

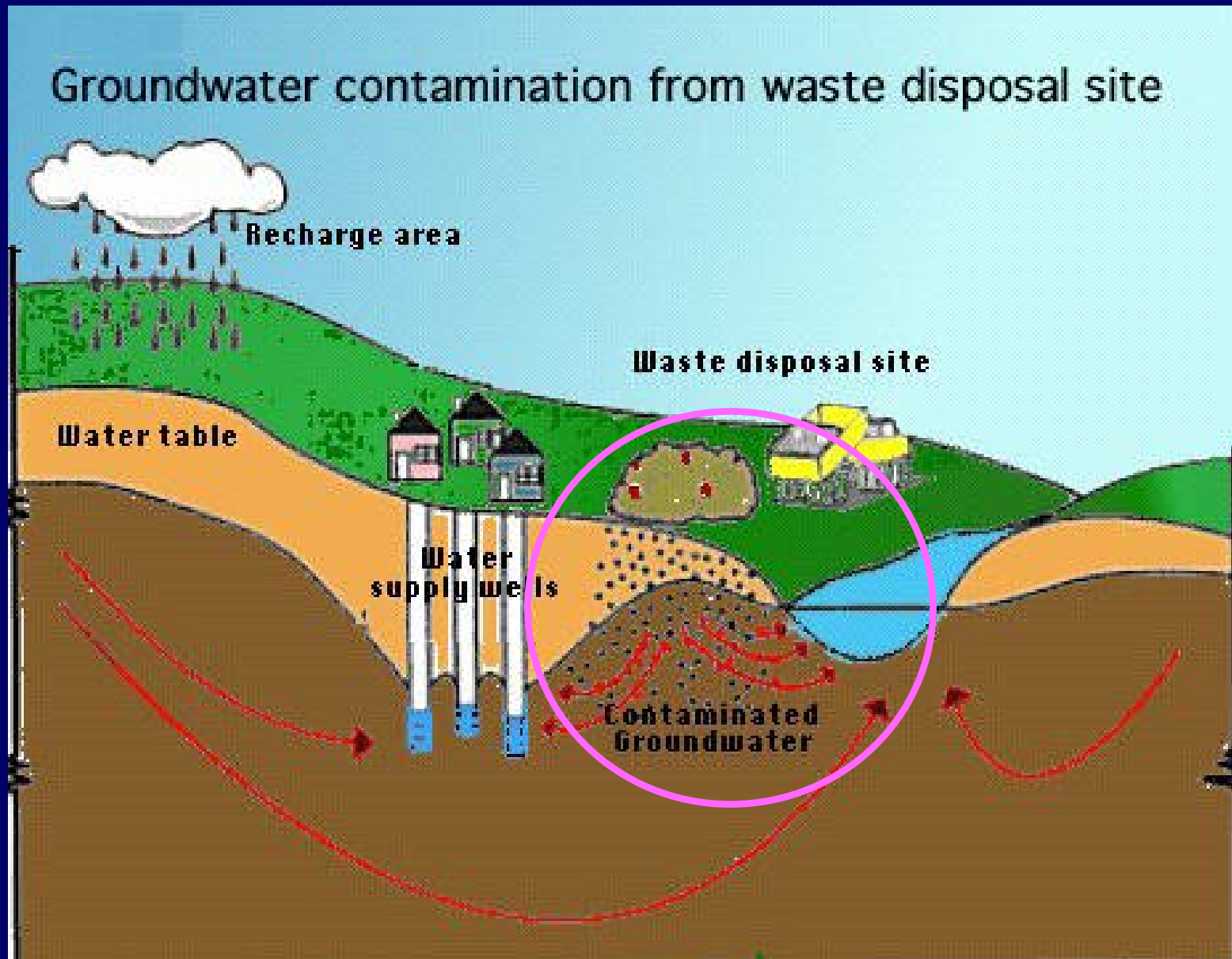
Can Ground Water Sampling
Strategy be Improved by
Incorporating Fuzzy Logic in a
GIS?

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The Problem!



Definition: Ground Water Vulnerability

- The tendency or likelihood for contaminants to reach ground water system after introduction to the surface above the aquifer.

(NRC, 1993)

Objective

- To improve ground water vulnerability mapping techniques by incorporating selected parameters from the DRASTIC model with
 - ✓ Fuzzy Logic
 - ✓ Landuse
 - ✓ Soils

Overview

- What is DRASTIC model?
- Development of a fuzzy logic-based vulnerability model in a GIS
- Improvements of the model(s) by incorporating landuse and soils parameter

Specific Topics

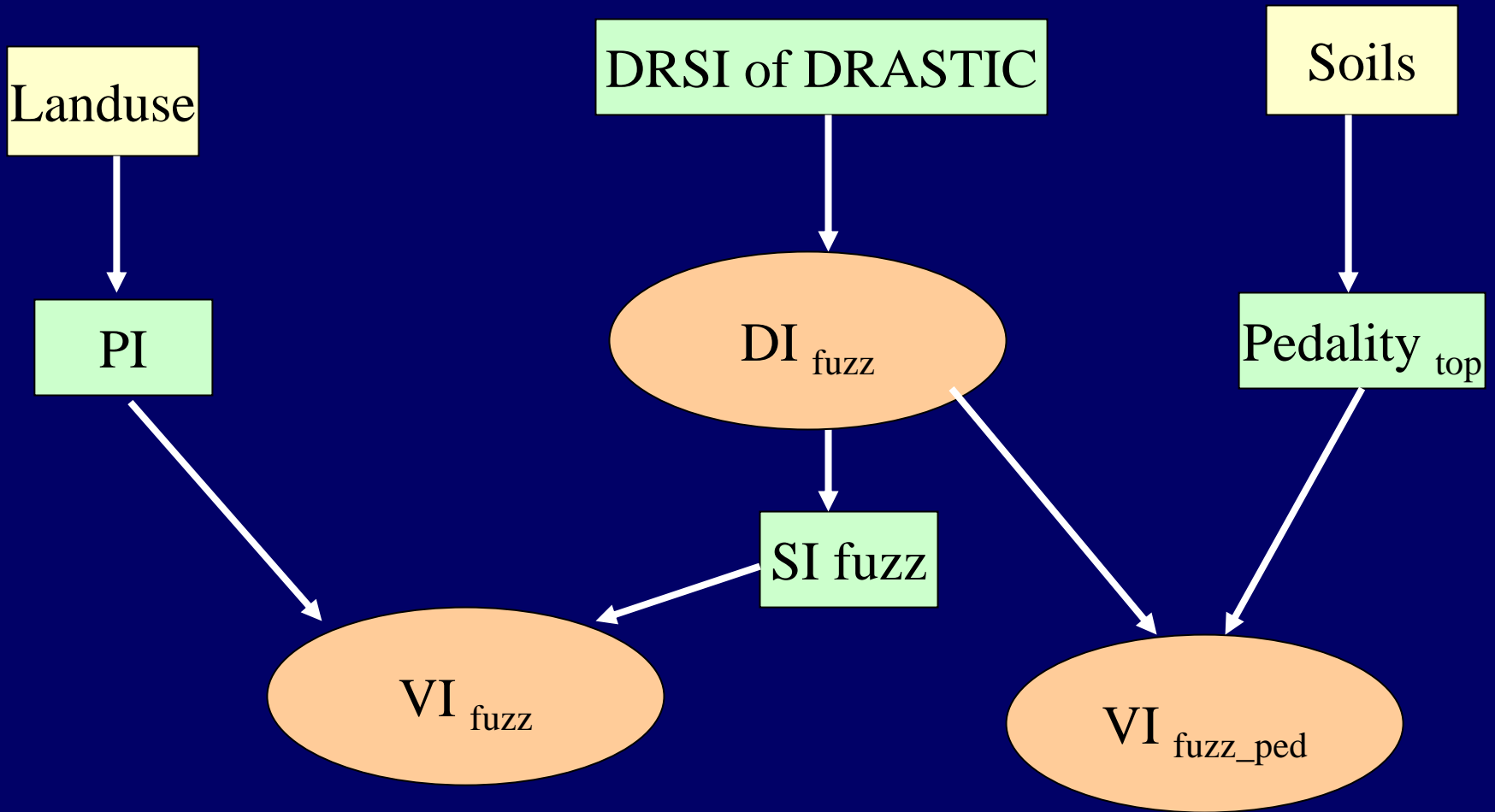
- ✓ DRASTIC model
- ✓ DI_{fuzz} model
- ✓ VI_{fuzz} model
- ✓ VI_{fuzz_ped} model

DI_{fuzz} = Modified DRASTIC Index based on fuzzy logic

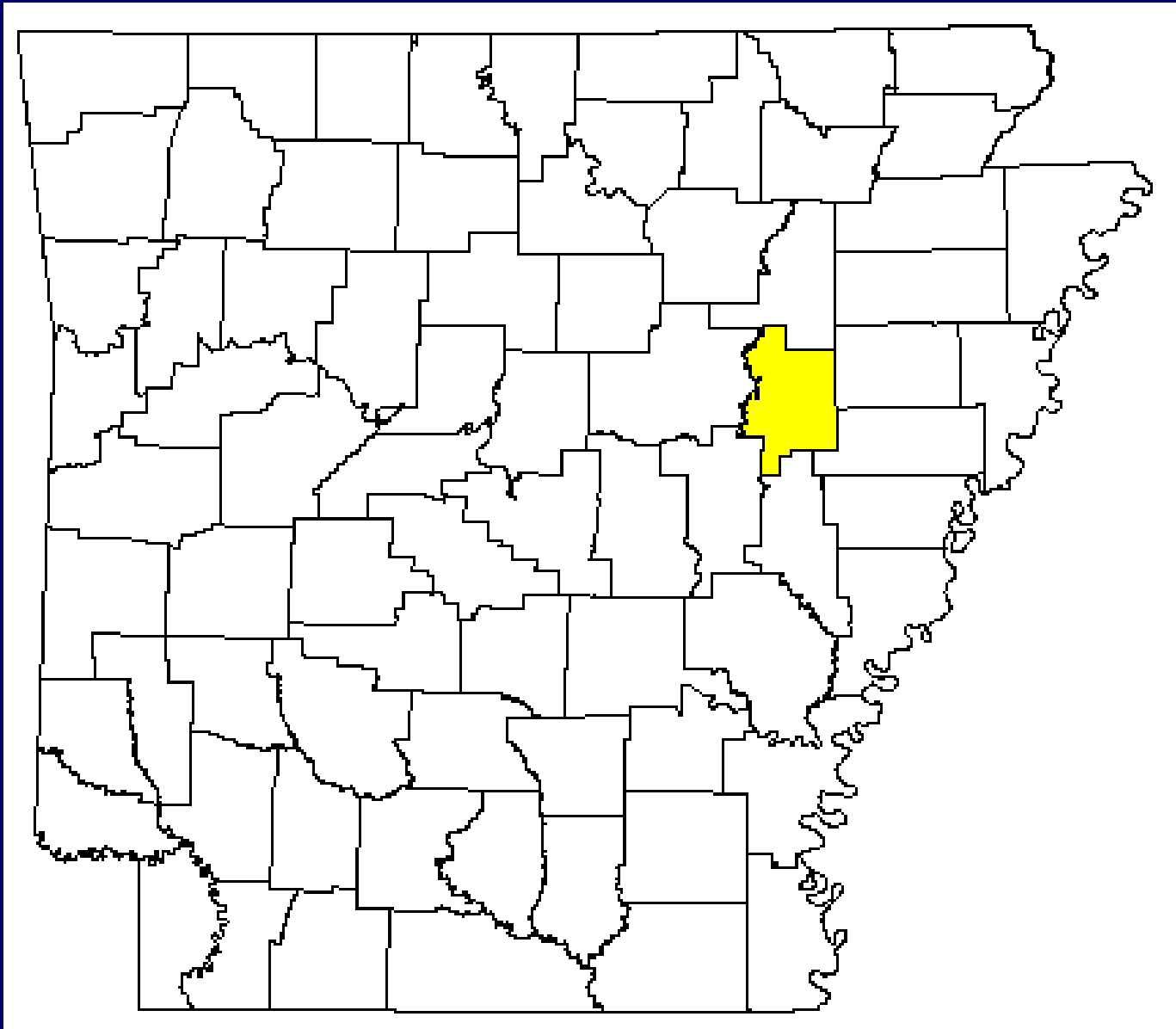
VI_{fuzz} = Vulnerability Index based on fuzzy logic and pesticide Information

VI_{fuzz_ped} = Vulnerability Index based on fuzzy logic and soils Information

The Link!



■ models



Location

Primary Data Layers Used

<u>Attributes</u>	<u>Source</u>
• Soils	NRCS
• Elevation	USGS
• Potentiometric surface	USGS
• Recharge	USGS
• Clay confining unit	USGS
• Geology	AGS
• Landuse	USGS
• Pesticide Application Rate	UAEX
• Well water quality/location	ADEQ

DRASTIC: The Vulnerability Model

- The agricultural DRASTIC model was developed for EPA by the American Water Well Association (AWWA) to assess ground water vulnerability from the physical parameters (Aller et al., 1987)

DRASTIC

- D = Depth to ground water
- R = Net Recharge of the aquifer
- A = Type of Aquifer media
- S = Soil media
- T = Topography (Slope)
- I = Impact of the vadose zone
- C = Hydraulic Conductivity of the aquifer

Nature of Model

$$DI = DrDw + RrRw + ArAw + SrSw + TrTw \\ + IrIw + CrCw$$

r = ratings (1- 10)

w = weight (3 - 7)

Aller et Al., 1987

Summary of Parameters used in DRASTIC Models

Parameters	Weight	Range	Rate
D	5	0 - 75	10 - 3
R	4	0 - 9	1 - 9
S	5	Soil Series	0 - 10
I	4	0 - 10	8 - 1
A, T, C	3, 3, 2	N.A.	

The Model: DI_{fuzz}

- Four parameters from DRASTIC were incorporated in fuzzy logic-based model

✓ D

✓ R

✓ S

✓ I

The Model: VI fuzz

- $$VI_{fuzz} = \frac{(SI_{fuzz} * PI)}{VI_{fuzz_max}} * 100$$

- Where,

- SI_{fuzz} = Aquifer sensitivity index

- PI = Pesticide loading Index

- VI_{fuzz_max} = Maximum value of the fuzzy rule-based vulnerability

- $SI_{fuzz} = (DI_{fuzz} / DI_{fuzz_max}) * 100$

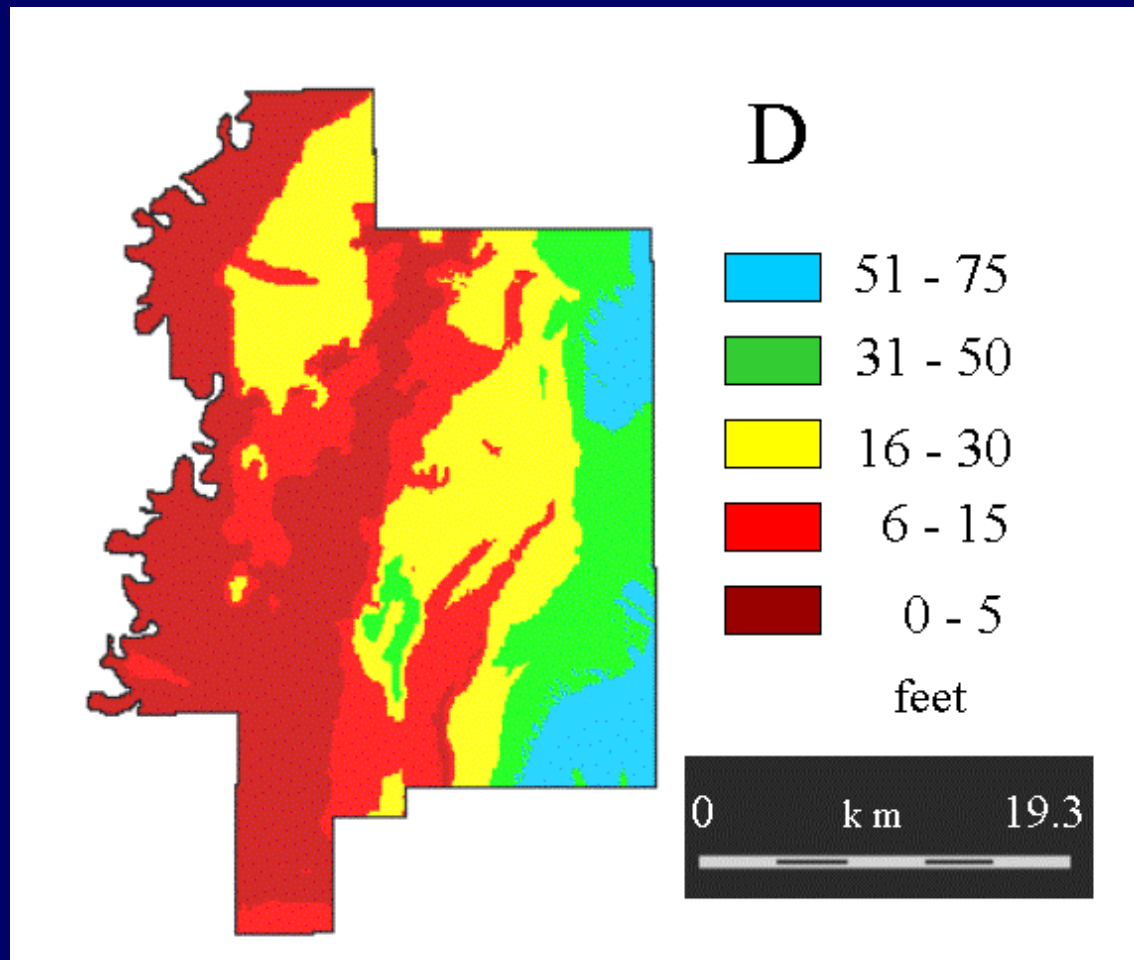
The Model VI_{fuzz_ped}

- $VI_{fuzz_ped} = DI_{fuzz} * Pedality_{top}$
- Where,
 - VI_{fuzz_ped} = vulnerability from the fuzzy rule-based model and soil structural information
 - DI_{fuzz} = Fuzzy rule-based vulnerability model
 - $Pedality_{top}$ = soil structure/ pedality information

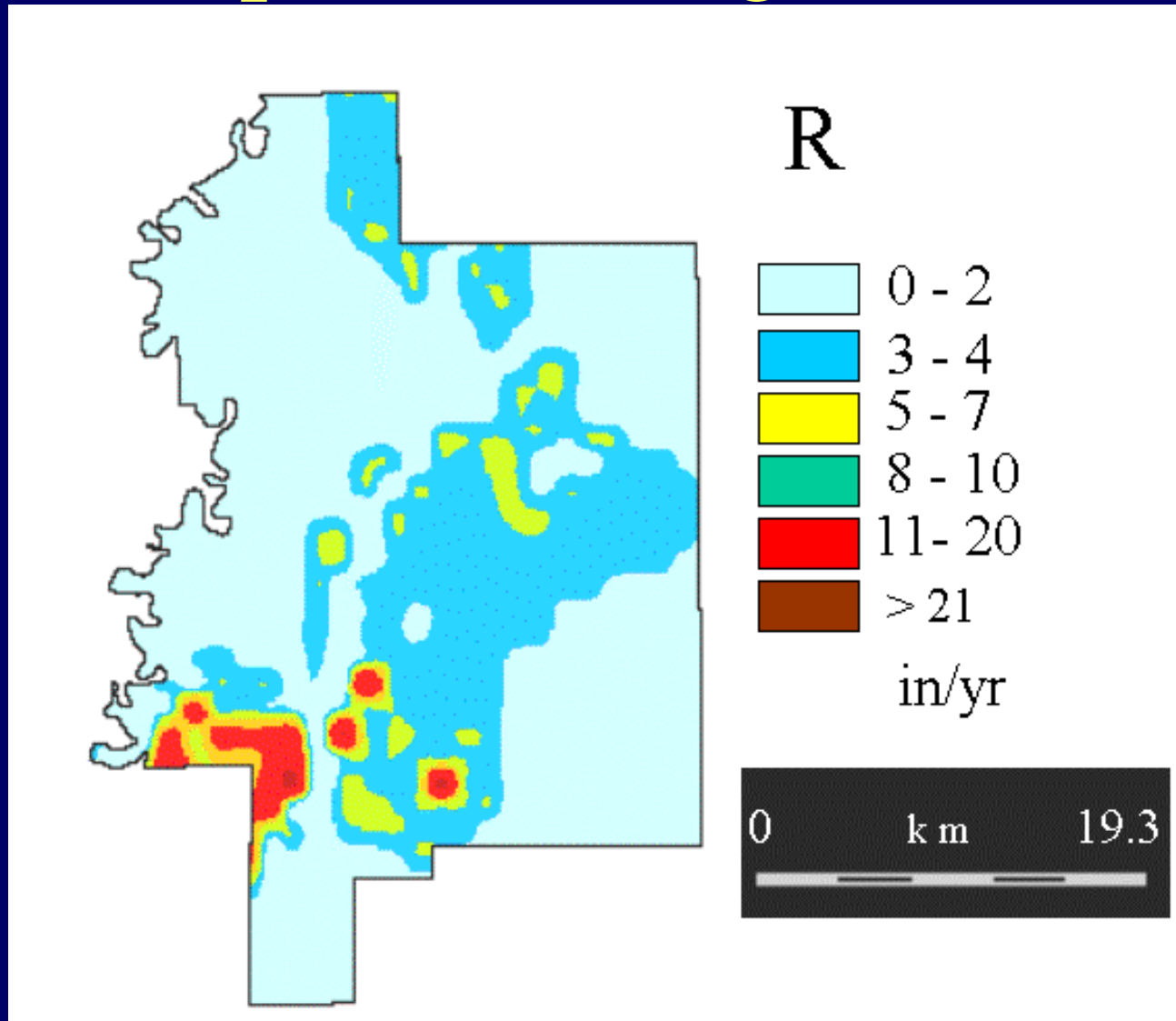
DI_{fuzz}: Model Inputs

- D
- R
- S
- I

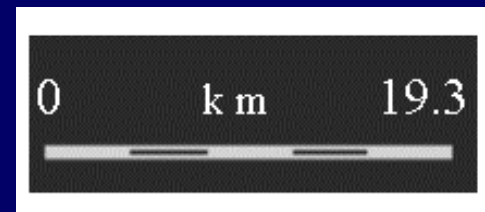
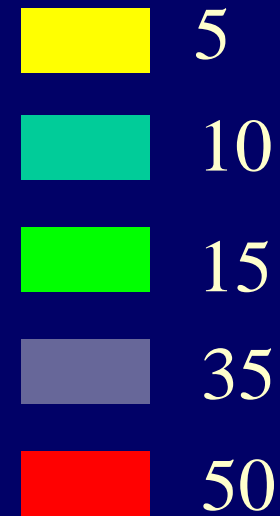
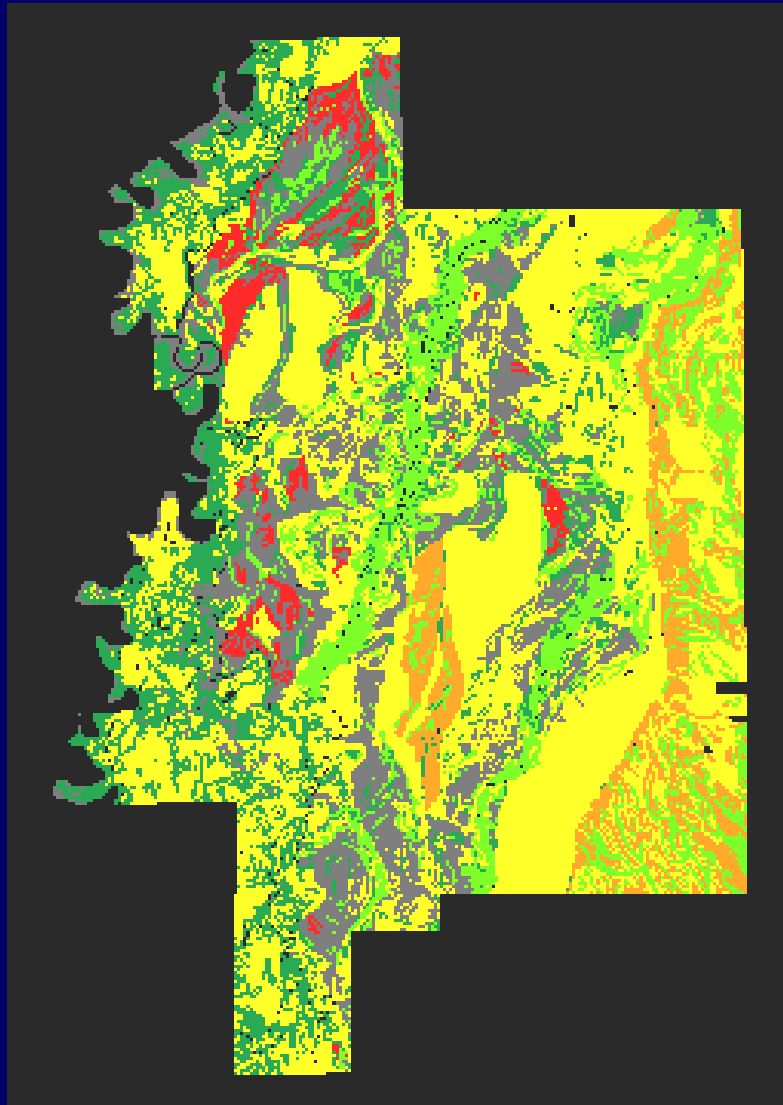
Input: Depth to Ground Water (D)



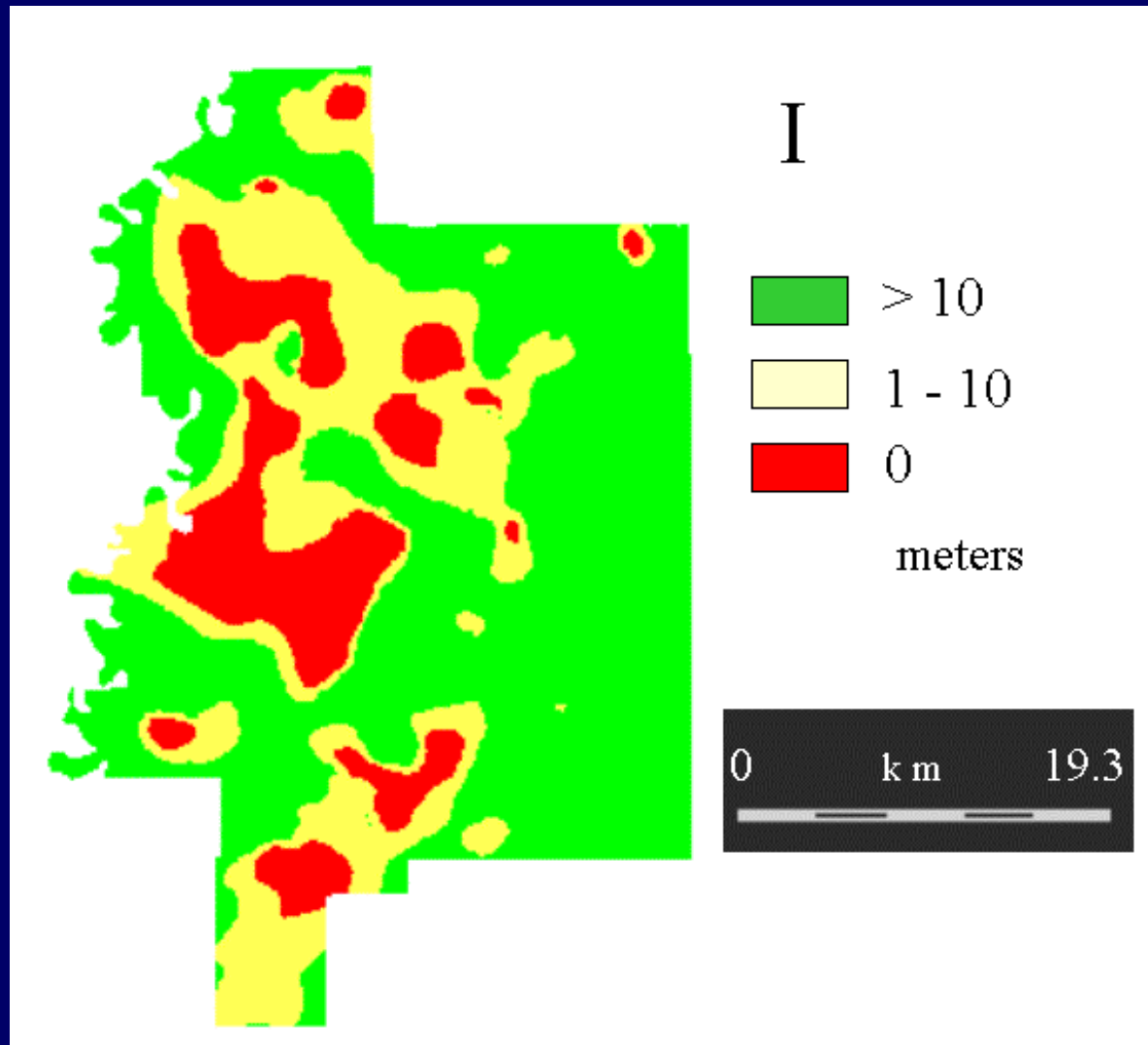
Input: Recharge (R)



Input: Soil Media (S)



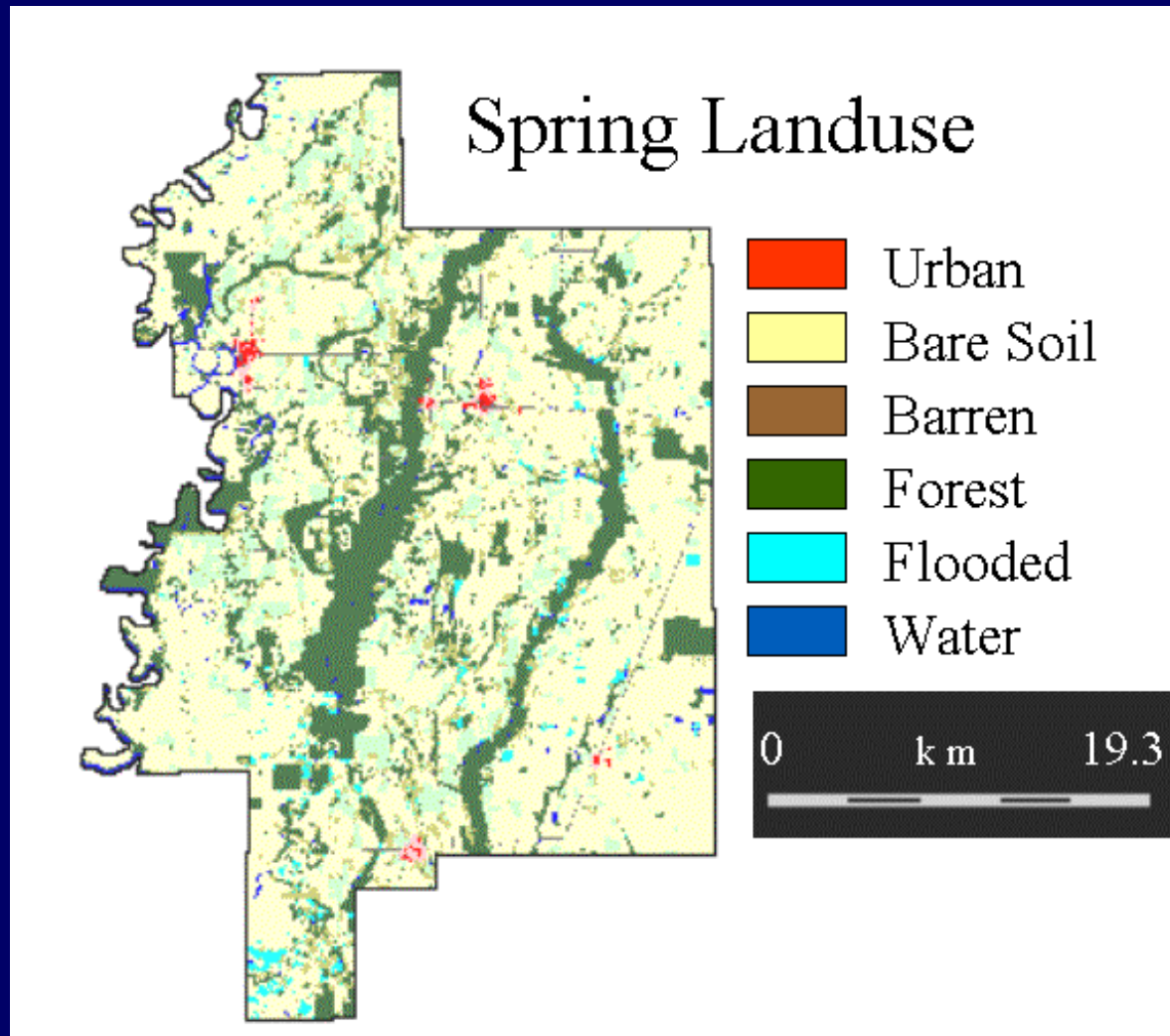
Input: Impact of the Vadose Zone



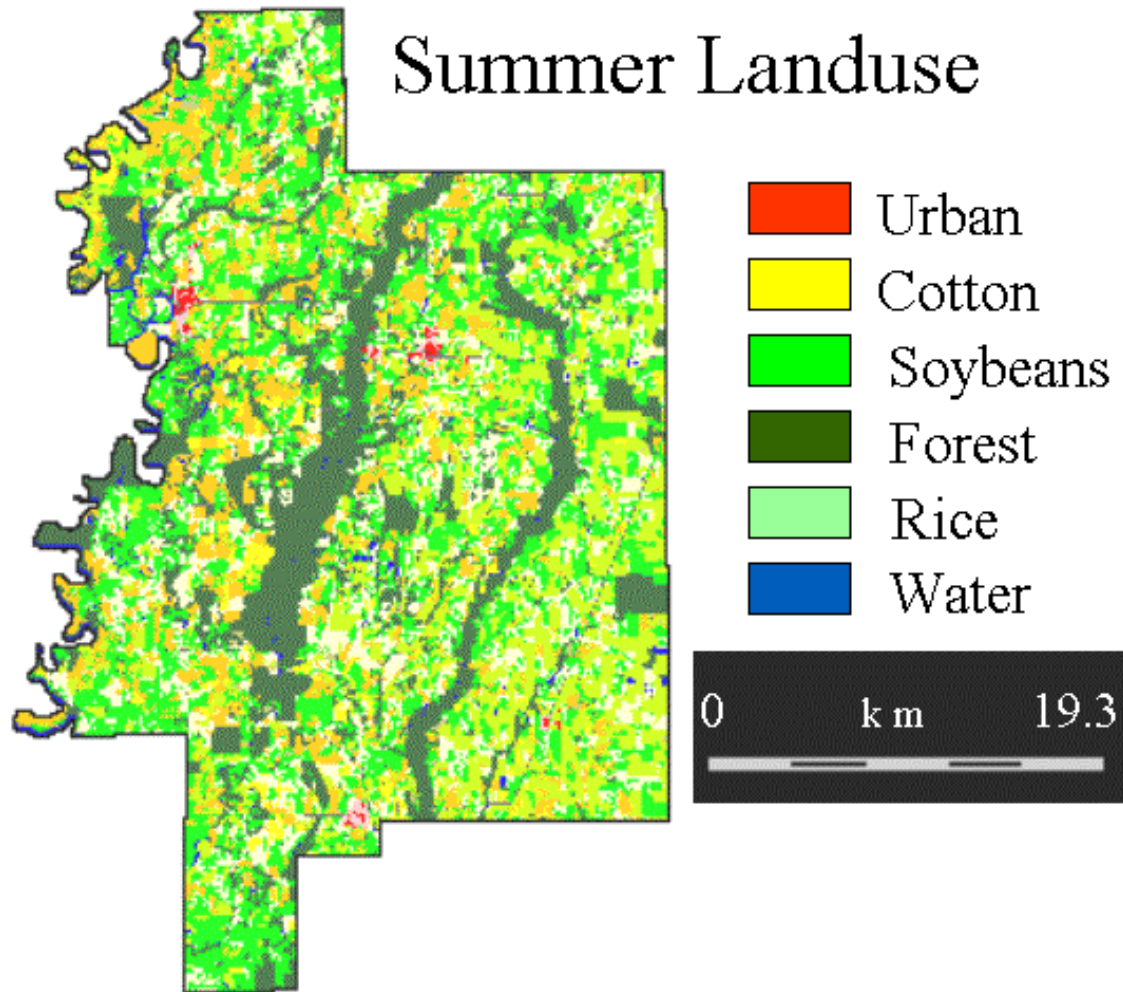
Model Input: VI_{fuzz}

- Pesticide loading index based on landuse

Landuse: Spring



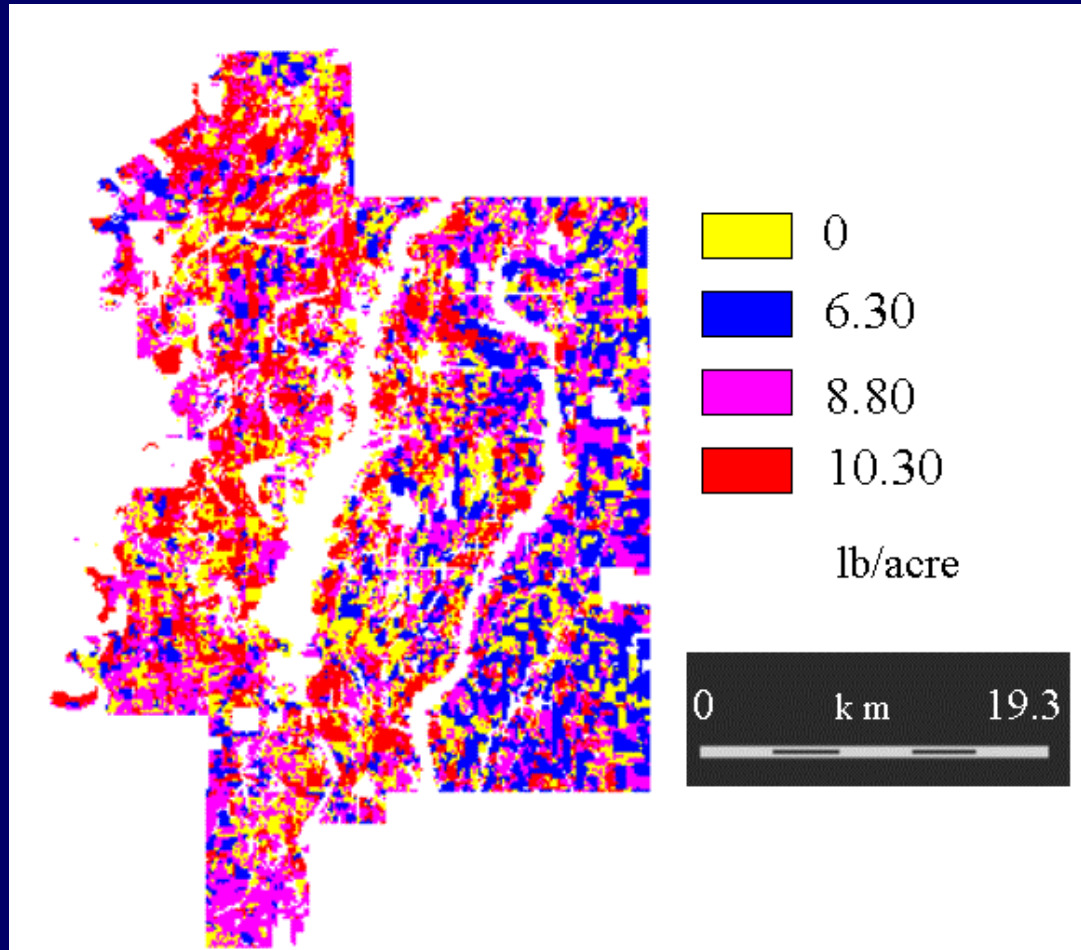
Landuse: Summer



Average Application Rate of Pesticide Application for Major Crops

Crops	Application (lbs/acre)
Soybean	8.825
Rice	6.313
Cotton	8.7
Wheat	1.625
Grain Sorghum	10.25
Corn	10.1

Input: PI



PI = Pesticide Loading Index

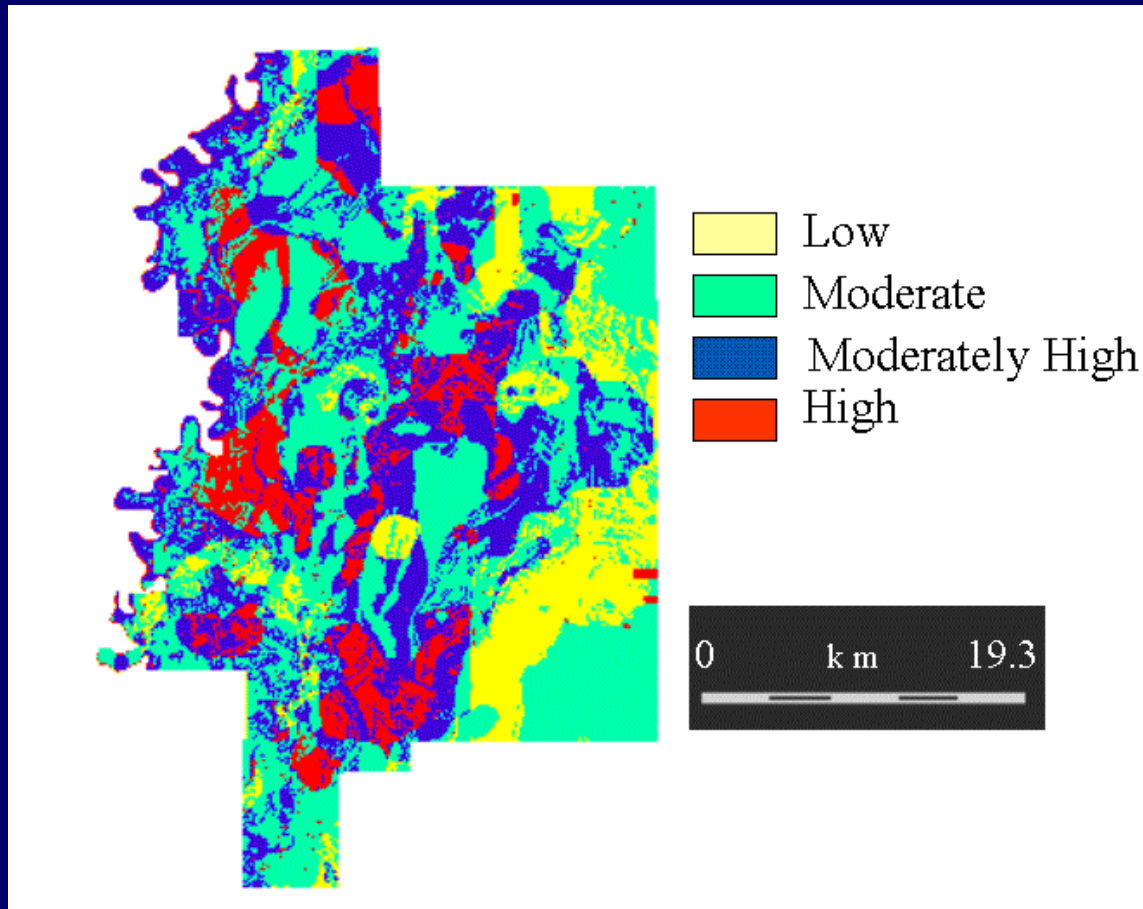
Outputs: The Three Models

DI fuzz

VI fuzz

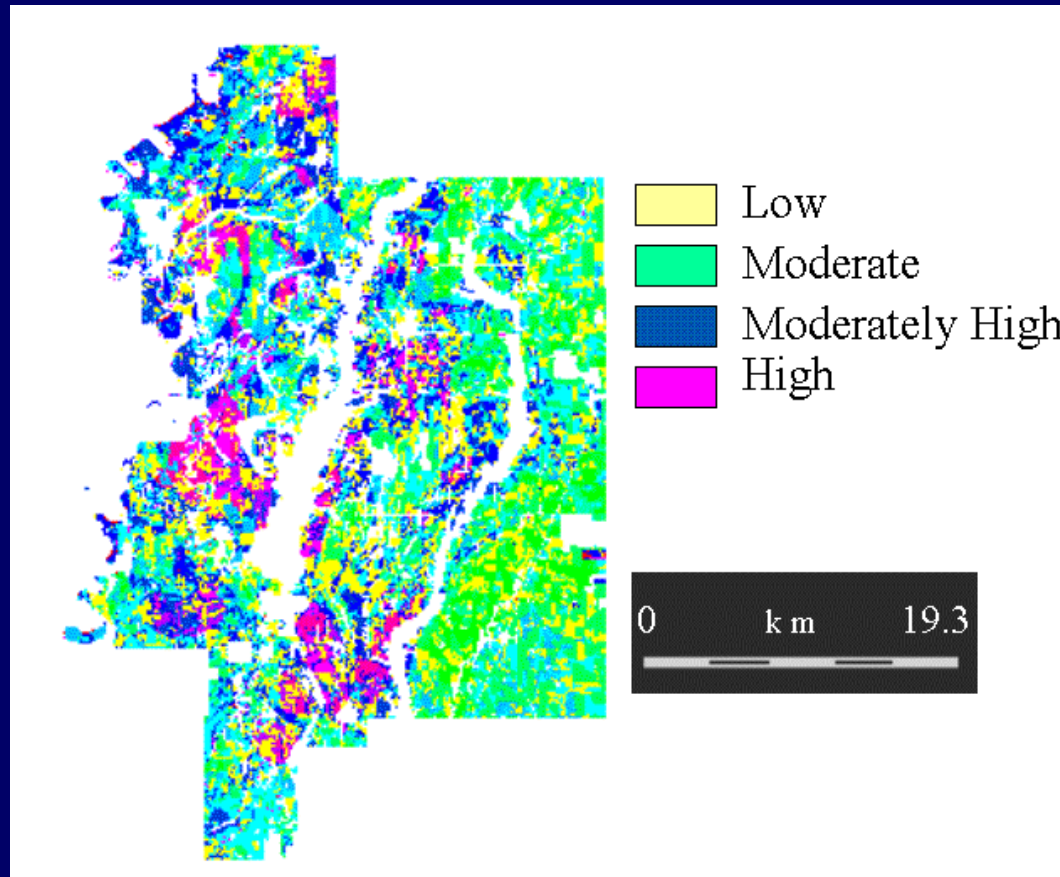
VI fuzz_ped

DI_{fuzz} : Vulnerability Categories



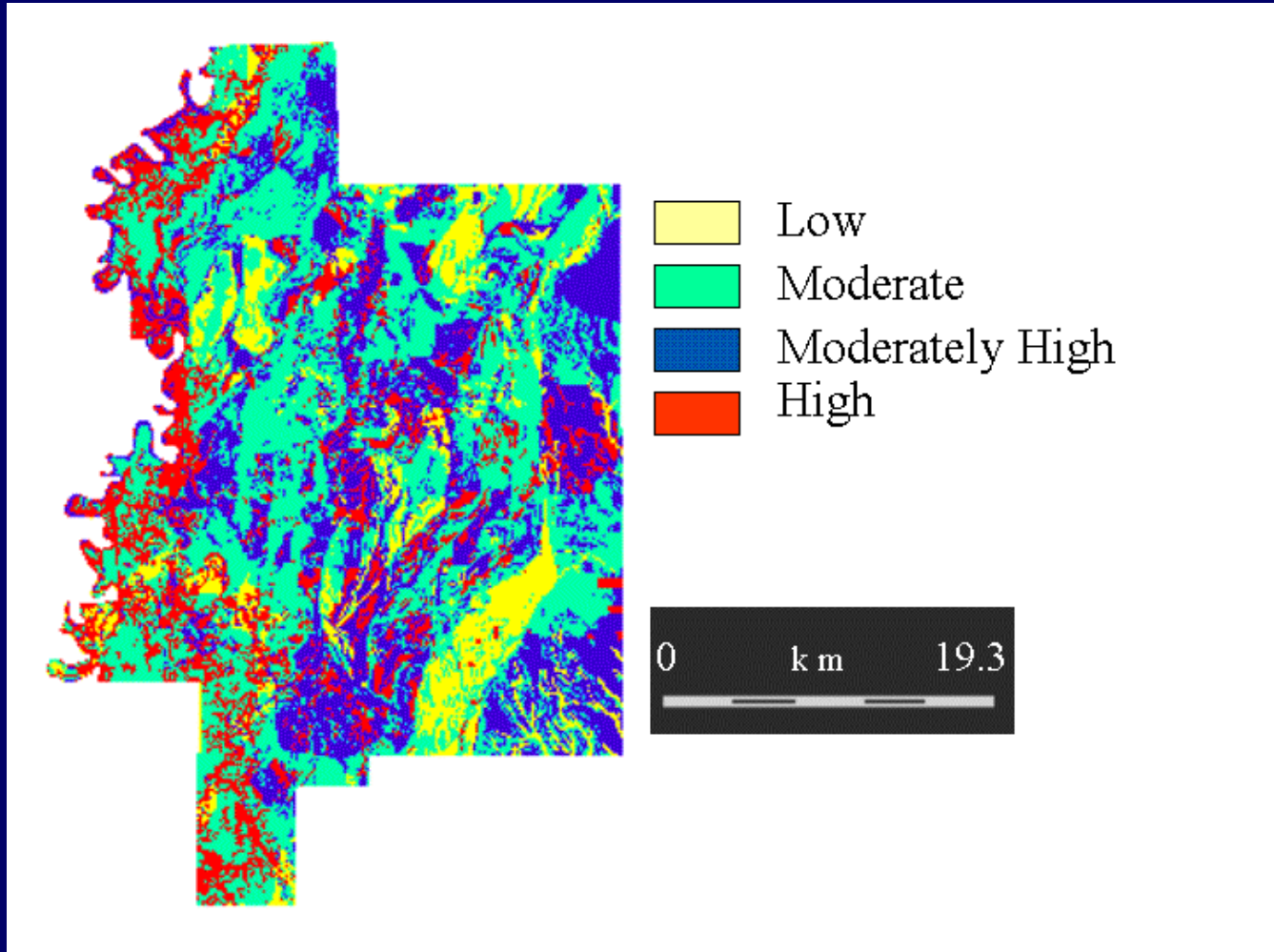
Fuzzy rule-based model with DRSI as inputs

VI_{FUZZ} : Vulnerability Categories



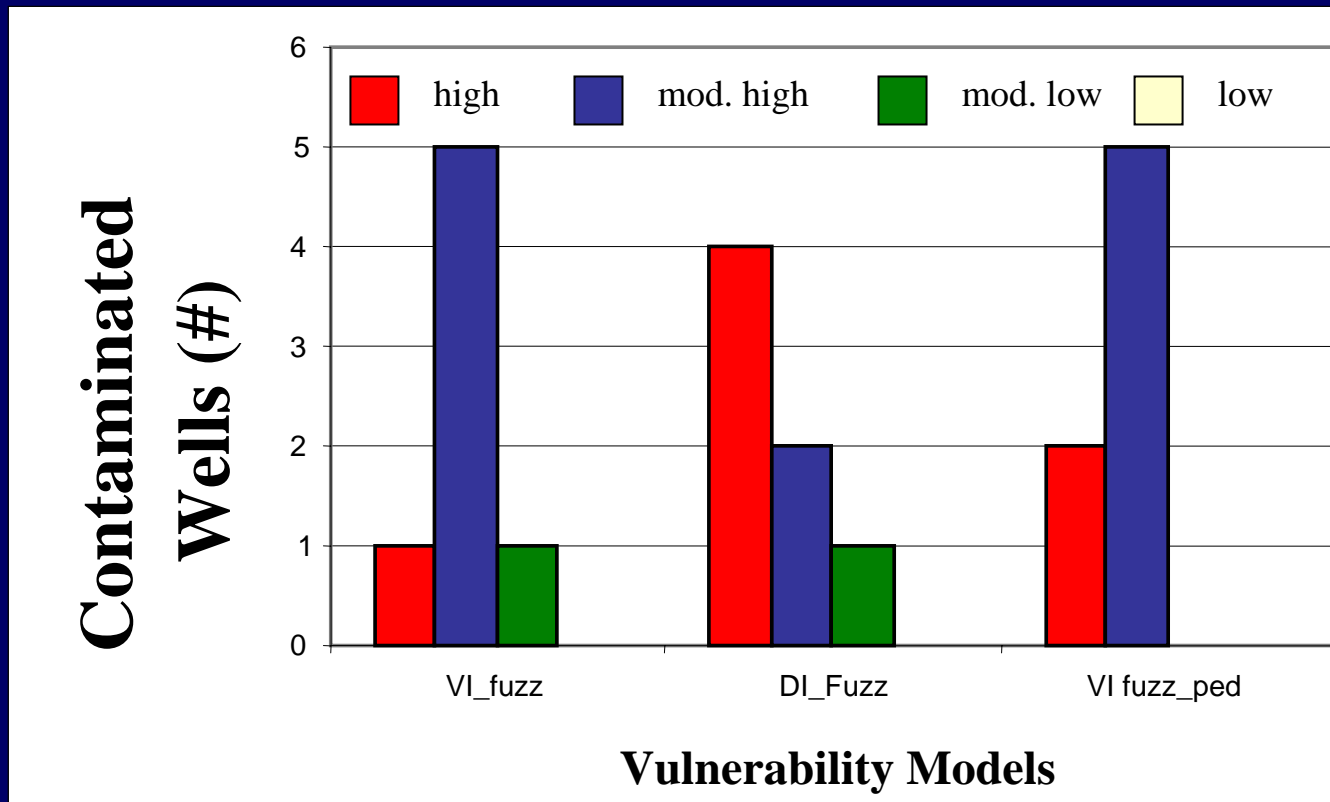
SI_{fuzz} and PI as model inputs

$VI_{FUZZ-PED}$: Vulnerability Categories

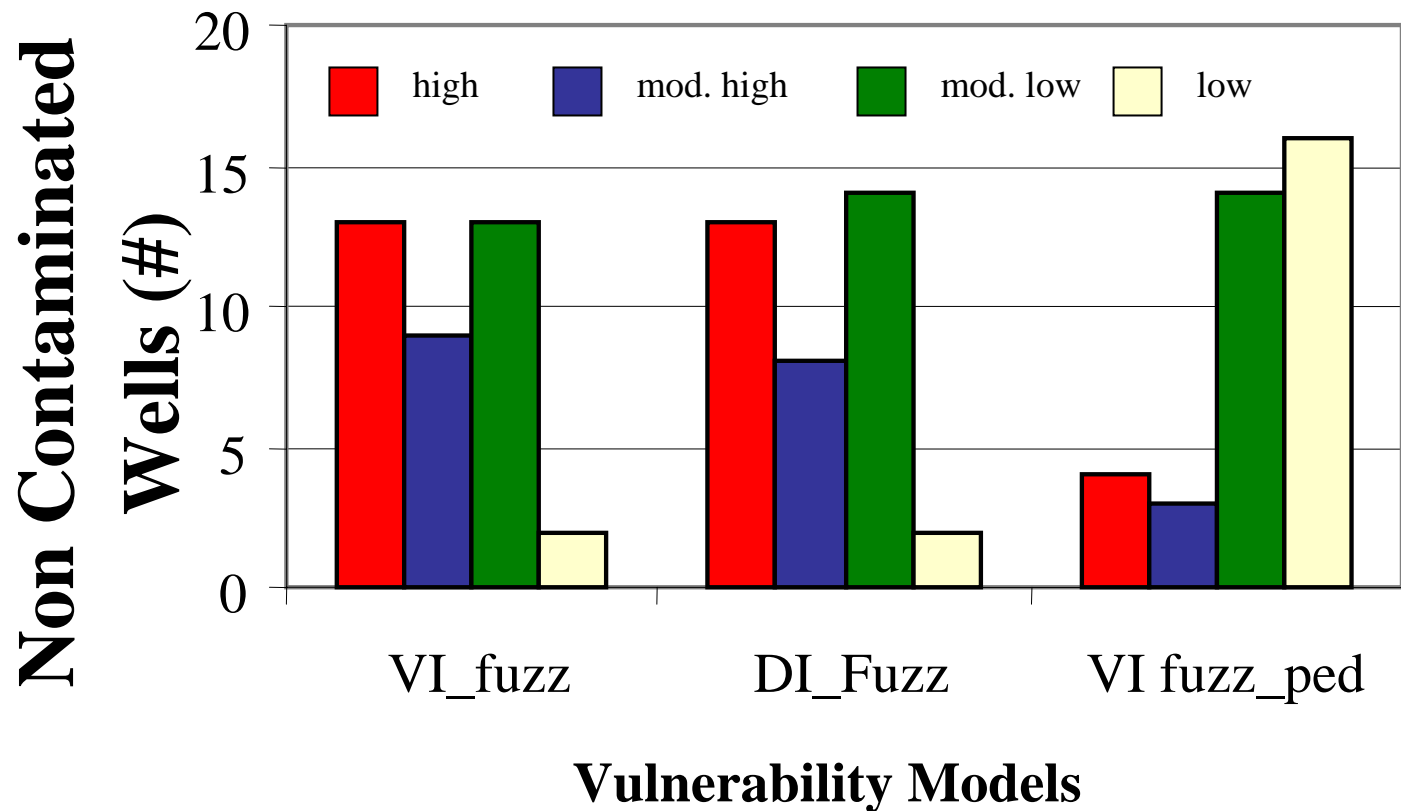


DI_{fuzz} and Soils as model input

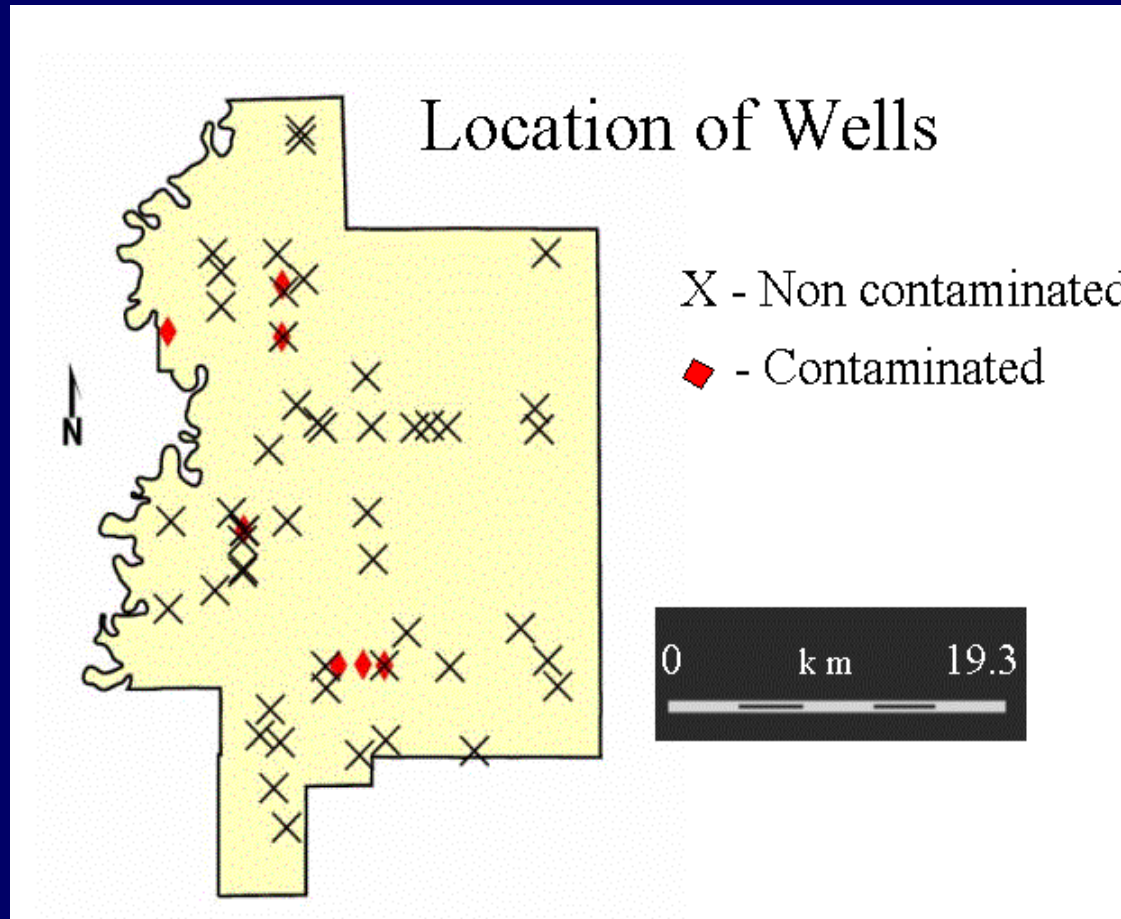
Mutual Occurrence of Contaminated Wells and Different Models



Mutual Occurrence of Non Contaminated Wells and Different Models



Location of Wells



Name and Occurrence of Pesticides

Pesticide	Occurrence
Bentazon	4
Metalochlor	2
Acifluorfen	1
Fluometron	1
Metribuzin	1

Conclusions

- The preliminary fuzzy rule-based model DI_{fuzz} generated by incorporating four parameters from the DRASTIC model was not adequate.
- The vulnerability map from the model VI_{fuzz_ped} showed better results when compared with the field water quality data.
- This map was generated using fuzzy rule-based model and soil structure (pedality) information.

Conclusions cont..

- The model VI_{fuzz} was generated using pesticide loading information which did not improve the prediction.
- Incorporation of pesticide use information needed to be explored further.