# FINE-SCALE (HUC 12) WATERSHED SAMPLING TO COMPLEMENT OR IN PLACE OF WATERSHED MODELING

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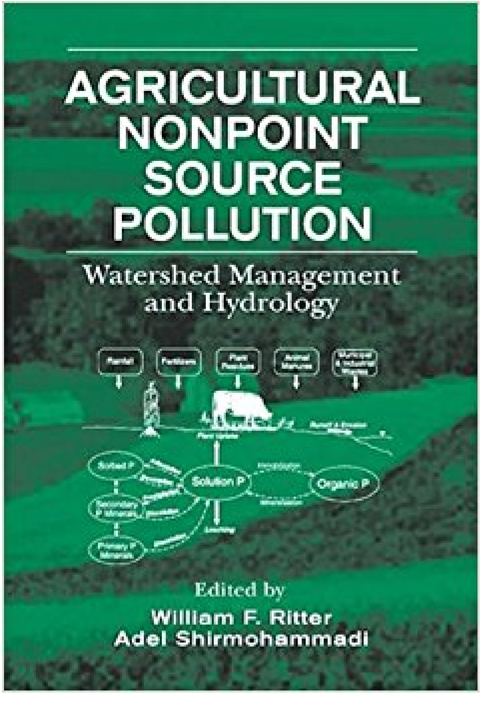
“Only two methods for tracking the environmental fate of chemicals and assessing the effectiveness of NPS management techniques…” (Shirmohammadi, Montas, Bergstrom, and Kinsel, 2000)

1. Field monitoring
2. Computer modeling




## Limitations of field monitoring

- Expensive to collect data for loads
  - Sample collection
    - A lot of man hours goes into sampling across the full range of flow conditions.
  - Equipment for monitoring flow is needed for load calculations.
  - Analysis of samples

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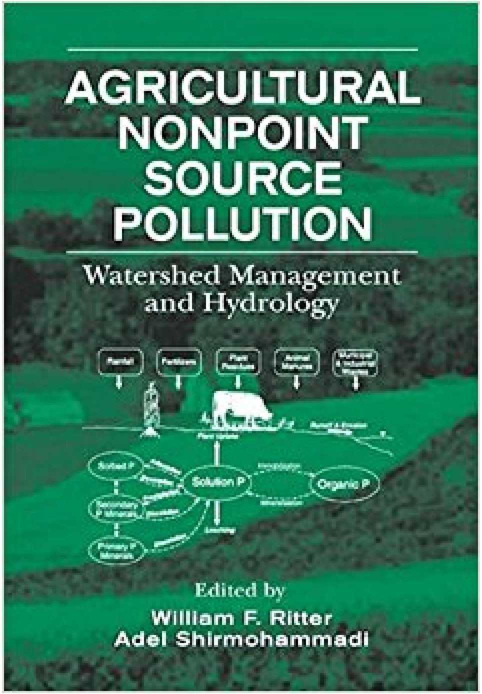
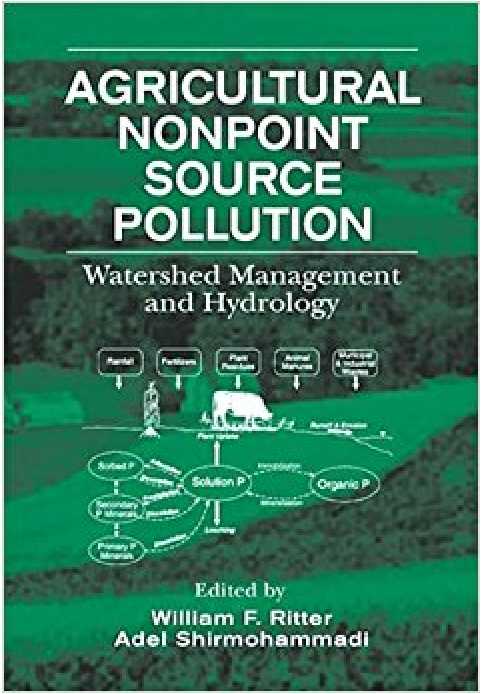



## <u>Limitations of field monitoring</u>

- Expensive to collect data for loads
- Long term datasets needed
  - Multiple years of data are needed to get at the variability seen in loads associated with wet and dry years.

"Only two methods for tracking the environmental fate of chemicals and assessing the effectiveness of NPS management techniques…" (Shirmohammadi, Montas, Bergstrom, and Kinsel, 2000)

1. Field monitoring
2. **Computer modeling**



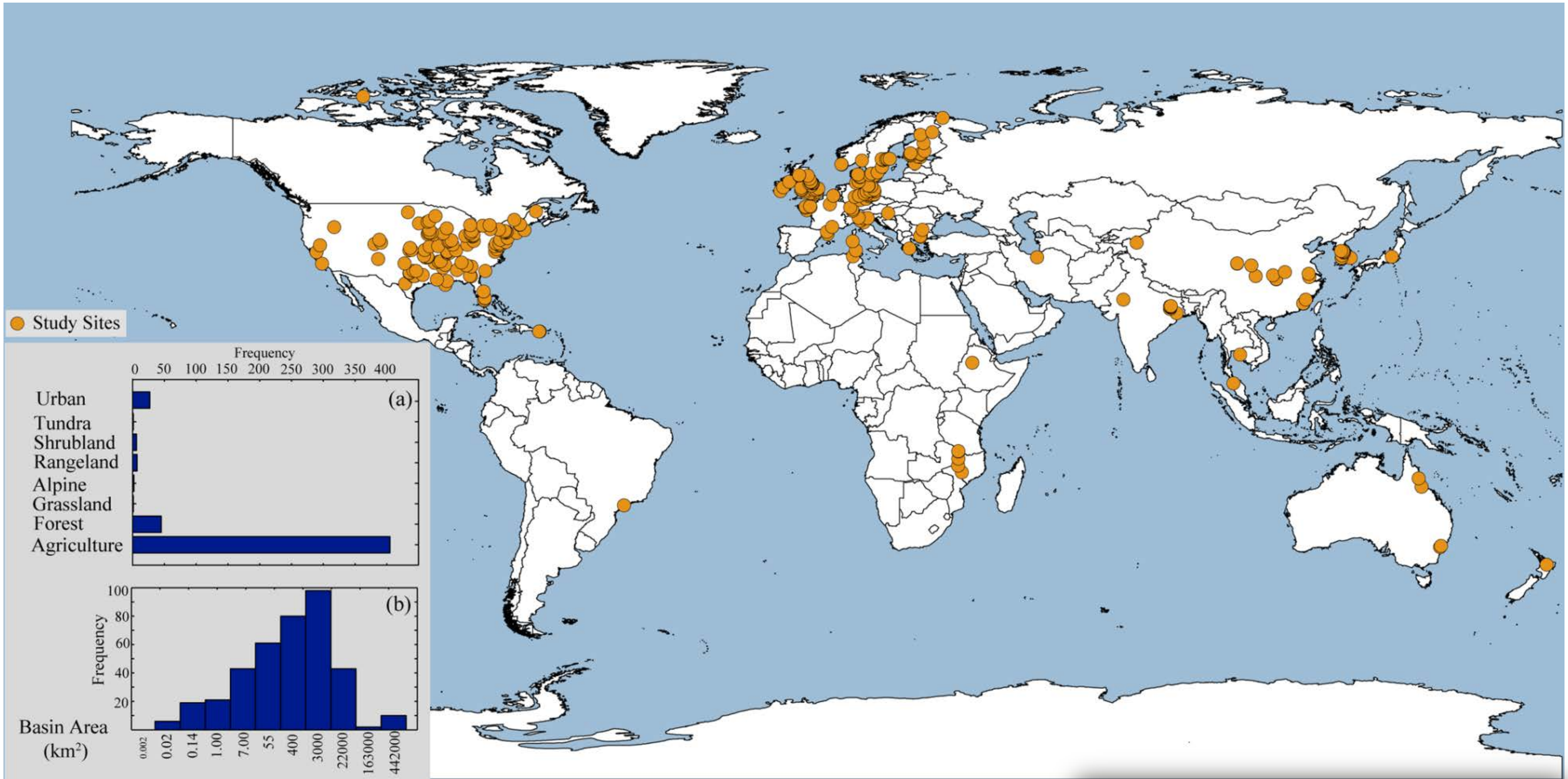

Basically, modelling allows you to predict loads under a bunch of "What If?" scenarios, that you can't always collect the necessary data for through edge of field methods.

# What goes into developing a model?

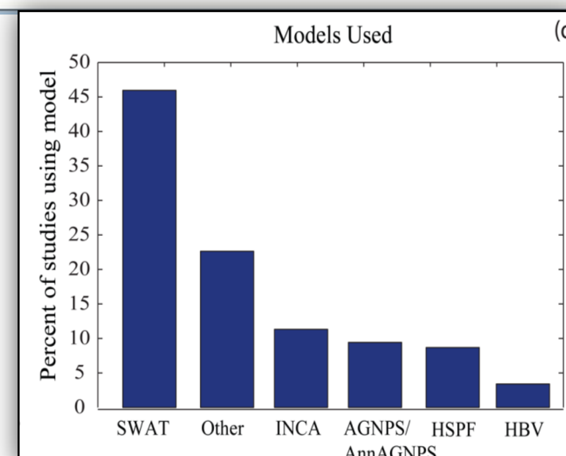
1. Identify the Question/Purpose
   – Prioritize HUC 12 watersheds for conservation
2. Select the Model that Best Fits the Purpose
3. Database Compilation
4. Model Calibration
5. Model Validation

# Watershed Modeling Options

- Chemicals, Runoff, and Erosion from Agricultural Management Systems (CREAMS)
- Areal Nonpoint-Source Watershed Environment Response Simulation (ANSWERS)
- Kinematic Runoff & Erosion Model (KINEROS)
- Groundwater Loading Effects of Agricultural Management Systems (GLEAMS)
- Agricultural Nonpoint-Source Model (AGNPS)
- Dynamic Watershed Simulation Model (DWSM)
- Erosion Productivity Impact Calculator (EPIC) Model
- Storm Water Management Model (SWMM)
- Hydrologic Simulation Package-Fortran (HSPF)
- Spreadsheet Tool for Estimating Pollution Load (STEPL)
- Pollution Loads for Watersheds (PLOAD)
- Long-Term Hydrologic Impact Assessment (L-THIA)
- Soil-Water Assessment Tool (SWAT)




- Watershed modeling is used globally.
- Primarily to predict the effects of agricultural land use for large watersheds.
- Of all the models, the Soil-Water Assessment Tool or SWAT model is by far the most commonly used.




Wellen et al. 2015

SWAT modeling is commonly used in both Arkansas and Oklahoma to prioritize subwatersheds for management purposes.

TECHNICAL REPORTS: SURFACE WATER QUALITY

## Evaluating Nonpoint Source Critical Source Area Contributions at the Watershed Scale

**Michael J. White*** USDA-ARS
**Daniel E. Storm and Philip R. Busteed** Oklahoma State University
**Scott H. Stoodley** AMEC Earth & Environmental
**Shannon J. Phillips** Oklahoma Conservation Commission

## IDENTIFYING PRIORITY SUBWATERSHEDS IN THE ILLINOIS RIVER DRAINAGE AREA IN ARKANSAS WATERSHED USING A DISTRIBUTED MODELING APPROACH

advances in watershed management

N. Pai, D. Saraswat, M. Daniels

WATER RESOURCES RESEARCH, VOL. 45, W06406, doi:10.1029/2008WR007094, 2009



## Development of a multiobjective optimization tool for the selection and placement of best management practices for nonpoint source pollution control

Chetan Maringanti,[1] Indrajeet Chaubey,[1,2] and Jennie Popp[3]

Received 15 April 2008; revised 3 March 2009; accepted 26 March 2009; published 11 June 2009.

# What goes into developing a model?

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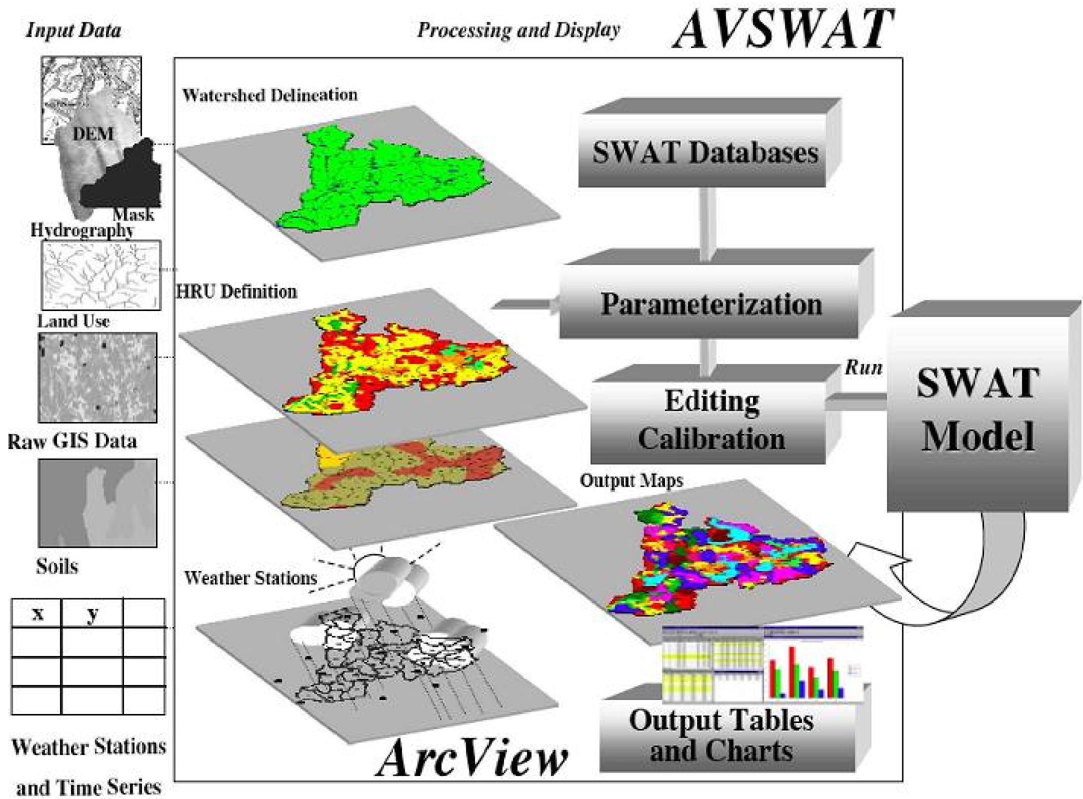
# Compiling Data

- Weather
  - Precipitation
  - Wind speed
  - Relative humidity
  - Temperature
  - Solar radiation
- GIS Layers
  - Land use and cover
  - Soil
  - Topography
- Hydrology and Water Quality Data
  - Flow
  - Nutrients
  - Sediment

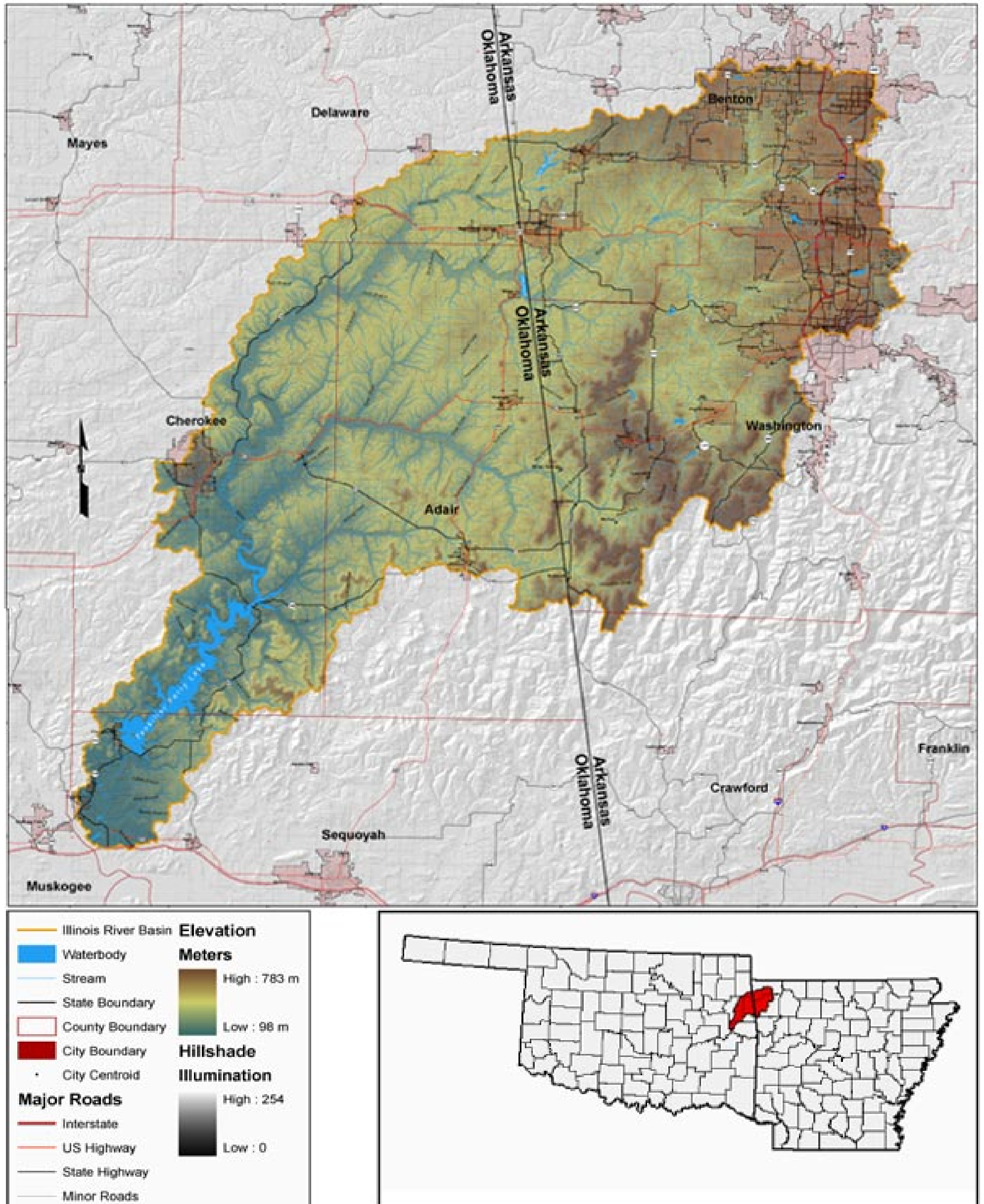



https://geo.arc.nasa.gov/sge/casa/hydrologic/swat.html

Used to generate Hydrologic Response Units (HRU's)

Important for calibration and validation of the model

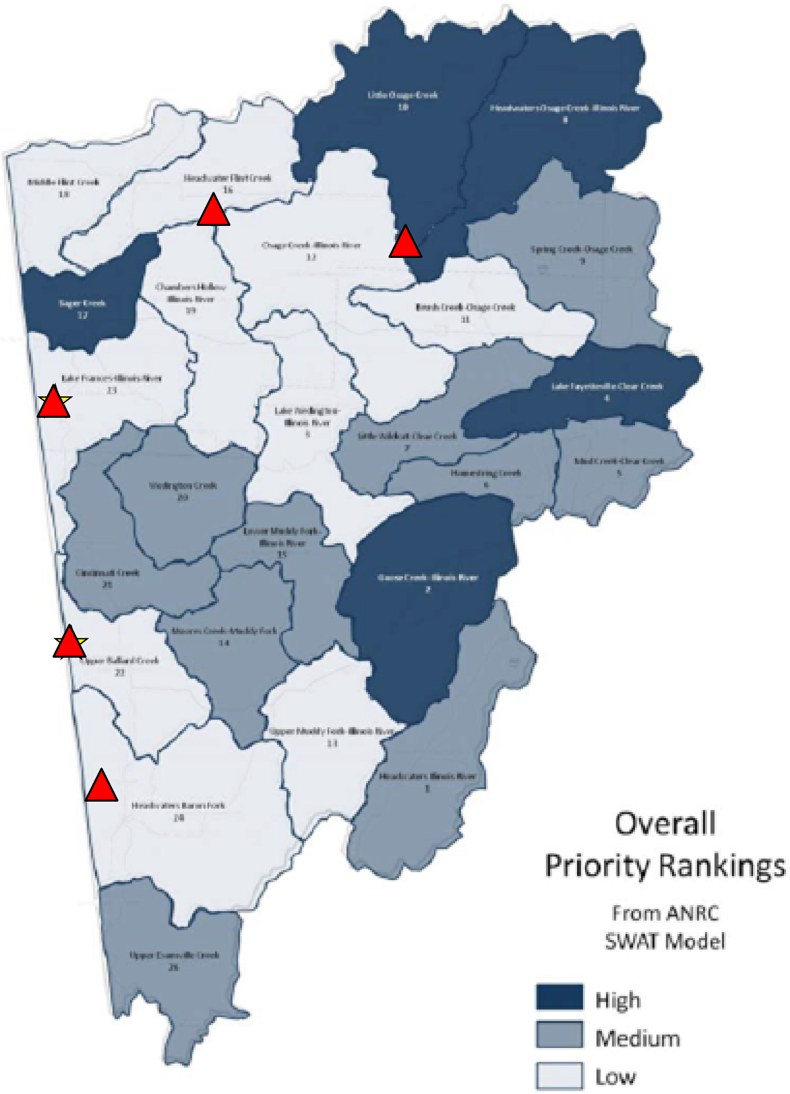
# Comparing Two Methods for HUC 12 Prioritization




## A Tale of Two Agencies… (and two methods)

- ANRC considers the IRW to be a priority watershed.
  - For all of their priority watersheds, ANRC uses SWAT modeling to prioritize the subwatersheds.
- Illinois River Watershed Partnership
  - At the same time IRWP was working with a separate group to prioritize the sub-watersheds using water quality monitoring data.

# Comparing Two Methods for HUC 12 Prioritization

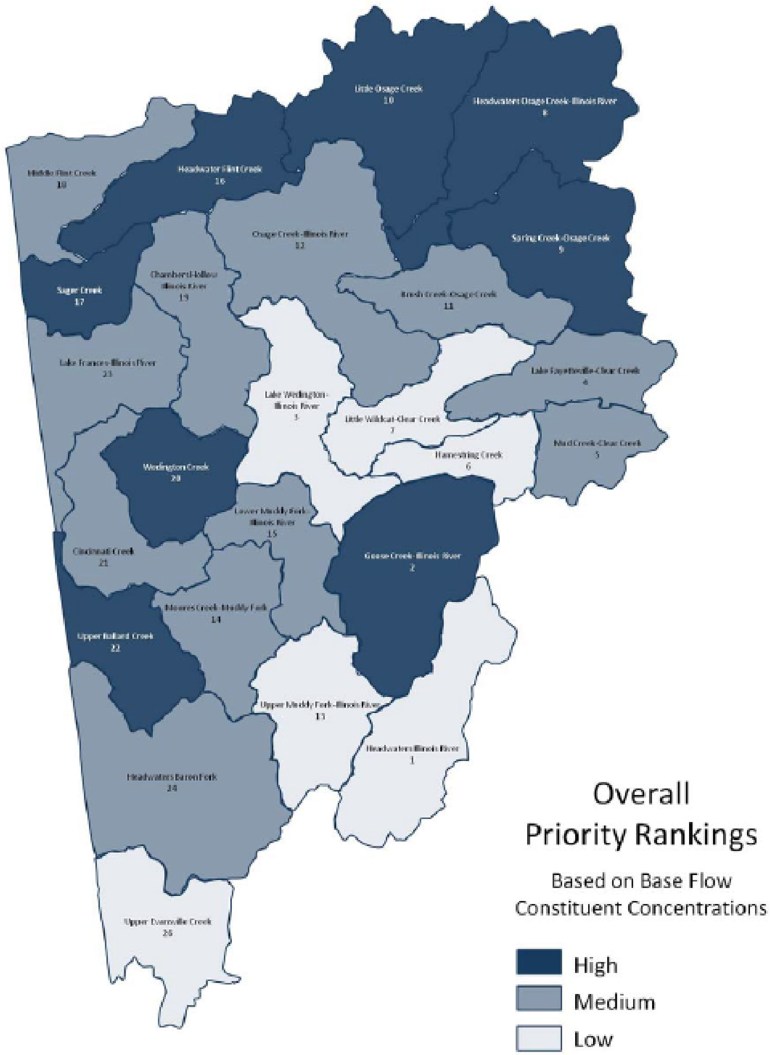



Saraswat et al. 2009

## SWAT Model

- The model was calibrated at the HUC 8 watershed scale
  - 5 sites used for flow calibration
  - Only 2 sites were used to calibrate nutrient and sediment loads
    - Illinois River
    - Ballard Creek
- Priority rankings are based on projected **non-point** source loads leaving each HUC 12 subwatershed
  - Each HUC 12 is an independent unit
- The darker the blue the higher the priority

# Comparing Two Methods for HUC 12 Prioritization



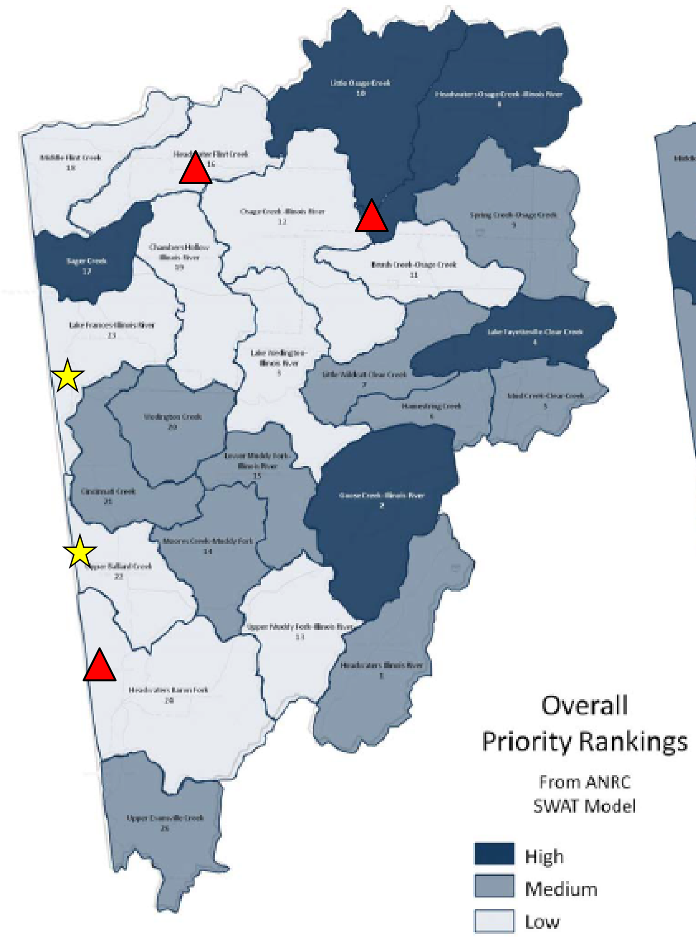

Haggard et al. 2010

## <u>Water Quality Monitoring</u>

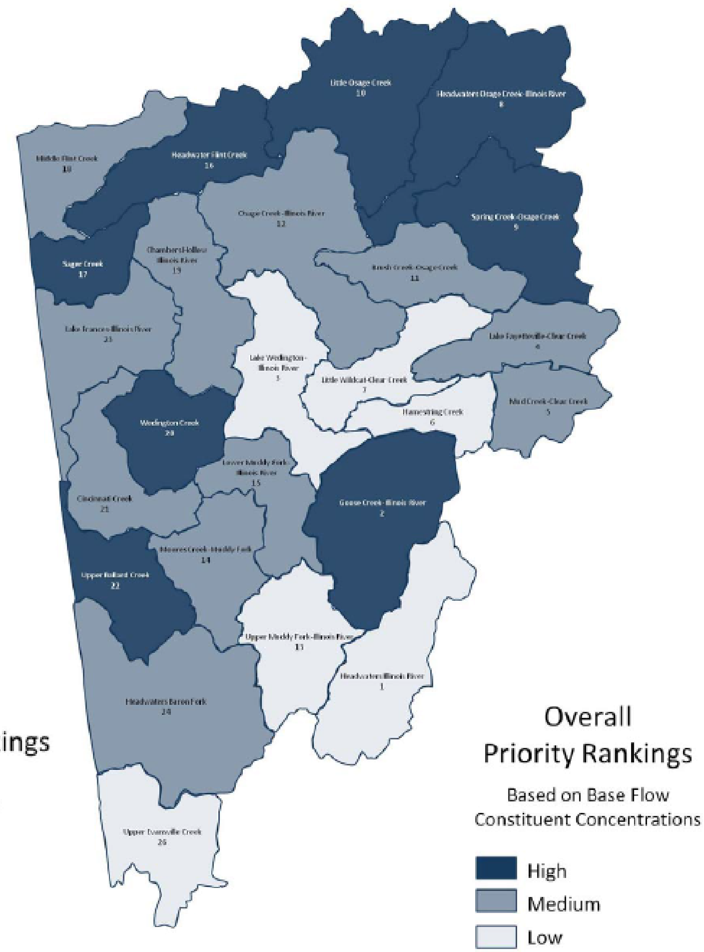
- Base flow WQ data collected at the outflow of each HUC 12.
- Data reflects both **point** and **non-point source** nutrients and sediments.
- HUC 12's are connected
  - What happens upstream influences what we see downstream
- The darker the blue the higher the priority

# What do we see when we compare these two approaches?

- There is a lot of overlap




Saraswat et al. 2009

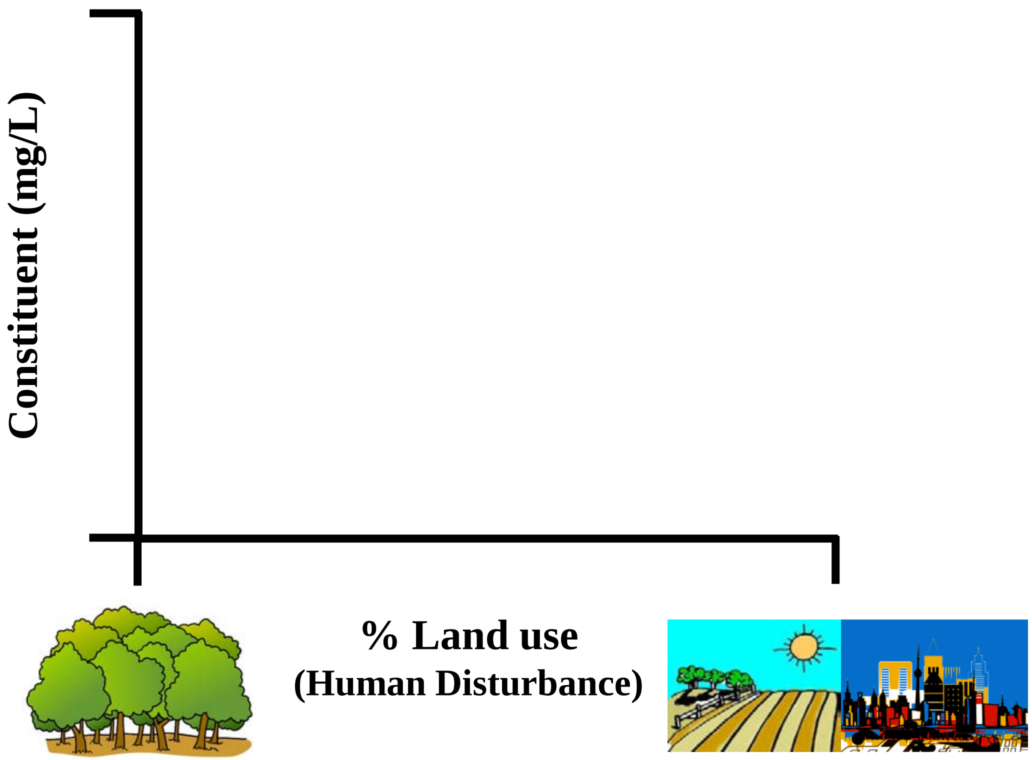



Haggard et al. 2010

However, there are some differences too.

- Some differences are easy to explain.
  - Point sources
  - Watersheds are connected
- Other differences are a bit more difficult to explain.
  - Ballard
  - Upper Illinois and Evansville HUC 12’s

Can we take what we learned from IRW about using water quality monitoring at base flow to prioritize HUC 12 watersheds in other basins?




- Yes! we think so.
- As % ag and urban land use increases

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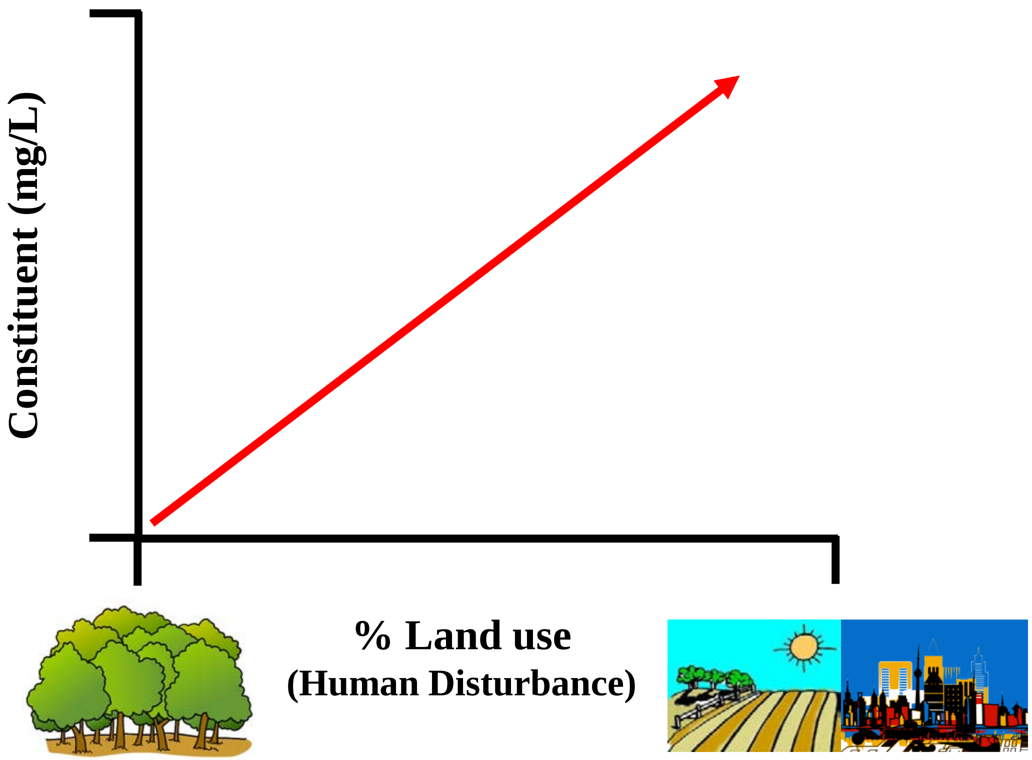


- Yes! we think so.
- As % ag and urban land use increase
  - Nutrient and sediment concentrations increase

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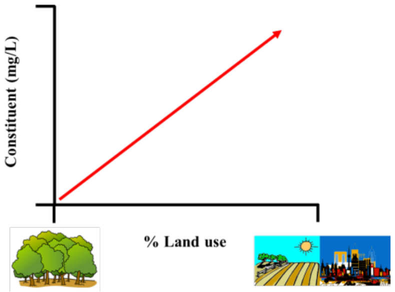
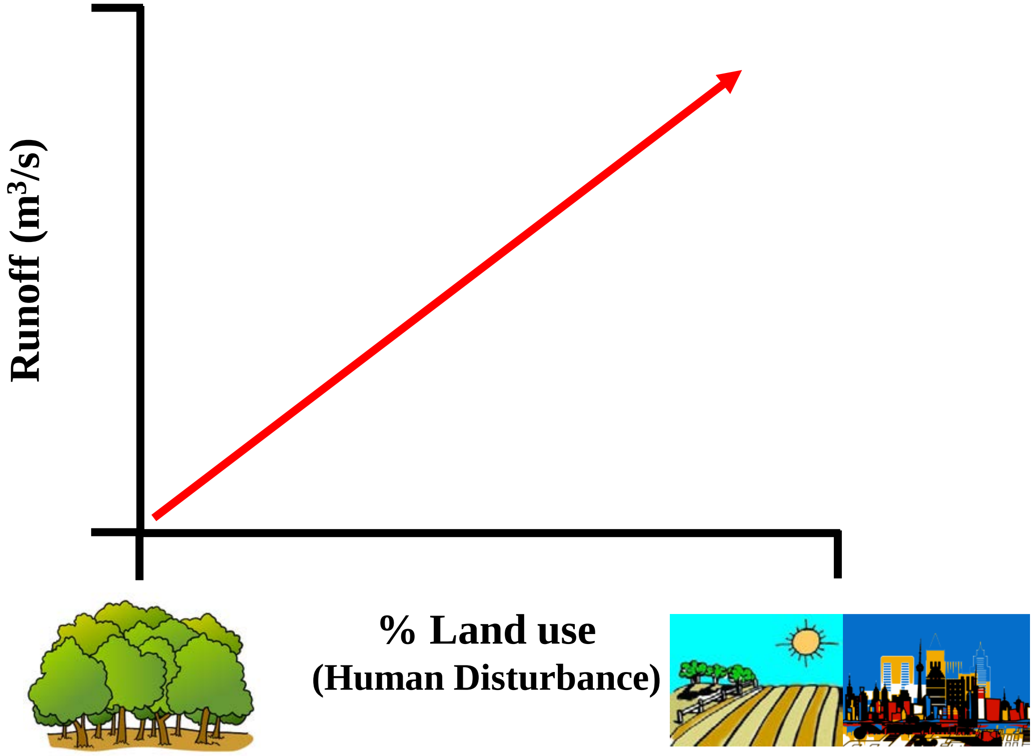
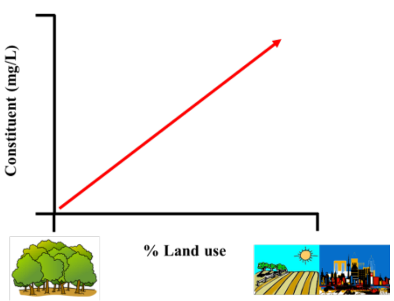
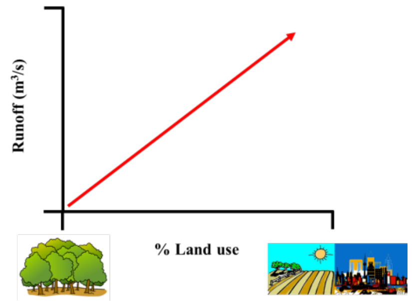



- Yes! we think so.
- As % ag and urban land use increase:
  - Nutrient and sediment concentrations increase
  - Increased impervious surface
  - Increased runoff

Can we take what we learned from IRW about using water quality monitoring at base flow to prioritize HUC 12 watersheds in other basins?

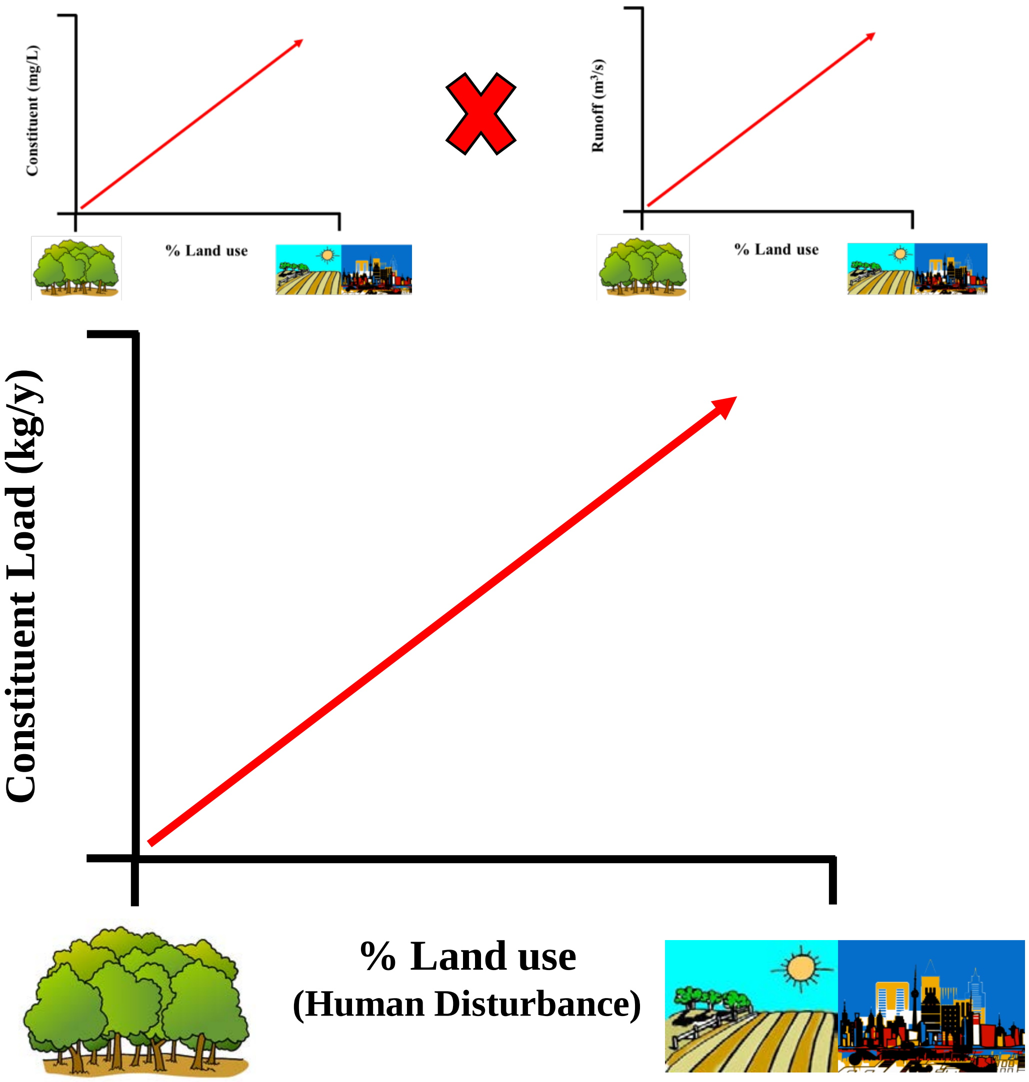



**C × Q = Load**

- Yes! we think so.
- As % ag and urban land use increase:
  - Nutrient and sediment concentrations increase
  - Increased impervious surface
  - Increased runoff

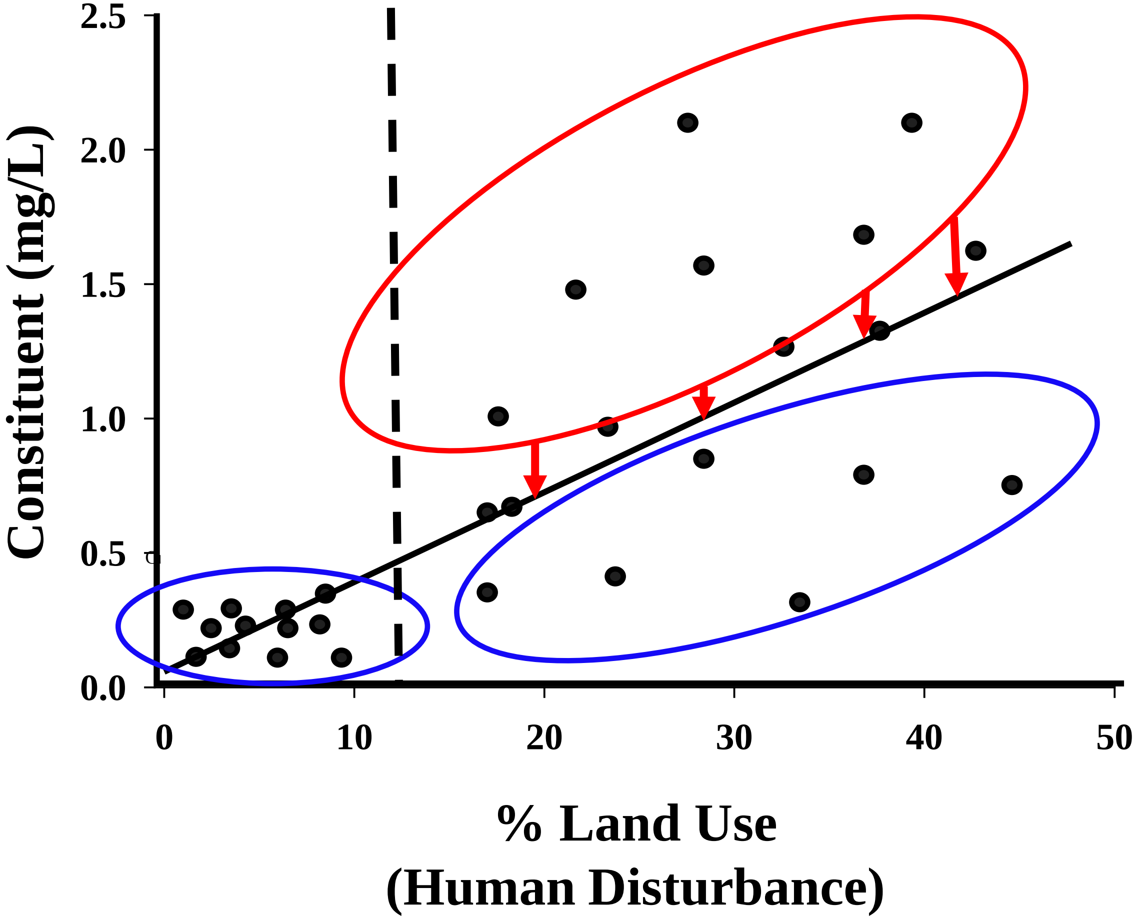
Can we take what we learned from IRW about using water quality monitoring at base flow to prioritize HUC 12 watersheds in other basins?




- Yes! we think so.
- As % ag and urban land use increase:
  - Nutrient and sediment concentrations increase
  - Increased impervious surface
  - Increased runoff
  - Loads will also increase

# How can this be used to prioritize subwatersheds?

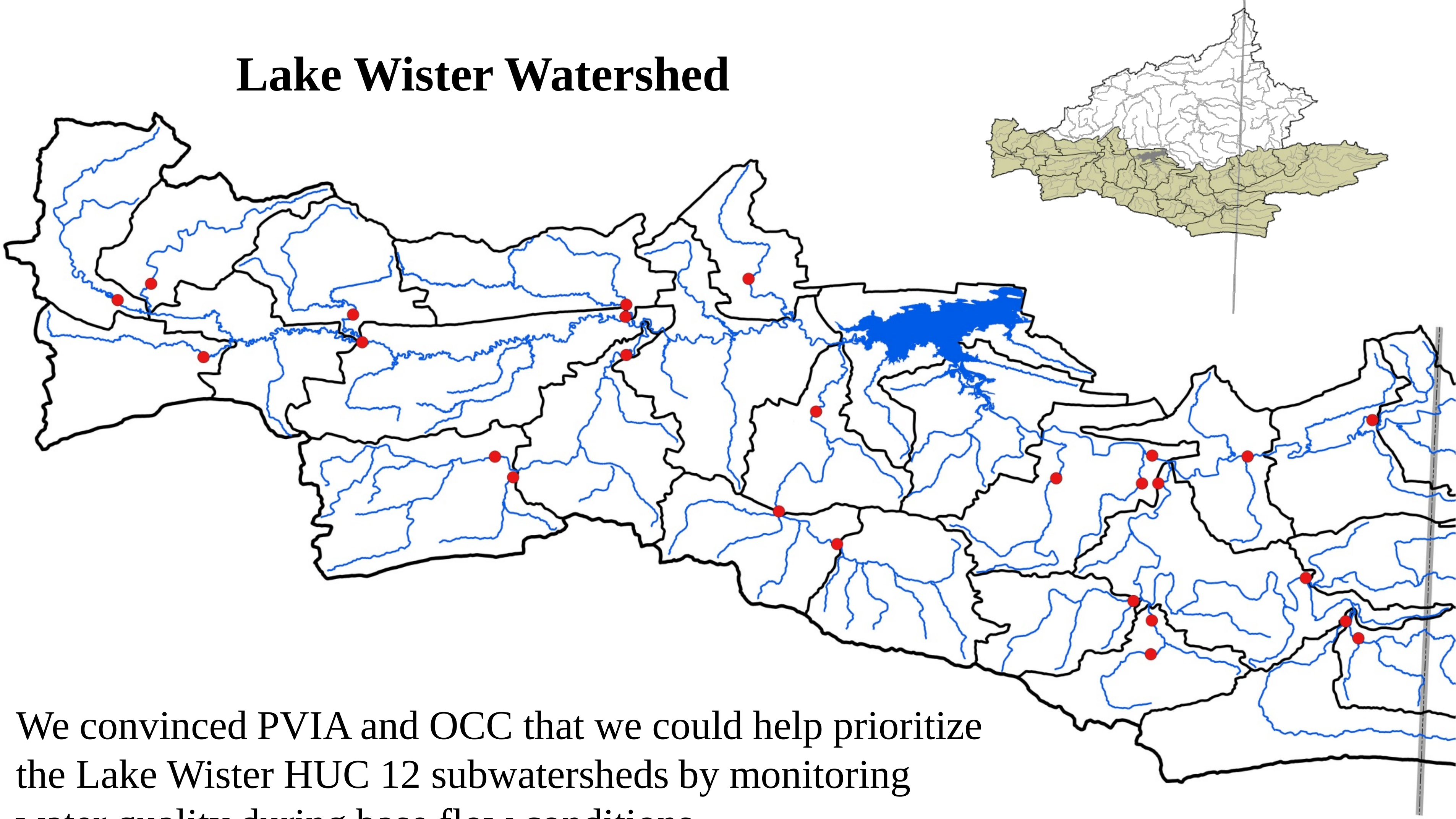
By relating our water quality data at base flow to land use, it allows us to make decisions on how to prioritize our sites.




**<u>We have three groups of data</u>**

- Sites that fall below a certain level of land use
  - Low measured concentrations
- Sites with higher land use but have concentrations less than projected.
- Sites with higher land use and with concentrations greater than projected.
  - These are the sites that should be selected as priority watersheds.

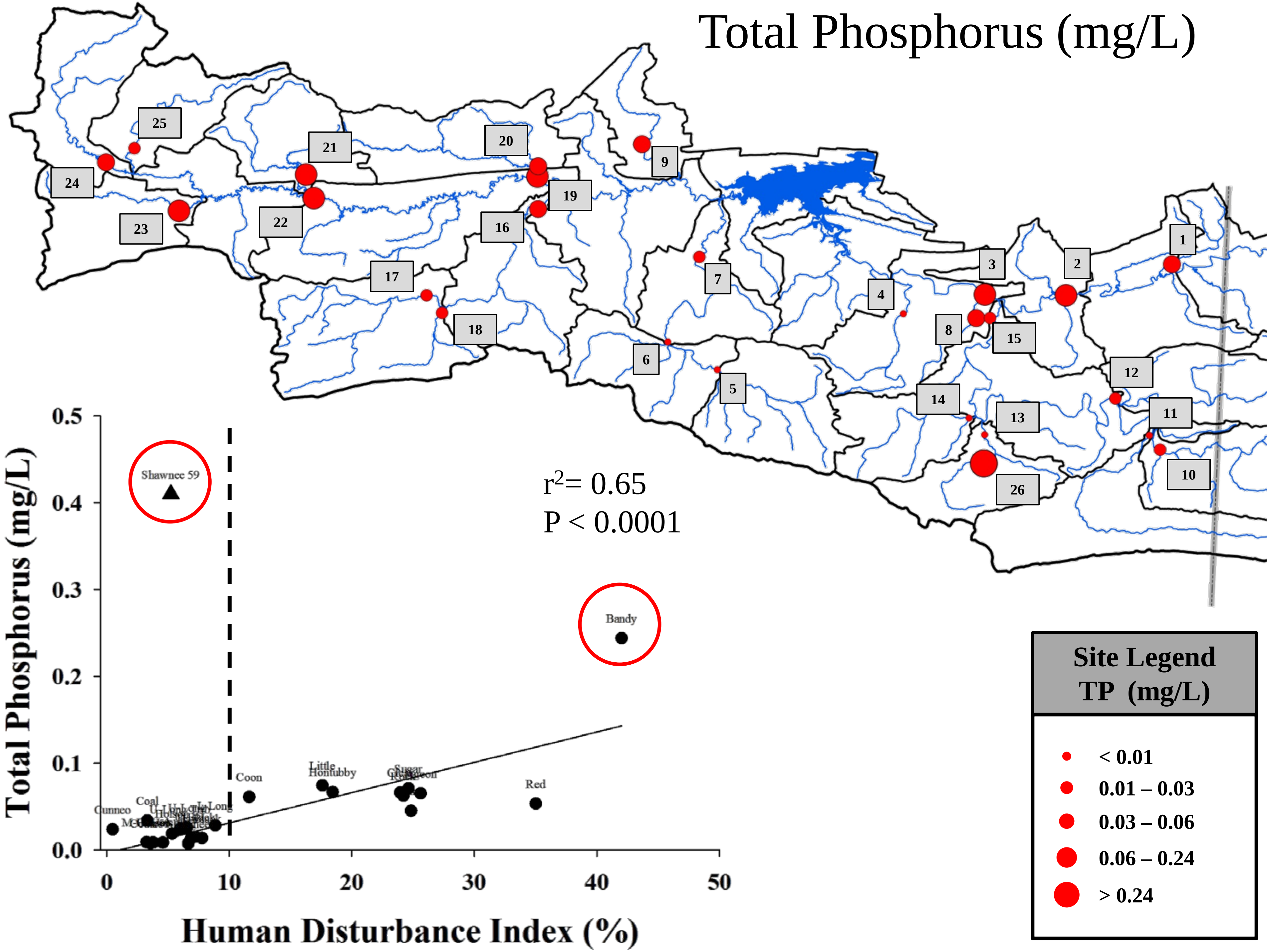
# Lake Wister Watershed



We convinced PVIA and OCC that we could help prioritize the Lake Wister HUC 12 subwatersheds by monitoring water quality during base flow conditions.

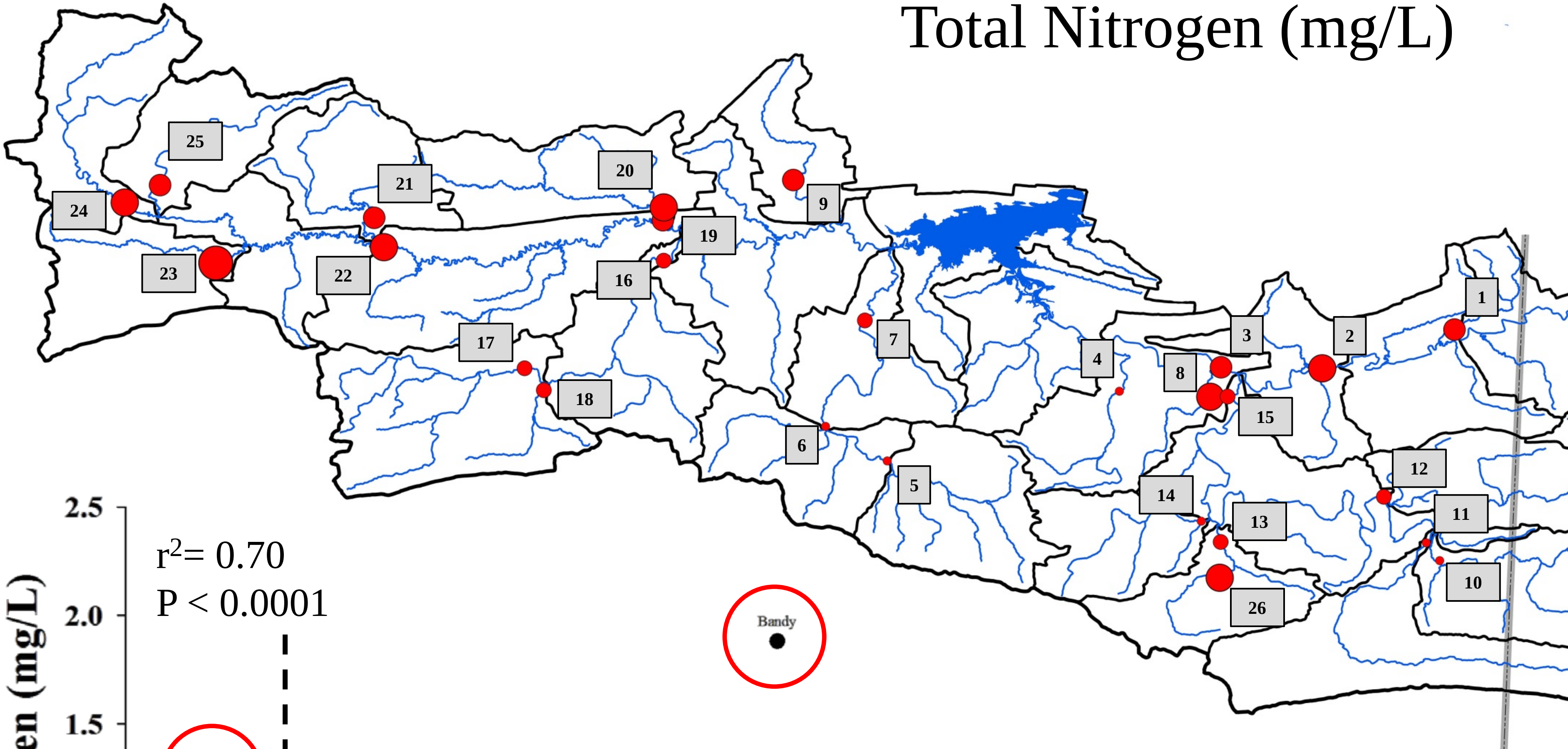
# Field Monitoring

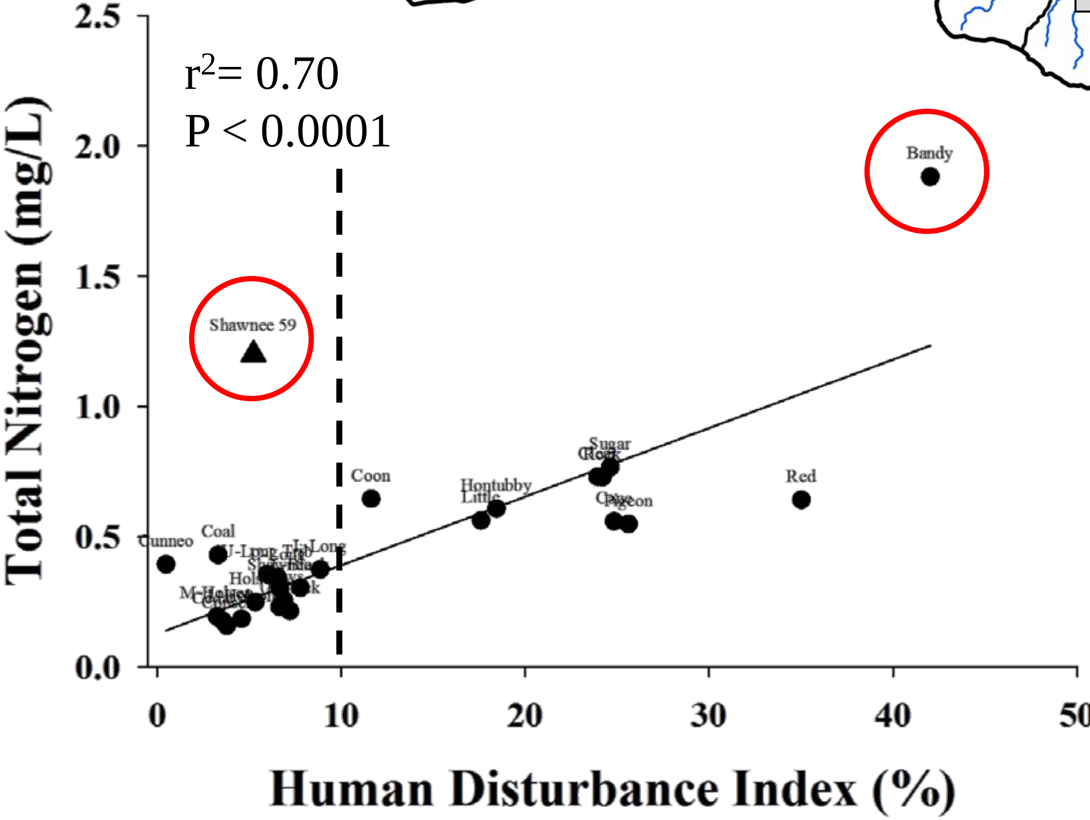
- 26 sites selected representing 23 HUC 12 watersheds flowing into Lake Wister.
- Sampled monthly during base flow conditions for a year.
- Samples were analyzed for:
  - **Total Phosphorus**
  - **Total Nitrogen**
  - Nitrate + Nitrite
  - Ammonia
  - Soluble Reactive Phosphorus
  - Turbidity
  - Total Suspended Solids
  - Chlorophyll *a*
  - Fluoride
  - Chloride
  - Sulfate
- Geometric means of the constituents were compared to a Human Disturbance Index
  - This is just the total percentage of ag and urban land use in a watershed.



Total Phosphorus (mg/L)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
Total Phosphorus (mg/L)
Human Disturbance Index (%)
0.0
0.1
0.2
0.3
0.4
0.5
0
10
20
30
40
50
Shawnee 59
Bandy
Coon
Red
Cunneo
Coal
$r^2 = 0.65$
$P < 0.0001$
Site Legend
TP (mg/L)
< 0.01
0.01 – 0.03
0.03 – 0.06
0.06 – 0.24
> 0.24

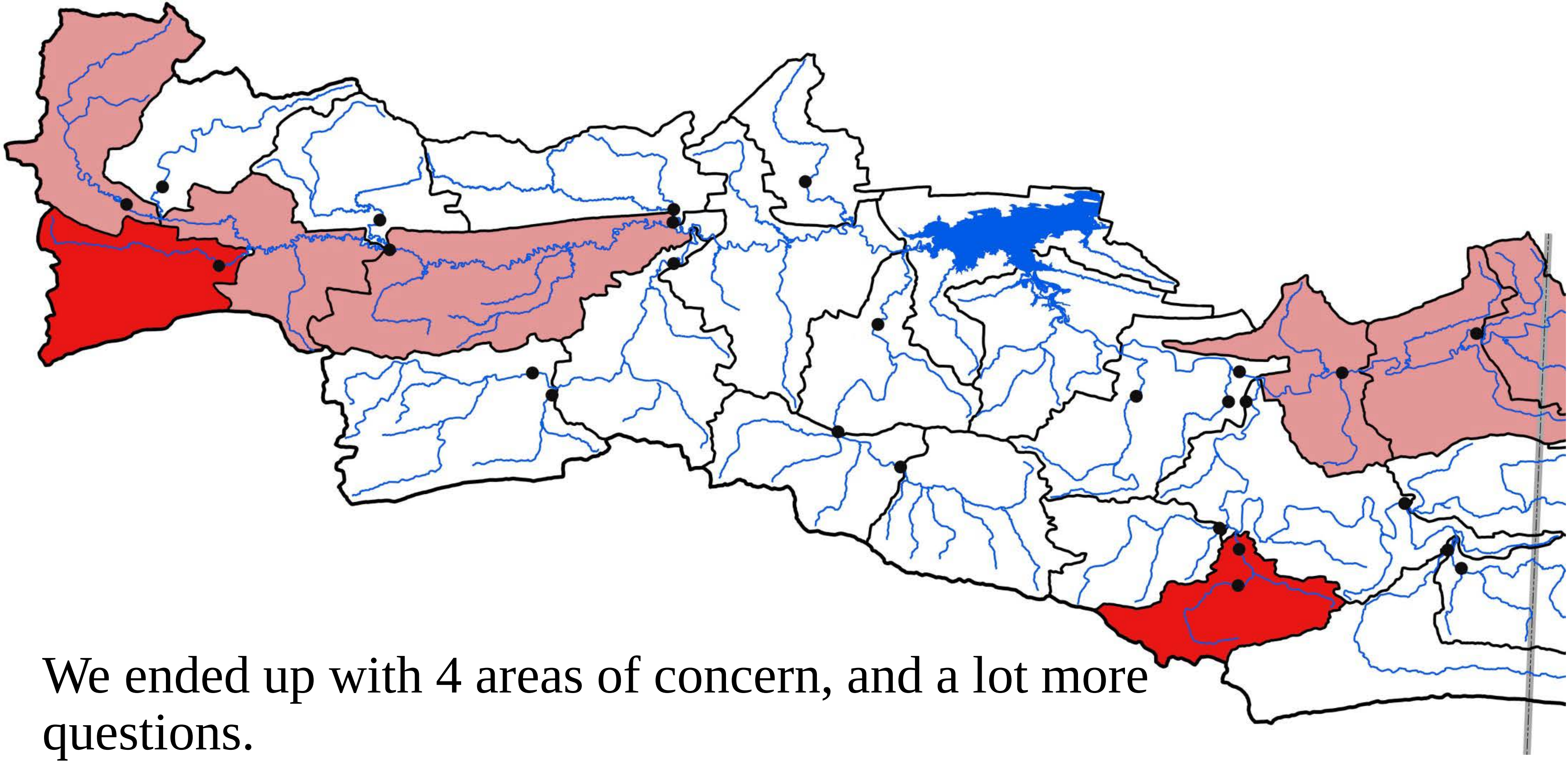
# Total Nitrogen (mg/L)




**Site Legend**
**TN (mg/L)**

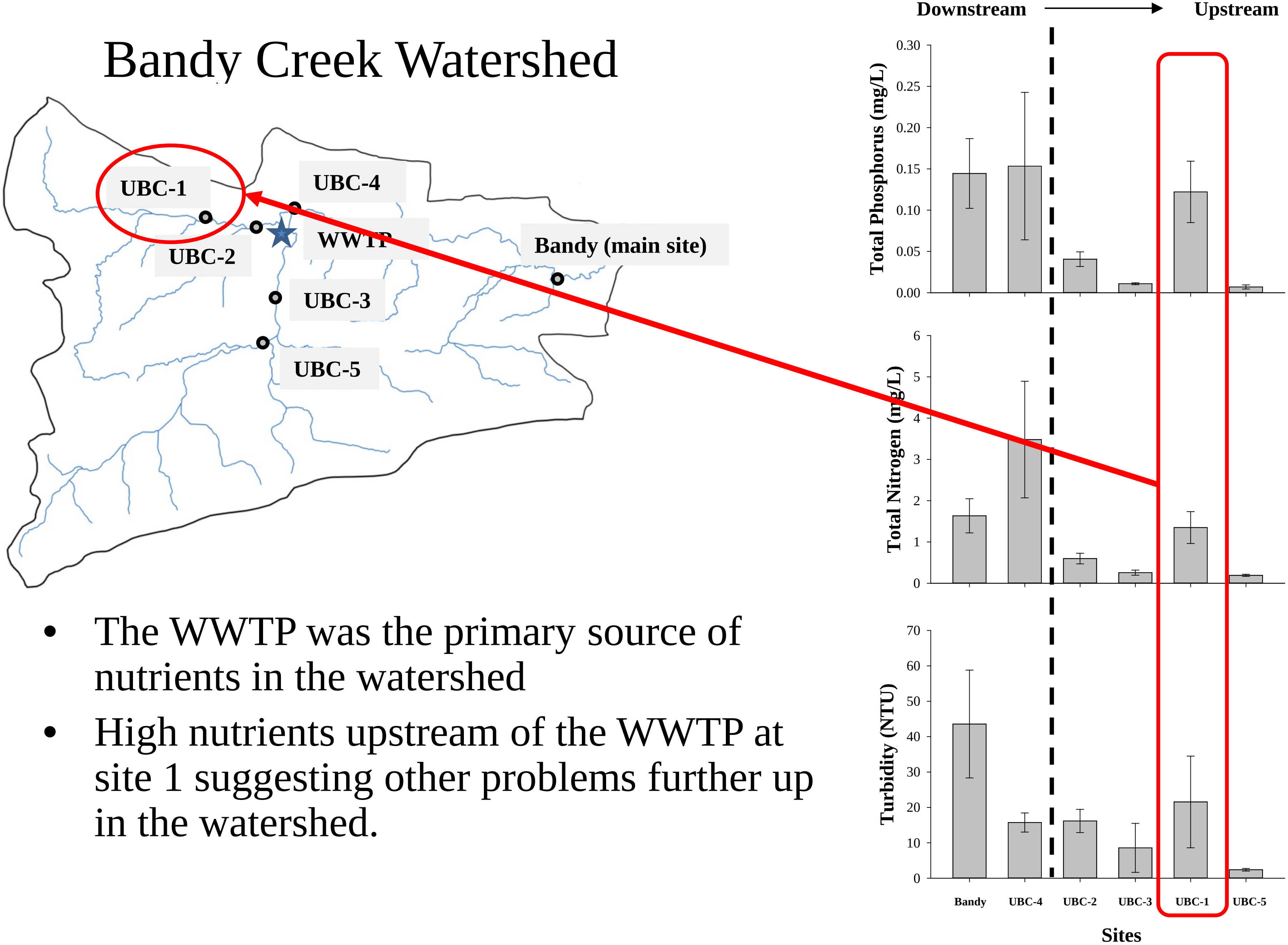
- < 0.24
- 0.23 – 0.37
- 0.37 – 0.62
- 0.62 – 1.20
- > 1.20



We ended up with 4 areas of concern, and a lot more questions.

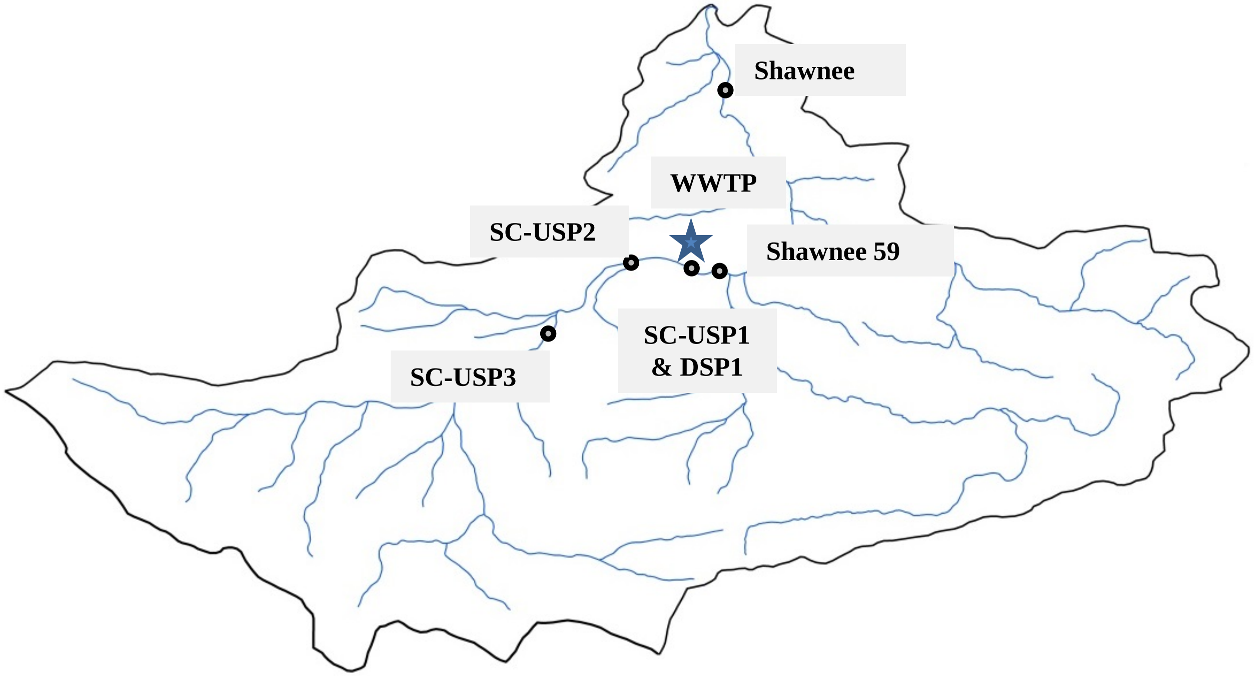
1. Are the high nutrients in the Bandy and Shawnee watersheds strictly from WWTP discharge, or does the problem extend upstream of the known point source?
2. Does the Fourche Maline “Bad Fork” have poor water quality even up into its headwaters?
3. Are high nutrients restricted to the main-stem of the Poteau, or are the tributaries high as well?

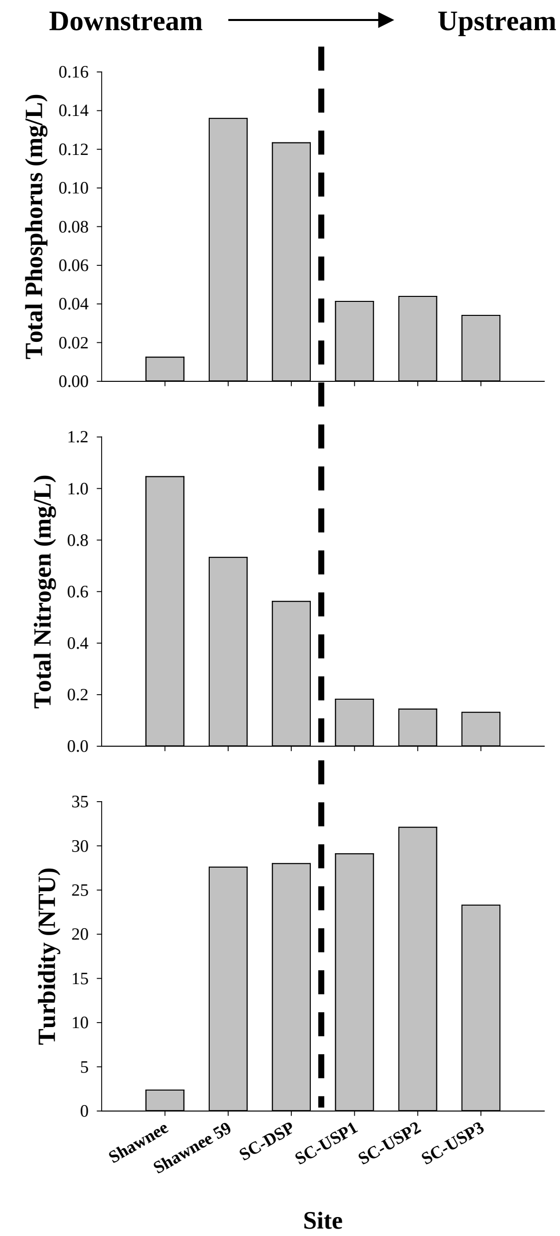
# Bandy Creek Watershed




- The WWTP was the primary source of nutrients in the watershed
- High nutrients upstream of the WWTP at site 1 suggesting other problems further up in the watershed.

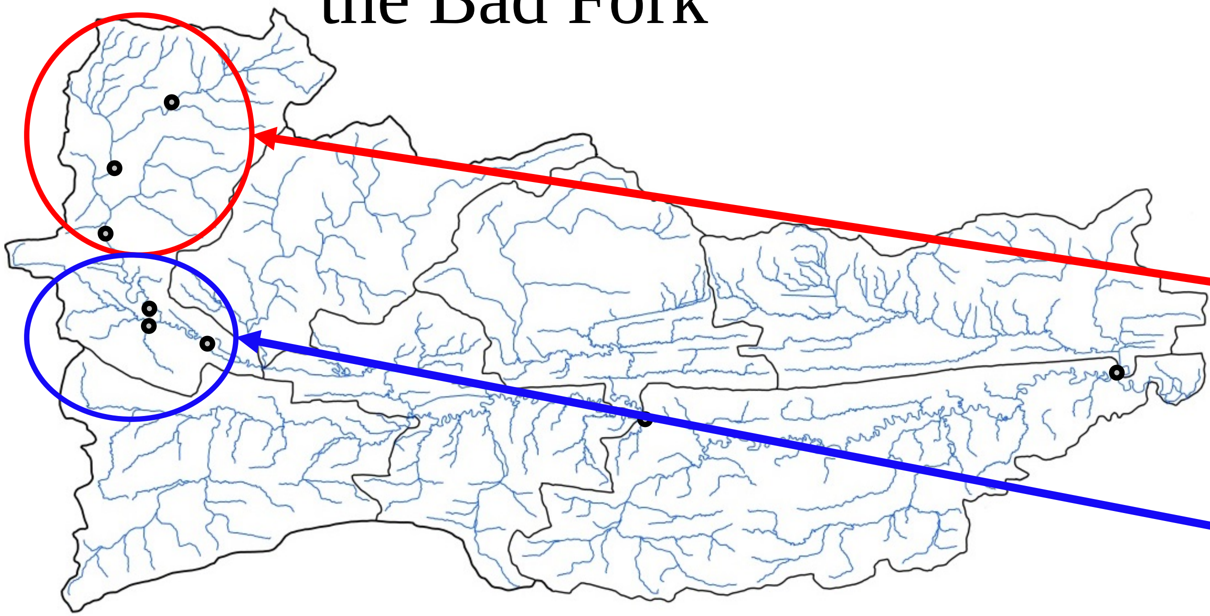
# Shawnee Creek

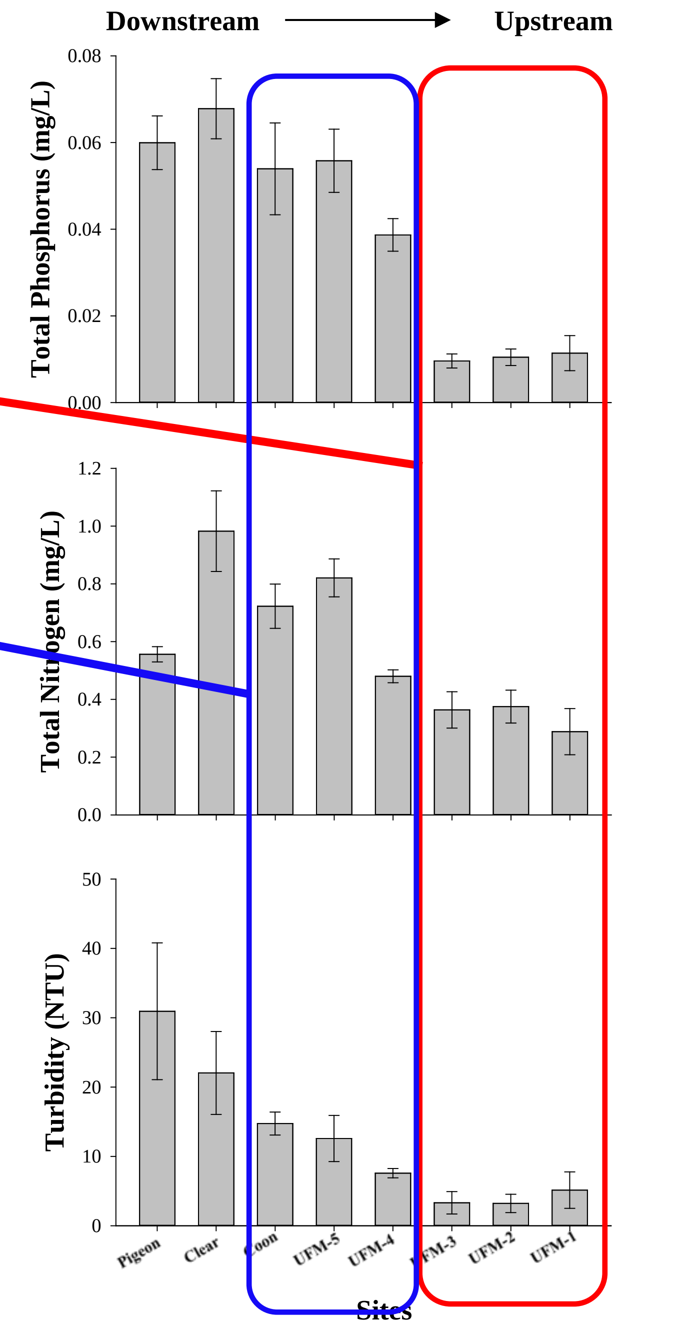



- As with Bandy, the WWTP is the primary source of nutrients to Shawnee Creek.
- The effects of the WWTP on both TP and turbidity dissipate before reaching the most downstream site.

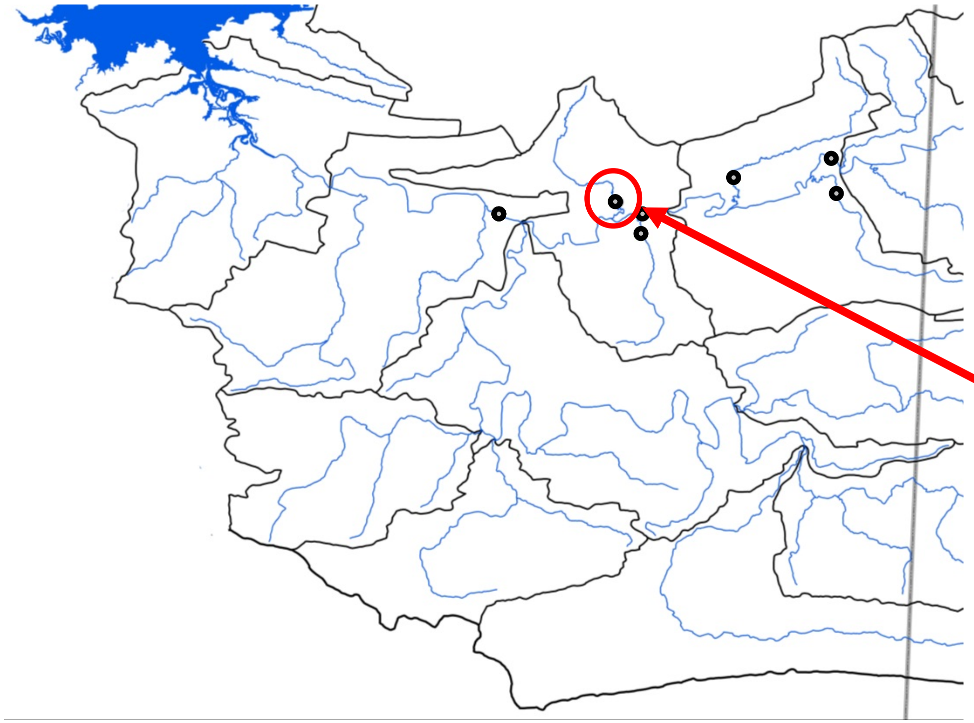
# Fourche Maline Watershed
# “the Bad Fork”



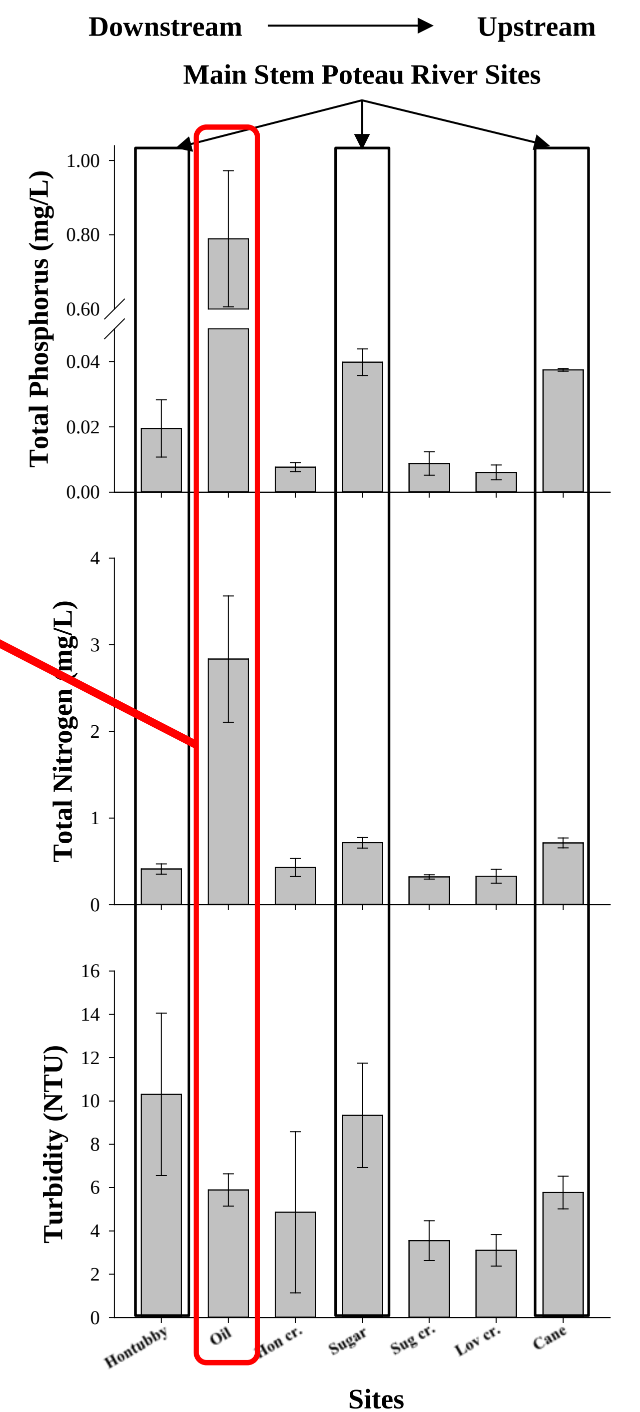



- The upper most reaches of the bad fork are not so bad.
- But PVIA should focus watershed management efforts starting just downstream of these sites

# Poteau River Watershed



- High nutrients and turbidity was generally restricted to the main-stem
- However, one tributary had the highest TN and TP values measured for this project.



- We believe our findings in the Lake Wister watershed supports the use of water quality monitoring during base flow conditions to prioritize HUC 12 watersheds.
  - Less time intensive
  - Less expensive

- The data we generated at the HUC 12 level resulted in additional questions.
  - Through further sampling at a finer scale we were able to isolate key areas that would have been overlooked with other methods.

- Having this information can complement watershed modeling efforts, by providing a means to validate model predictions of priority watersheds.

# Acknowledgements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  - Brina Smith
  - Keith Trost
  - Jennifer Purtle