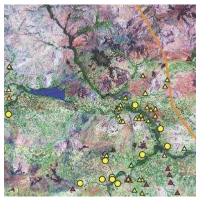
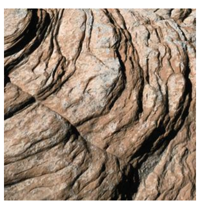
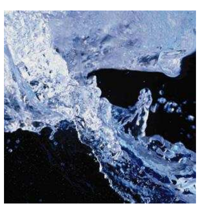


Development of Complex Hydrologic Response Unit (HRU) Schemes and Management Scenarios to Assess Environmental Concentrations of Agricultural Pesticides





Michael Winchell, Raghavan Srinivasan, Tammara Estes, Susan Alexander

2005 International SWAT Conference, Zurich Switzerland

7/15/05

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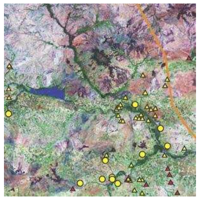
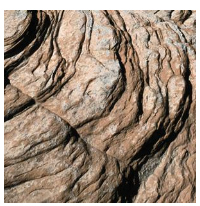




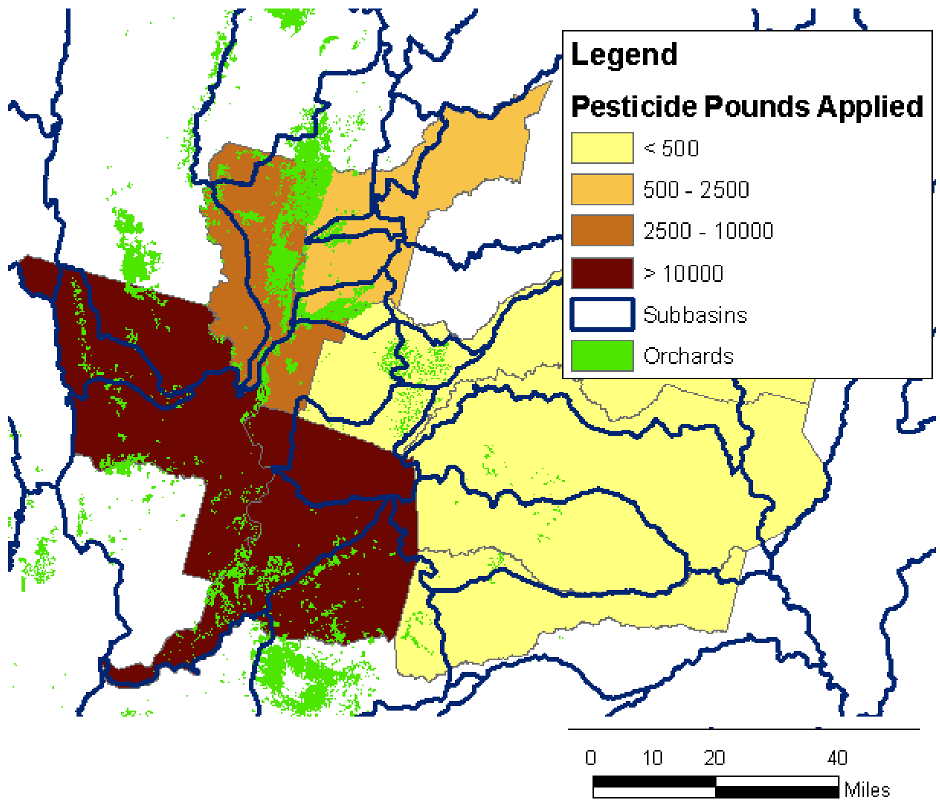


Watershed Scale Modeling of Pesticide Exposure

- Objective
  - Predict peak magnitude, duration, and frequency relative to a defined LOC (level of concern)
- Management related input requirements
  - Application rate
  - Application area
  - Application timing
- Calibration data requirements
  - Observed flow
  - Observed pesticide concentration

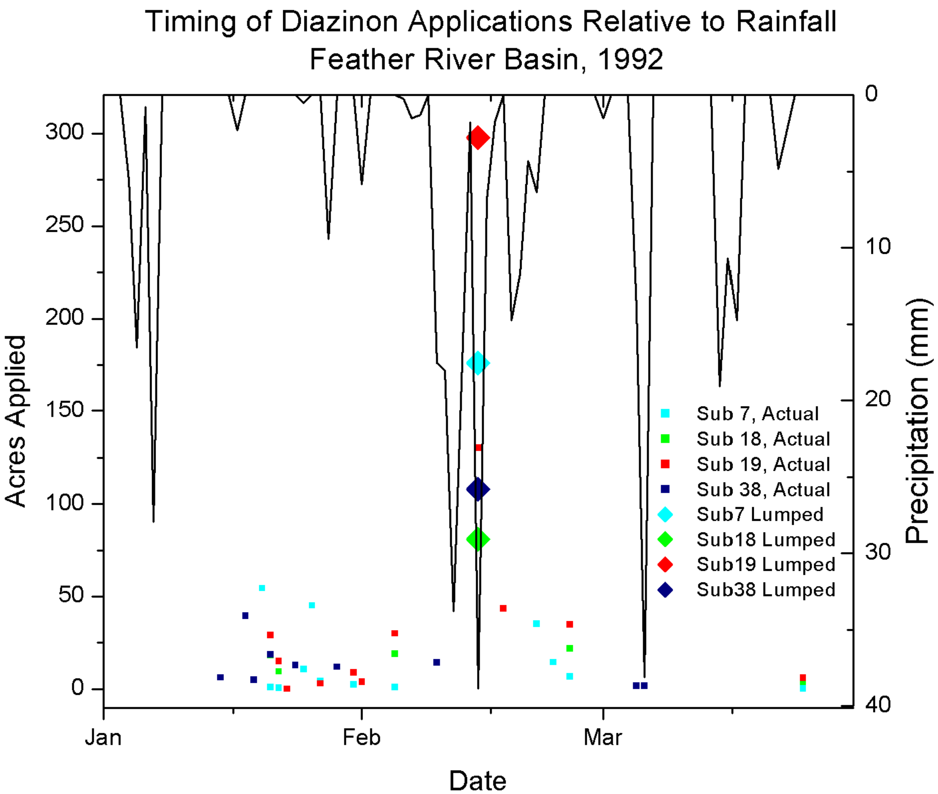
Challenges in Modeling Pesticides: Pesticide Application Area

- In most location in the United States, pesticide use data is at the county-level
- When modeling watersheds or subbasins at the sub-county scale, this can result in significant uncertainty in the area of application within a subbasin



Challenges in Modeling Pesticides: Pesticide Application Timing

- Application timing significantly impacts
  - Pesticide runoff peak magnitude
  - Pesticide runoff peak frequency
- A poor understanding of application timing will result in
  - A poor calibration
  - Inaccurate exposure estimates



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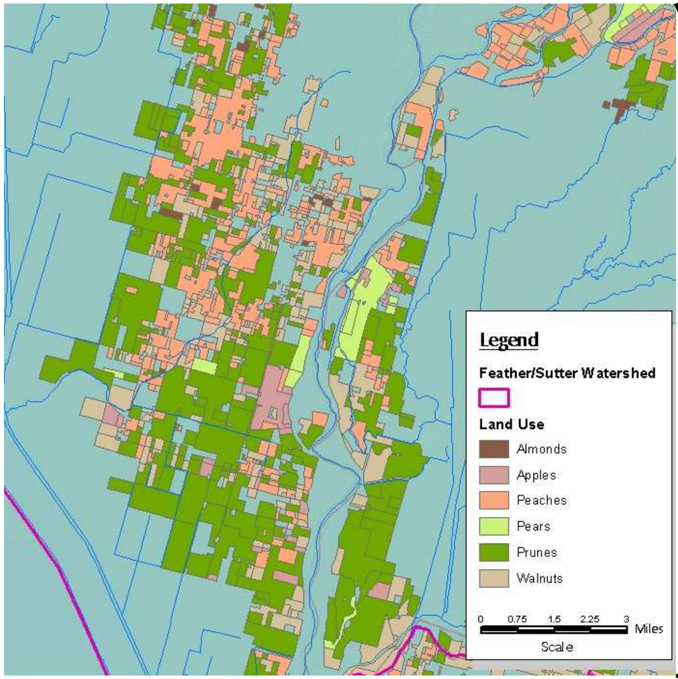
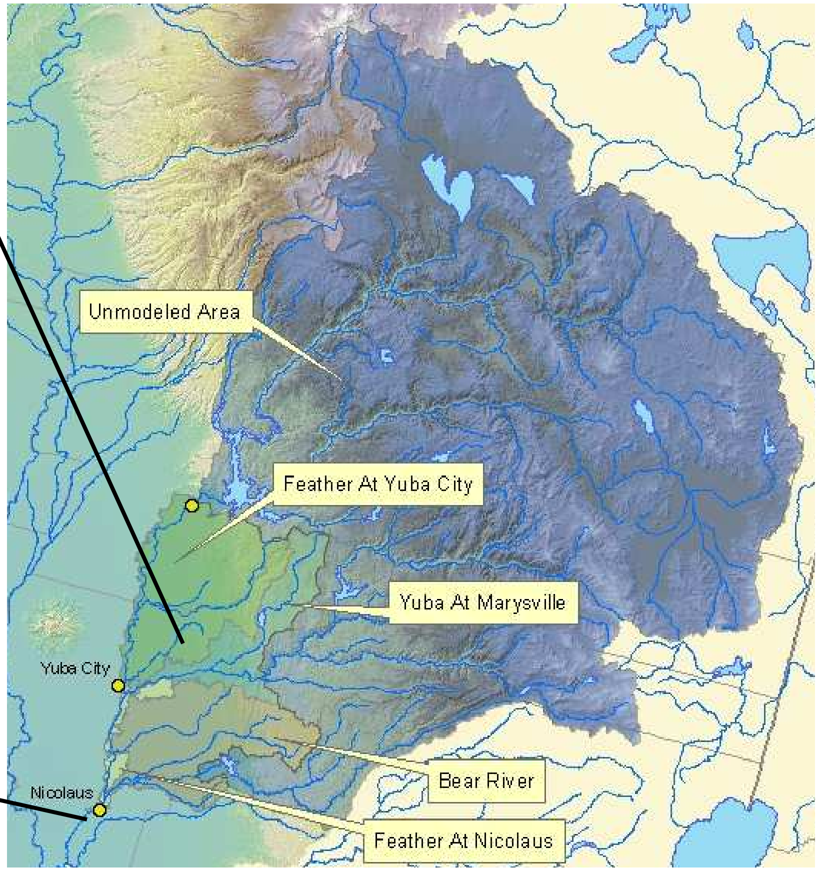
Case Study: HRU and Management Scenario Strategies, California, U.S.A

- Study Area: Feather River watershed (~15,000 sq. km.)
- Pesticide of Interest: Diazinon applied orchard crops
- Objective: Estimate LOC exceedances

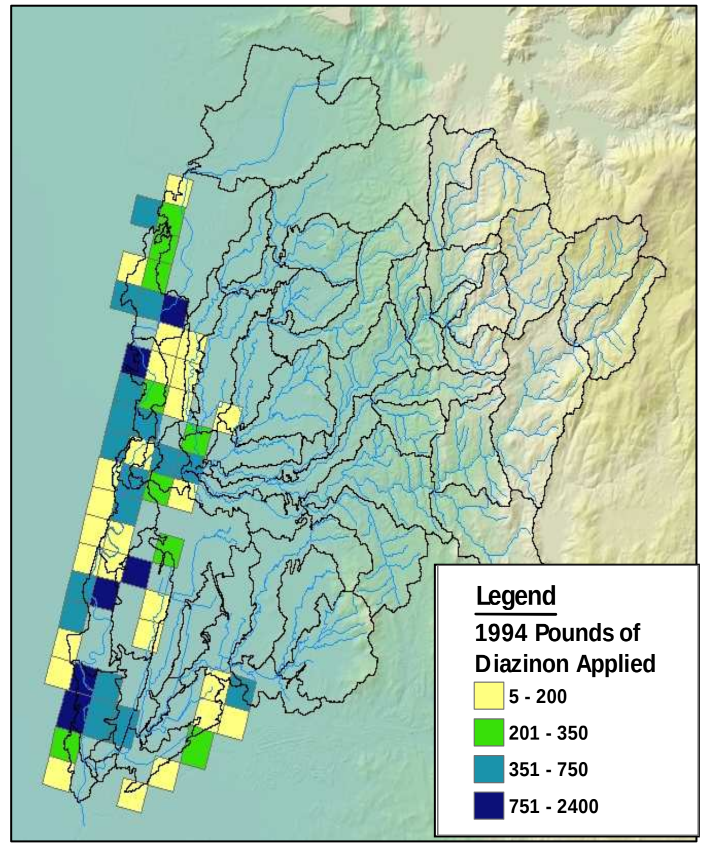




Detailed crop data was available for the Feather River watershed

Case Study, California: Pesticide Use Data

- Daily pesticide application records for 1993-2001 on a 1 square mile section grid.
  - Acres treated
  - Pounds of chemical applied
  - Crop treated



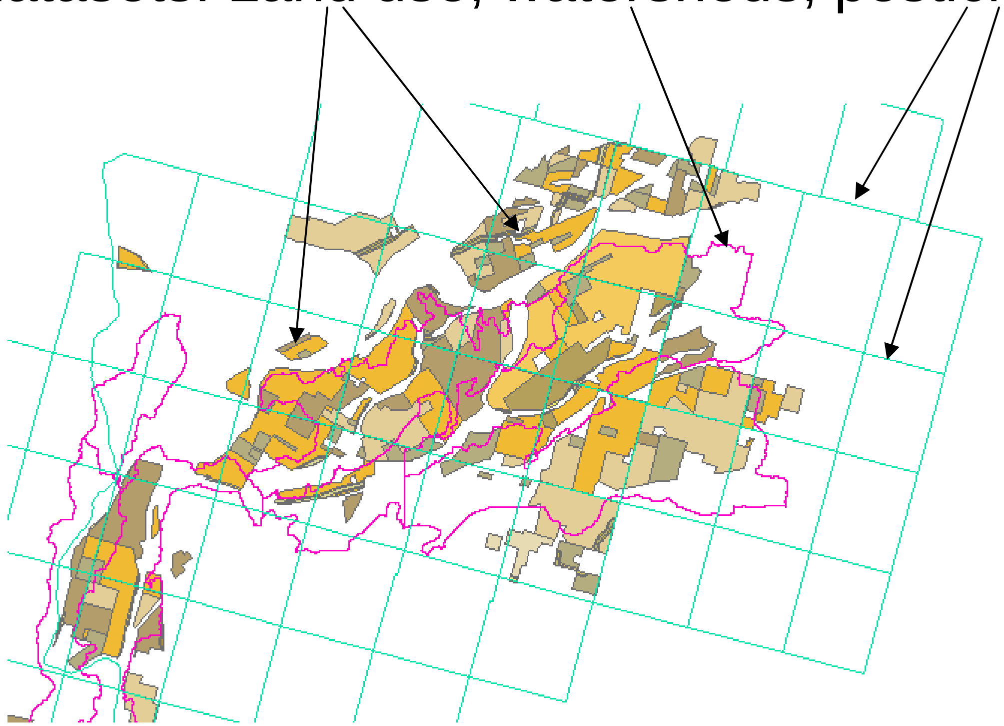
Pounds of Diazinon Applied in the Feather at Yuba City Subwatershed in 1994 by Township, Section, Range

Case Study, California: Pesticide Management Scenario Requirements

- Reproduce historical input scenario to enable model calibration (limited chemical data available)
- Within each subbasin, preserve …
  - Application location
  - Application timing
  - Application area
  - Application rate

Case Study, California: Spatial Distribution of Applications by Subbasin

- Union spatial datasets: Land use, watersheds, pesticide use sections



- Calculate daily acres treated and application rate in a subbasin

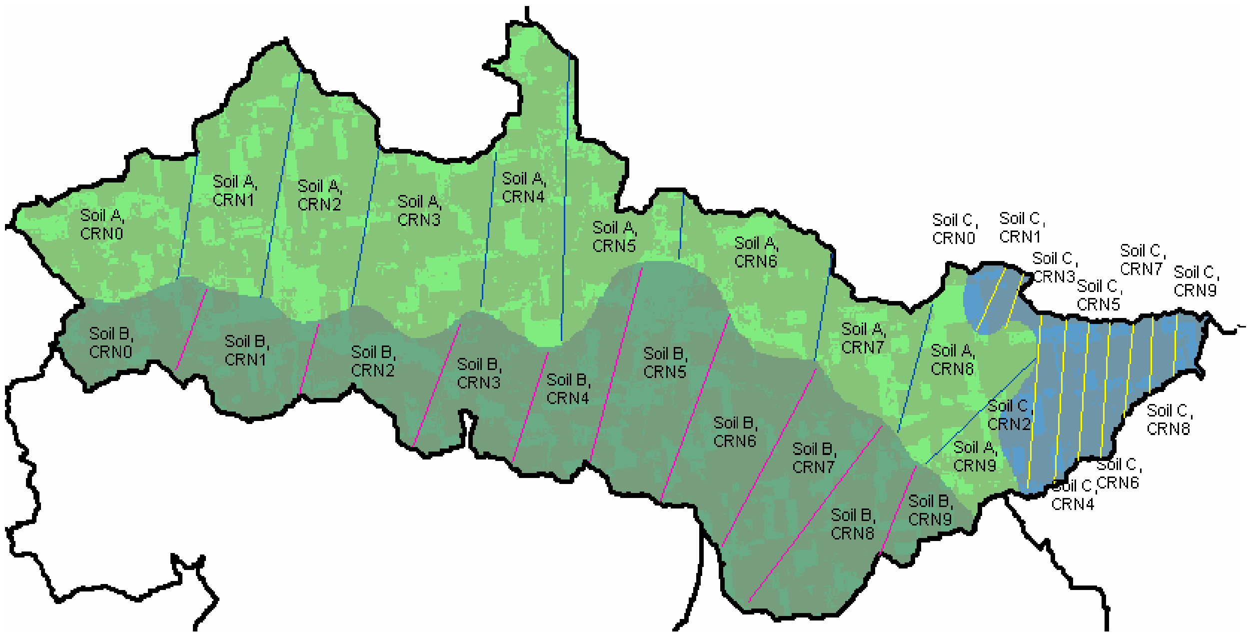
$$SubAcresTreated = \sum_{i=1}^{n}\left(\frac{AcresTOinSubinTRS_i}{AcresTOinTRS_i}\right) * AcresTreatedinTRS_i$$

$$SubAppRate = \sum_{i=1}^{n}\left(\frac{AcresTreatedinSubinTRS_i}{AcresTreatedinSub}\right) * AppRateinTRS_i$$

Case Study, California: A Sub-HRU Strategy for Pesticide Management

- Create sub-HRUs to allow partial management of target crops

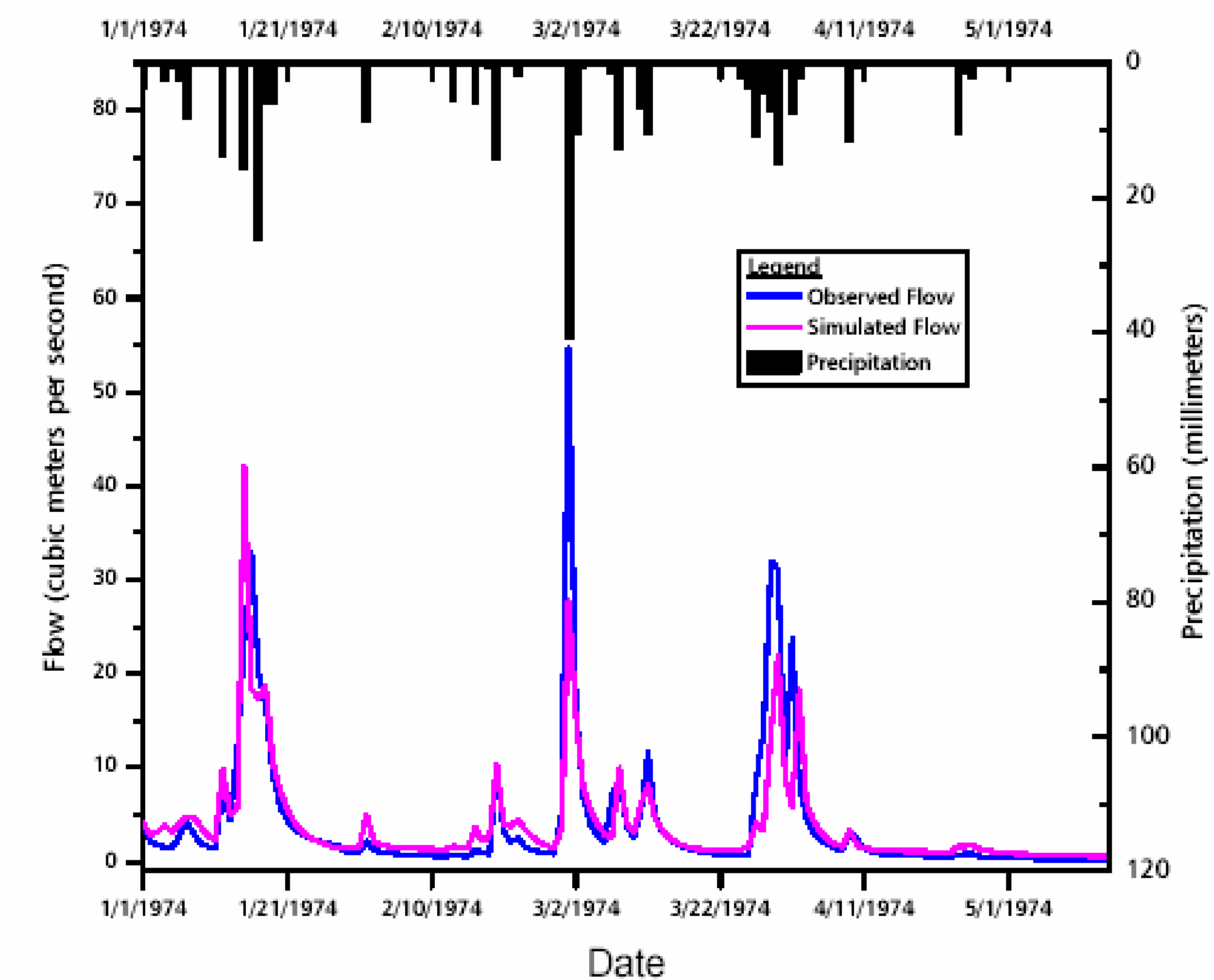
Date	% Treated	HRUs
2/12/1994	10	HRU0
2/21/1994	20	HRU1, 2
2/28/1994	40	HRU3, 4, 5, 6
3/4/1994	30	HRU7, 8, 9



- SWAT Requirements
  - An input pre-processor to create Sub-HRU level application time series
  - Manipulation SWAT mgt1.dbf and mgt2.dbf outside the AV-interface

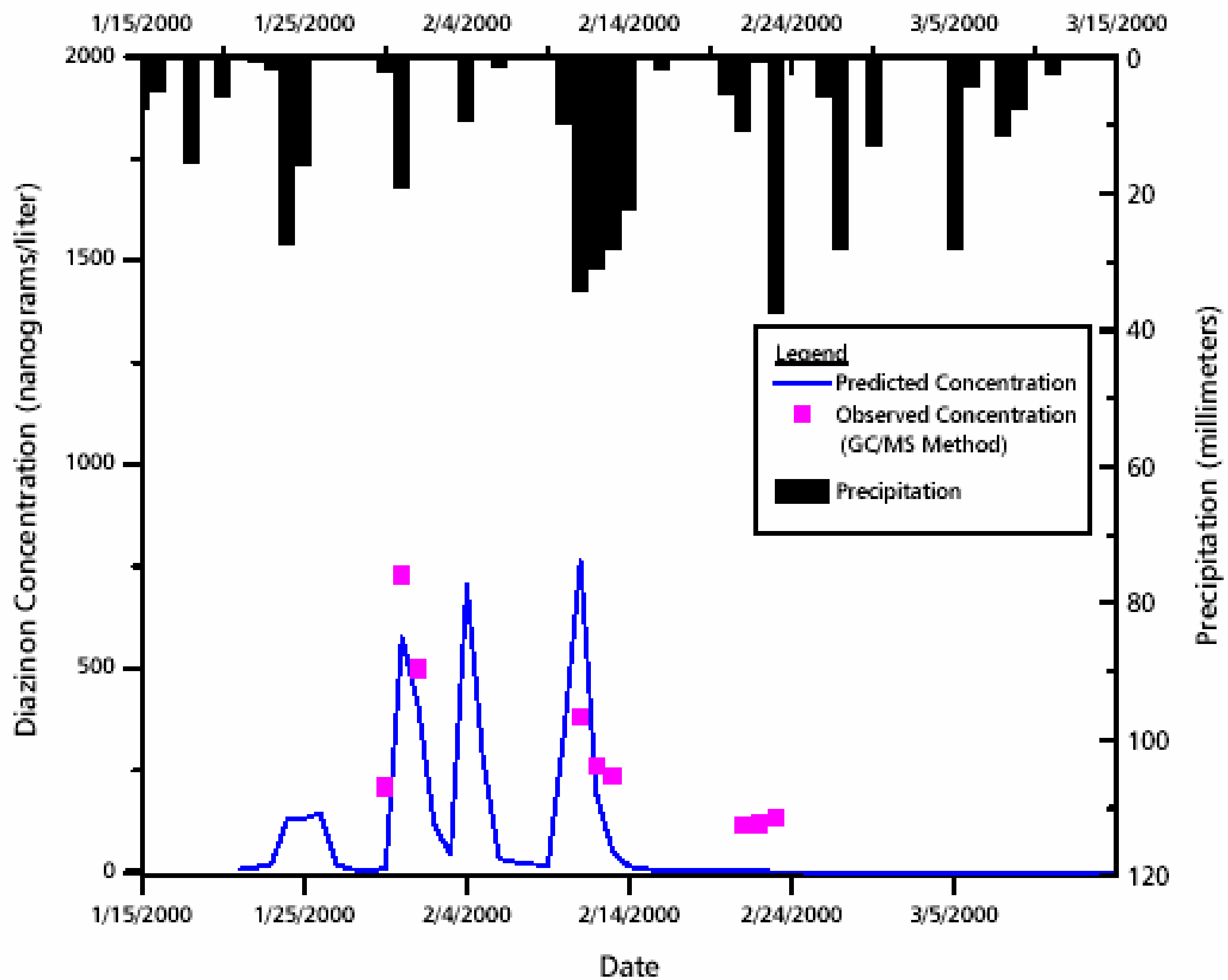
Case Study, California: North Honcut Creek (Unregulated Headwater)

Comparison of Observed and Simulated Flow 1974



Case Study, California: Jack Slough at Doc Adams

Comparison of Observed and Simulated Concentrations 2000



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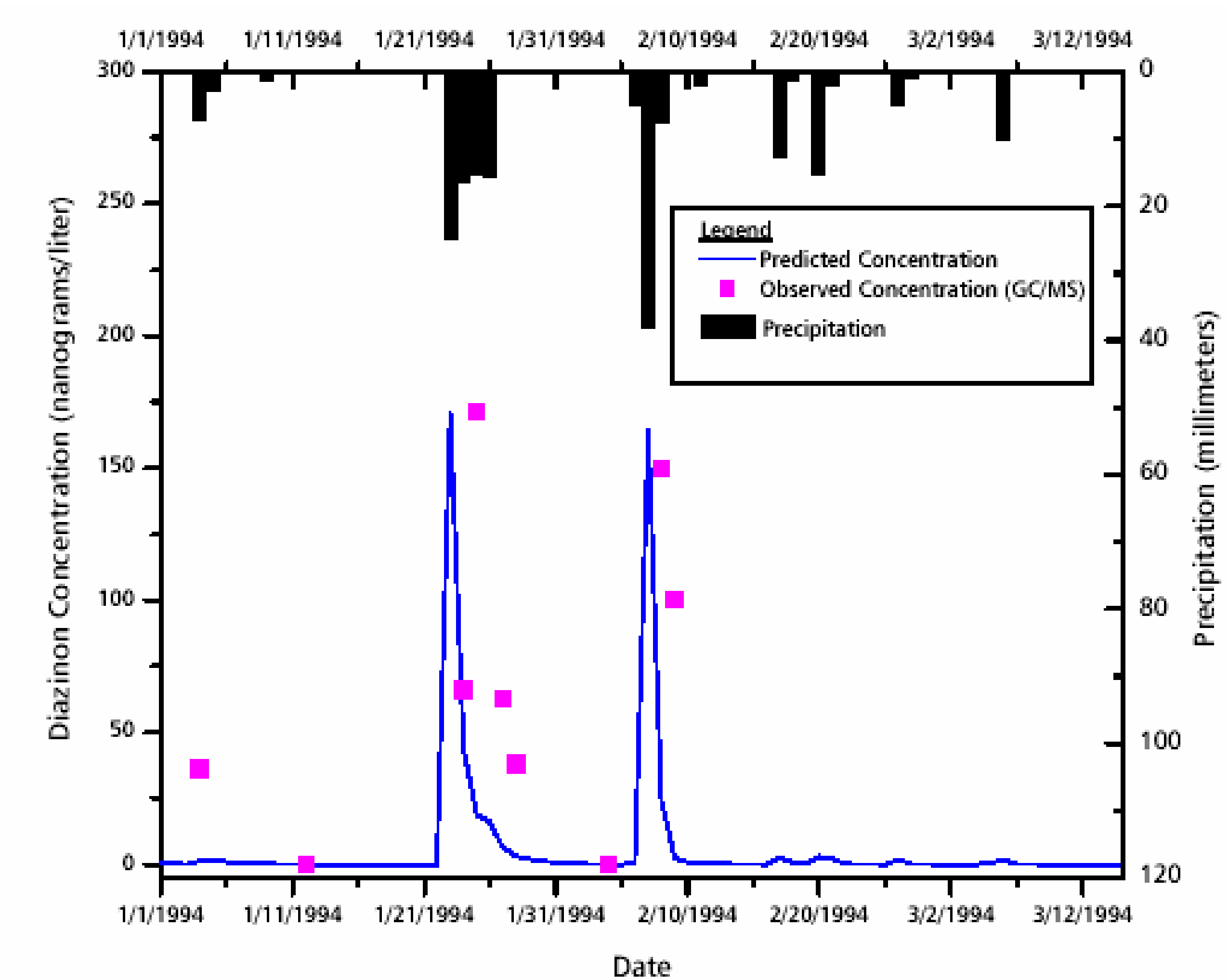
Case Study, California: Feather River at Yuba City

Comparison of Observed and Simulated Concentrations 1994



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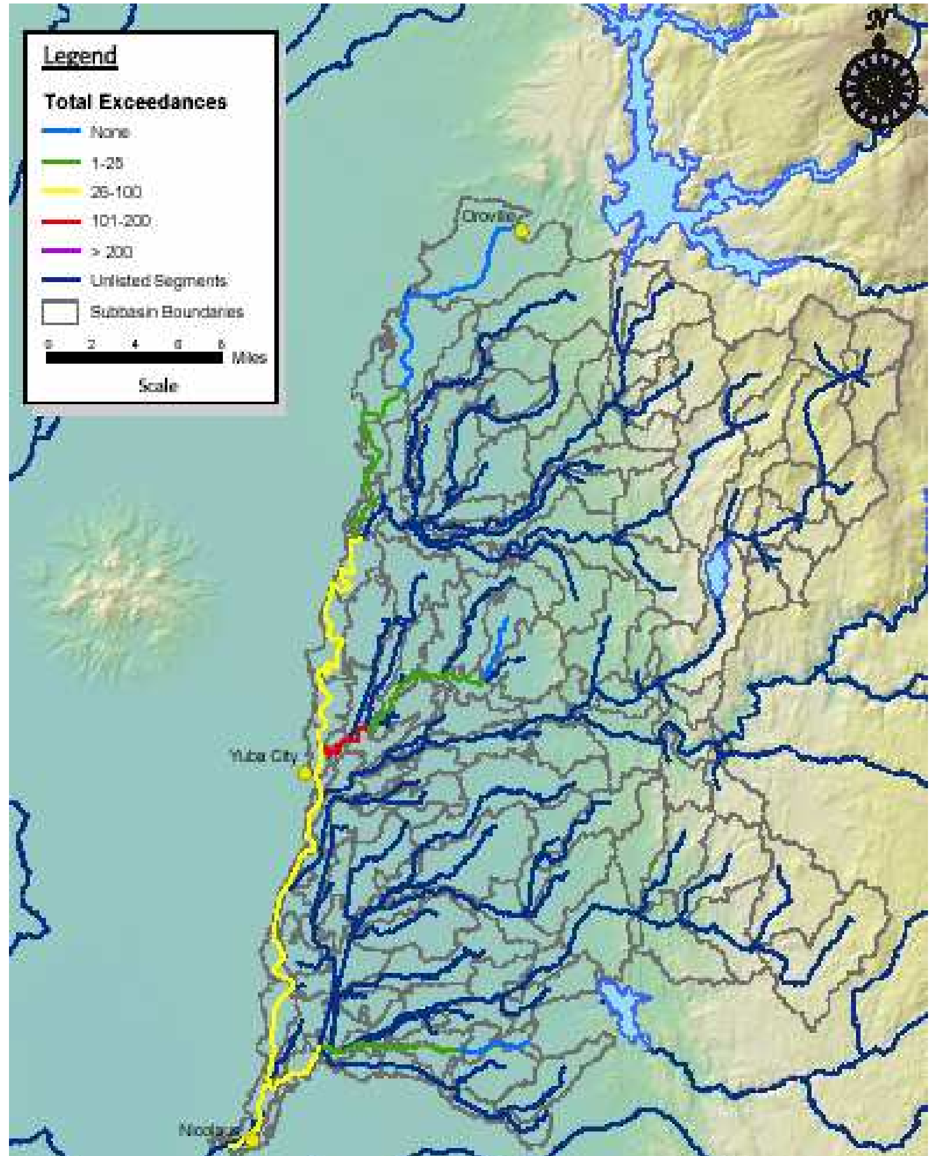
Case Study, California: Spatial Assessment of Model Output

- Identification of reaches which more frequently exceed the diazinon level of concern

- Additional model output statistics may be mapped to individual reaches



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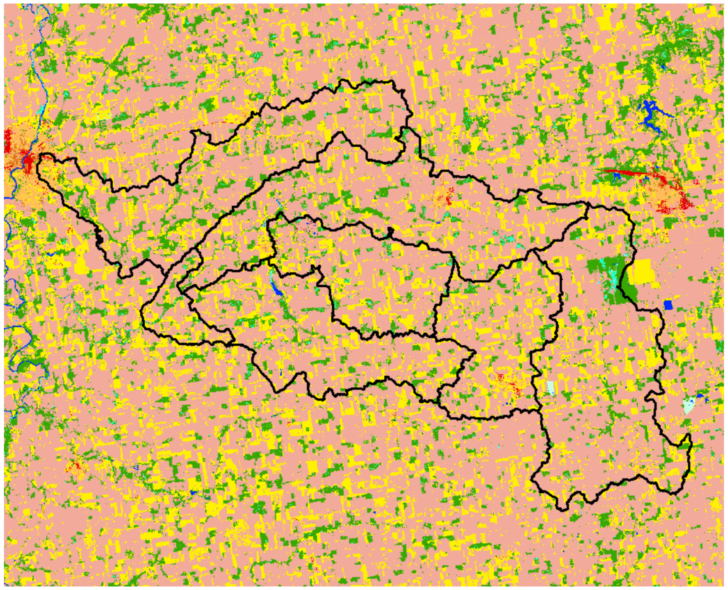
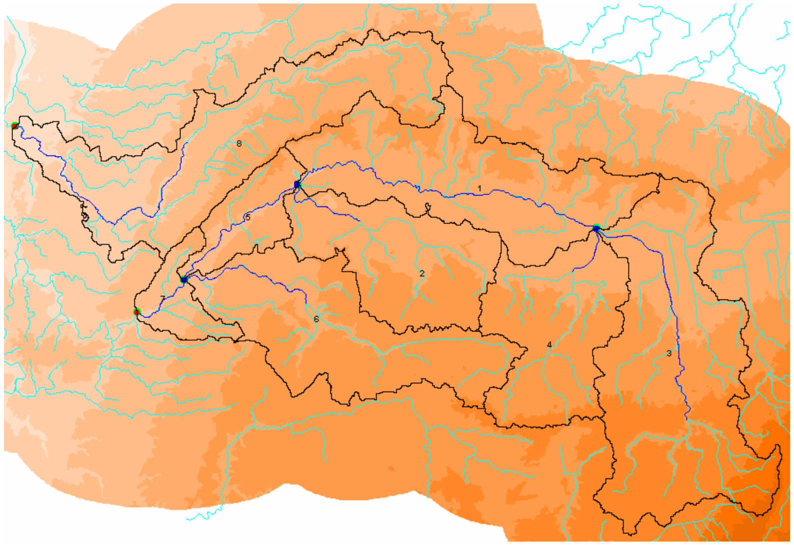
Case Study: HRU and Management Scenario Strategies, Midwest, U.S.A

- Study Area: Small watersheds, Midwestern U.S.
- Pesticide of Interest: A pesticide applied at or shortly after planting
- Objective: Evaluate “Cold Run” model performance



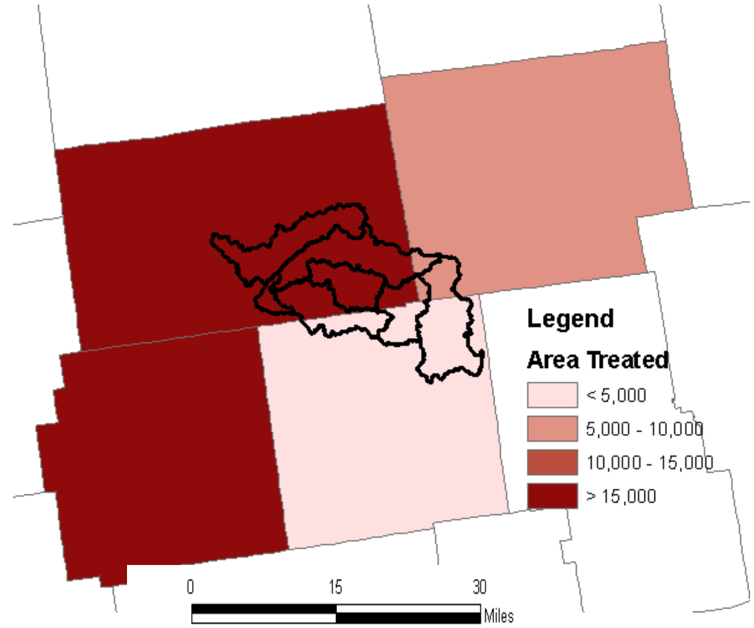
General crop data available from remote sensing was available for the Midwestern watersheds



Topography and watershed delineation for Midwestern watersheds

Case Study, Midwest: Pesticide Use Data

- Annual pesticide use data at the county-level
  - Acres treated
  - Pounds of chemical applied
  - Crop treated
- Distribution of pesticide within cropped areas of a county is uncertain
- Pesticide application timing must be estimated based on
  - Planting dates
  - Heat units



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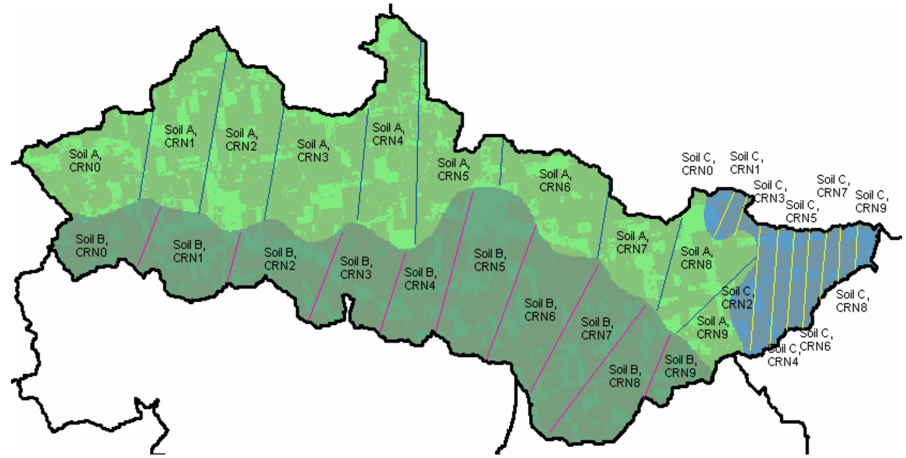
Case Study, Midwest: Strategy for Pesticide Management

- Create same sub-HRU approach to allow partial management of target crops (10 sub-HRUs, each 10% of the HRU area)



- Application Timing Method 1:Develop application timing dates based on state-level planting dates

- Application Timing Method 2:Develop application timing based on a distribution of accumulated heat units

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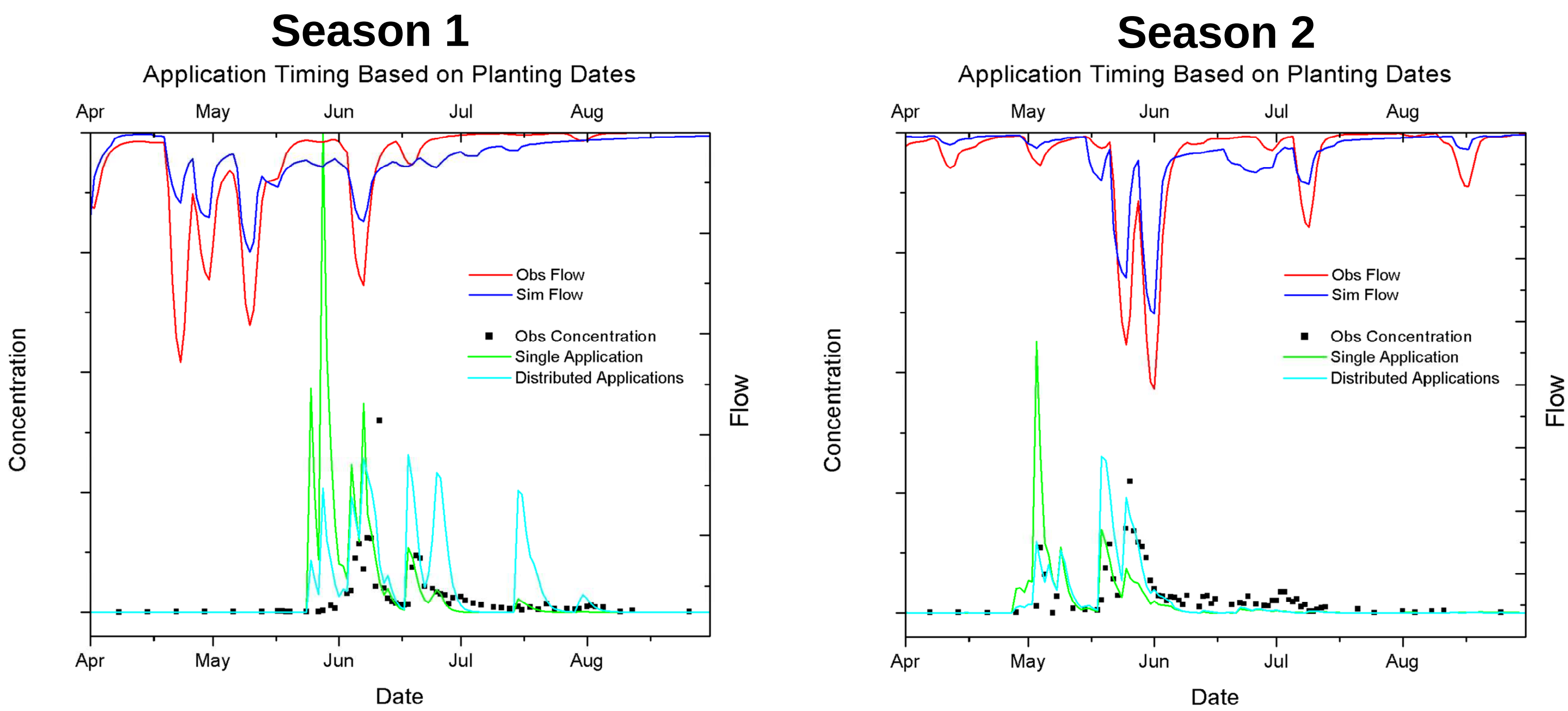
Case Study, Midwest: Application Timing from Crop Planting Dates

- State-level planting dates were used to estimate subbasin-level planting and application percentages

tblPlantDatesOrig : Table

Date	PctPlanted	HRUs Treated
4/12/1992	0	
4/19/1992	2	
4/26/1992	4	
5/3/1992	20	CRN0, CRN1
5/10/1992	72	CRN2 - CRN6
5/17/1992	98	CRN7, CRN8
5/24/1992	100	CRN9
5/2/1993	7	
5/9/1993	24	CRN0, CRN1
5/16/1993	29	
5/23/1993	76	CRN2 - CRN6
5/30/1993	95	CRN7, CRN8
6/6/1993	100	CRN9
4/17/1994	0	
4/24/1994	11	CRN0
5/1/1994	25	CRN1
5/8/1994	55	CRN2 - CRN4
5/15/1994	92	CRN5-CRN8
5/22/1994	100	CRN9

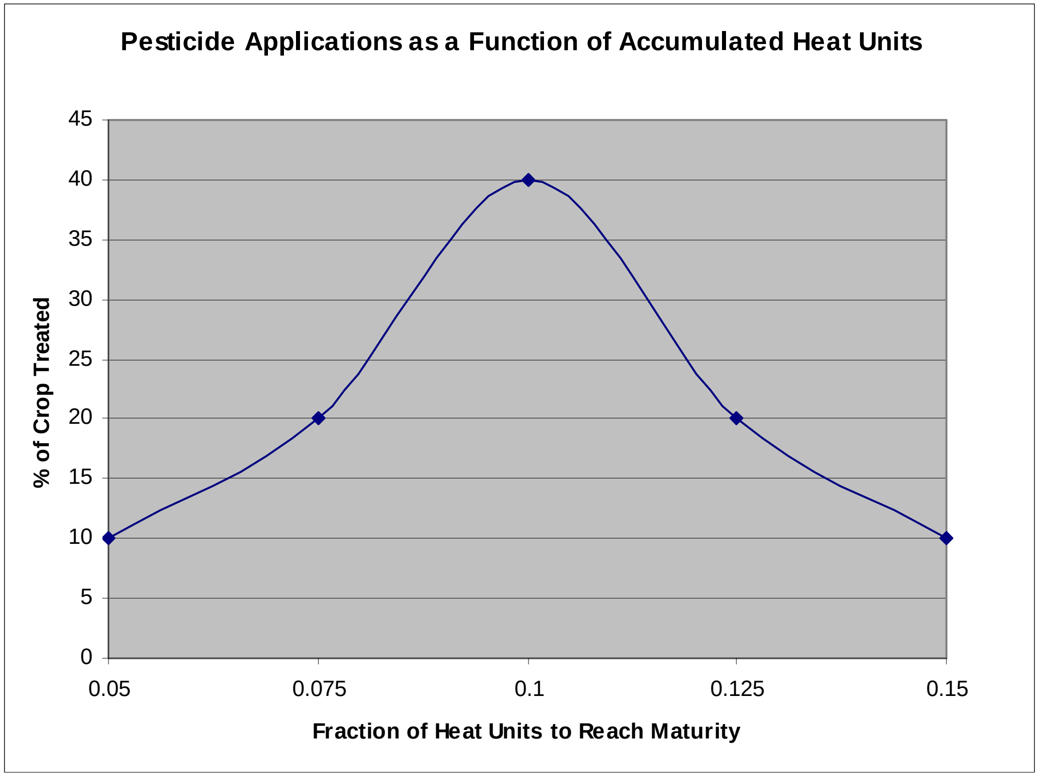
Case Study, Midwest: Model Simulations Based on Planting Dates



- The "single" application date approach results in peak concentrations too early in the season
- The "distributed" application date based approach results in peak magnitudes and peak frequency closer to the observed

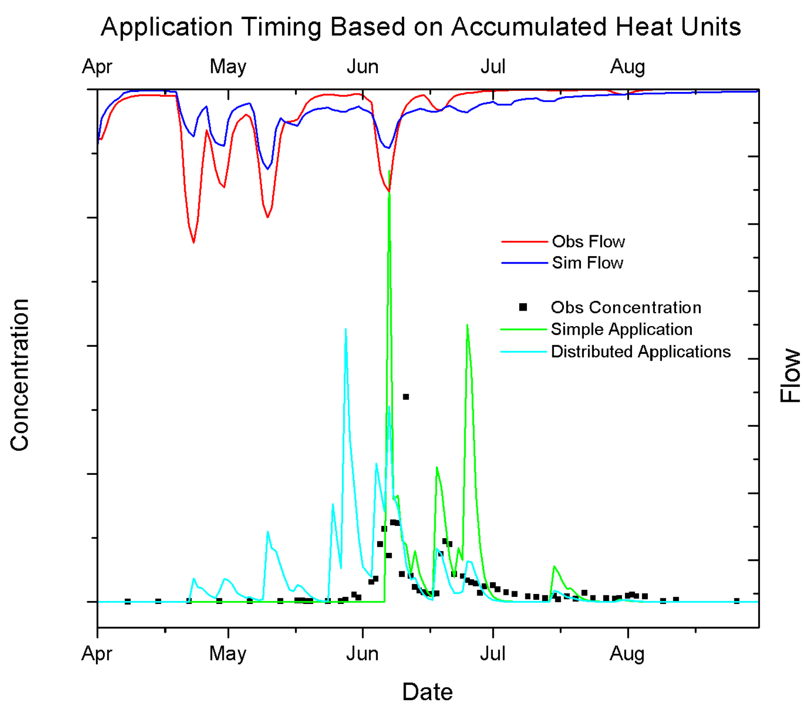
Case Study, Midwest: Application Timing from Heat Units

- A distribution of accumulated heat units was used to schedule pesticide applications in SWAT
- This allowed different sub-HRUS to receive pesticide applications at different times

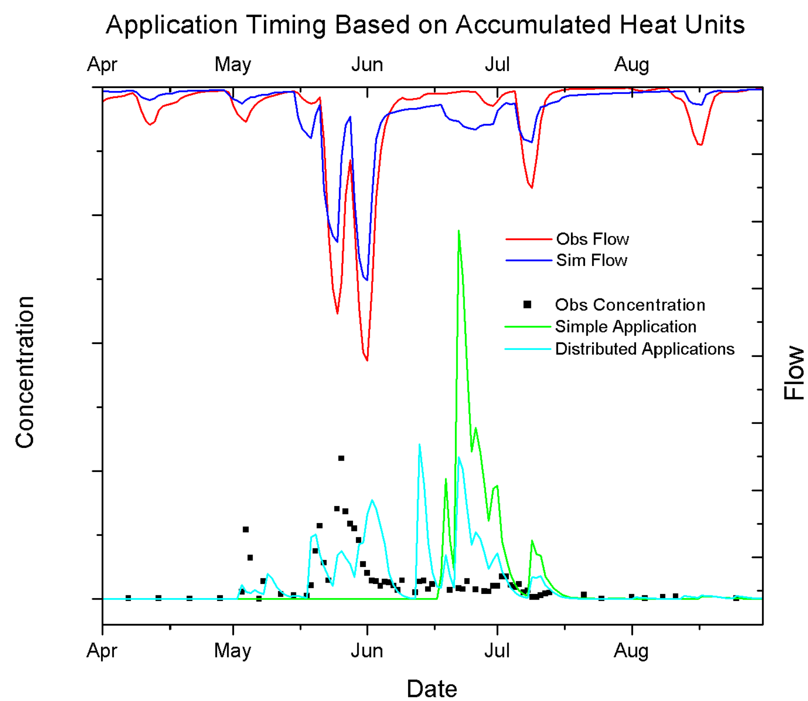


Case Study, Midwest: Model Simulations Based on Heat Units

Season 1



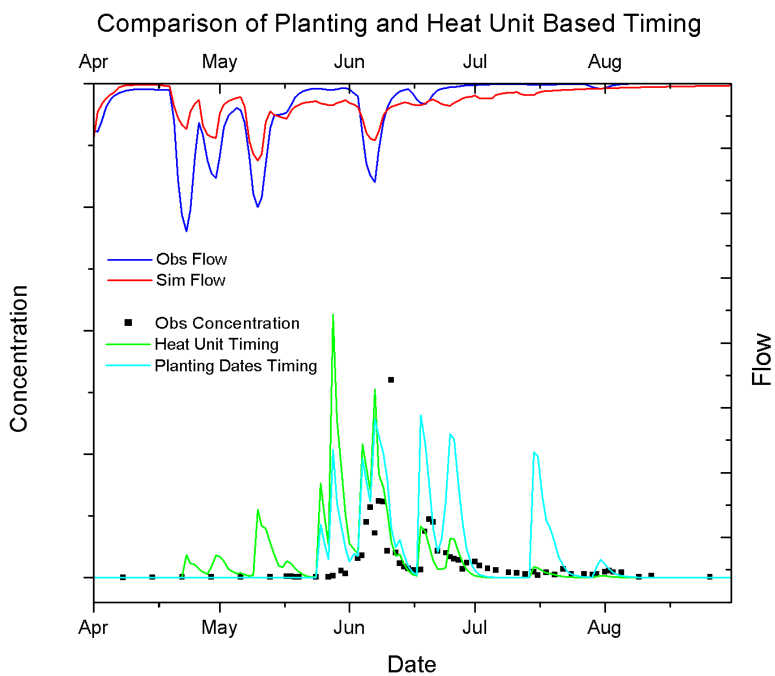
Season 2



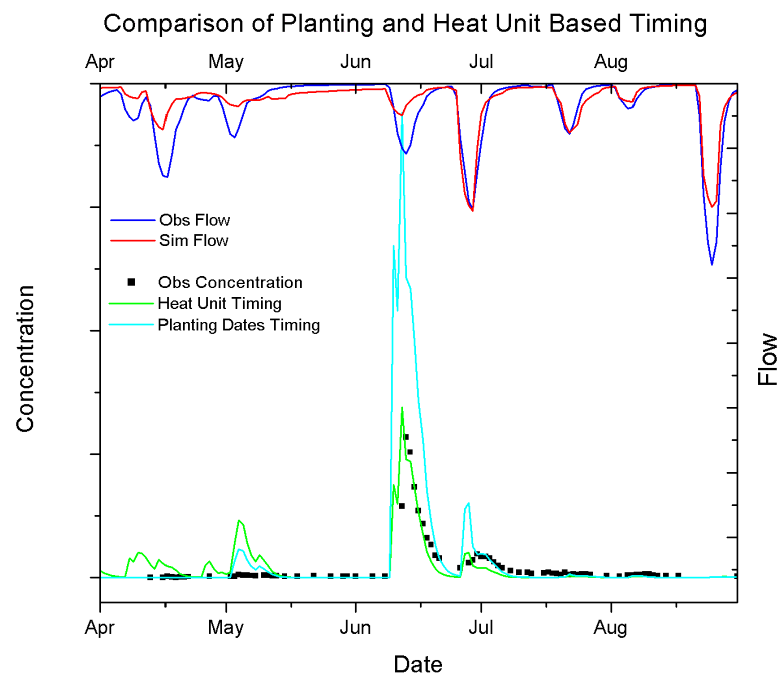
- The “simple” heat unit approach results in peak concentrations significantly higher than observed
- The “distributed” heat unit based approach results in peak magnitudes and peak frequency closer to the observed

Case Study, Midwest: Planting Dates and Heat Units Timing Comparison

Season 1



Season 2



- Heat unit based scheduling results in too much pesticide runoff at the end of season 1
- Planting date based scheduling results in too high a peak in the major event during season 2

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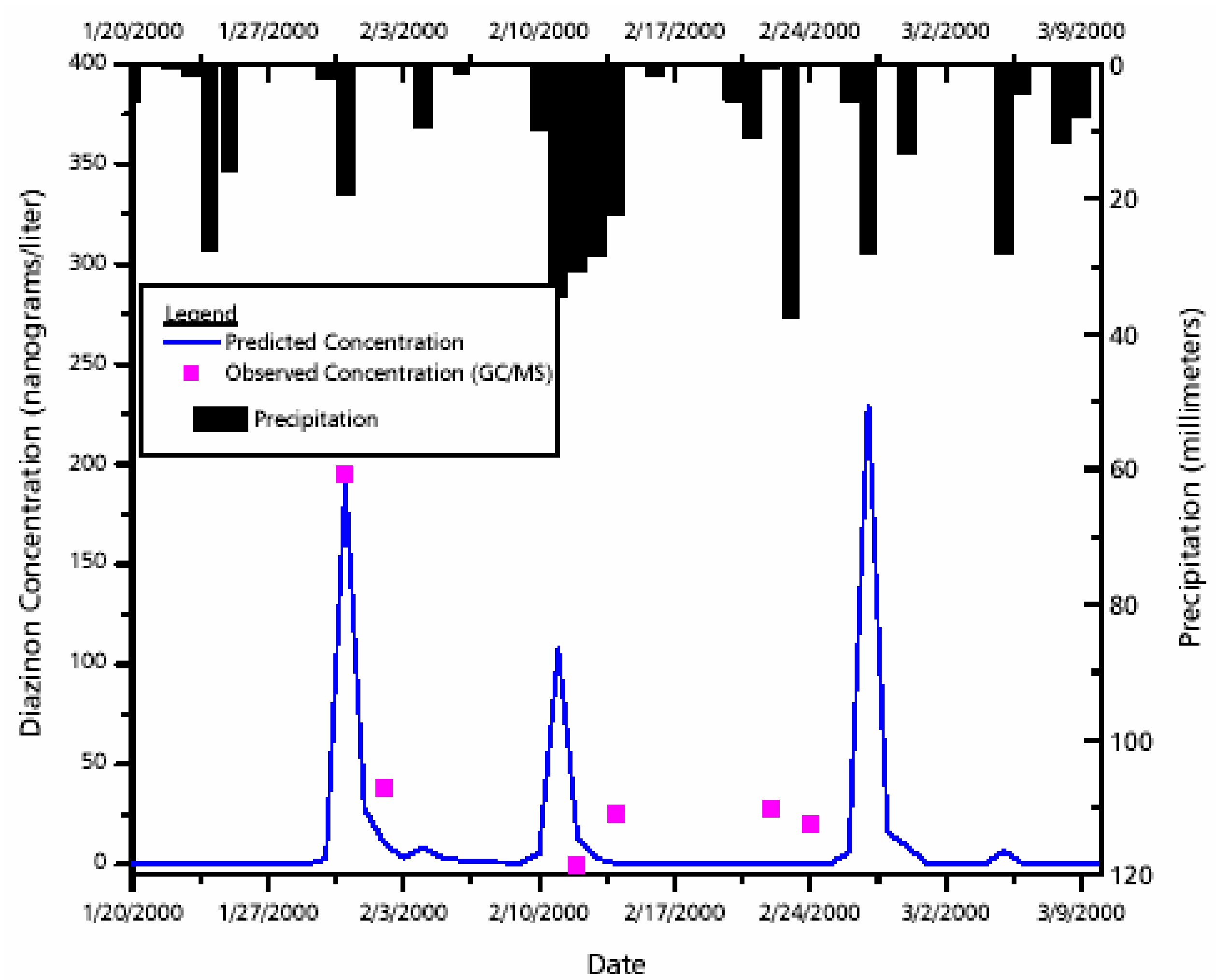
Conclusions and Recommendations

- Modeling realistic pesticide management scenarios requires complex HRU schemes
- High resolution (spatial and temporal) use data will result in the best simulations
- Acceptable simulations using coarser use data can be achieved using approaches that distribute applications throughout the full range of expected application dates
- Best management practices can be modeled through HRU design and application scenario modification
- Development of tools to incorporate complex management scenarios into the SWAT model input structure will improve the effectiveness and efficiency of modeling pesticides

Thank You!

Case Study, California: Bear River at Outlet

Comparison of Observed and Simulated Concentrations 2000



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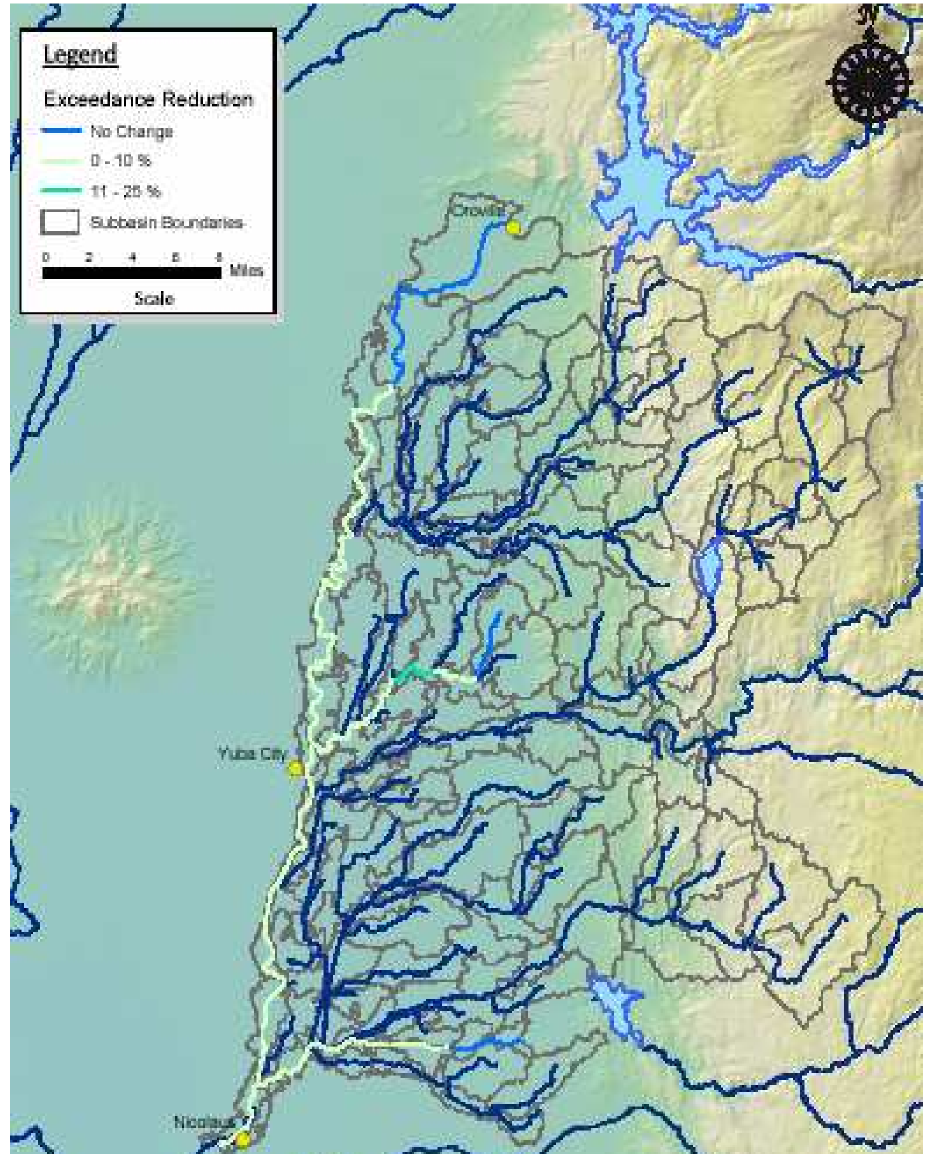
Case Study, California: Mitigation Through Best Management Practices

- Four different BMP scenarios simulated in SWAT
  - Surface water buffer
  - Application timing
  - Vegetated buffer
  - Combined

- Model results provided an indication of the effectiveness of each BMP in reducing pesticide concentrations in surface waters

Case Study, California: Surface Water Application Buffer

- A 75-ft buffer around all surface waters was simulated through HRU modification
  - Each HRU split into a buffer and non-buffer sub-HRU
  - Applications restricted from buffer sub-HRUs
- Total reduction in exceedances: 2%



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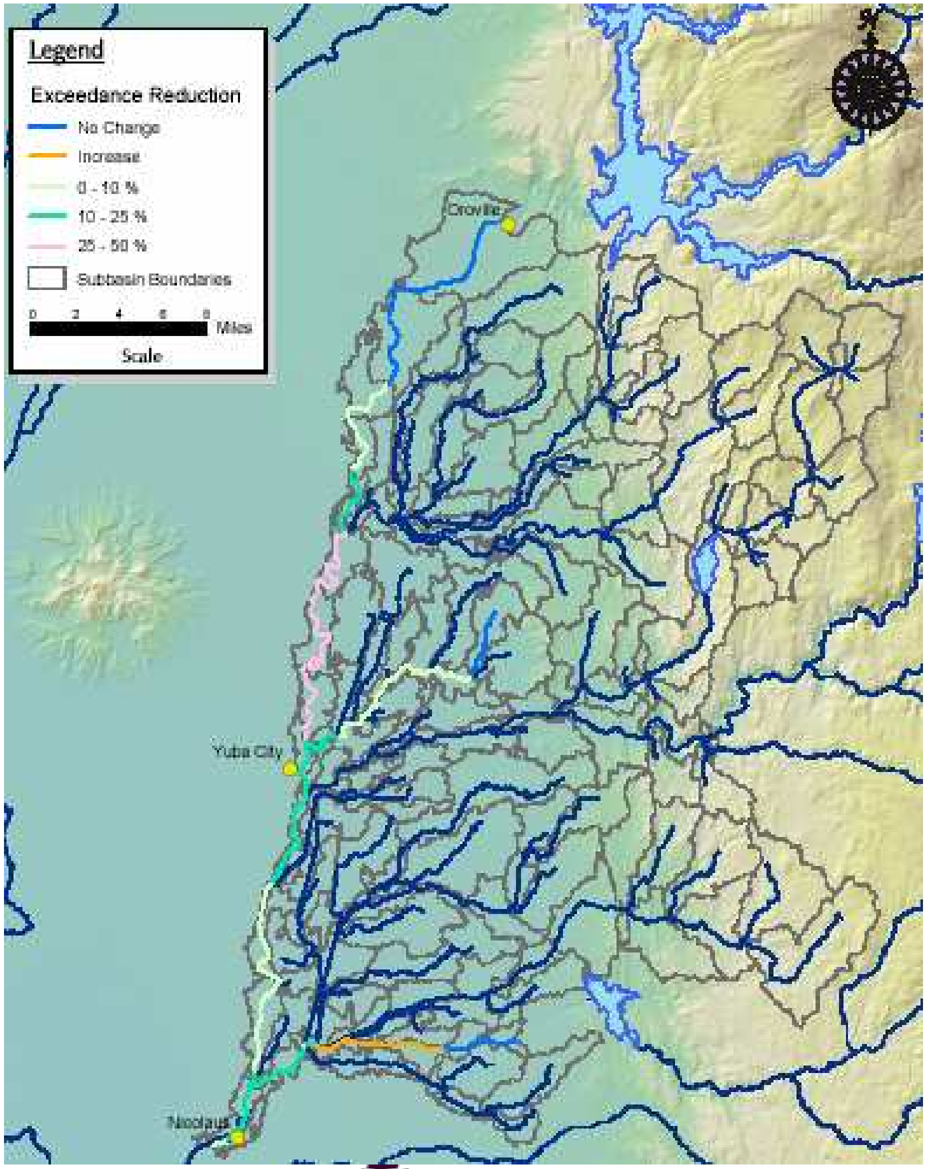
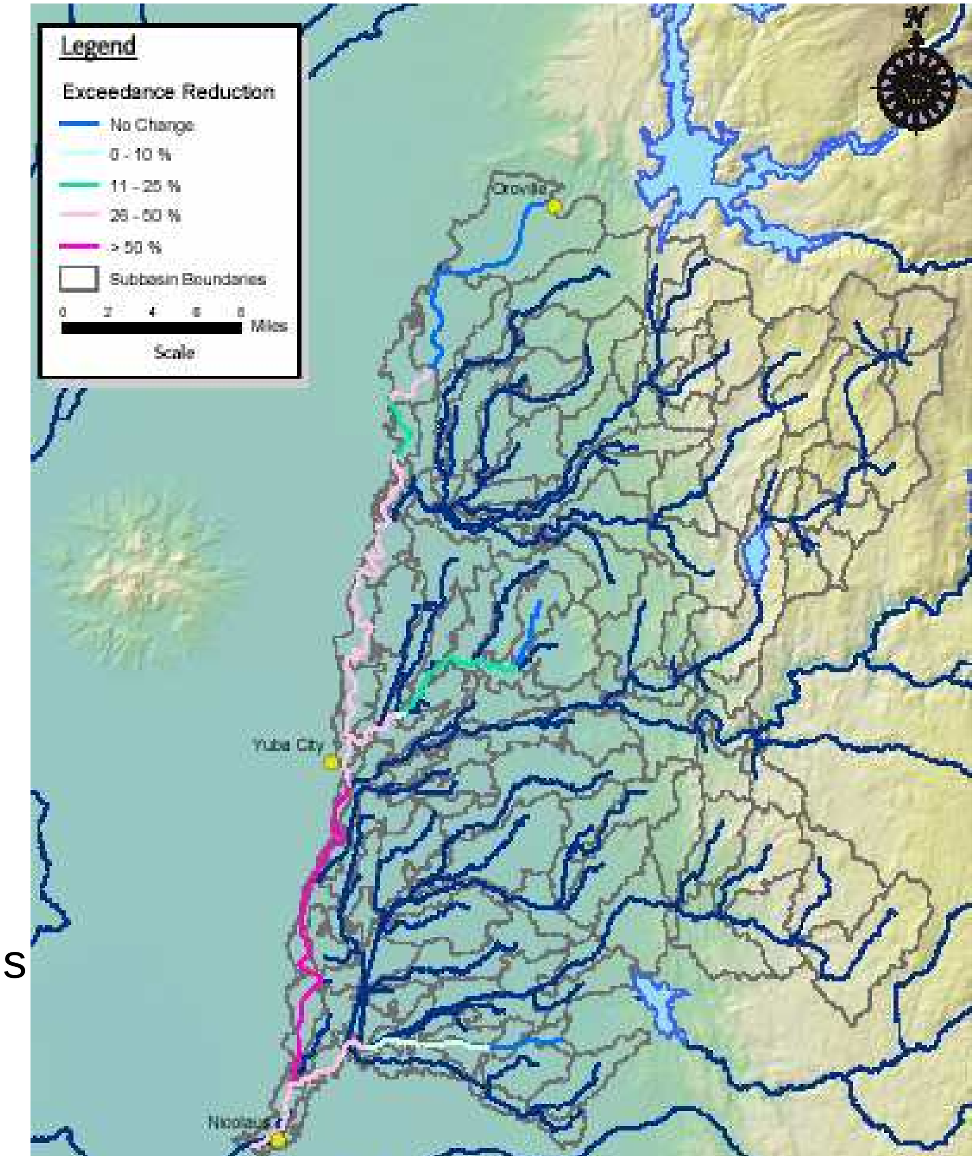
Case Study, California: No Application Before Storms

- Diazinon applications occurring within 48 hours of a 0.5” or greater daily rainfall were restricted
  - Daily precipitation time series for each subbasin reviewed
  - Pesticide application operations moved to the nearest unrestricted day
- Total reduction in exceedances: 12%



Case Study, California: Vegetated Buffer Strips

- A simulated 10-ft buffer strip was applied to all orchard HRUs
  - Assumes buffer is maintained and in good condition and down-gradient of all fields
  - Buffer equations based on nutrients
  - May not accurately represent true conditions
- Total reduction in exceedances: 37%



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