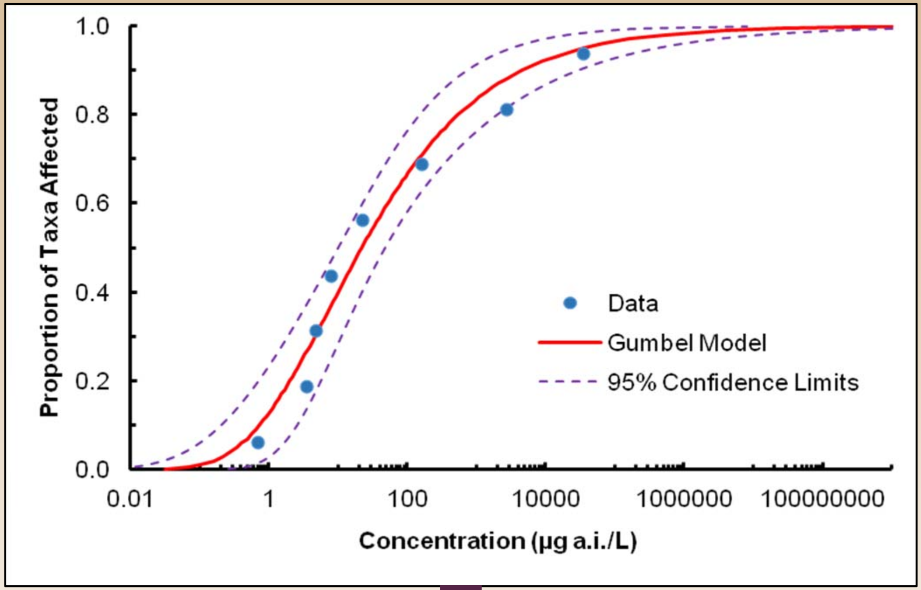
Model Simulations of Spatially Explicit EEC Distributions

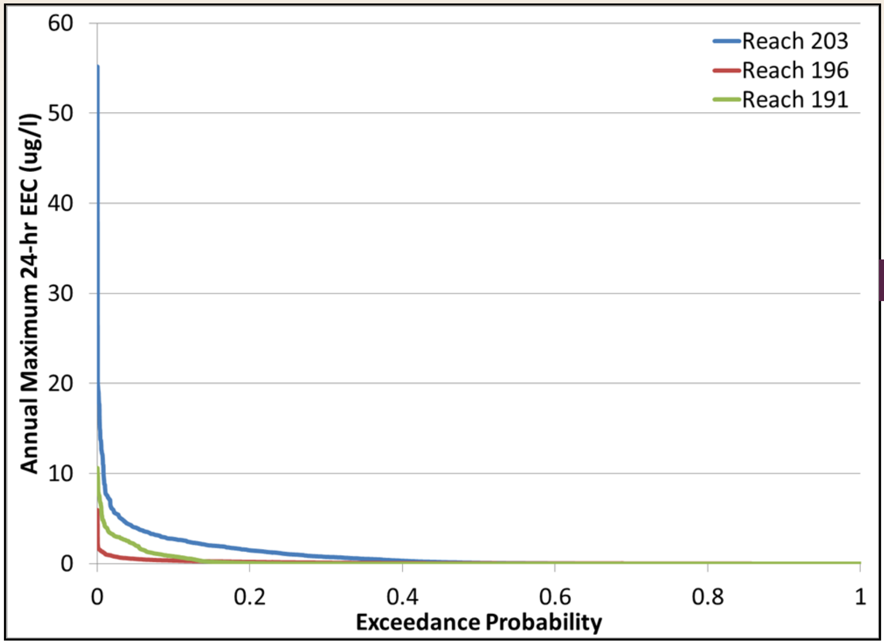
- A Monte Carlo simulation approach was used to generate 100 30-year simulations accounting for uncertainty in:
  - Percent Treated Area (total applied)
  - Spatial location of treated areas
  - Timing of applications
  - Method of application
- EEC distributions were generated for each of 59 water within the Critical Habitat.
- Comparisons made with monitoring data showed good agreement.

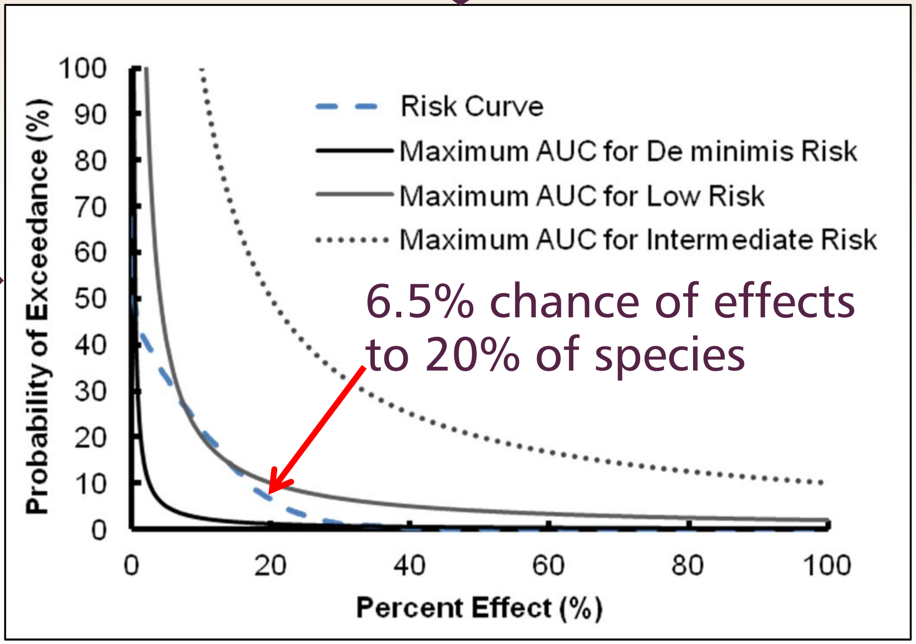


Use of Spatially Explicit EEC Distributions in Risk Characterization

- The EEC probability distributions were integrated with an SSD for aquatic invertebrates to generate risk curves for water bodies within the DS Critical Habitat.







Summary and Conclusions

- Recommendations from the NAS report were incorporated into an endangered species exposure assessment that required analysis as the watershed scale.

- The modeling approach incorporated:
  - Best available “authoritative” geospatial datasets
  - Uncertainty in several key inputs associated with pesticide applications
  - Observed flow and chemical data for model calibration/validation

- The probabilistic exposure modeling results have been used in the assessment's risk characterization through integration with probabilistic species sensitivity distributions.

- The approach presented can be adapted to additional species habitats and expanded to include additional uncertainties.