WATERBORNE ENVIRONMENTAL

November 16, 2016

Historical perspectives on landscape-based pesticide assessments in the US over the last 25 years

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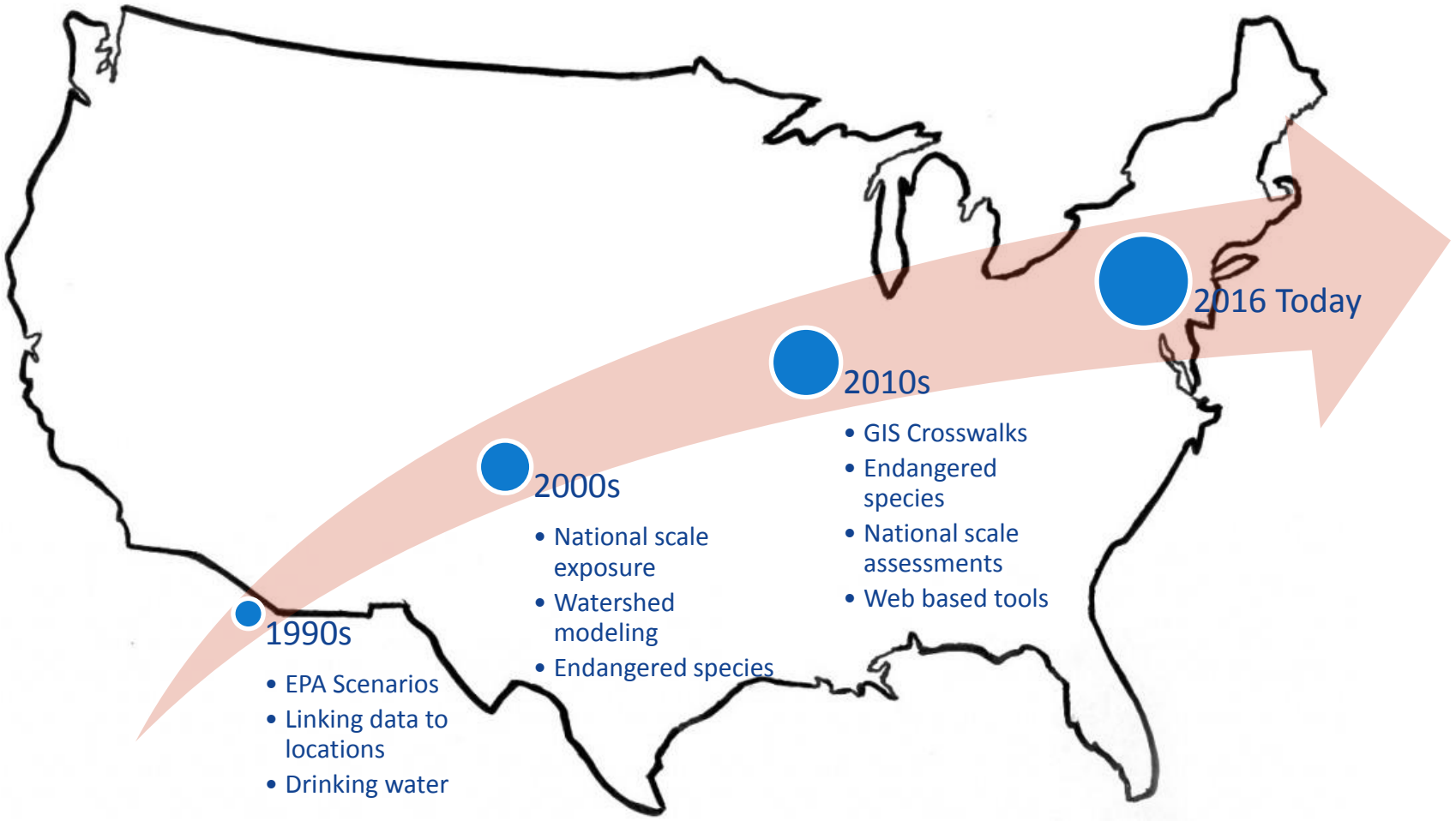
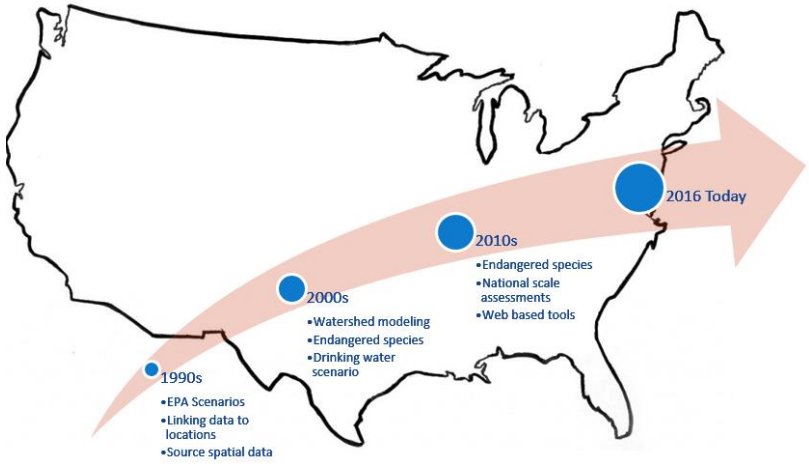
25 years of landscape information in the US



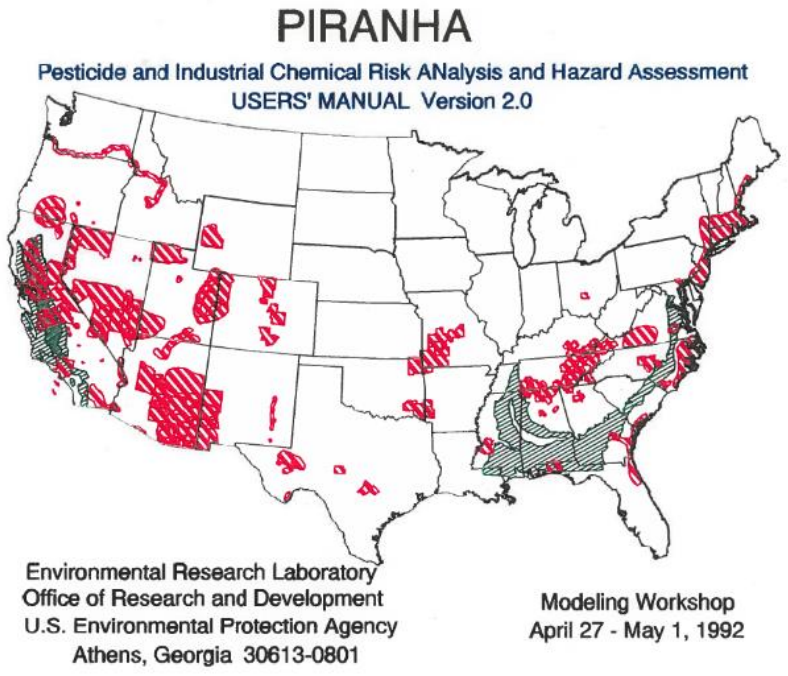
Introduction

- The last 25 years have seen important and rapid changes in the conduct of pesticide risk assessments, especially as it relates to the use of geo-information in the estimation of potential exposure
- These landscape-based assessments have enabled efficient predictions of exposure, and subsequent evaluation of risk, across large geographic areas down to site-specific locales
- These approaches have been applied across all tiers of the risk assessment paradigm, from simple scenario definition to informing probabilistic and spatially explicit assessments



Starting in the 1990s

- EPA ORD Pesticide and Industrial Chemical Risk Analysis and Hazard Assessment (PIRANHA)
  - Development of first PRZM-EXAMS scenarios
  - Used soil, rainfall, cropping, chemical properties
  - User selected region or crop – used most vulnerable soil in Major Land Resource Area
- PIRAHNA not fully adopted by EPA OPP
  - But use of PRZM-EXAMS was catalyzed



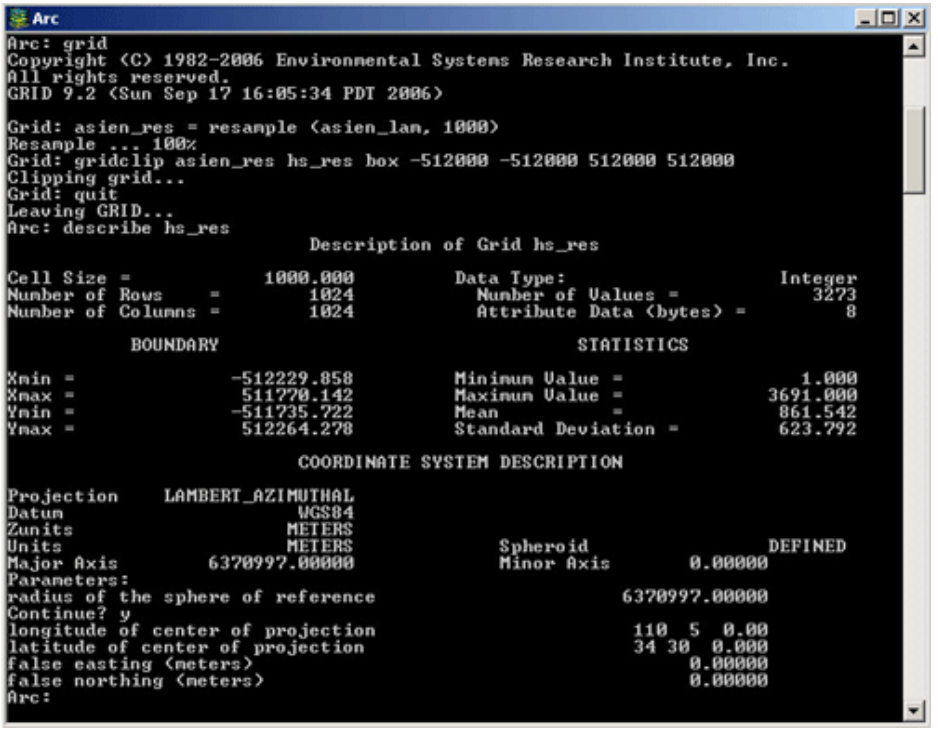
US EPA Tier II standard scenarios for pesticides

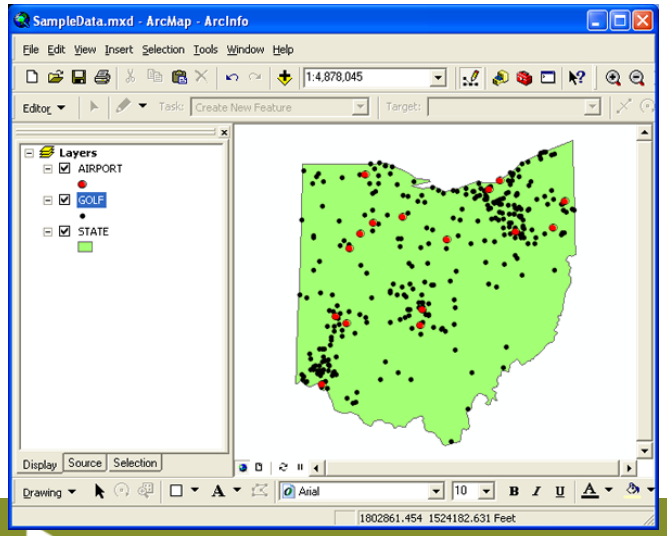
- Edge-of-field exposure scenarios by crop
- Based on state-level cropping data
- Representative soils for crop (hydrologic group C or D)
- 30-yr weather data from standardized set

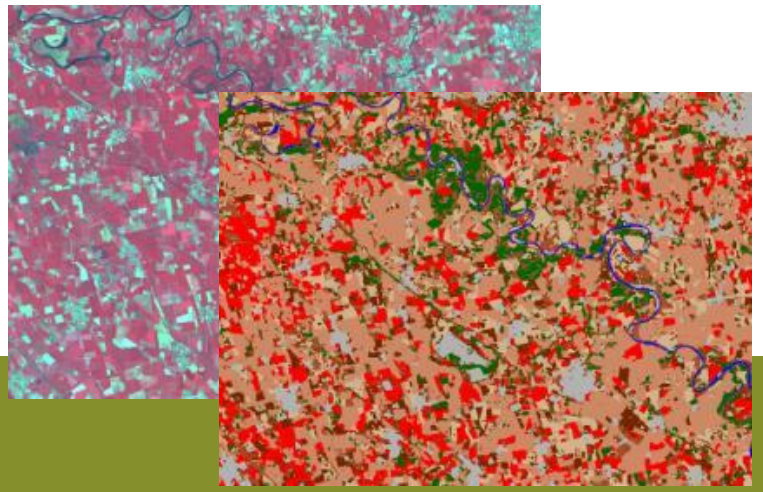
EPA Surface Water standard scenarios

GIS software in the 1990s

- Generally required experienced user
  - Graphical interfaces came later
- Custom image classification







EPA drinking water exposure scenario

- Index reservoir to "… to represent a watershed capable of supporting a drinking water facility that is prone to high pesticide concentrations."
- Implements a national Percent Crop Area (PCA) adjustment factor
- Over time regional PCAs derived for multiple crops using spatial data and methods

Table 2. Maximum percent cropped area (PCA) adjustment factors for various crop combinations, by Water Resource Region (HUC-2). Listed PCAs are specifically recommended for use in surface drinking water exposure modeling.

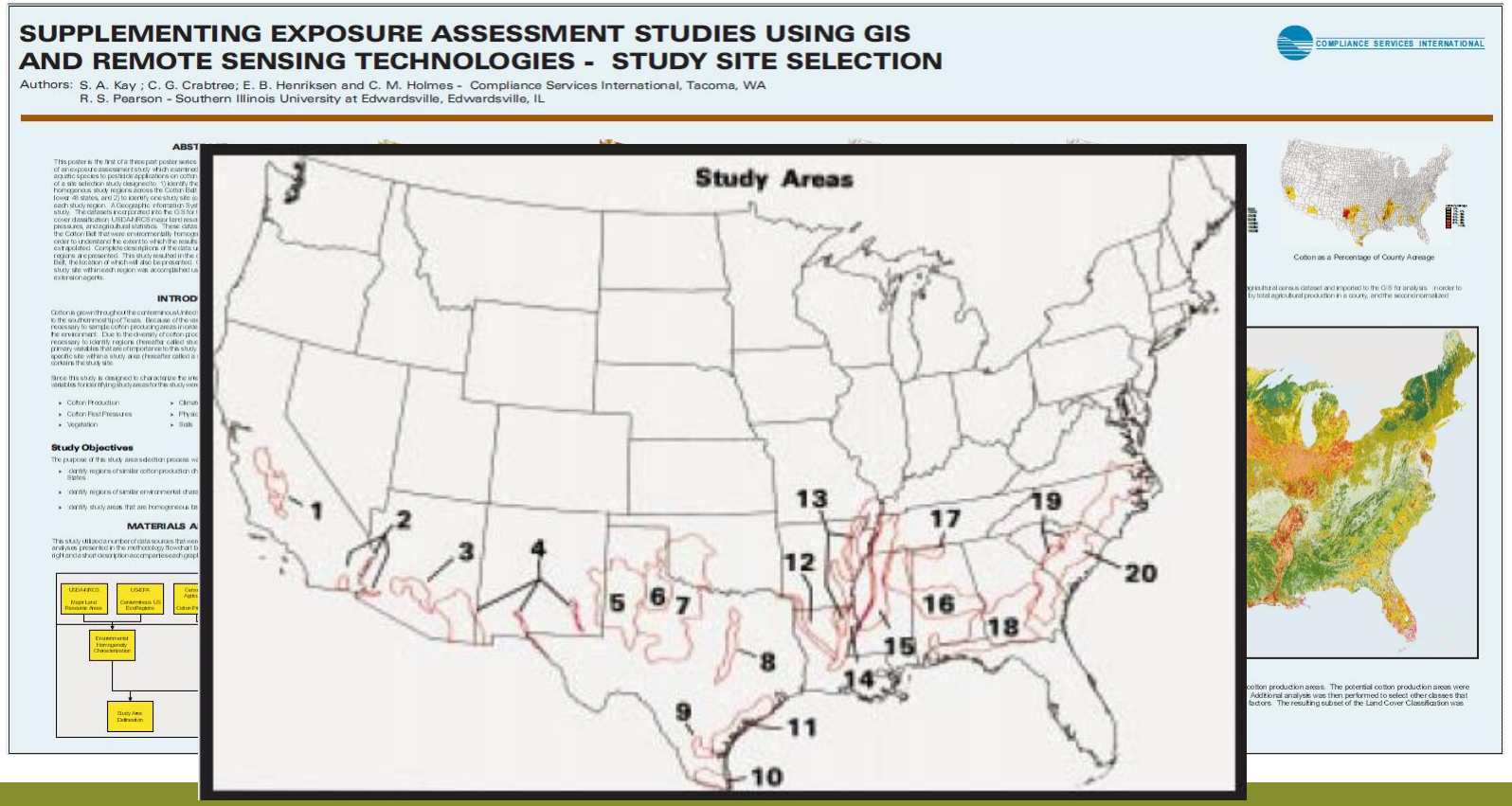
HUC-2	Corn-Wheat	Soybean-Wheat	Turf[a]-Corn	Turf[a]-Orchard	Turf[a]-Soybean	Turf[a]-Vegetable	Turf[a]-Wheat	Vegetable-Orchard	Turf[a,b]-All Ag
01	0.08	0.00	0.86	0.86	0.86	0.86	0.86	0.12	0.98
02	0.36	0.17	0.60	0.60	0.60	0.60	0.60	0.10	0.82
03	0.18	0.25	0.64	0.64	0.64	0.64	0.64	0.13	0.65
04	0.42	0.52	1.00	0.85	0.85	0.85	0.85	0.06	1.00
05	0.52	0.59	0.58	0.49	0.64	0.49	0.49	0.04	0.96
06	0.13	0.13	0.38	0.38	0.38	0.38	0.38	0.03	0.58
07	0.73	0.85	0.72	0.59	0.65	0.59	0.59	0.01	1.00
08	0.22	0.12	0.53	0.52	0.52	0.52	0.52	0.00	0.75
09	0.42	0.44	0.20	0.06	0.25	0.07	0.46	0.02	0.99
10	0.38	0.47	0.51	0.51	0.51	0.51	0.51	0.02	1.00
11	0.41	0.55	0.70	0.70	0.70	0.70	0.70	0.05	0.81
12	0.20	0.18	0.29	0.25	0.25	0.25	0.26	0.07	0.82
13	0.01	0.00	0.11	0.11	0.11	0.11	0.11	0.02	0.57
14	0.06	0.06	0.09	0.08	0.08	0.08	0.10	0.01	0.41
15	0.08	0.08	0.49	0.49	0.49	0.50	0.50	0.23	0.57
16	0.00	0.00	0.04	0.04	0.04	0.04	0.04	0.00	0.07
17	0.38	0.38	0.35	0.35	0.35	0.35	0.40	0.03	0.74
18	0.18	0.07	0.59	0.59	0.59	0.59	0.59	0.34	0.83

*Shaded cells indicate the highest value for each crop.
[a] Represents residential turf including golf courses, but does not include sod farms. Sod farms are included in the all-agriculture land cover class PCA.
[b] Because all-agriculture PCAs were calculated two different ways, some exceed the maximum Turf-All Ag PCAs. In such cases (*i.e.*, for HUC-2 regions 2 and 8), the maximum all-agriculture PCA is substituted in this table for the regional maximum Turf-All-Ag PCA listed in Table 3-7.

Source: https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/development-and-use-index-reservoir-drinking-water
https://www.epa.gov/sites/production/files/2015-07/documents/development_and_use_of_community_water_system.pdf

National cotton study at a local level

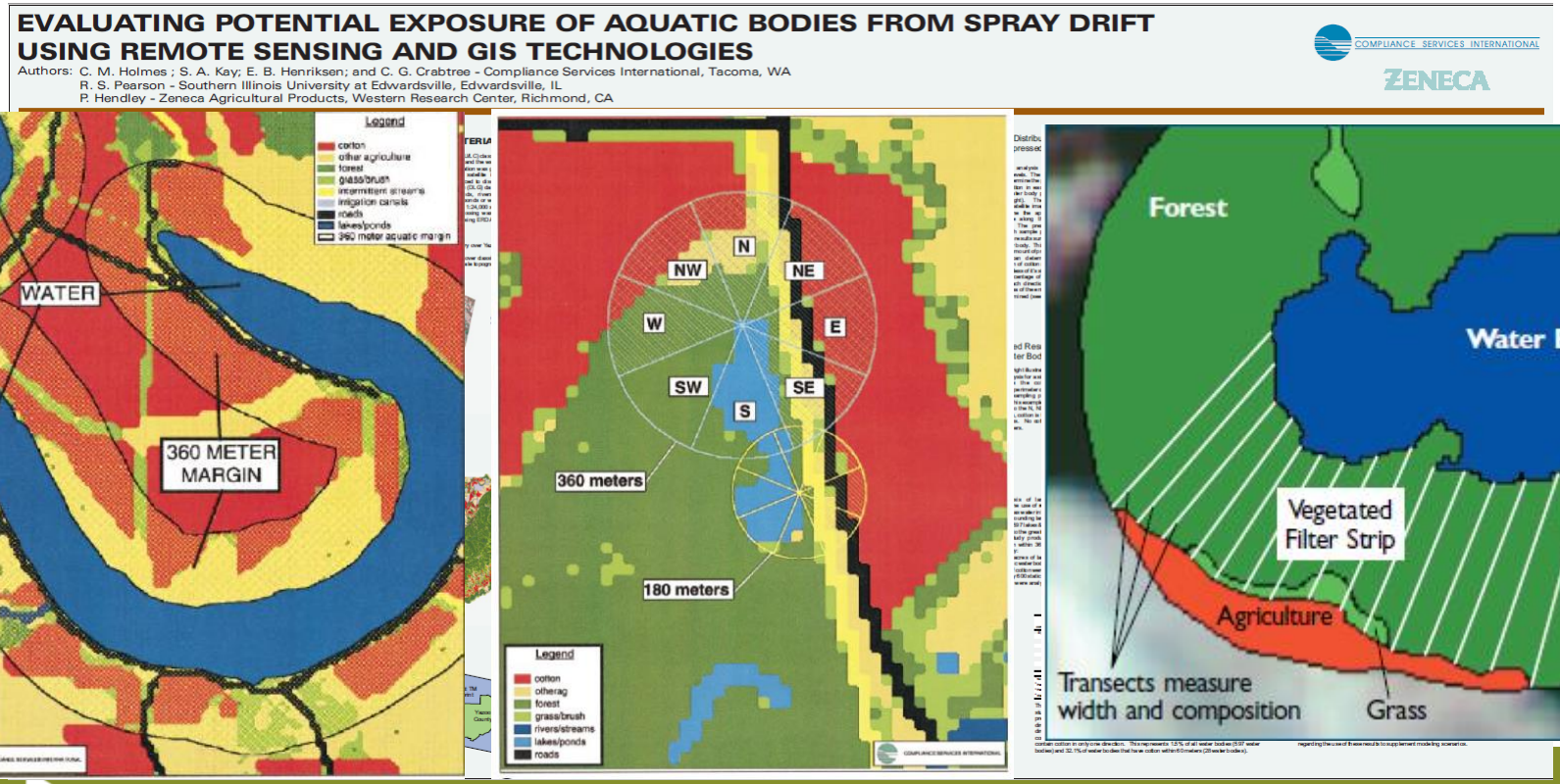
- Identified 20 study areas across US based on cotton production, pest pressures, vegetation, climate, physiography, soils
- Characterized a study site in each study area using spatial information



Kay et al, 1997. SETAC NA Annual Meeting.

Probabilistic risk assessment of cotton pyrethroids

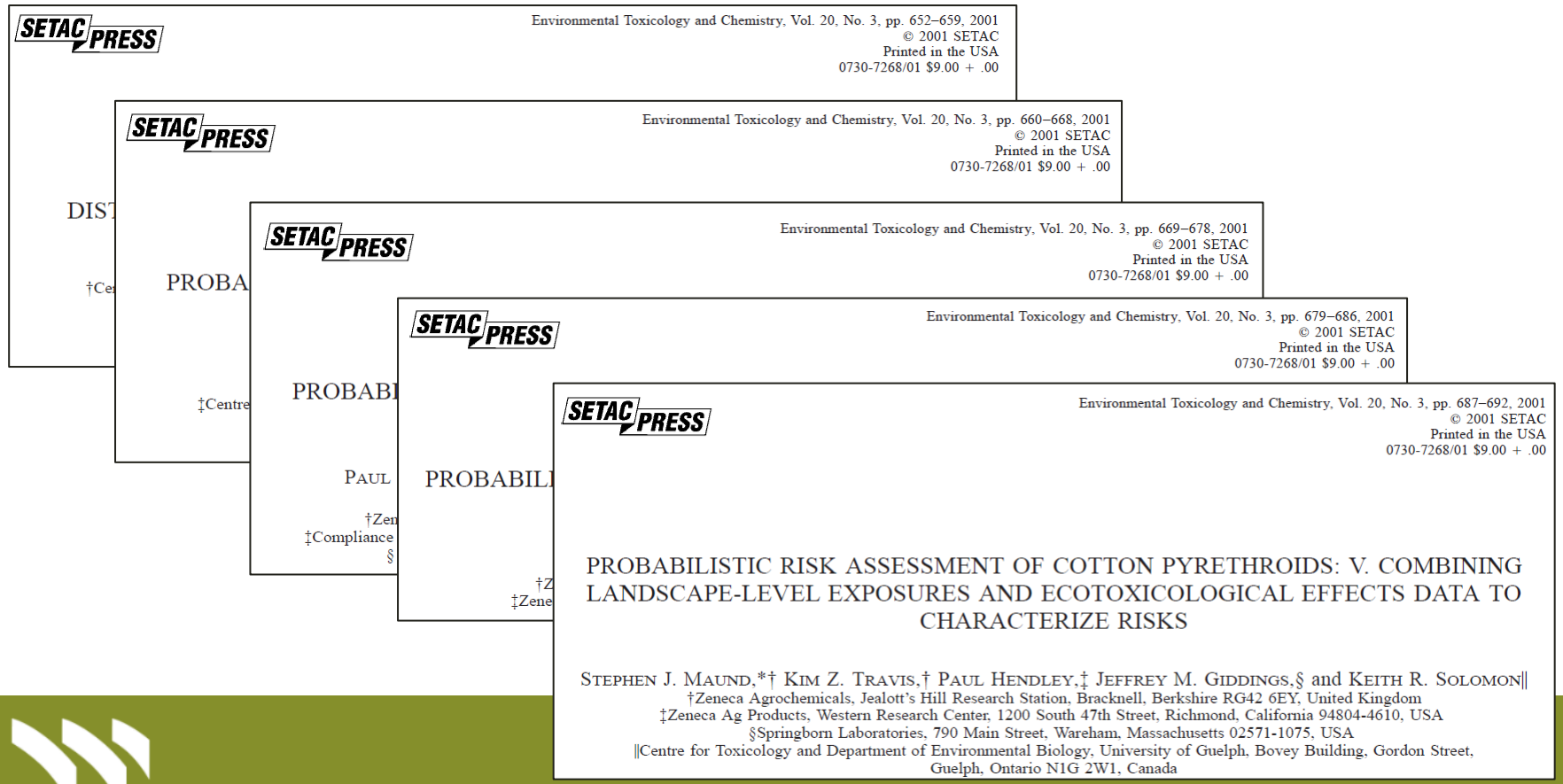
- Developed approaches for spatially relating crop locations (derived from custom satellite & aerial imagery classification) and surface water (4 types)
- Utilized ‘margins’ of varying distances to quantify crop, including directionality
- Buffers characterized by width and composition



Holmes et al, 1998. SETAC NA Annual Meeting.

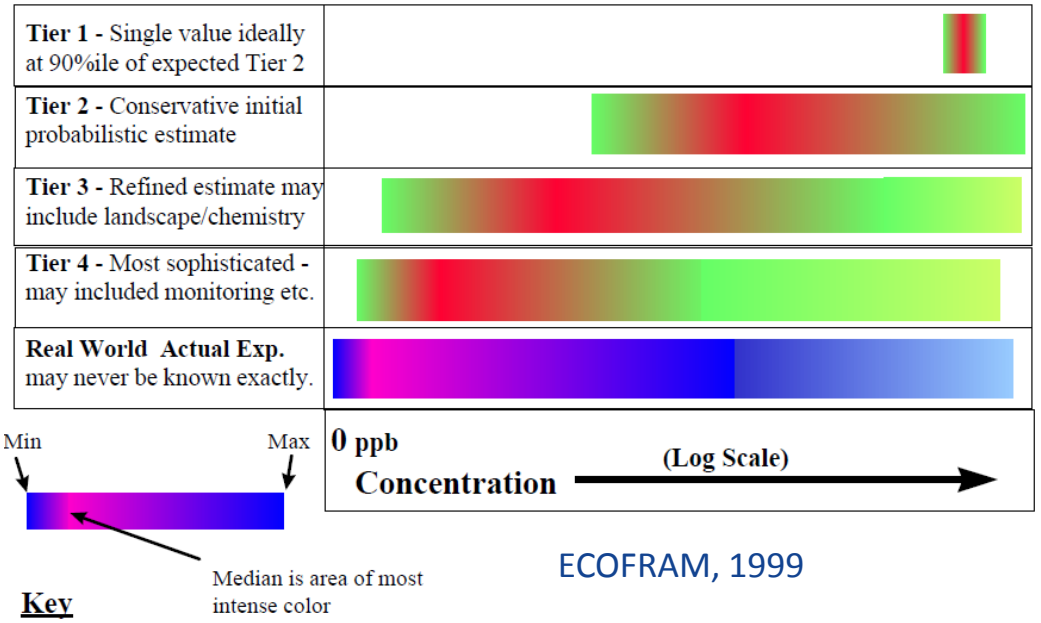
Probabilistic risk assessment of cotton pyrethroids

- Landscape-based exposure analysis used to **characterize probabilistic risk** to static water bodies of pyrethroids applied to cotton in Yazoo County, MS
- Series of 5 papers published in Environmental Toxicology & Chemistry



Ecological Committee on FIFRA Risk Assessment Methods

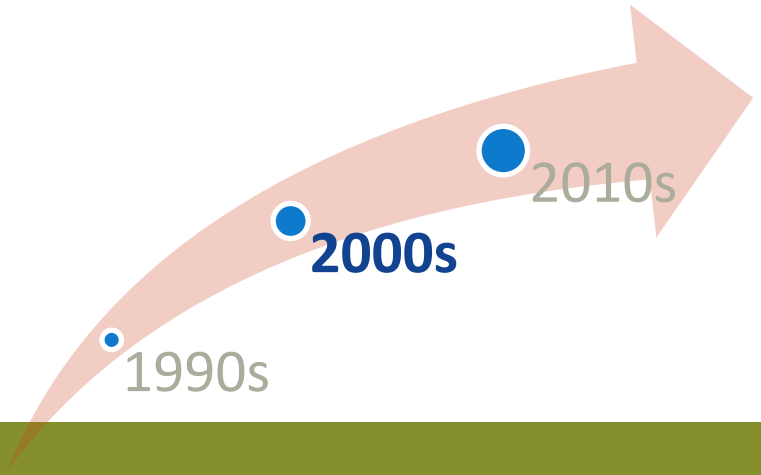
- USEPA Science Advisory Panel (SAP) encouraged OPP to develop and validate tools and methodologies to conduct **probabilistic assessments of ecological risk**, which led to the formation of **ECOFRAM** in the late 1990s
- Continuation of the **tiered framework** for pesticide risk assessment
- Tier 3: inclusion of more realistic scenarios representing the **relevant agricultural landscape** using GIS and/or spatial modeling approaches



ECOFRAM, 1999

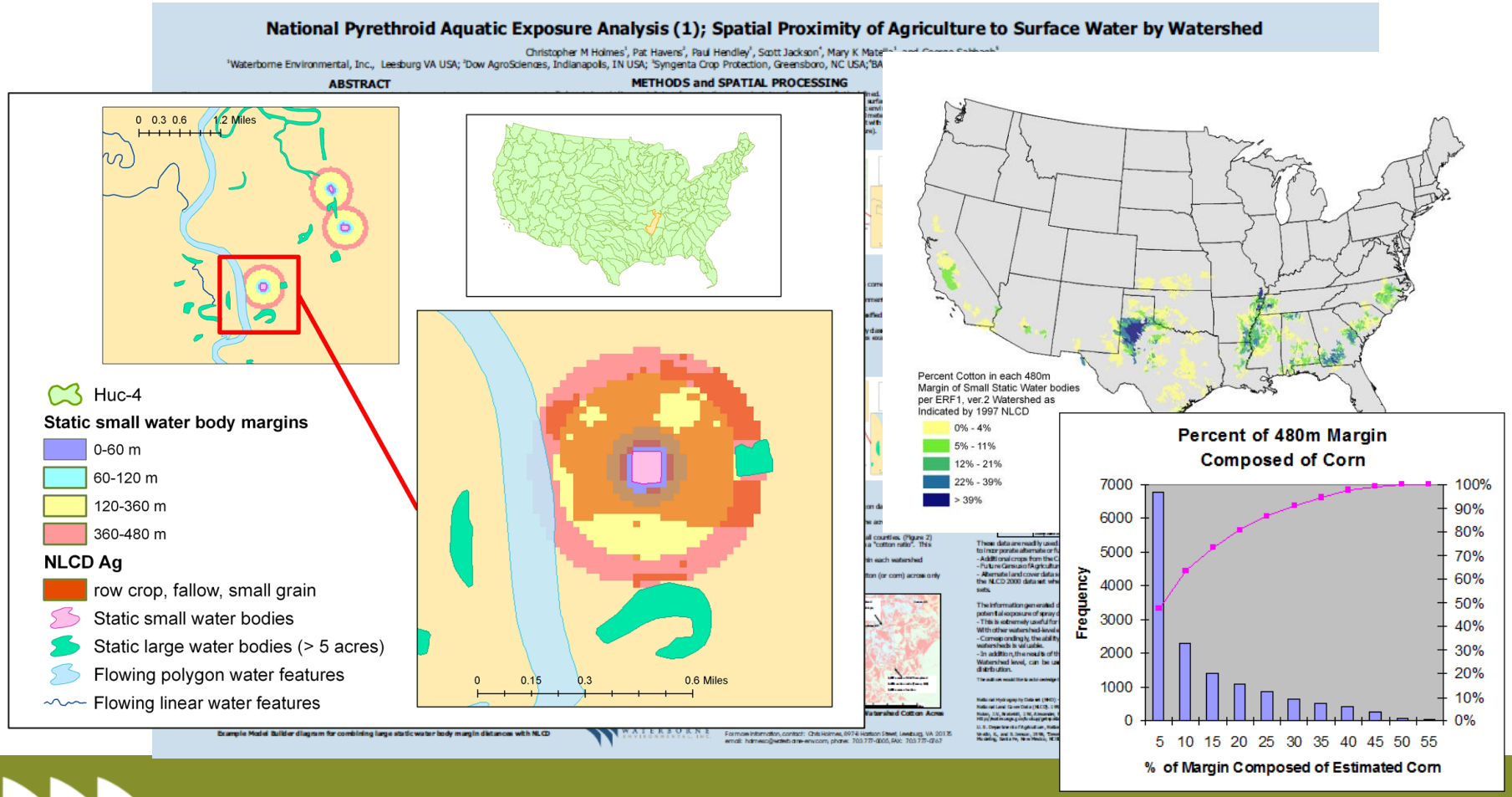
A new century – the 2000s

- Dramatic increase in available spatial datasets
- National scale exposure assessments
- Local scale watershed modeling
- Spatial data to inform endangered species assessments
- EPA scenario expansion – additional EPA for species / chemicals, other countries built on US modeling shell



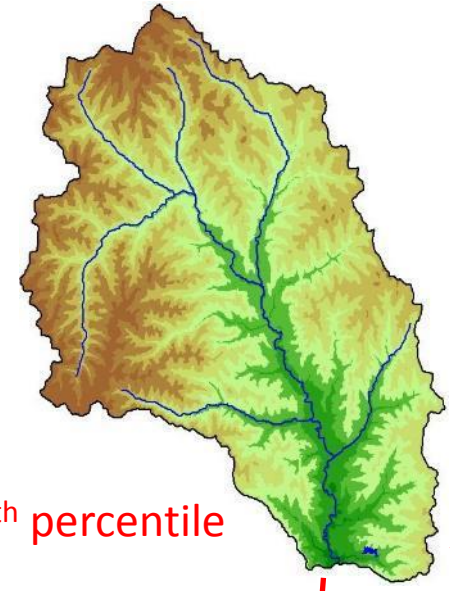
National scale crop proximity to surface water

- Examined ~61,000 watersheds across the US – expansion from previous Yazoo
- Located and quantified cropland within 4 ‘margins’ around water (60m-480m)

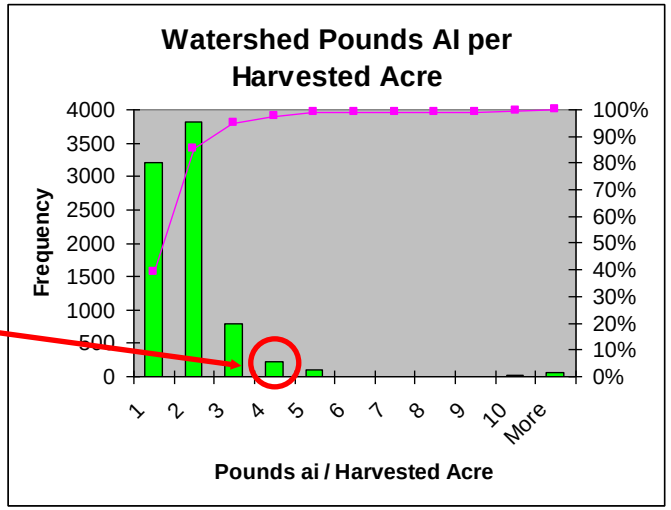


Holmes et al., 2005. American Chemistry Society national meeting.

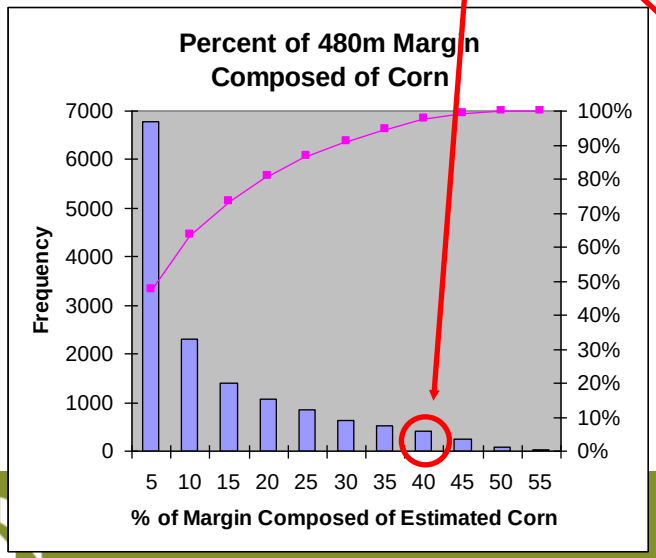
Watersheds placed in national distributions



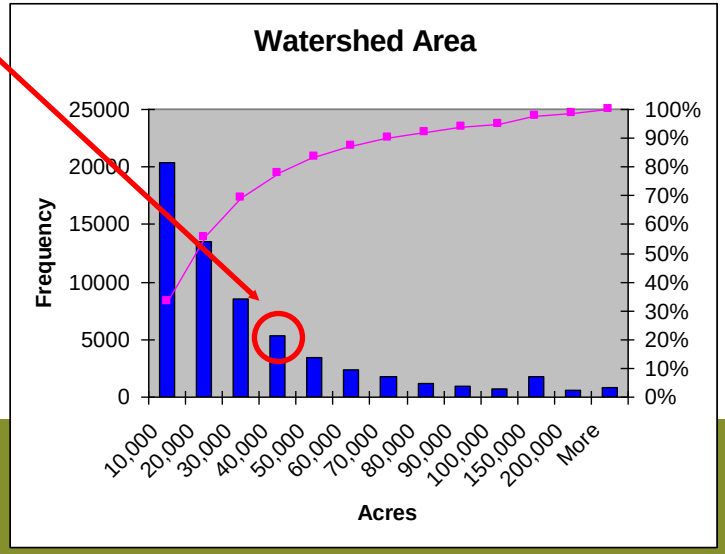
99th percentile



98th percentile

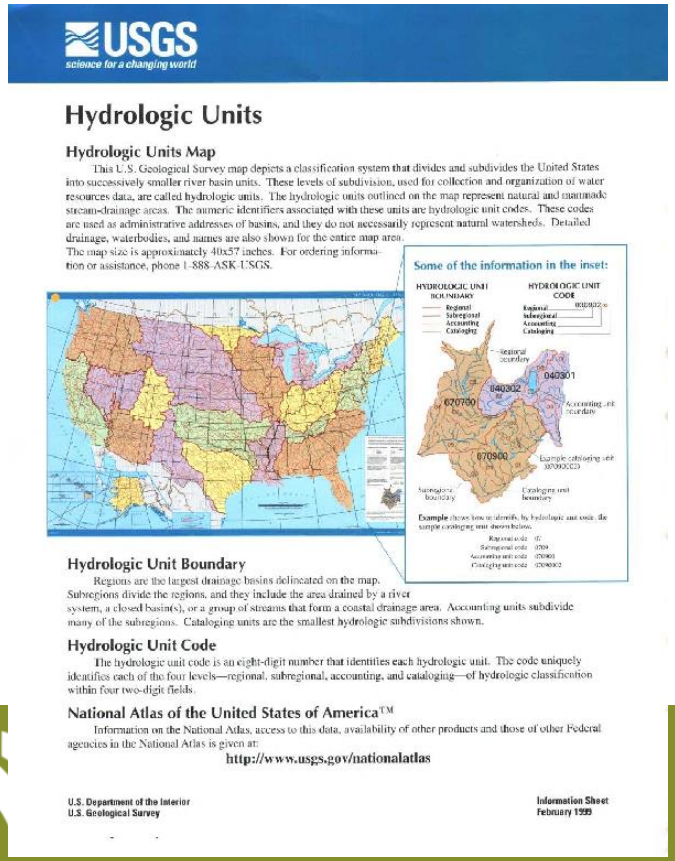


75th percentile



Hydrologic units and watersheds

- Often processed in hydrologic units, but not true watershed processing
- Multi level from Region to Cataloging Unit (i.e. HUC8)



USGS
science for a changing world

Hydrologic Units

Hydrologic Units Map

This U.S. Geological Survey map depicts a classification system that divides and subdivides the United States into successively smaller river basin units. These levels of subdivision, used for collection and organization of water resources data, are called hydrologic units. The hydrologic units outlined on the map represent natural and manmade stream-drainage areas. The numeric identifiers associated with these units are hydrologic unit codes. These codes are used as administrative addresses of basins, and they do not necessarily represent natural watersheds. Detailed drainage, waterbodies, and names are also shown for the entire map area.
The map size is approximately 40x57 inches. For ordering information or assistance, phone 1-888-ASK-USGS.

Some of the information in the inset:

HYDROLOGIC UNIT BOUNDARY
Regional
Subregional
Accounting
Cataloging

HYDROLOGIC UNIT CODE
Regional
Subregional
Accounting
Cataloging

040301
040302
070700
070900

Hydrologic Unit Boundary

Regions are the largest drainage basins delineated on the map. Subregions divide the regions, and they include the area drained by a river system, a closed basin(s), or a group of streams that form a coastal drainage area. Accounting units subdivide many of the subregions. Cataloging units are the smallest hydrologic subdivisions shown.

Hydrologic Unit Code

The hydrologic unit code is an eight-digit number that identifies each hydrologic unit. The code uniquely identifies each of the four levels—regional, subregional, accounting, and cataloging—of hydrologic classification within four two-digit fields.

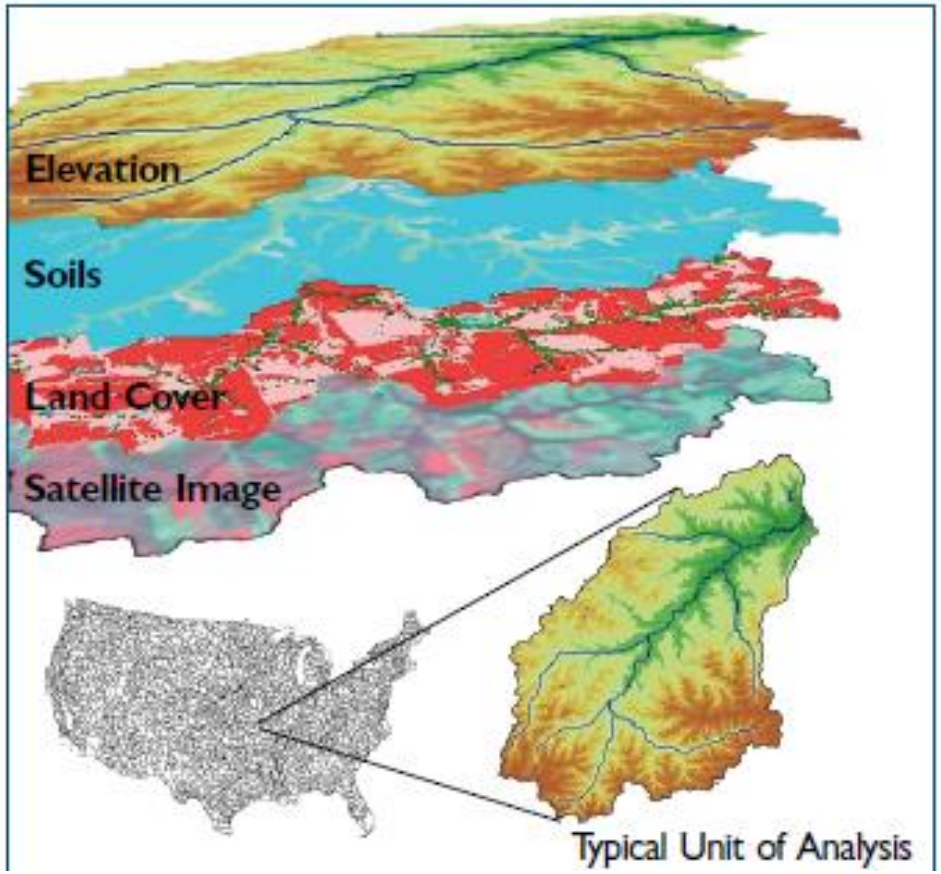
National Atlas of the United States of America™

Information on the National Atlas, access to this data, availability of other products and those of other Federal agencies in the National Atlas is given at:

http://www.usgs.gov/nationalatlas

U.S. Department of the Interior
U.S. Geological Survey

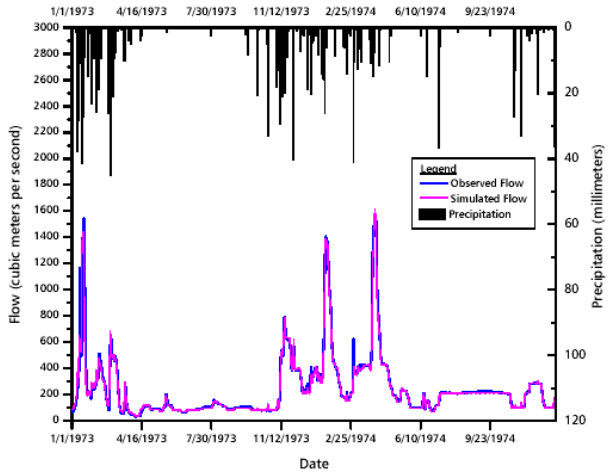
Information Sheet
February 1999

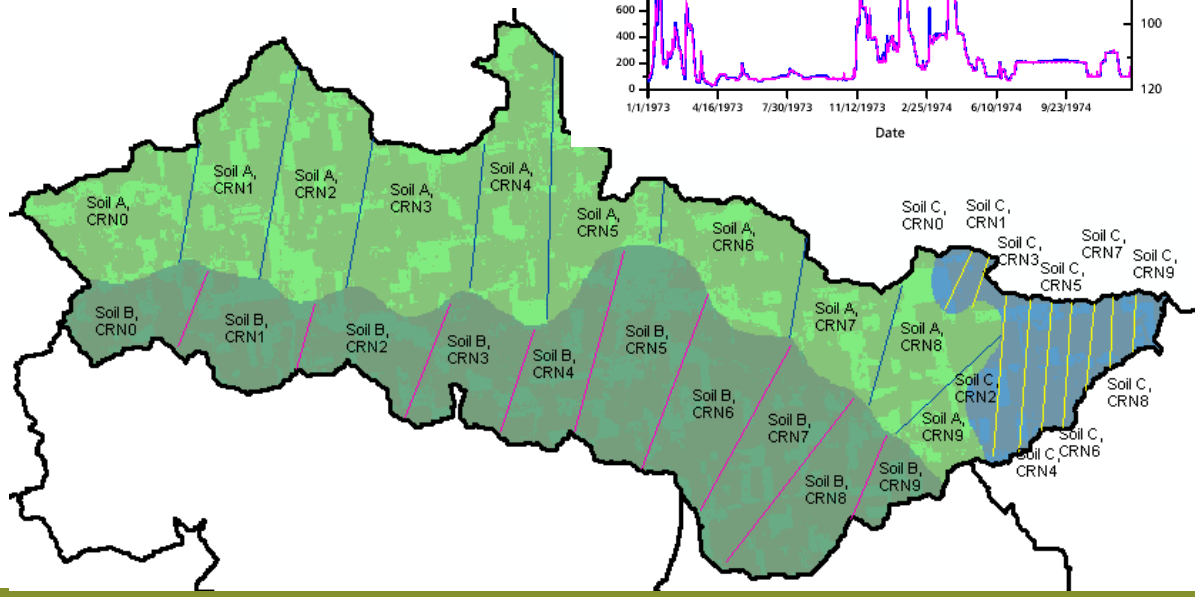


http://pubs.usgs.gov/gip/hydrologic_units/pdf/hydrologic_units.pdf

"True" watershed-scale modeling for pesticides

- Spatial combination of soil, weather, crop location, pesticide usage
- Coupled with temporal flowing hydrologic network
- USDA Soil Water Assessment Tool (SWAT)
  - Later added GIS "front-end" to develop model inputs

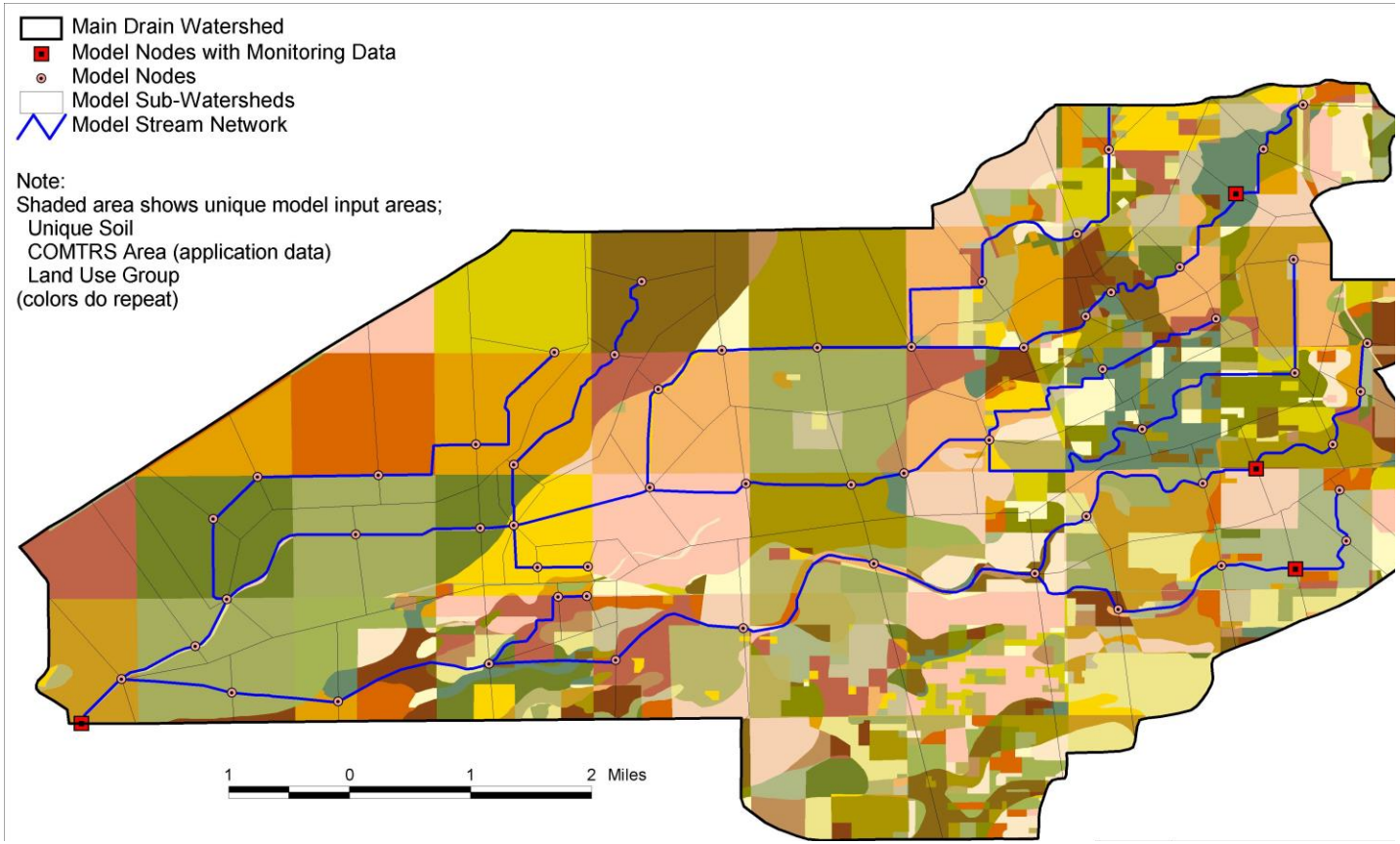




Winchell et al., 2004. American Chemistry Society national meeting.

Watershed modeling with regulatory models

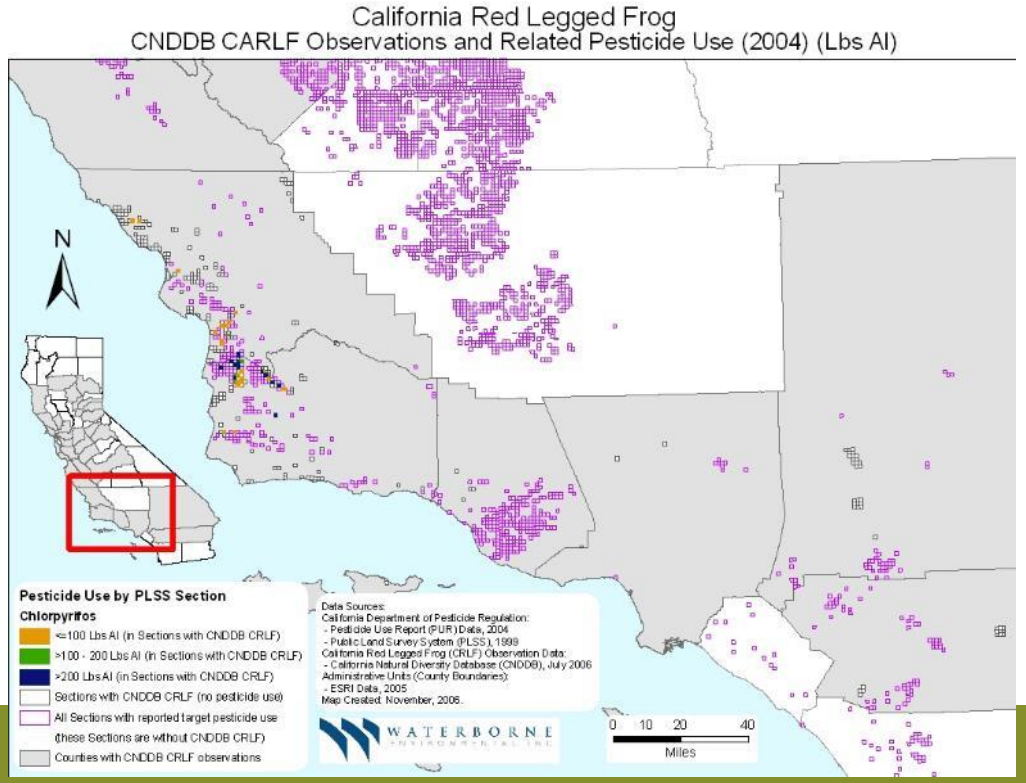
- Link regulatory model (PRZM) for chemical loading to flowing hydrology (RIVWQ) to generate time series aquatic concentrations



Cheplick et al., 2004. American Chemistry Society national meeting.

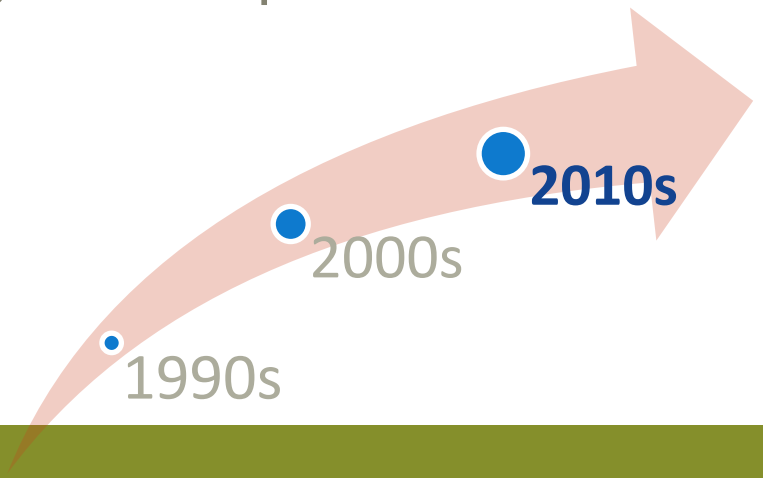
Spatial data and endangered species assessments

- Litigation related to Endangered Species Act stimulated assessments for Barton Springs salamander, CA Red Legged Frog, Pacific salmonids, CA “Goby 11”
- Definition of use area and potentially impacted surrounding area as defined by fate/transport models (i.e., the “action area”)
- May be overland distance or downstream movement
- Overlap with critical habitat or species locations
- Refined use of pesticide application data in California



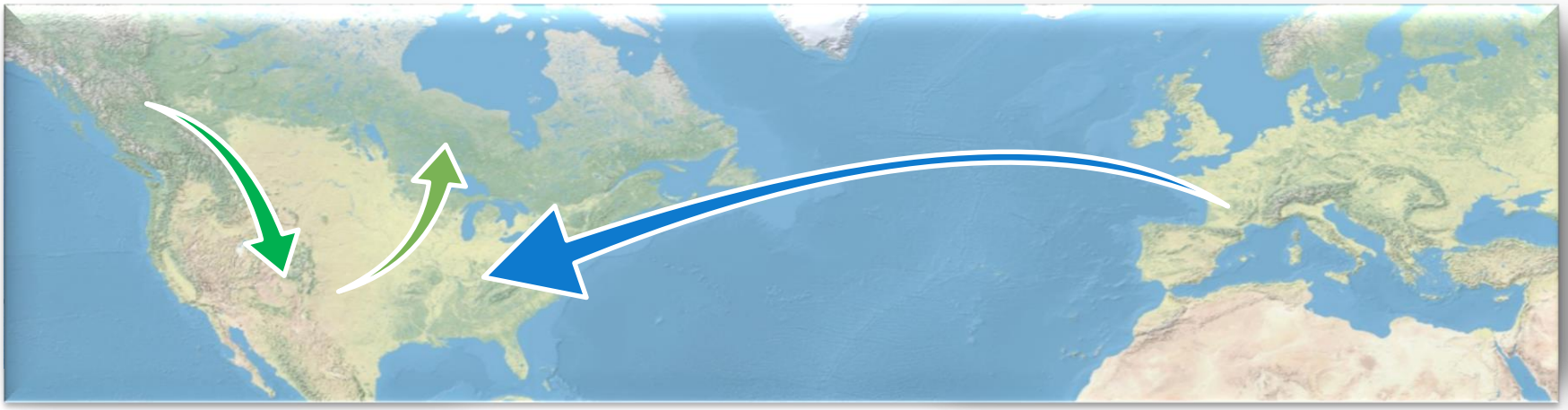
The current decade … 2010s

- Ecoregion crosswalk tools
- Endangered species continues
- Nation-wide assessments and context setting
- Quantitative uncertainty analyses
- Increase in web-based tools
- Spatial Aquatic Model (US EPA)
- Ecological modeling- informed by landscape data



Ecoregion crosswalk tool

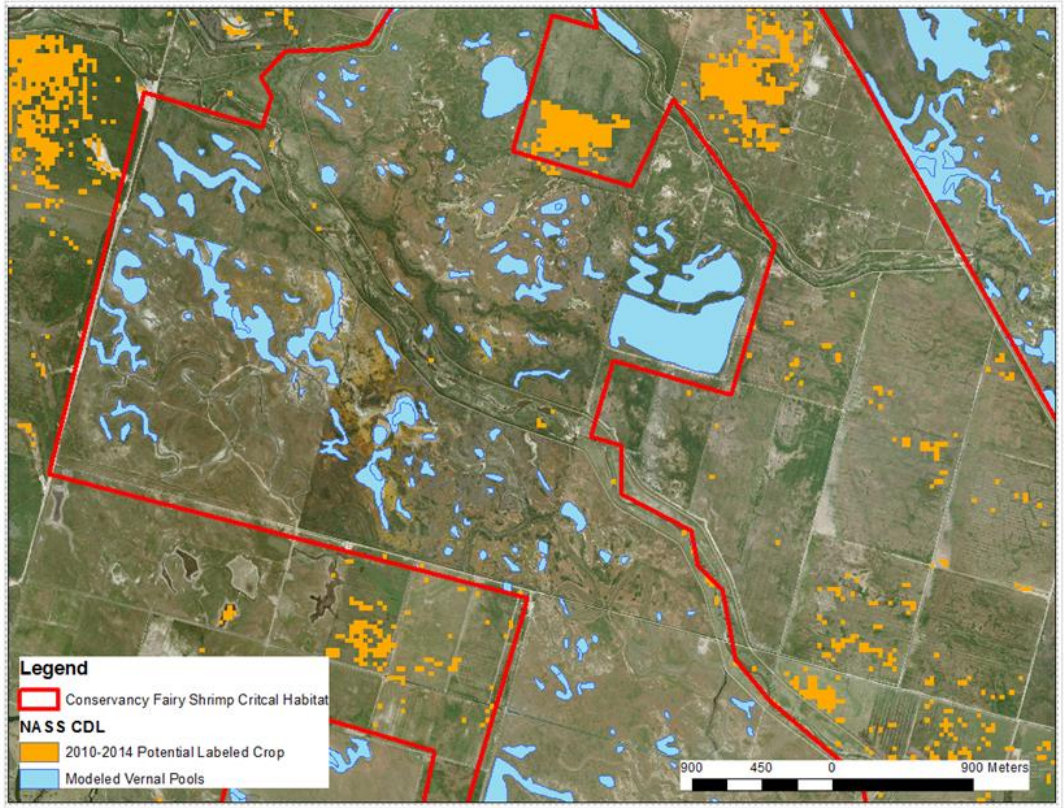
- Europe – North America Soil Geographic Information for Pesticide Studies (ENASGIPS)
- Linking multi-continent terrestrial field dissipation data using landscape information
- OECD tool: USEPA, PMRA, JRC, and EFSA



Hoogeweg and Zelonis, 2013. American Chemistry Society national meeting.

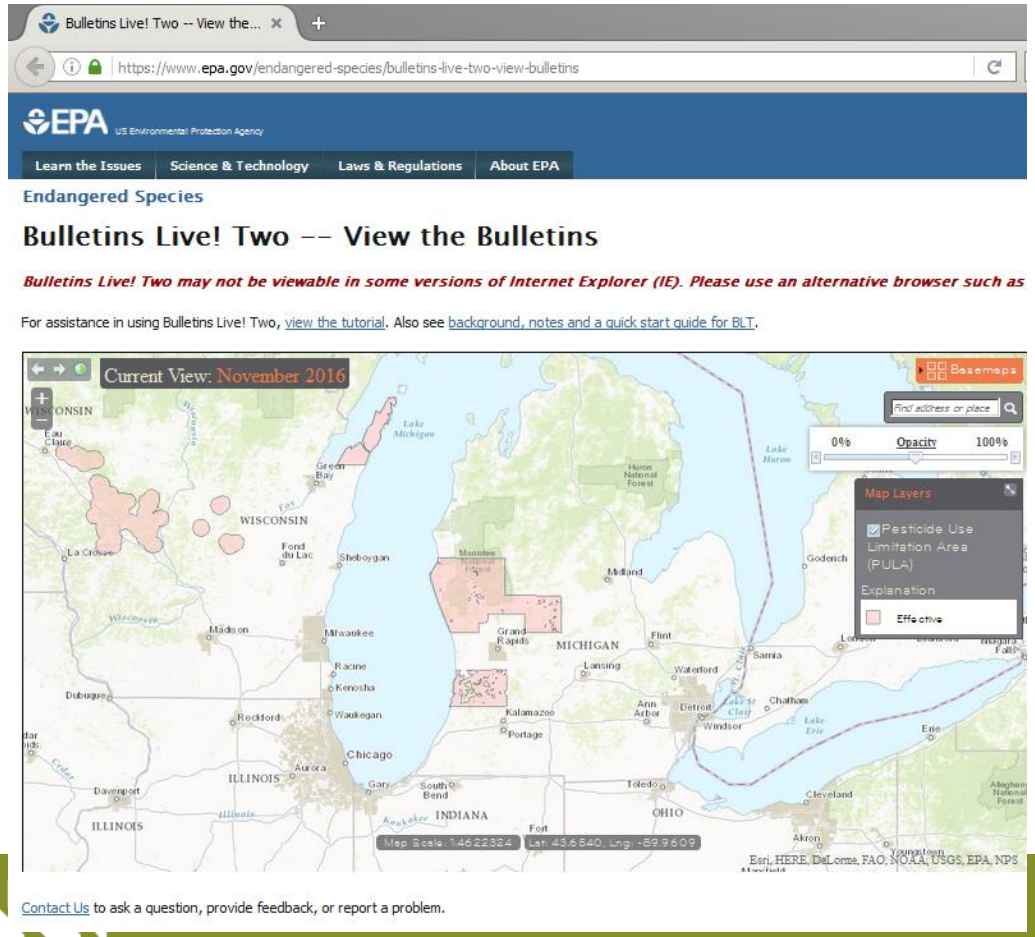
Endangered species efforts continue

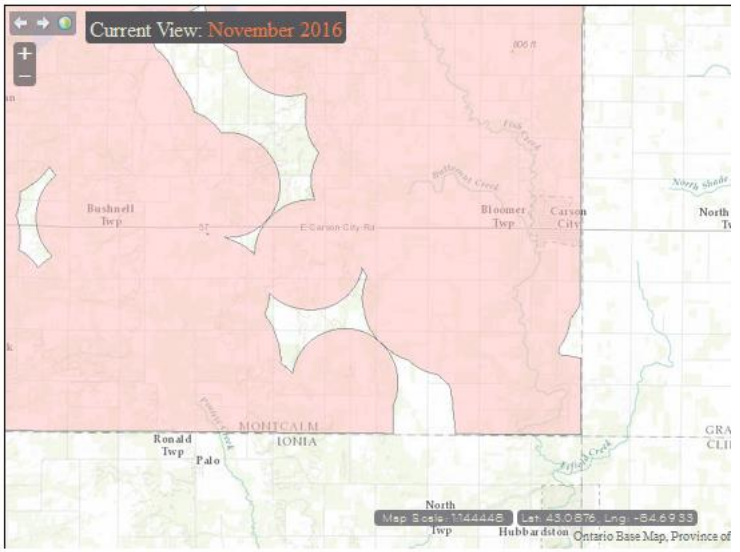
- National Academy of Science (NAS) Panel report (2013)
- Examine proximity of use and species locations early in the process
- Spurred the refinement of species range datasets in a spatial format
- Relate species to potential use areas and off-target exposure using standard models
- Population modeling if ‘likely to adversely affect’ individuals
- Stakeholder interaction continues



Bulletins Live! Two

- EPA web-based tool to present the "*enforceable, geographically-specific restrictions on pesticide use*" relative to threatened or endangered species and critical habitat

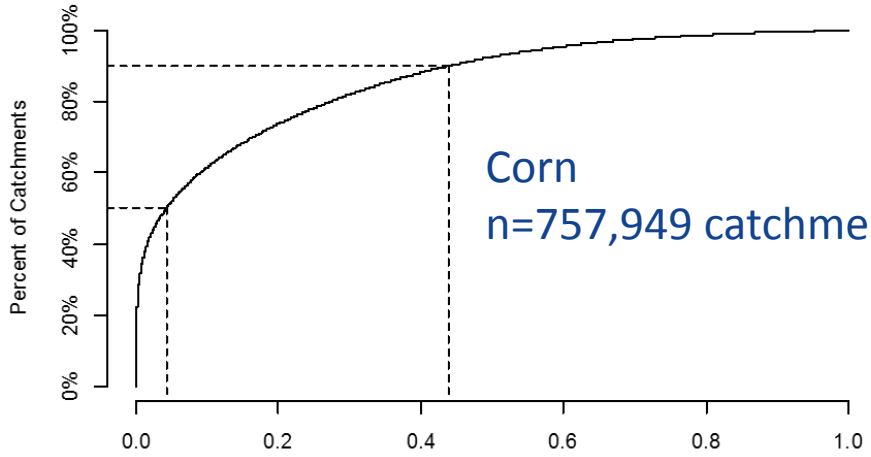




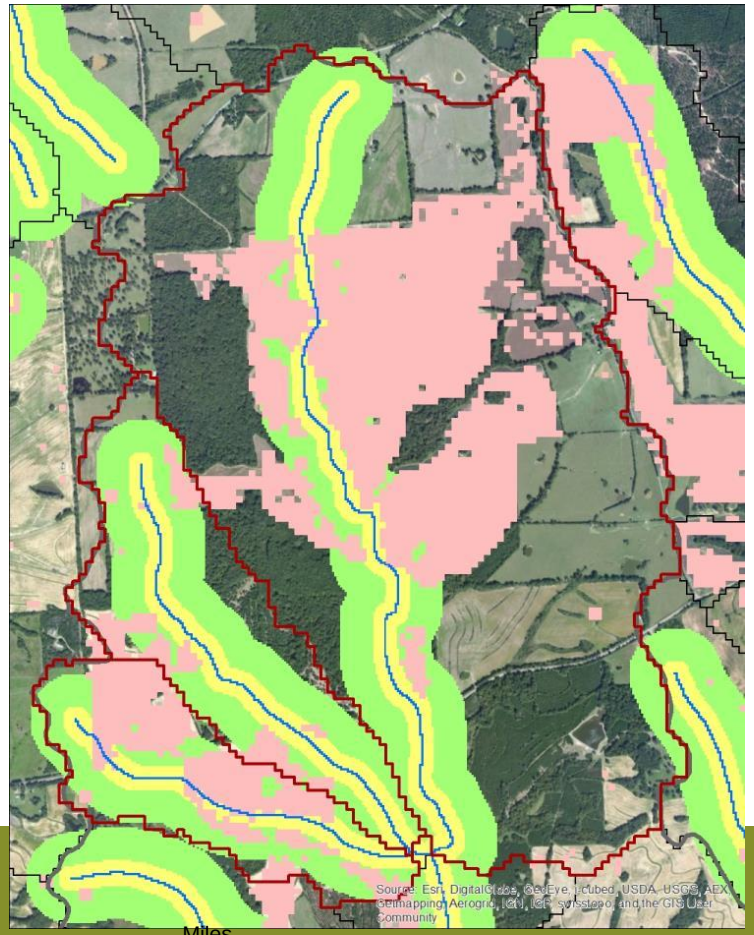
https://www.epa.gov/endangered-species/bulletins-live-two-view-bulletins

Pyrethroid Working Group national scale analysis

- Built on USGS/USEPA National Hydrography Dataset Plus (NHD+)
  - Framework for many other EPA, USGS, other national programs
  - Contains over 2 million agricultural catchments
- Spatial combination of crop location & type (over 5-year period), soils, weather, pyrethroid usage estimates
- Crop density w/i 200m of water to refine baseline exposures of “100% cropped”



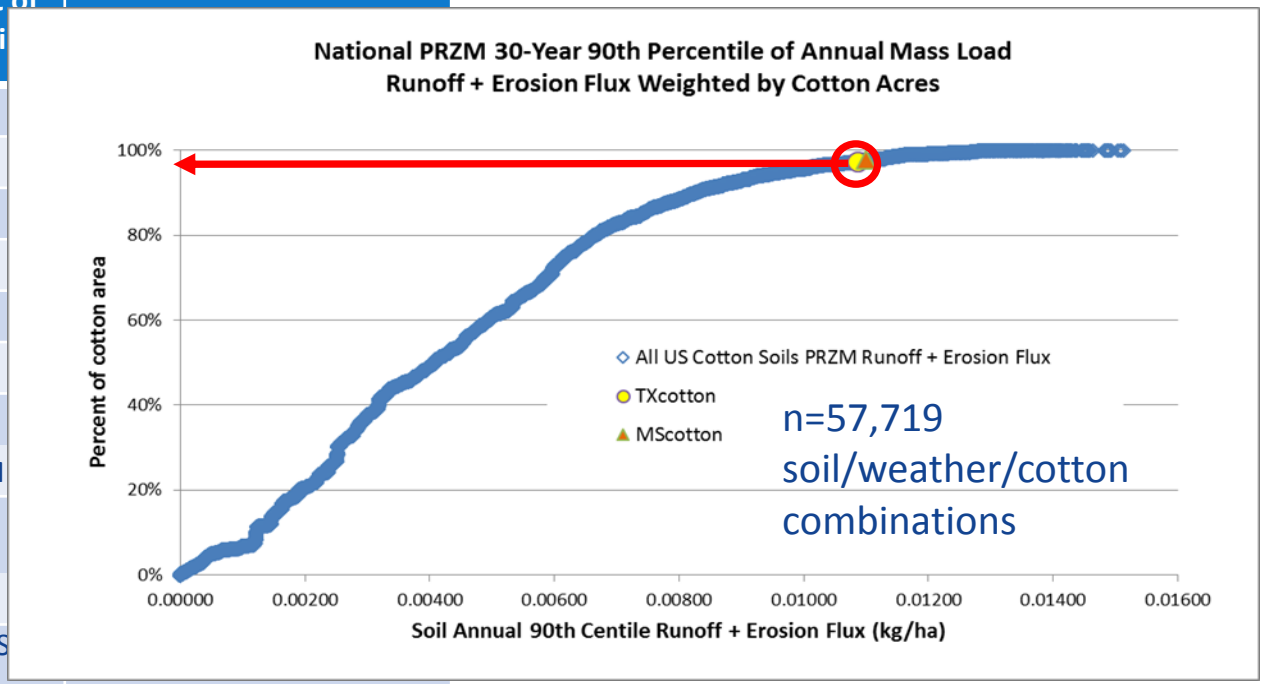
Corn 2012 10-200 Zone PCA



Placing regulatory scenarios into national context

- Performed PRZM runoff/erosion modeling for 377,000 soil/weather combinations
- Examined runoff/erosion mass flux loss leaving field (9 crops)
- Compared Tier II scenarios for runoff/erosion vulnerability in national context
- Comparable assessment at **catchment scale** for multiple crop/soil combos

PWG Crop	Spatial extent of PWG analysi	Number of soil/weather
Alfalfa	US	
Citrus	FL	
Corn	US	
Cotton	US	
Soybeans	US	
Sweet corn	US	
Tree Nuts	CA	
	GA, TX, NM	
Vegetables / Ground Fruit	CA	
	FL	
Wheat	ND, MT, MN, S OR, WA, ID	



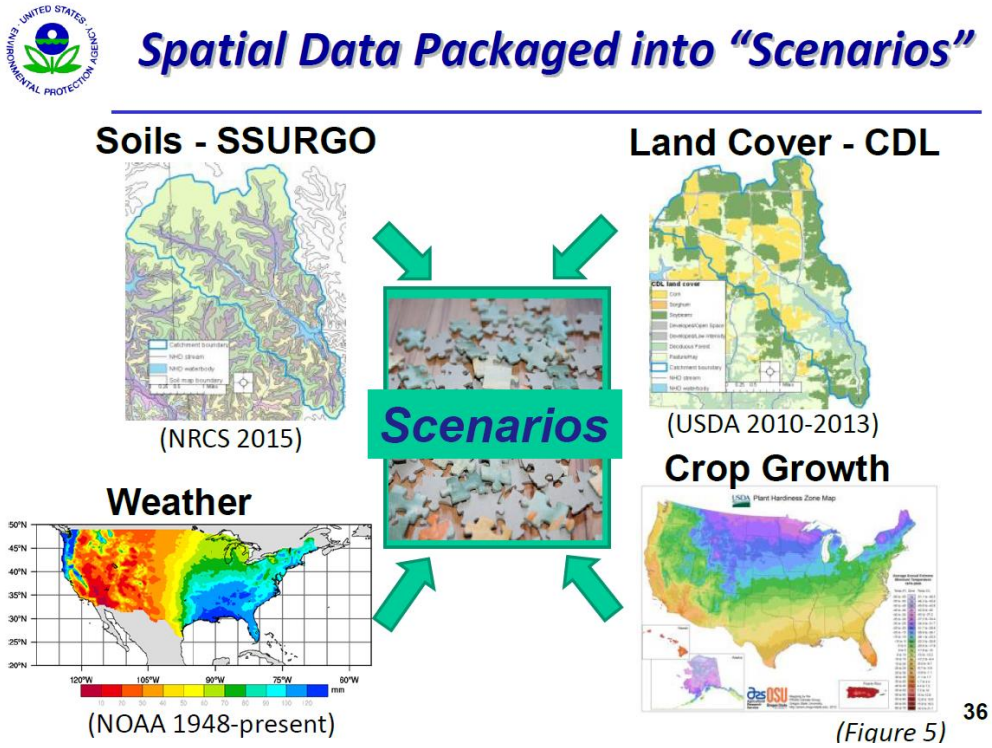
Holmes et al, 2016. American Chemistry Society national meeting.

Examining uncertainty in exposure estimation

- Pyrethroid Working Group examined over 30 key potential sources of uncertainty associated with the exposure scenarios
- Many have a landscape component (e.g., PCA, crop classification, drainage area, wind direction)
- Determine the magnitude by which they increase or decrease concentrations compared to a ‘baseline’ scenario
- Provides an understanding of baseline scenario configuration and the effect variations in the landscape may contribute to uncertainty in predicted environmental concentrations
- Individual and combined uncertainty factors
- Comprehensive report to EPA and publication in 2017

Spatial Aquatic Model (SAM)

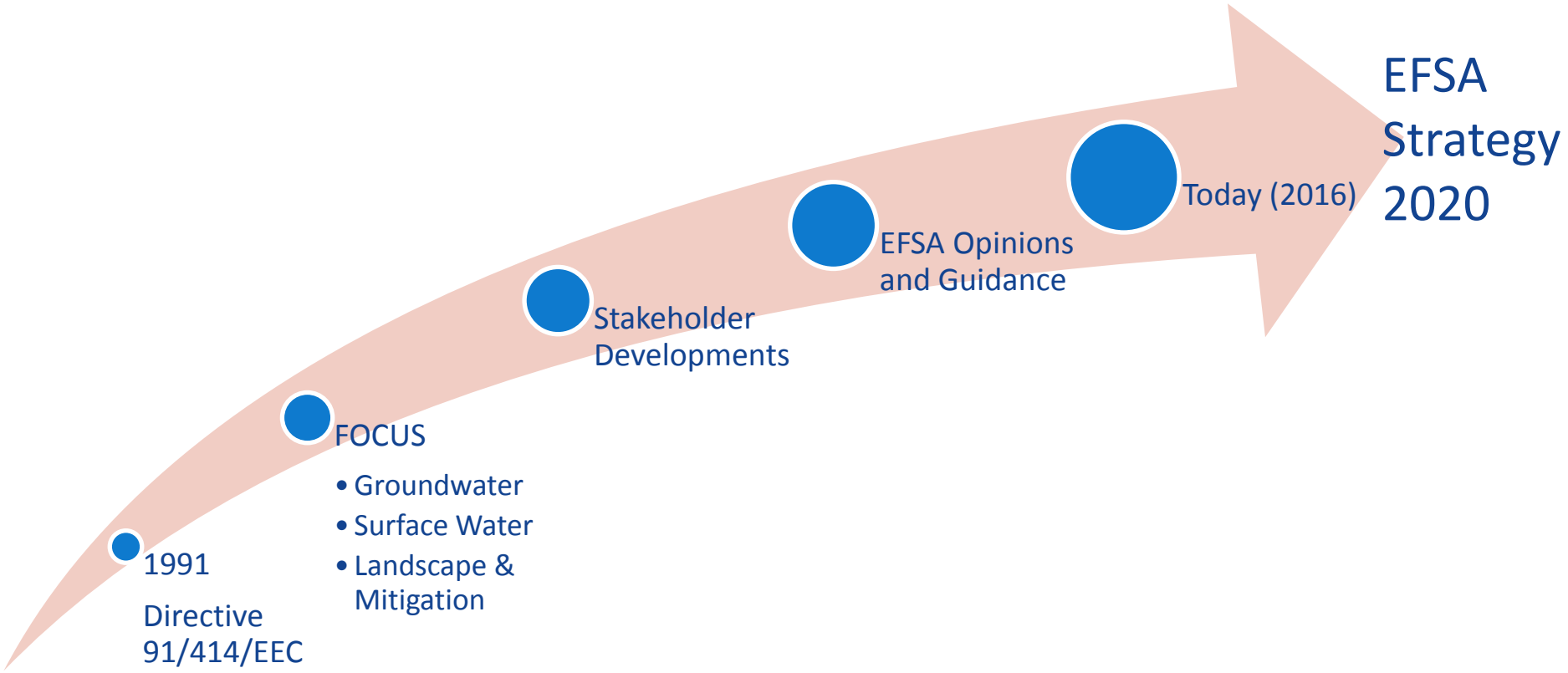
- SAM is a US EPA exposure model designed to simulate the magnitude, duration, and location of aquatic exposure concentrations of pesticides at a national scale
- SAM incorporates spatial heterogeneity of assessed drainage areas into scenarios and watersheds
- Web-based, open access
- Solicited user feedback on beta version, review by Scientific Advisory Panel (SAP) and held subsequent stakeholder workshops
- Still under development



From: Development of a Spatial Aquatic Model (SAM) for Pesticide Assessments
MEETING OF THE FIFRA SCIENTIFIC ADVISORY PANEL, September 15-18, 2015

https://qed.epa.gov/ubertool/sam

Where we are going now …



Thank You

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This presentation represents a personal perspective on landscape-based pesticide risk assessment and does not constitute a comprehensive survey of methods or accomplishments