SWAT Model Study for Illinois River Drainage Area (IRDA) in Arkansas

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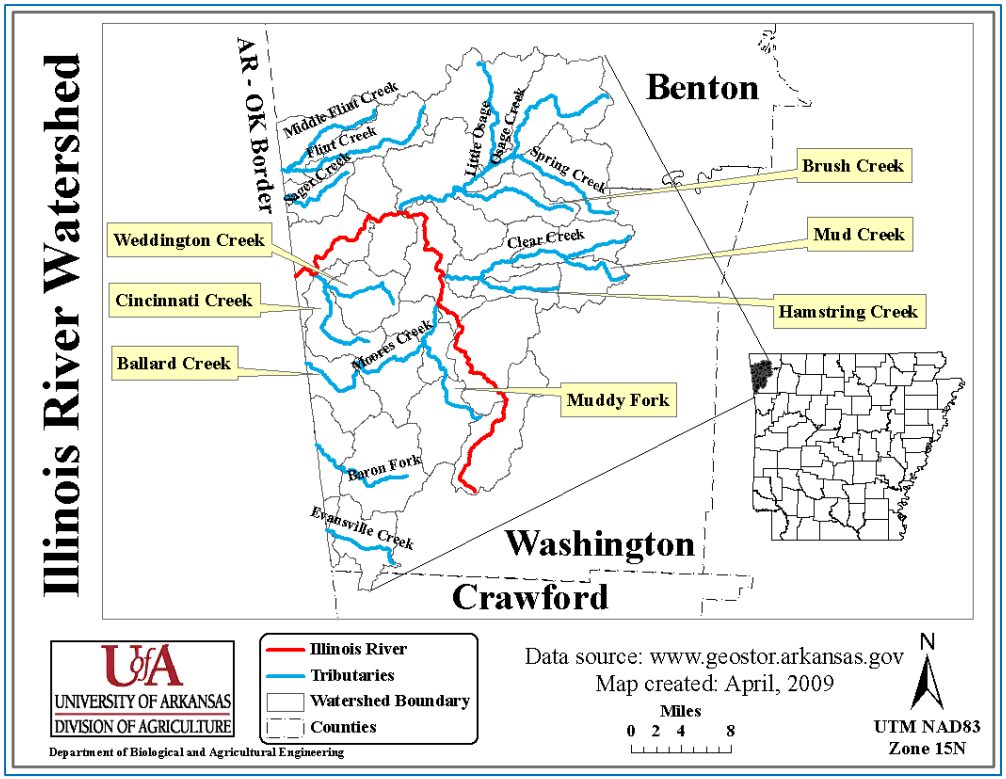
Cooperative Extension Service

INTRODUCTION



- Illinois River Watershed: 757 mi^2 (1960 km^2)
- Counties: Benton (39.5%), Washington (60.3%), and Crawford (0.2%)

Concern: siltation/turbidity, pathogens, total phosphorus, and nitrogen

OBJECTIVE

The study was conducted to:

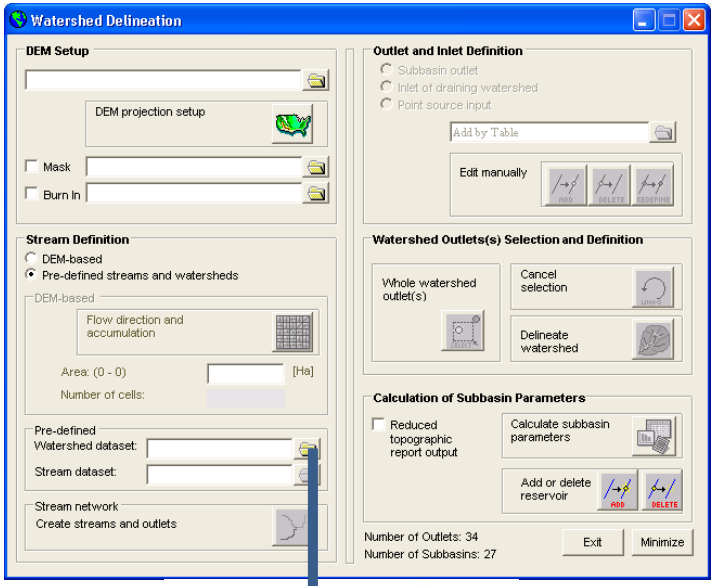
a) **Organize input data for the Soil and Water Assessment Tool (SWAT) model setup**
b) **Calibrate and validate the SWAT model for flow, sediment, and nutrients**
c) **Use model outputs to identify 12-digit hydrologic unit code (HUC) watersheds based on their contribution to sediment and nutrients**

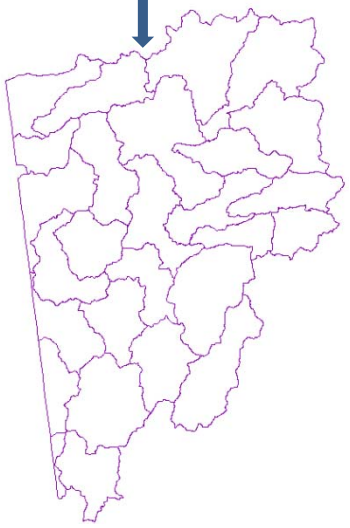
POINT TO REMEMBER

MODEL IS AN ABSTRACTION OF REALITY

MODEL SETUP

Interface: ArcSWAT Ver. 2.1.5a
Model: SWAT2005
Delineation: USGS 12-digit HUC
DEM: 10 m
Soil: SSURGO
Land Use: 2006 LULC
Point Sources: 7 WWTP(ADEQ)
Pond: 9019 (1550.4 ha)
27 subwatersheds- 1272 HRUs
(10% soil and 5% land cover)
Study Period:
Calibration: 1996-2004(92-95)
Validation: 2005-2007





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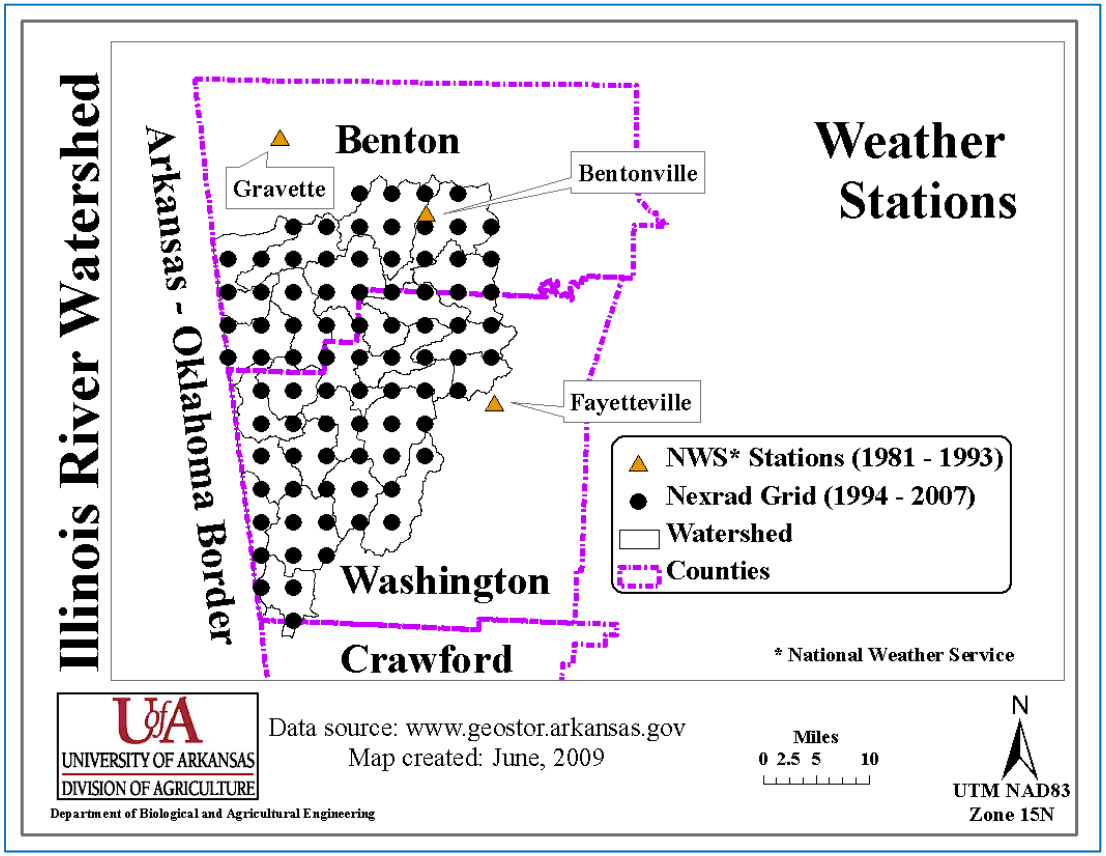
DATA USED

Weather



- Period: 1981 – 2007
- Daily precipitation and temperature
- 1981-1993 – 3 weather stations*
- 1994 – 2007 – NEXRAD*
  - Hourly data
  - 4 x 4 km resolution
  - 82 grid cells

* NOAA -NWS

DATA USED

Management Data

- **Nutrient Sensitive Area- home to a number of animal enterprises including poultry, pigs/hogs, and cows (beef and dairy)**
  - **Estimated animal population: USDA- NASS, 2002/2007**

Data organization:

Grazing and manure deposition
Poultry litter application
Pig manure application
Urban lawn management

Management Data—contd.

- **Grazing and manure deposition**

-Watershed level cow population (dairy and beef) determined through weighted area

-Cow population was further apportioned to sub-watershed

Operation	Details
Grazing operation	May-1 to Sep-30 (Bermuda), Oct-1 to Nov-30 (Fescue), Mar-1 to Apr 30 (Fescue). 12.55 kg dry weight grass/ha/day; Benton 15.31 kg dry weight grass/ha/day; Washington
Manure deposition	5.99 kg/ha/day
Hay cutting	May 31 and July 15 , 85 % removal

Management Data—contd.

- **Poultry litter application**

-SWAT model was adjusted for broiler litter nutrients based on Arkansas data

-Litter application rate adjusted for type of grasses and temporally as well*

-Cool-season: 2 tons/acre Warm season: 3 tons/acre

-January 2004 onwards, rate declined to 1.16 tons/acre

	H2O (%)	Total N (lb/ton)	NH_4-N (lb/ton)	NO_3-N (lb/ton)	Total P (lb/ton)
Mean	30.8	62	7.7	0.8	30
Std. dev.	8.9	5	1,473	816	0.3

(*Sharpley et al., 2009)

(Sharpley et al., unpublished report)

Sensitivity Analysis

- **Purpose: Identify critical parameters in the model for calibration**
- **Tool: Latin Hypercube and One-factor-at-a-time (OAT) sampling**
- **Variables included: 41; 420 SWAT Model runs**
- **Evaluation criteria: Calibrate first using top 5 sensitive parameters**

Sensitivity Analysis

Output	Ranking				
	1	2	3	4	5
Total Flow	ALPHA_BF	SURLAG	RCHRG_DP	ESCO	CN2
Sediment	SPCON	ALPHA_BF	PRF	SPEXP	SURLAG
Organic P	CN2	SURLAG	BLAI	SOL_Z	CH_K2
Mineral P	SOL_Z	SOL_AWC	ALPHA_BF	CN2	ESCO
Nitrates	RCHRG_DP	CN2	CH_K2	BLAI	ALPHA_BF

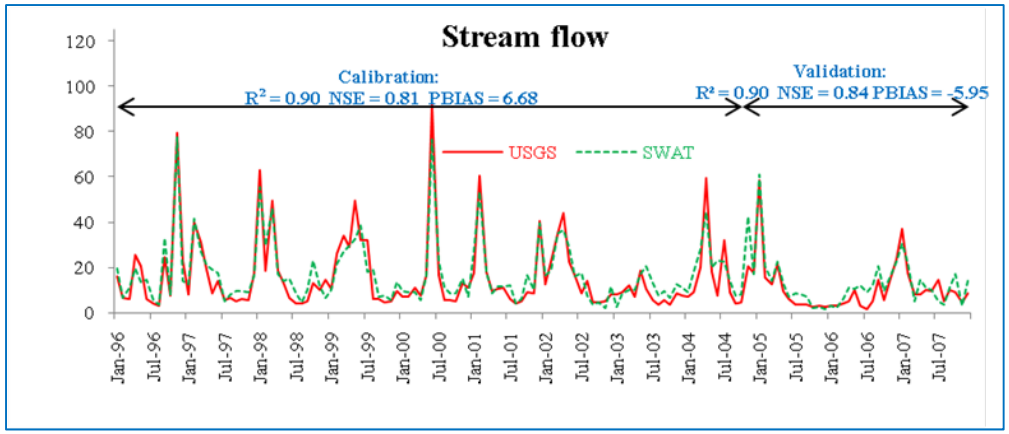
Model Performance Parameters

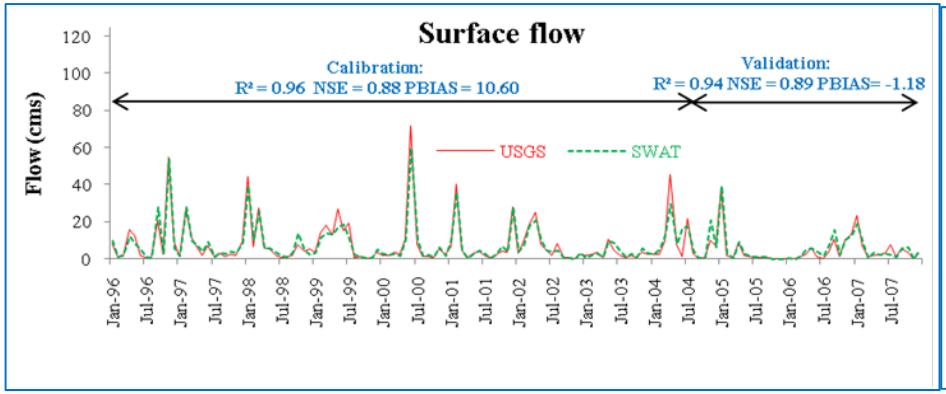
Performance Rating	E	PBIAS (%)		
		Streamflow	Sediment	TP
Very good	$0.75 \leq E \leq 1.00$	PBIAS $\leq \pm 10$	PBIAS $\leq \pm 15$	PBIAS $\leq \pm 25$
Good	$0.65 \leq E \leq 0.75$	$\pm 10 \leq$ PBIAS $\leq \pm 15$	$\pm 15 \leq$ PBIAS $\leq \pm 30$	$\pm 25 \leq$ PBIAS $\leq \pm 40$
Satisfactory	$0.50 \leq E \leq 0.65$	$\pm 10 \leq$ PBIAS $\leq \pm 25$	$\pm 30 \leq$ PBIAS $\leq \pm 55$	$\pm 40 \leq$ PBIAS $\leq \pm 70$
Unsatisfactory	$E \leq 0.50$	PBIAS $\geq \pm 25$	PBIAS $\geq \pm 55$	PBIAS $\geq \pm 70$

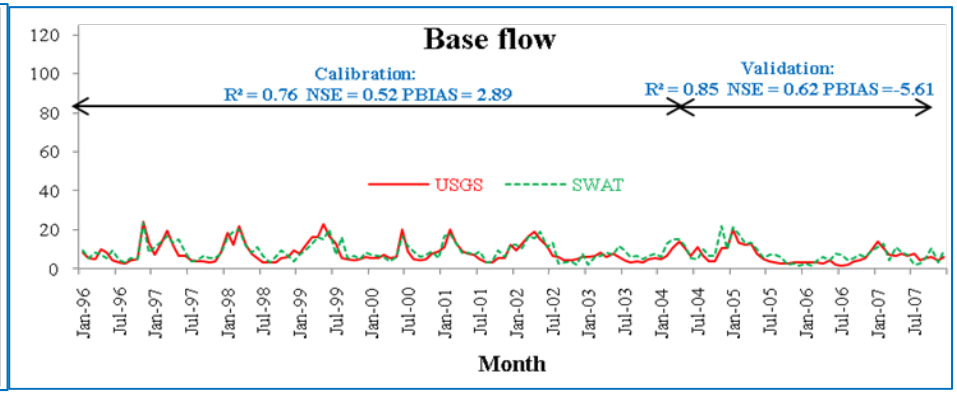
Source: Moriasi et al., 2007

CALIBRATION/VALIDATION

Stream flow @ Siloam Springs

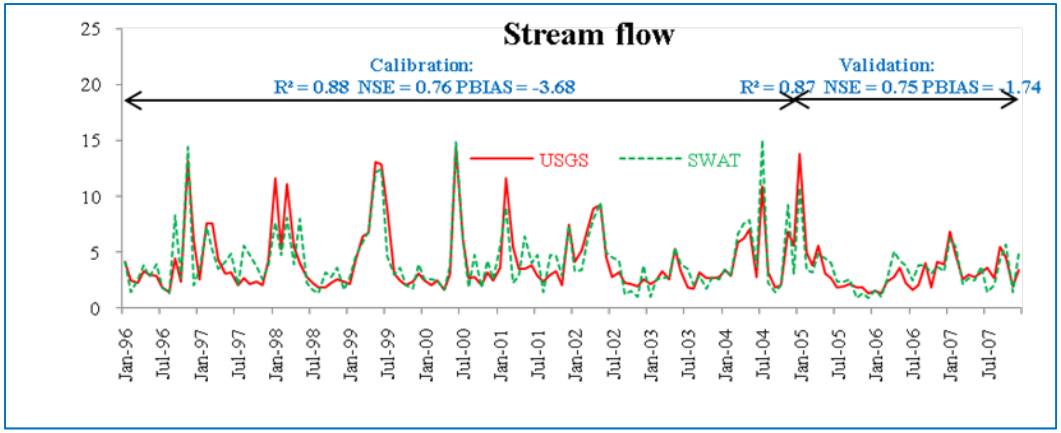


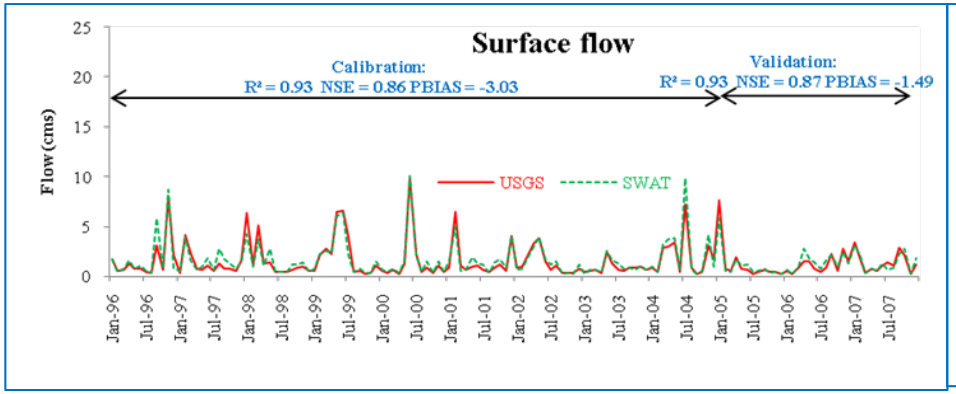


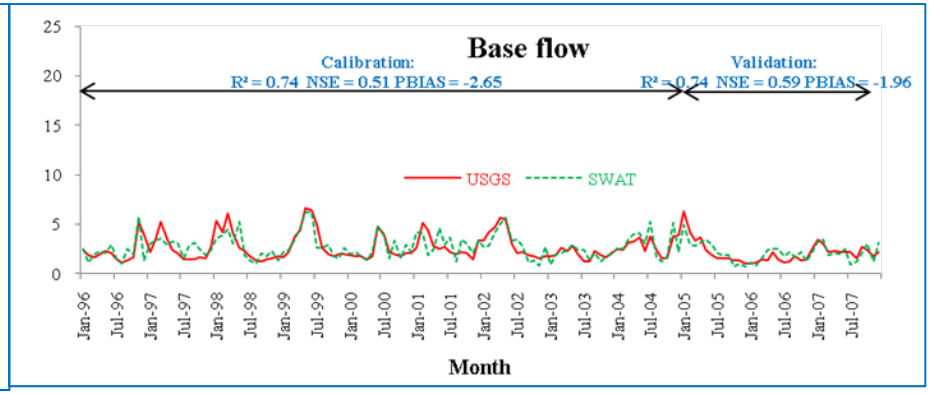


CALIBRATION/VALIDATION

Stream flow @ Osage Creek

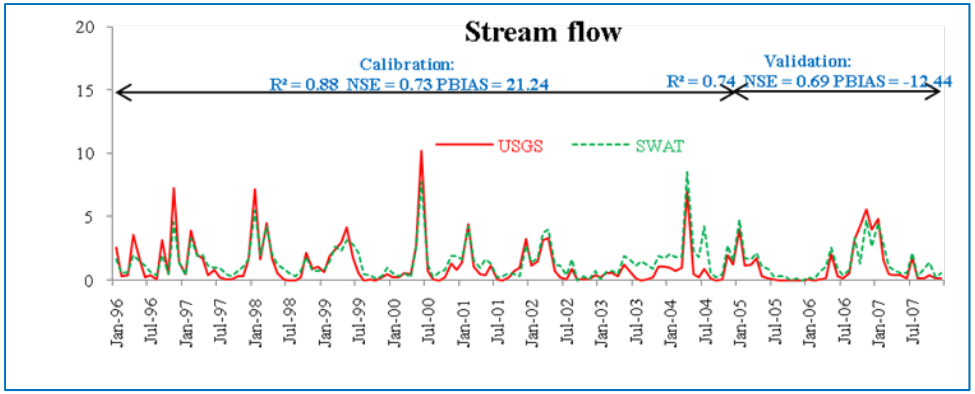


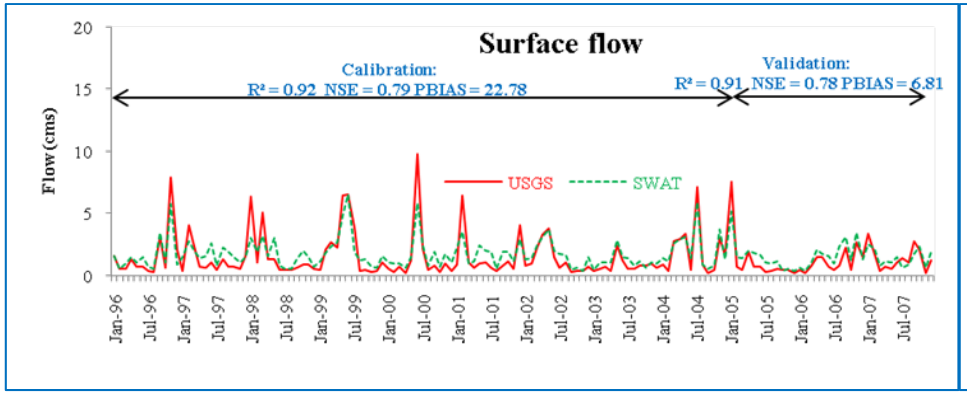


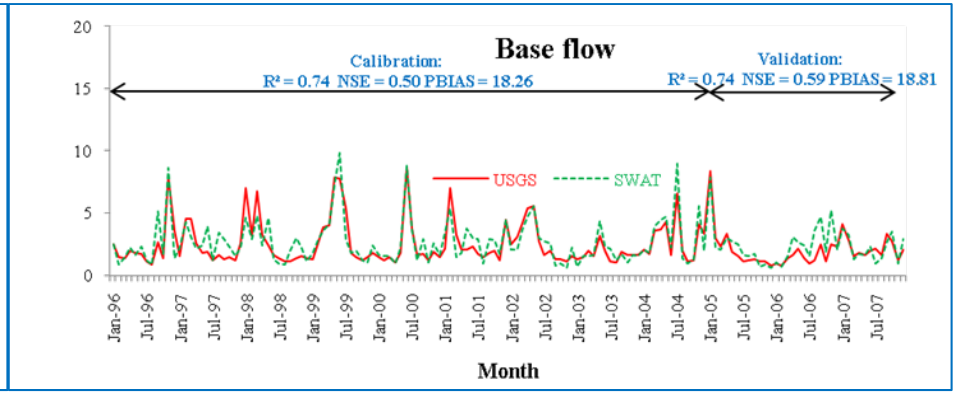


CALIBRATION/VALIDATION

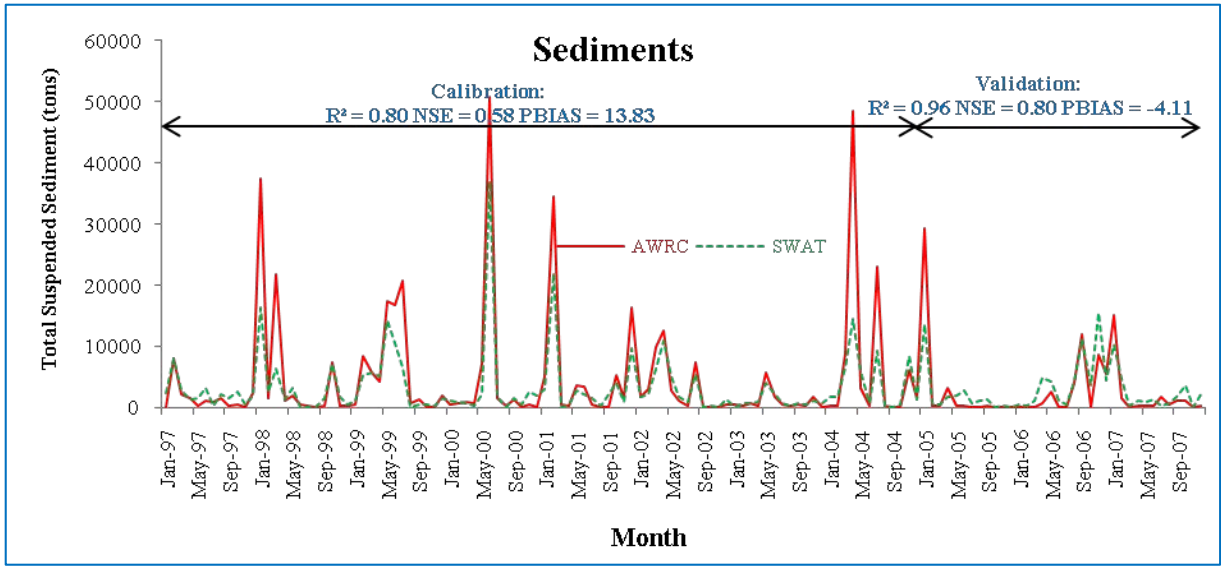
Stream flow @ Baron Fork





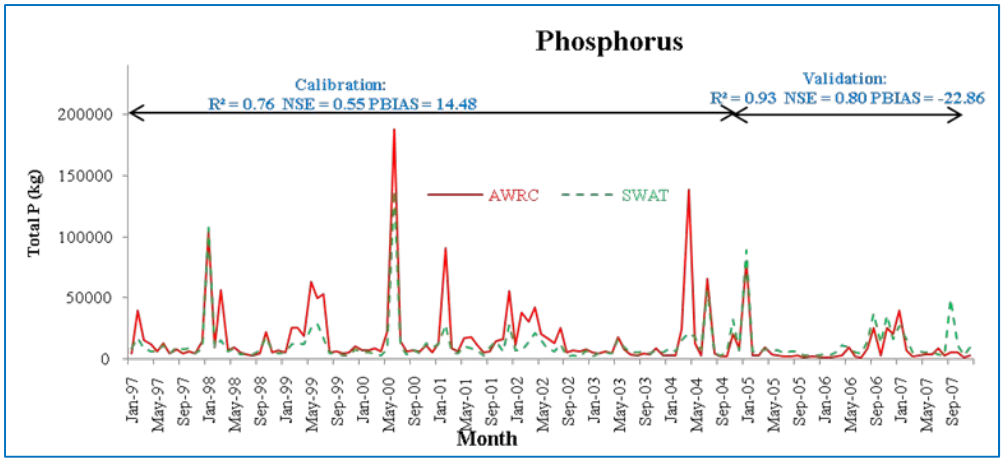


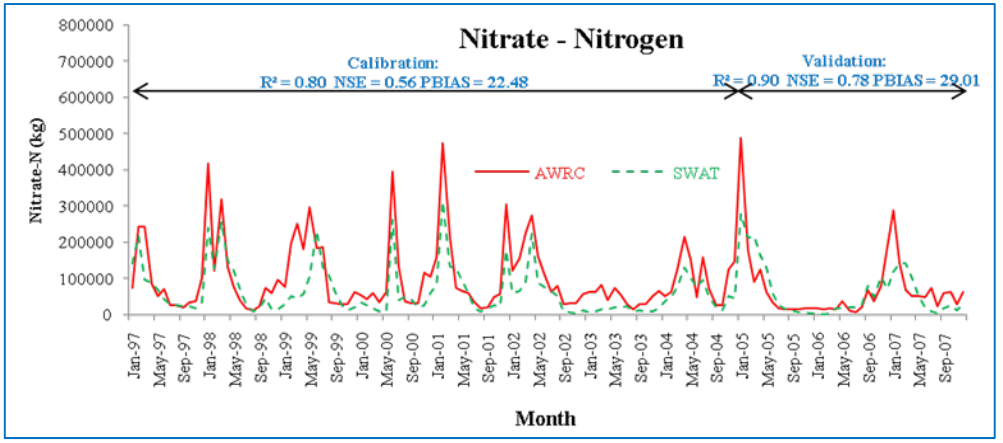
Sediment @ Siloam Springs



CALIBRATION/VALIDATION

Nutrients@ Siloam Springs





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SUBWATERSHED IDENTIFICATION

Three approaches

A. Percentile Ranking

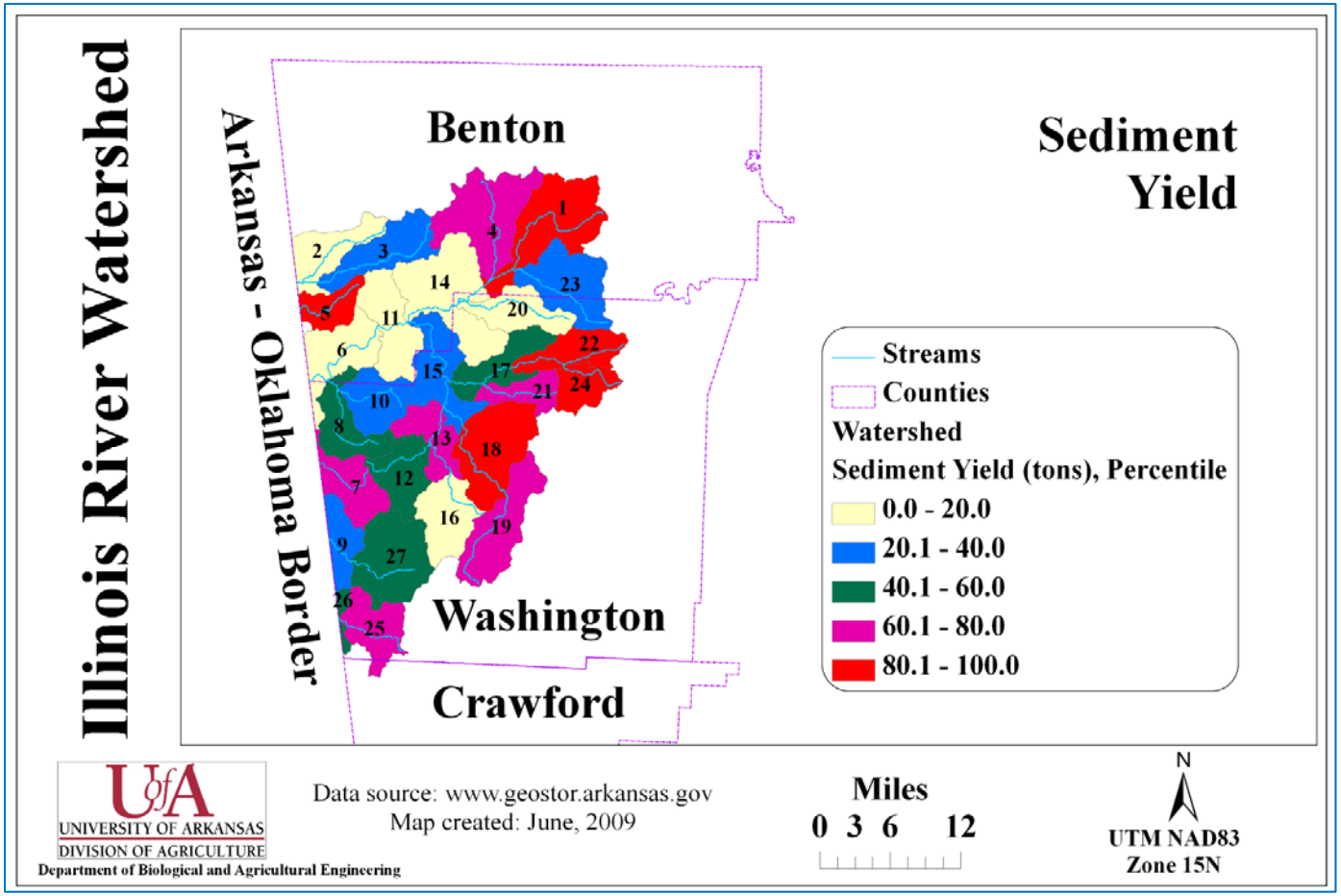
B. Average annual phosphorus yield

C. Cartographic Score

- Loadings for sediment, TP, and nitrogen divided into quartiles
- Each sub-watershed assigned a score of 1 to 4
- Higher cumulative score indicates sub-watershed likely to contribute more NPS pollution

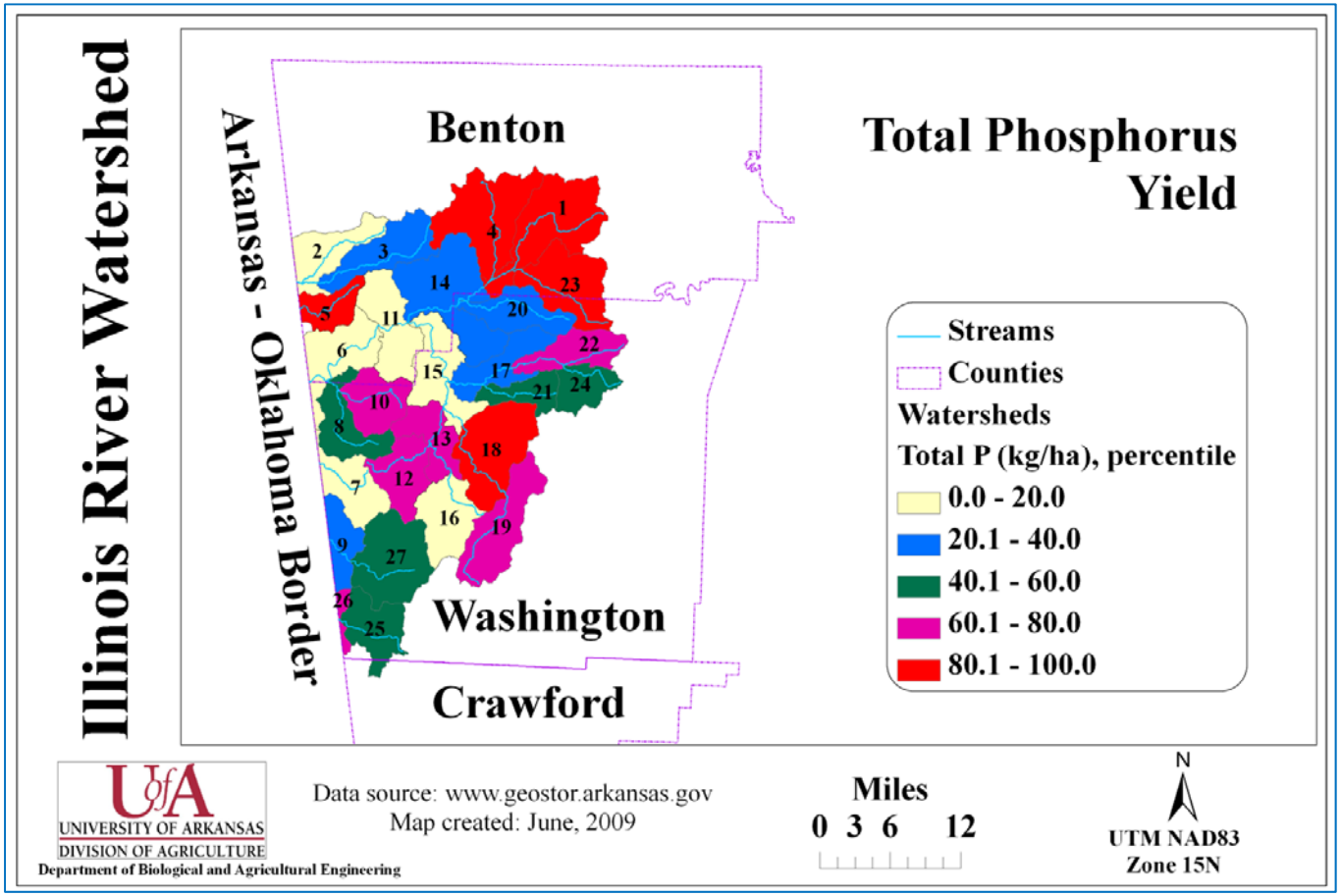
SUBWATERSHED IDENTIFICATION

Percentile Approach – Sediment



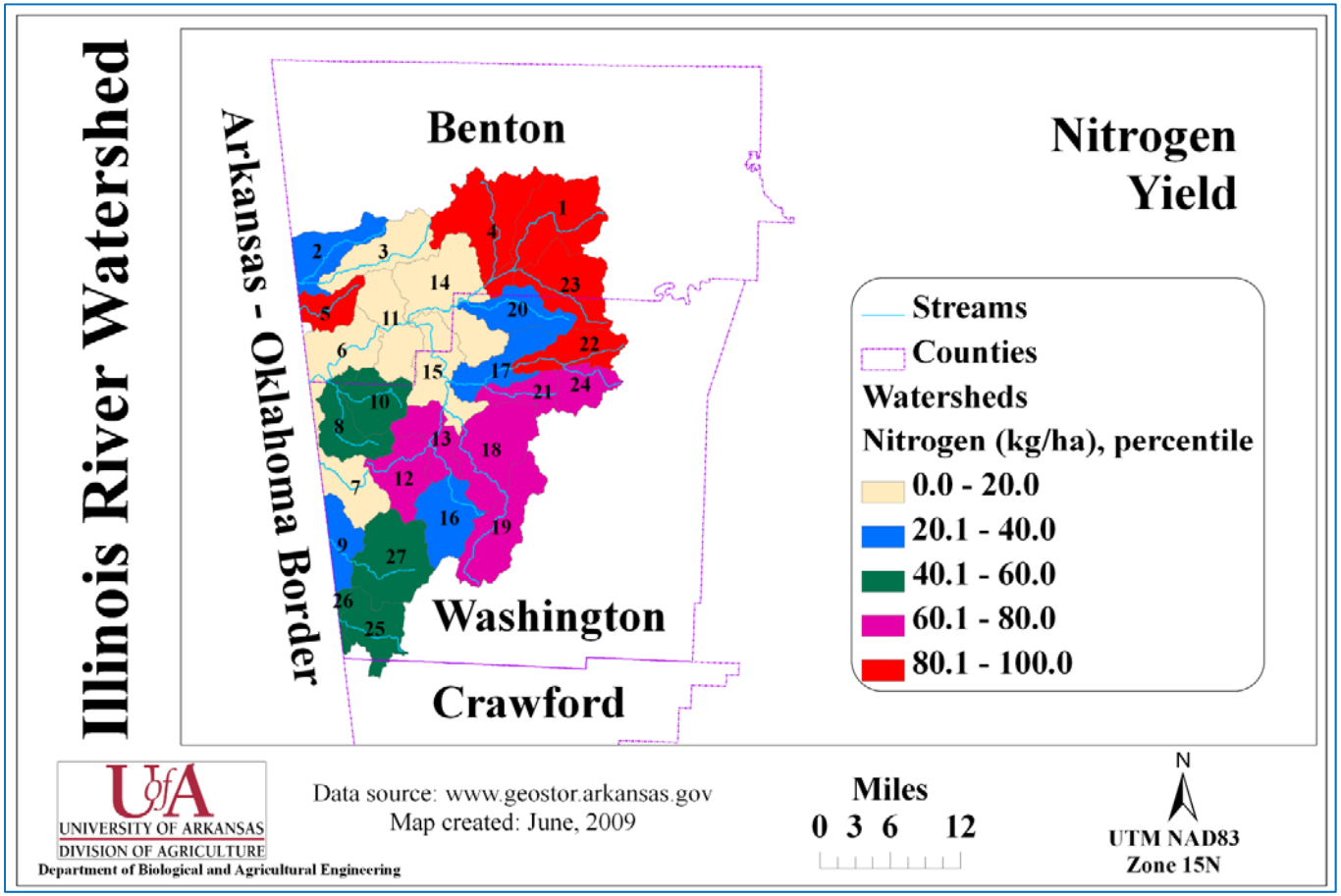
SUBWATERSHED IDENTIFICATION

Percentile Approach – Phosphorus



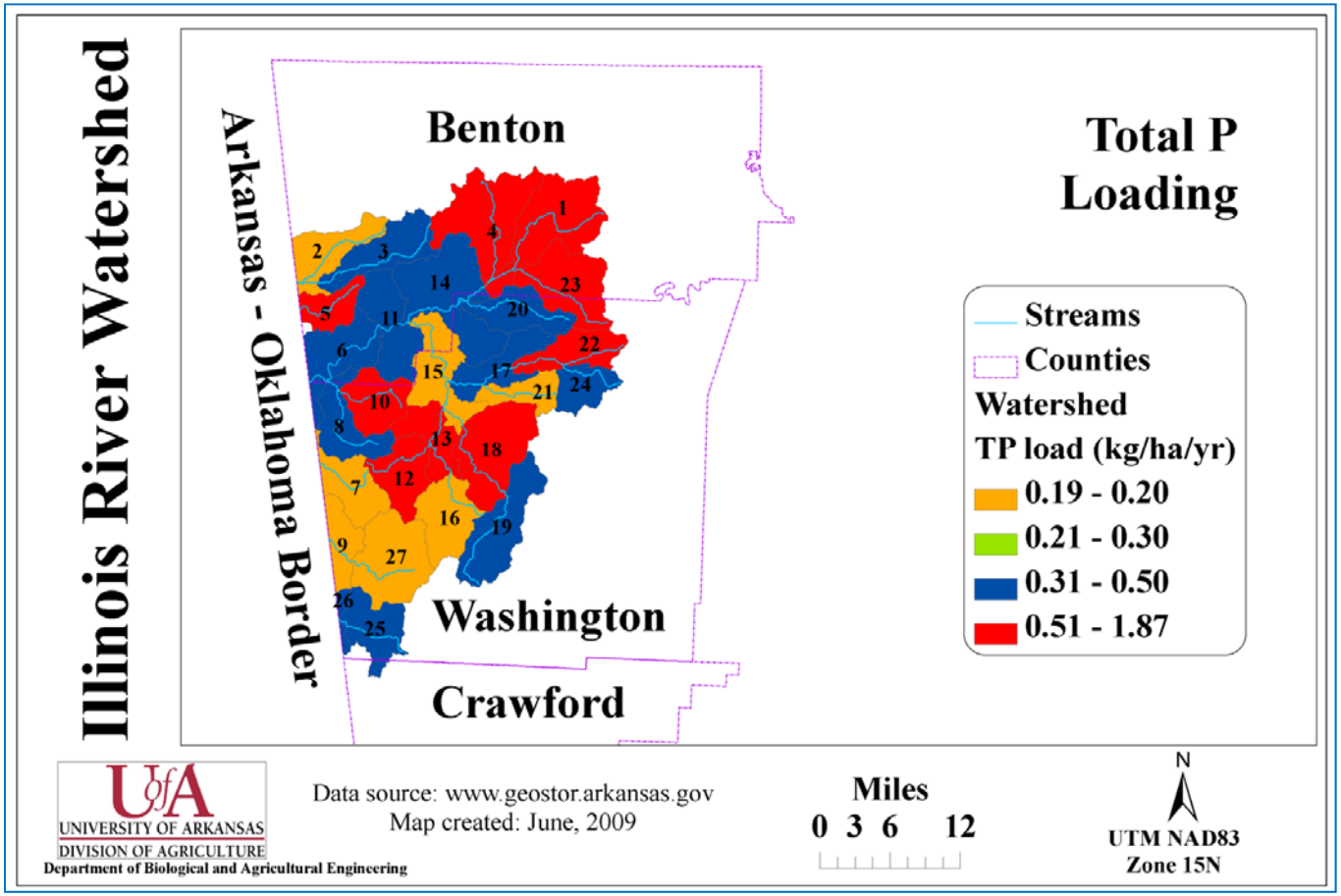
SUBWATERSHED IDENTIFICATION

Percentile Approach – Nitrogen



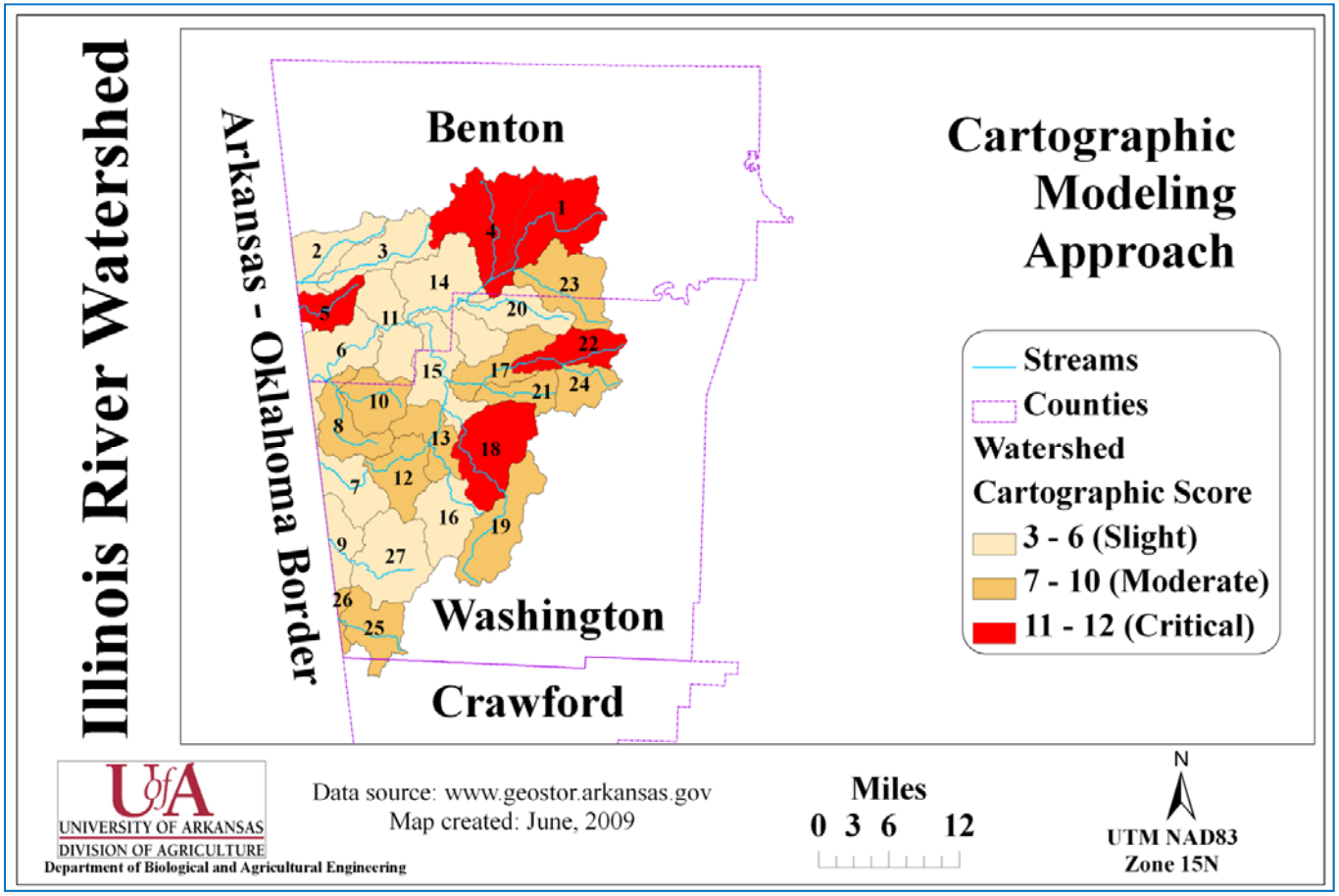
SUBWATERSHED IDENTIFICATION

Annual P loading



SUBWATERSHED IDENTIFICATION

Cartographic modeling



SUBWATERSHED IDENTIFICATION

Frequent subwatersheds

Sub-watershed	Frequency
5 (Sager Creek)	5
1 (Osage Creek)	5
4 (Little Osage)	4
22 (Clear Creek)	4
18 (Goose Creek)	4

These five subwatersheds encompass 23.6% of the total watershed area but contributed 32.6% of annual P load, 36.9% of annual nitrate-nitrogen load, and 62.3% of annual average sediment load

SUMMARY

- Most recent input data and NEXRAD data were used for model setup
- SWAT model was calibrated for 1996 – 2004 and validated for 2005 – 2007
- Simulated flow, sediments, TP, and nitrate had good to very good correlation with measure data
- Model responses were used to identify subwatersheds using three approaches
- In conjunction with other known information, these subwatersheds are prime candidates for further management support

ACKNOWLEDGMENTS

- Arkansas Natural Resource Commission (ANRC)
- Many individuals, groups, state and federal agencies
- University of Arkansas subject matter specialists and extension agents for fine tuning the management data
- Mr. John Pennington, Washington County extension agent
- SWAT model developers, namely Dr. Raghavan Srinivasan, Dr. Jeff Arnold and his team at USDA-ARS, Temple, TX

QUESTIONS?

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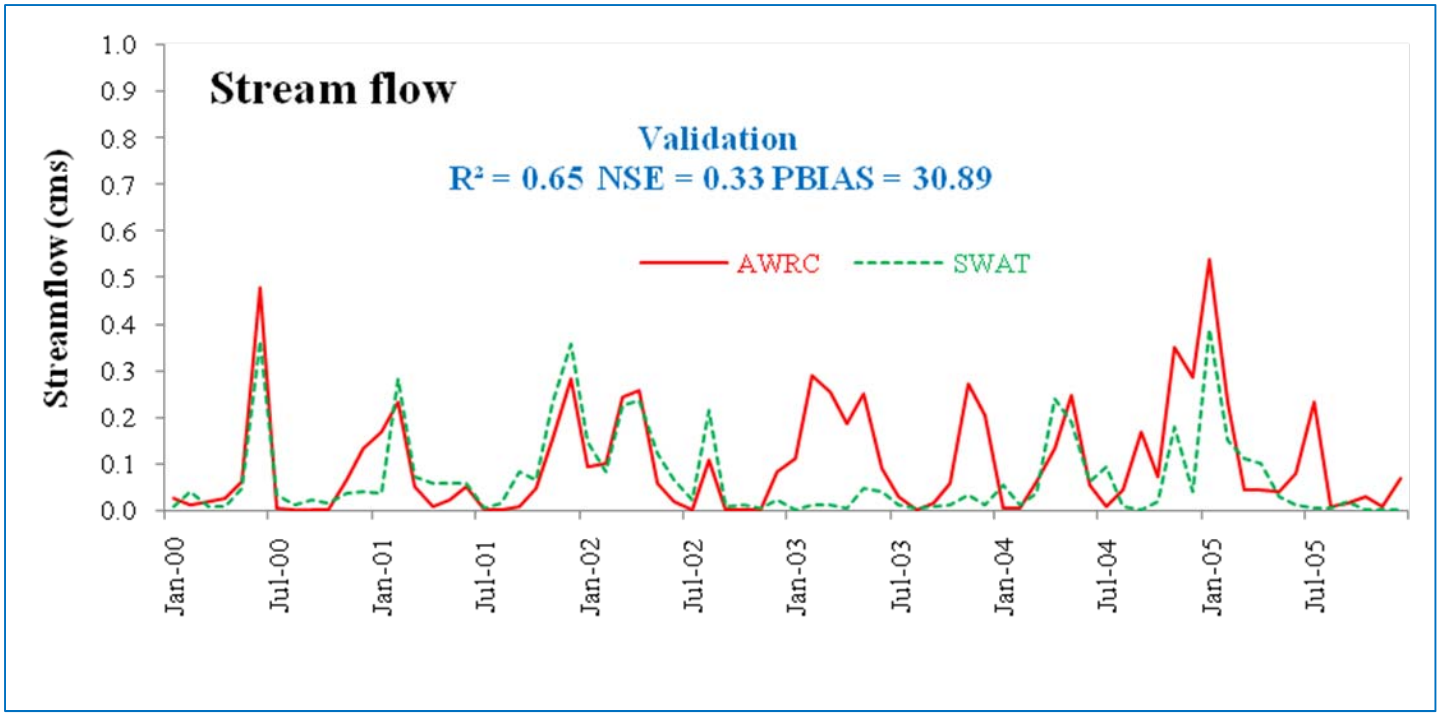
Stream flow @Moore's Creek



Nutrients @Moore's Creek