



Estimating pesticide concentrations in U.S. streams from watershed characteristics and pesticide properties: WAtershed Regressions for Pesticides (WARP)

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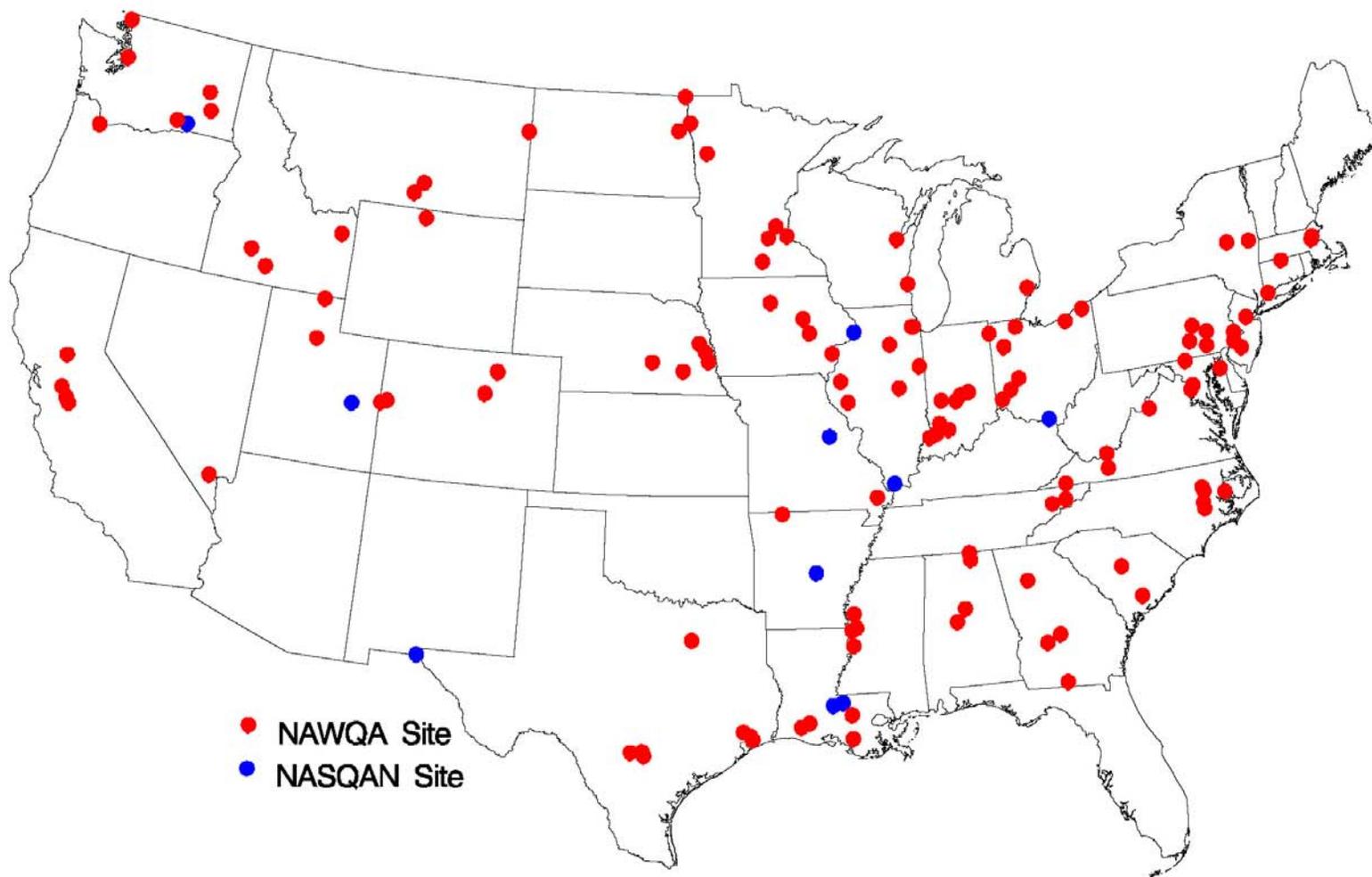
What is WARP?

- **WARP relates pesticide concentrations in streams to watershed characteristics using an empirical regression approach**
- **Independent models are developed for selected concentration percentiles**

Why do we need WARP?

- **Too few available monitoring data to meet need**
- **Prohibitively expensive to sample everywhere**

LOCATION OF MONITORING SITES USED FOR WARP MODELS



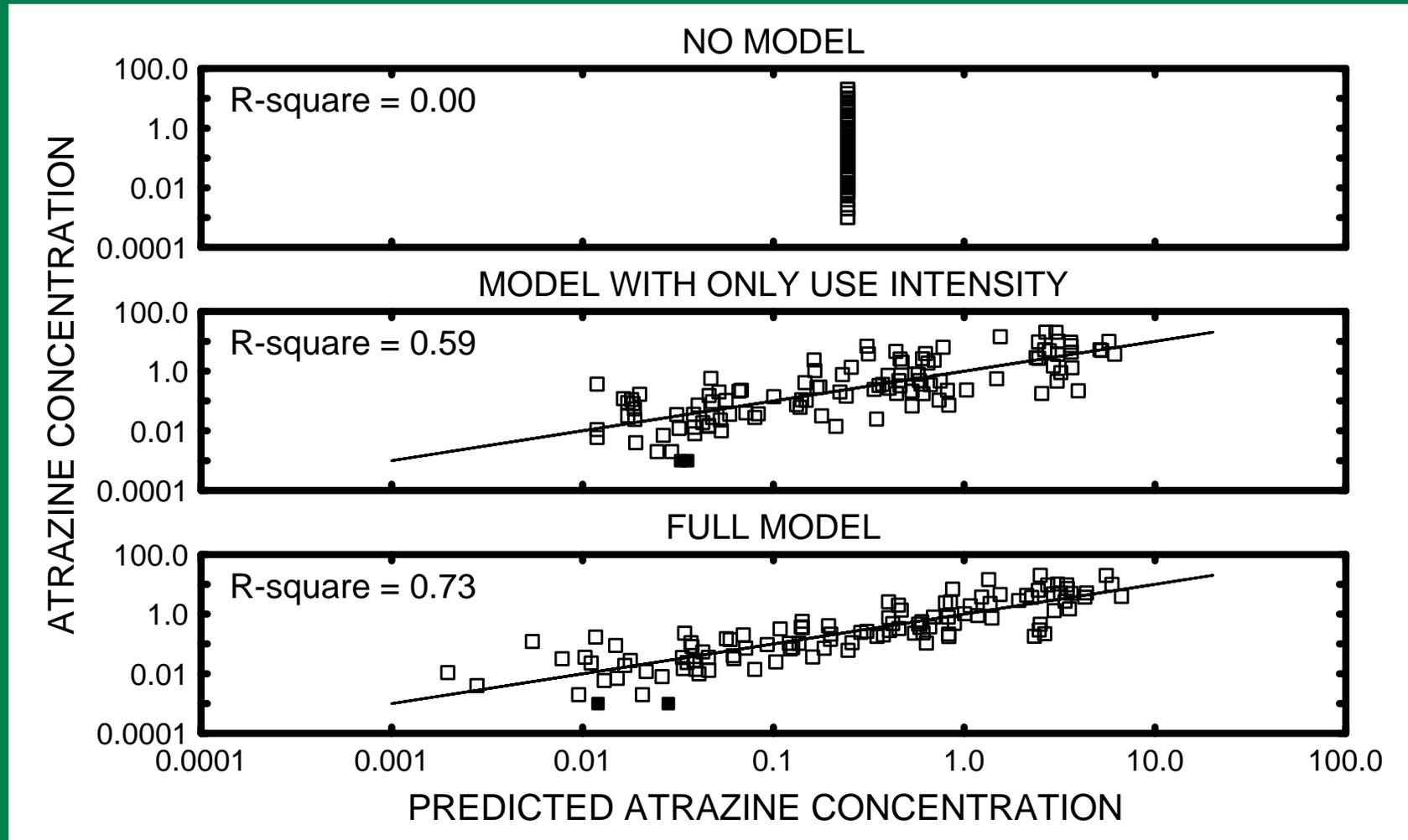
POTENTIAL PREDICTORS: Explanatory Variables Evaluated

- Pesticide Use
- Physical Basin Characteristics
- Other Basin Characteristics
- Agricultural Management Practices
- Soil Properties (STATSGO)
- Hydrologic Parameters
- Weather/Climate

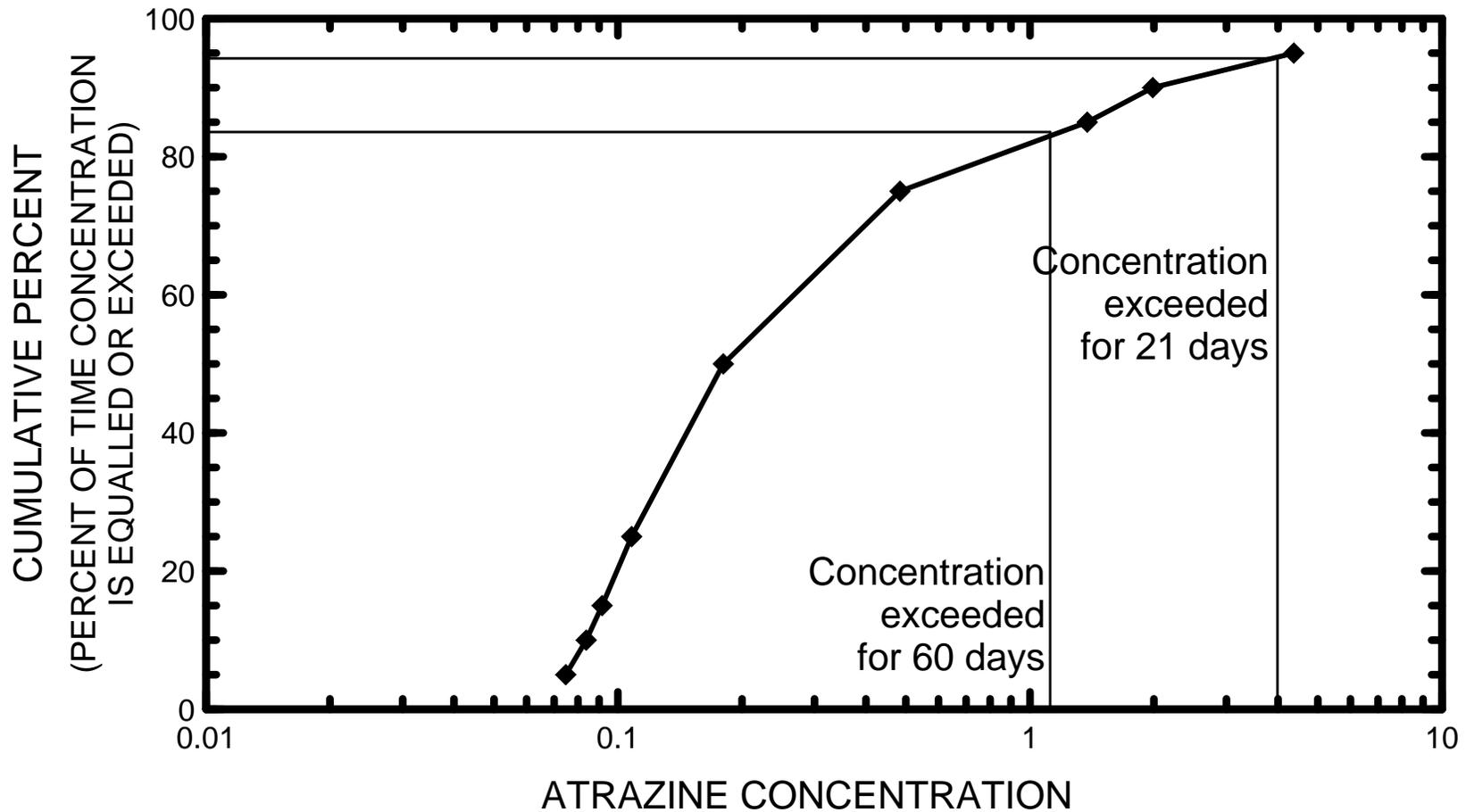
In the WARP models atrazine concentration is a function of:

- (+) atrazine use intensity (use per unit area),**
- (+) rainfall erosivity factor from Universal Soil Loss Equation (USLE),**
- (+) soil erodibility factor from USLE,**
- (+) area of drainage basin,**
- (-) percentage of total stream flow derived from Dunne overland flow**

Watershed characteristics help us predict pesticide concentrations in streams



By combining models for the nine percentiles we can predict the annual distribution of pesticide concentrations



36 pesticides were used to extend atrazine models for use with multiple pesticides

Surface and Foliar Applied Herbicides

Acetochlor	Metolachlor
Acifluorfen	Metribuzin
Alachlor	Nicosulfuron
Bentazon	Norflurazon
Bromoxynil	Oryzalin
Chlorimuron ethyl	Pronamide
Cyanazine	Propachlor
Fluometuron	Terbacil
Linuron	

Herbicides applied to paddys

Propanil	Thiobencarb
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Insecticides and Fungicides

Benomyl	Oxamyl
Carbofuran	Phorate
Ethoprop	Propargite
Fonofos	Propiconazole
Methomyl	Terbufos
Methyl parathion	

Incorporated Herbicides

Butylate	Pebulate
EPTC	Triallate
Ethalfuralin	Trifluralin

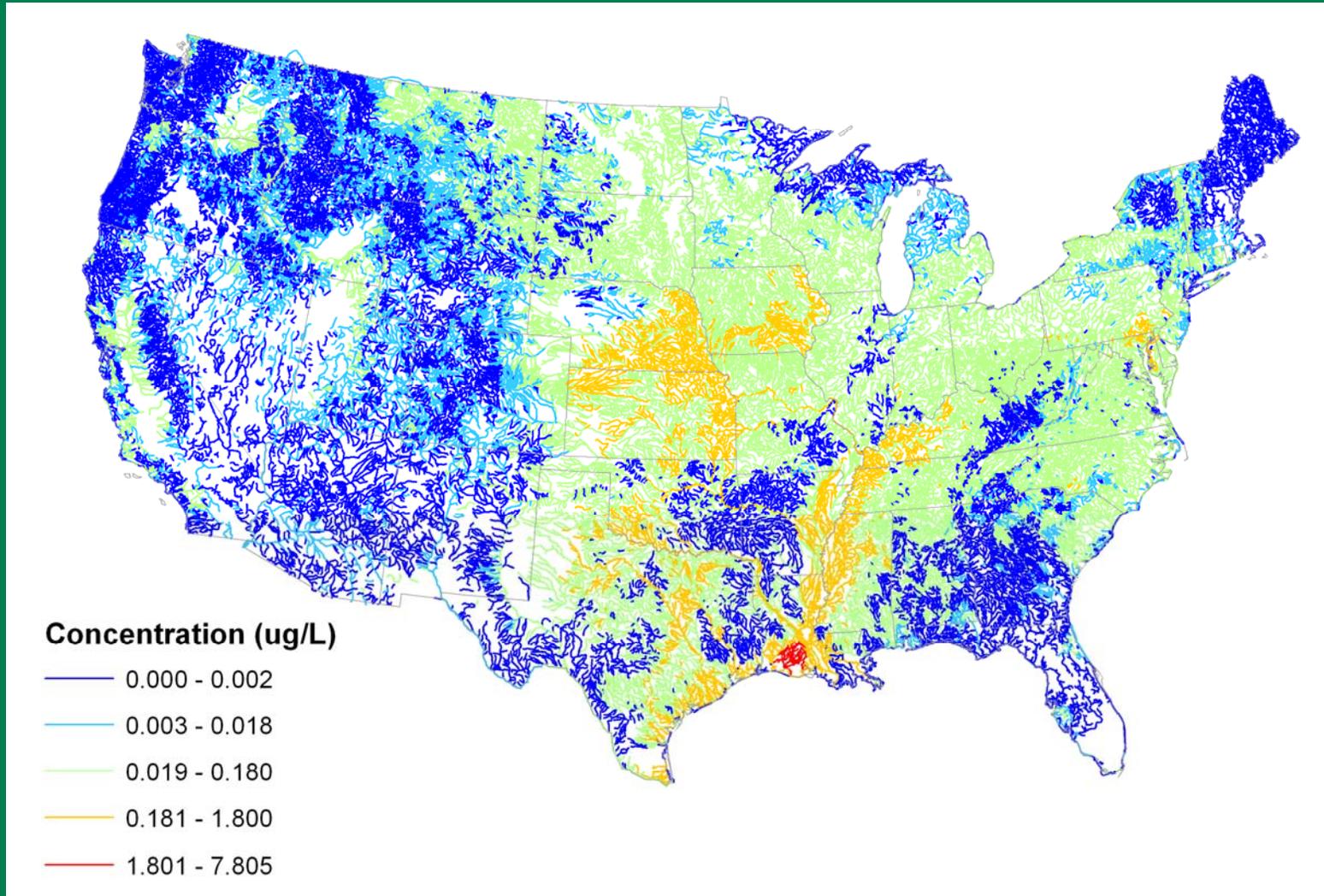
The WARP atrazine models are adjusted for multiple pesticides by

- **a factor based on the Surface Water Mobility Index (SWMI)**
- **a factor based on vapor pressure**

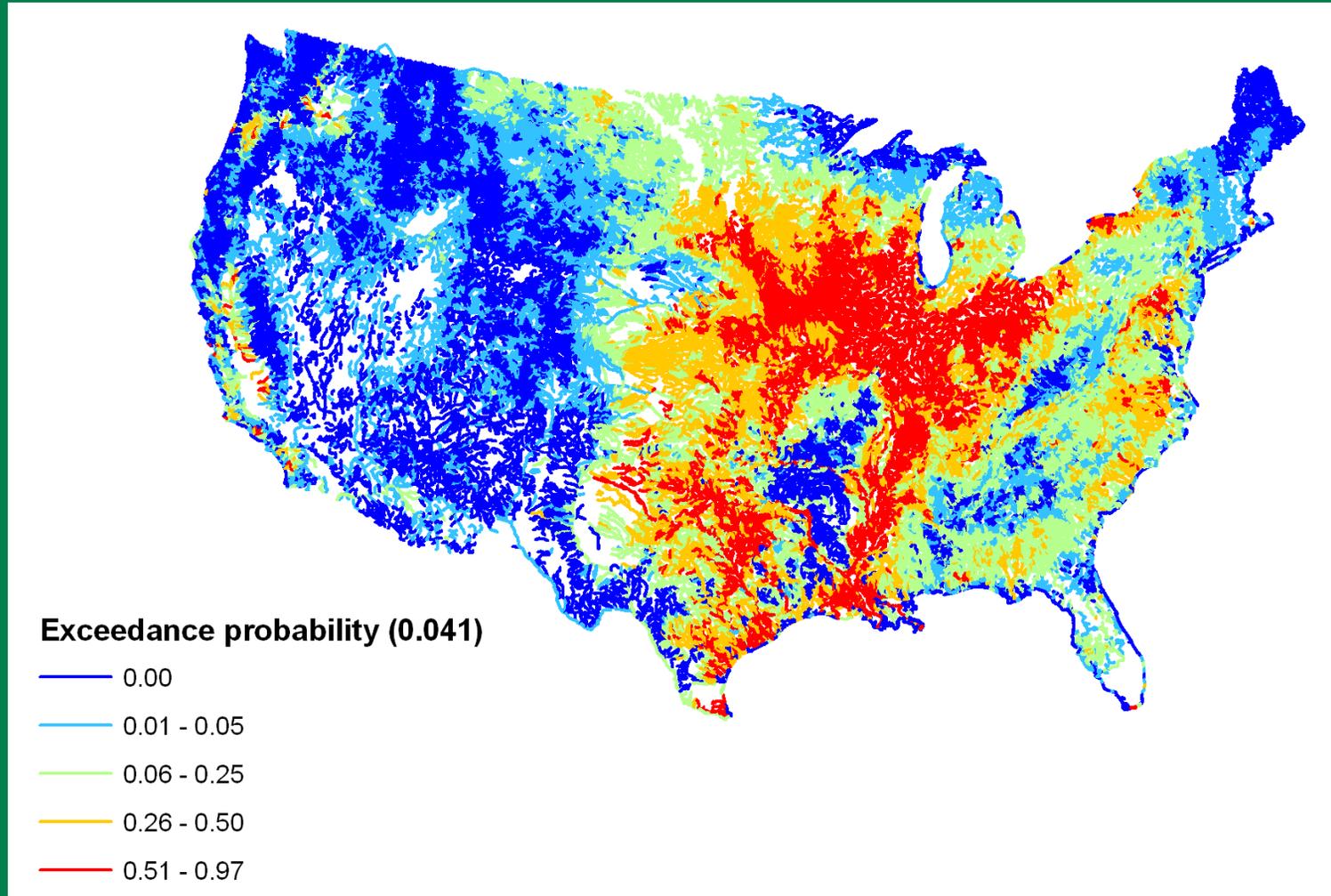
USES: National extrapolation

- Estimate exposure in streams
- Guide monitoring design
- Identifying at risk populations

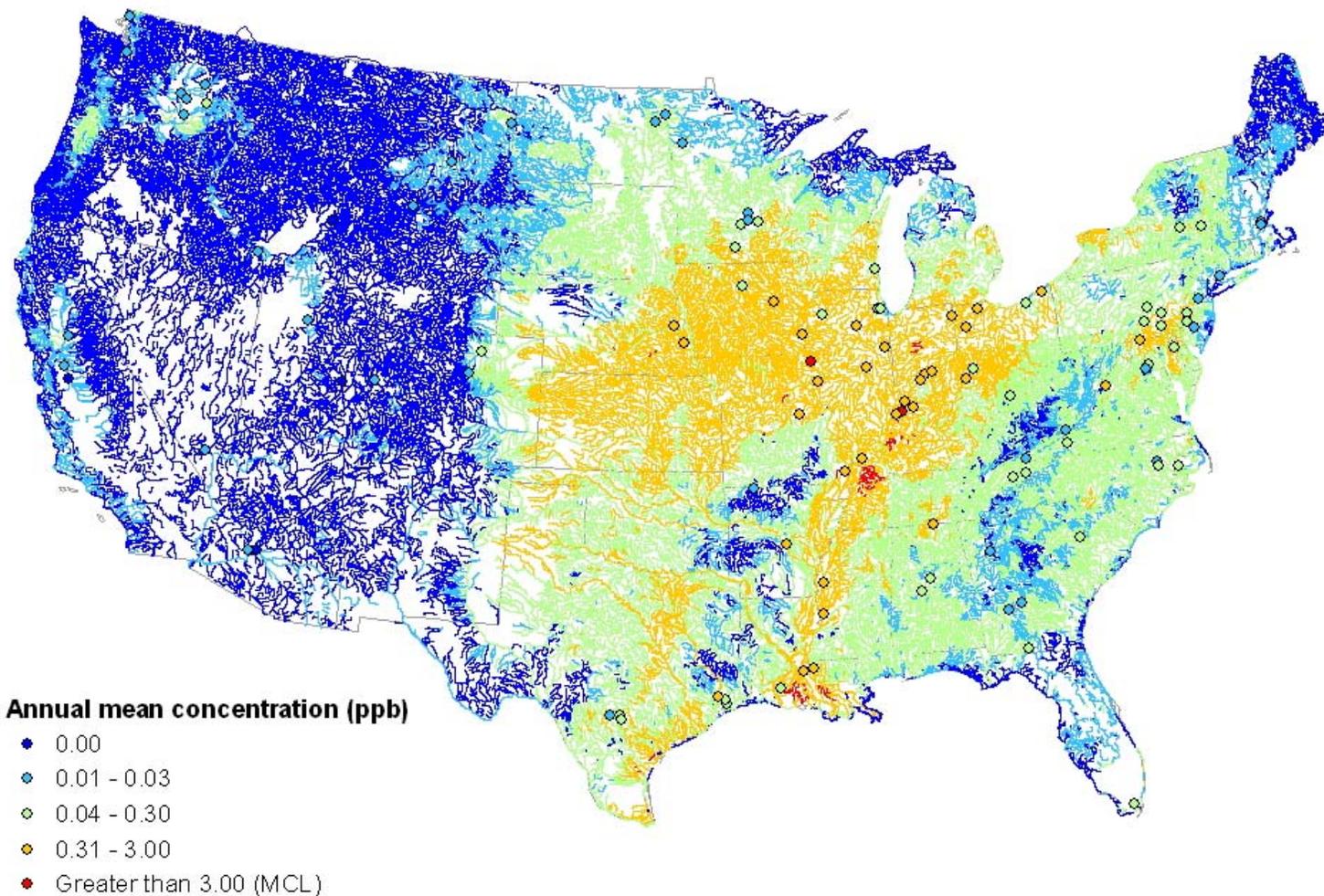
Predicted 95th percentile carbofuran concentration



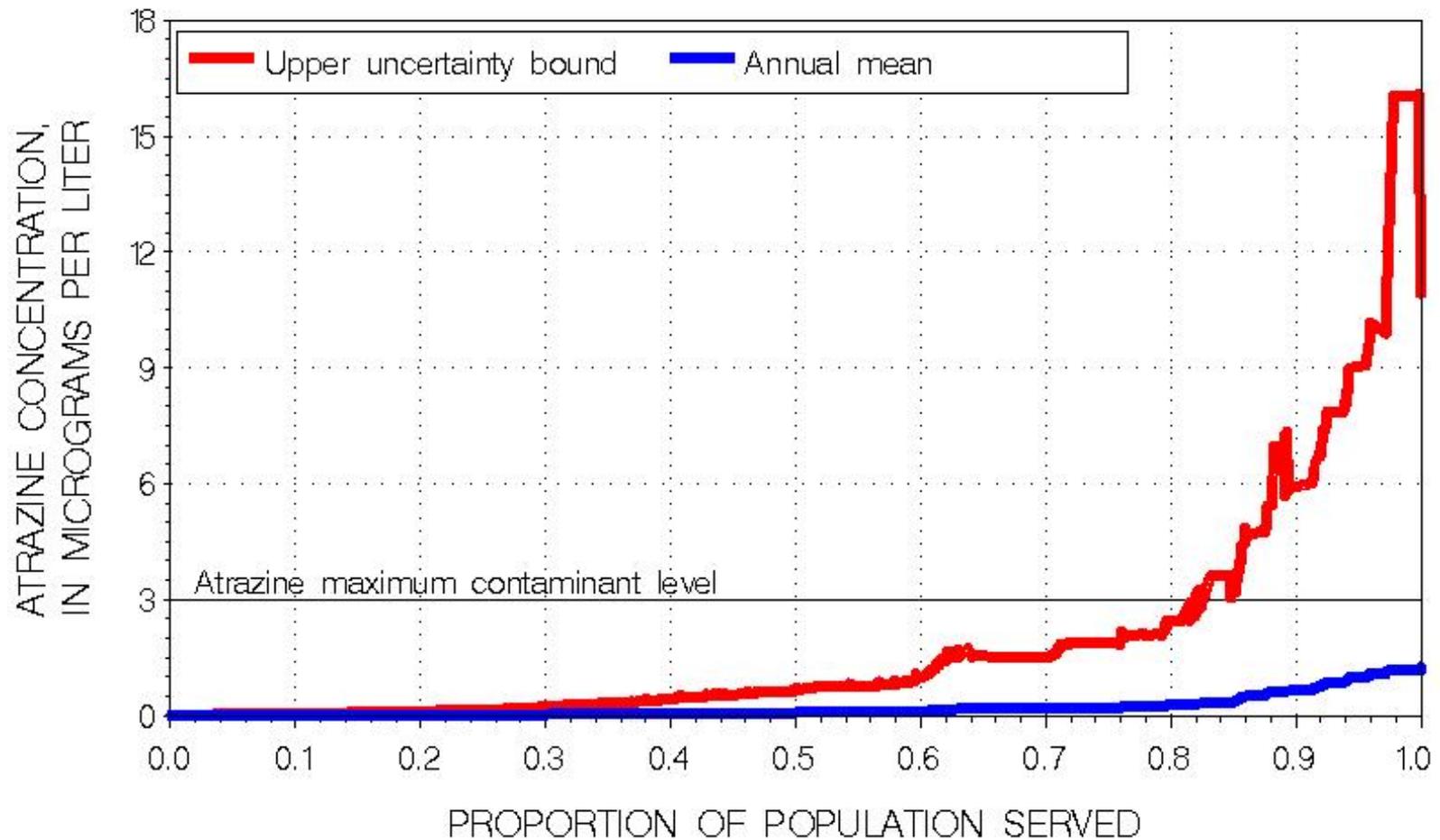
Probability that 95th percentile chlorpyrifos concentration exceeds 4-day moving average ambient water-quality criteria for aquatic life



Predicted annual mean atrazine concentrations



Cumulative population in relation to predicted
annual mean atrazine concentration
(1473 intakes, ~ 65 million people)



WARP model limitations

- Existing WARP models are for flowing waters only (not reservoirs)
- We can only predict where we have delineated watersheds
- No co-occurrence of multiple pesticides
- Can't incorporate factors for which there are no data (i.e. buffer strips)
- Can't address factors that significantly change the relationships underlying WARP models without new data

Summary

- Statistical models have been developed to predict pesticide concentrations at unmonitored streams
- These models allow us to extrapolate our limited monitoring data to unmonitored locations so we can:
 - Estimate pesticide exposure in streams
 - Identify areas of concern for future monitoring
 - Identify populations where pesticide exposure through source waters may be of concern

For more information:

USGS NAWQA program:

<http://water.usgs.gov/nawqa/>

NAWQA pesticide national synthesis project:

<http://ca.water.usgs.gov/pnsp/>

WARP atrazine models:

<http://pubs.usgs.gov/wri/wri034047/>