A Decision Support System Framework for Integrated Agricultural Watershed Management

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Co-Investigators

- Brian Schaffer
- Phil Tacker
- Earl Vories
- Jennie Popp
- German Rodriguez

What is a DSS?

- A Decision Support System (DSS) is a knowledge-based system that requires personnel and technology to collect, catalogue, and place vast amount of data, historical information, research findings, resource inventories, and scientific knowledge (Rais et al., 2000).
- Can be defined as computer based information systems designed to improve the decision-making processes (Monash University, 1995).
- A watershed management DSS is a knowledge-based computer system that integrates data, information, physical simulation models and other economic analyses on a holistic basis to identify alternatives for solving specific watershed problems (Fulcher et al., 1996)

Why Watershed Management DSS is Essential?

- To provide watershed and water quality information of past, present, and future on a single platform
  - To help planners and end users
- To provide watershed modeling results to facilitate watershed management
  - To report on various scenario analysis
- To facilitate discussion among researchers, watershed managers and stakeholders to derive optimum watershed management solutions

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http://baeg.uark.edu/DSS/LRWDSS

Objectives

- Develop comprehensive cost-benefit analyses of water conservation and water quality management to optimize row crop production and water quality improvement in L'Anguille River watershed located in Arkansas
- Develop a GIS based decision support system
- Part of a USDA-CSREES funded project

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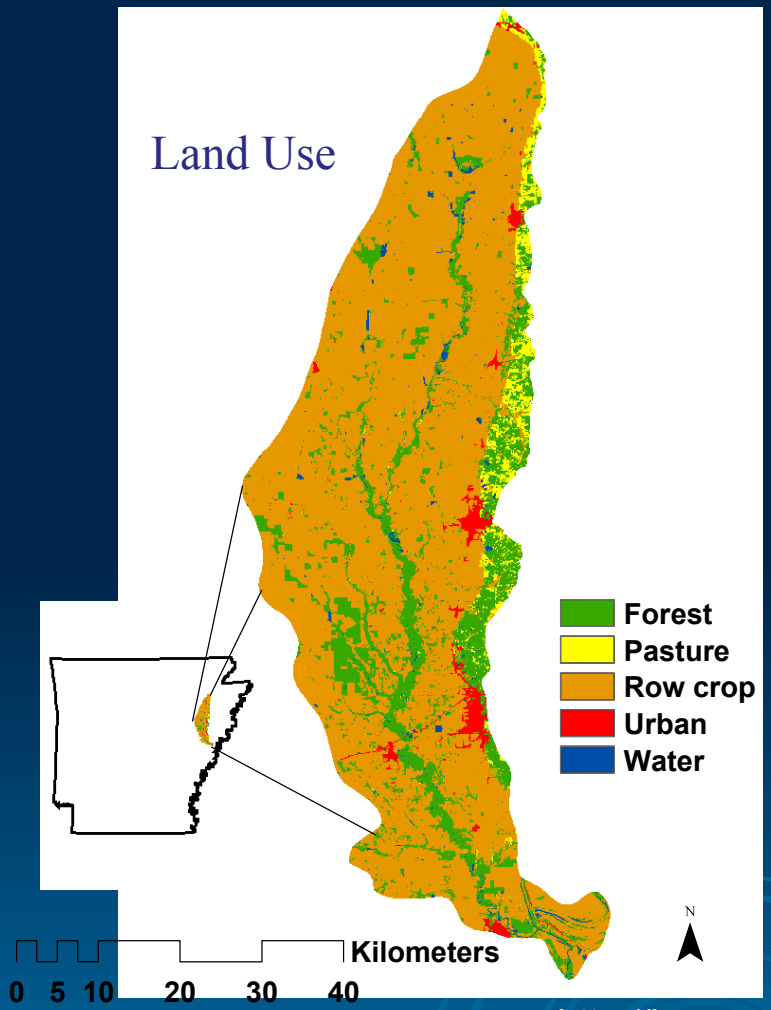
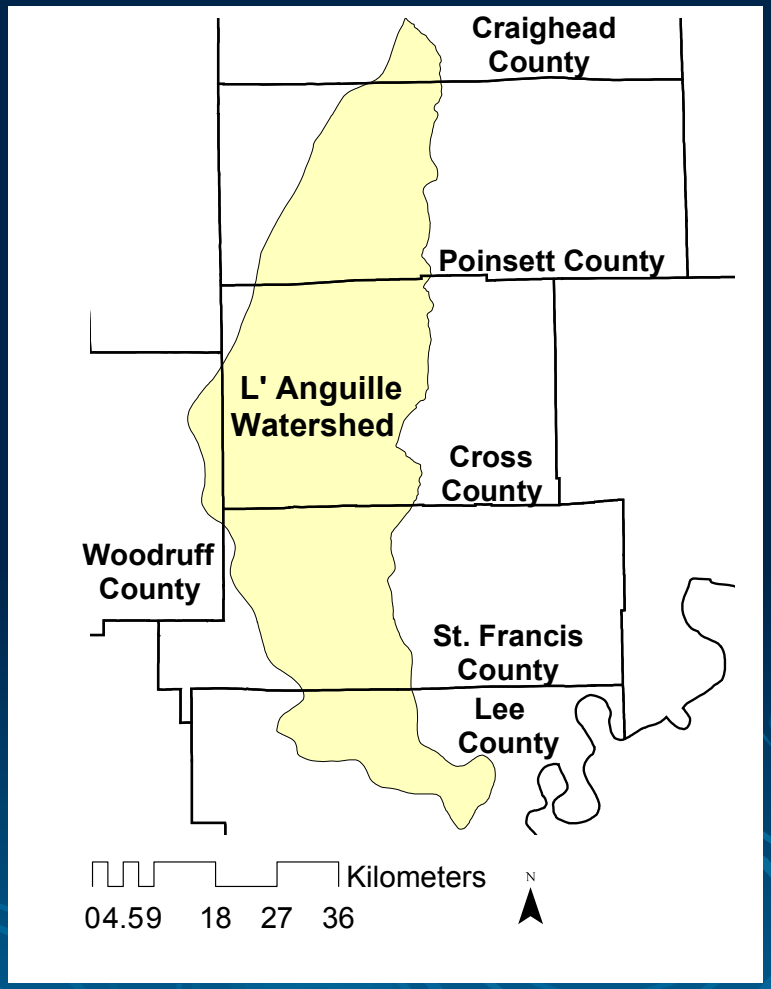
L'Anguille River Watershed in Eastern Arkansas





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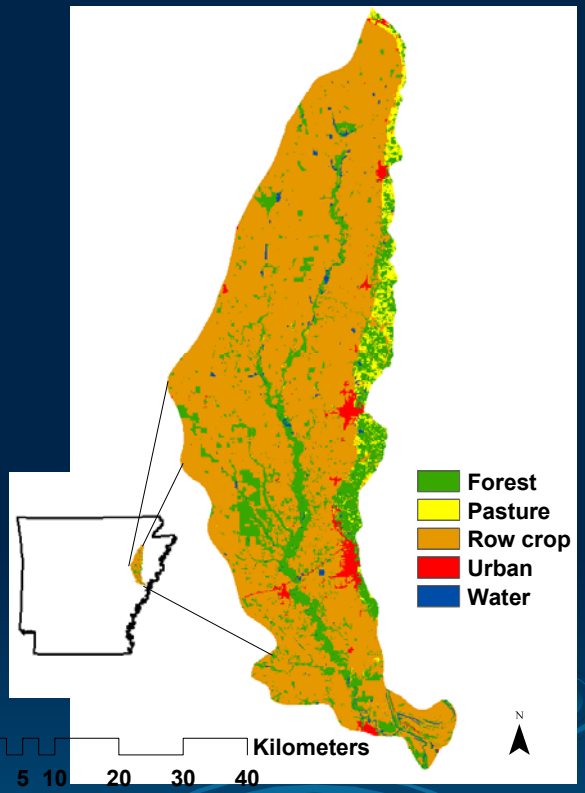
Watershed

- Approximately 620,000 ac
- Land use:
  - 76% row crop agriculture
    - (90% of agriculture is soybeans and rice)
  - 18% forest
  - 3% pasture
  - 2% urban
  - 1% Water
- River Transported in excess of 500 million cubic meters of water and 90 thousand metric tonnes of sediment past Palestine bridge in 2004*



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Issues

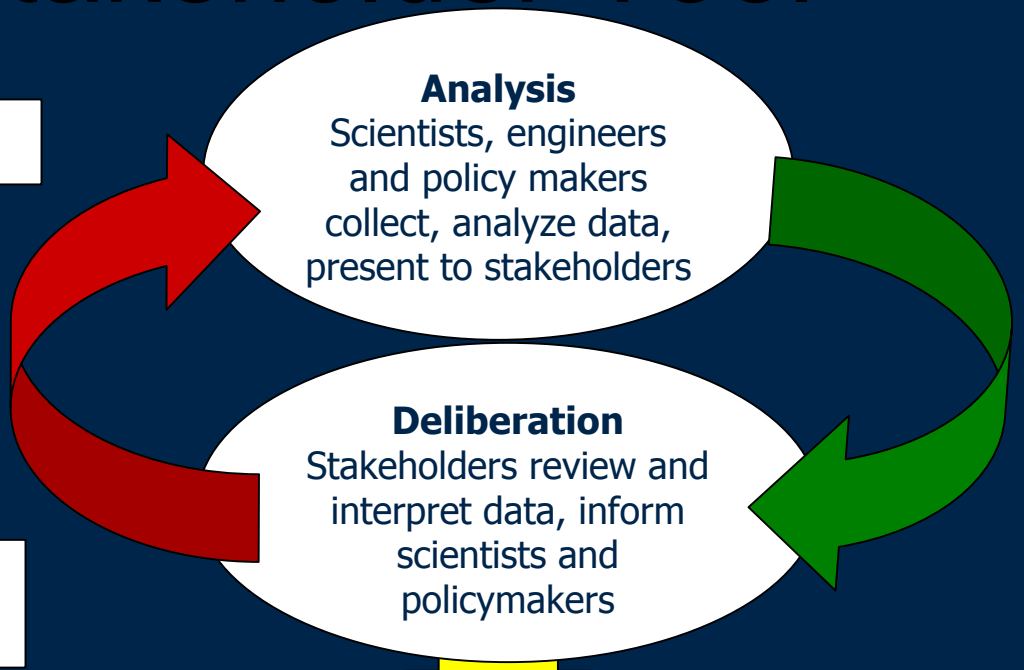
- Entire length of the L'Anguille River is listed in 303(d)
- Excess sediment identified as the cause of impairment
- Spring (February-April) and summer (July-October) identified as critical periods contributing to elevated sediment loads
- TMDL states that existing NPS loads must be reduced by 40% in spring and 38% in summer

DSS is a Stakeholder Tool

Objective 1: Develop DSS

Objective 2: Develop Stakeholder Structure

Objective 4: Evaluate DSS



Scenario Analysis
(with feedback and requirement of stakeholders and decision makers)

Evaluation
Performed by stakeholders, policy makers, Coop Extension

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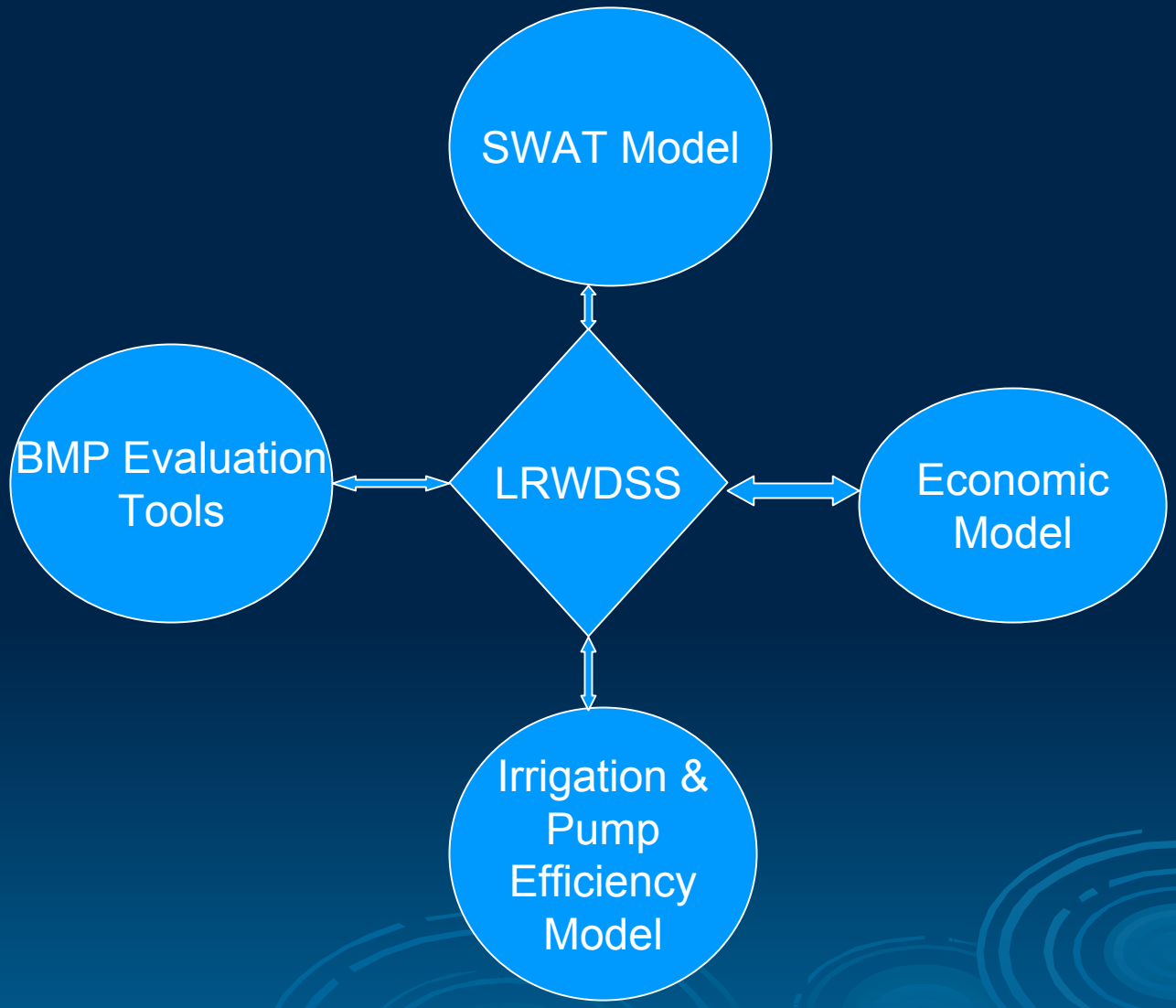
Engines of the L'Anguille River DSS



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Decision Support System

http://www.baeg.uark.edu/DSS/LRWDSS/

L'Anguille River Watershed Decision Support System

Watershed Data

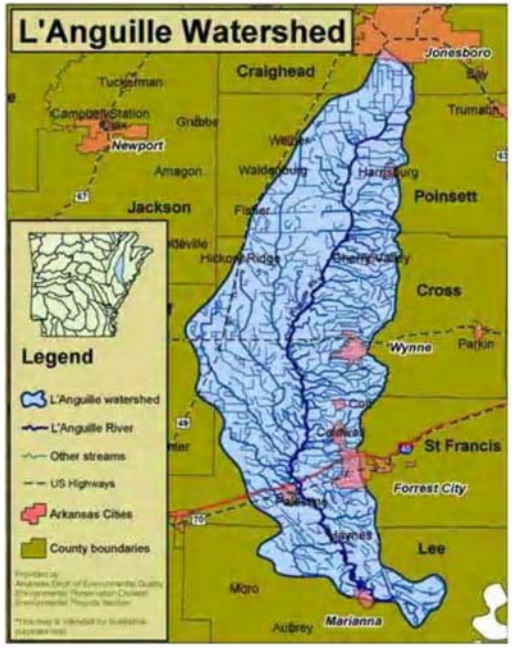
Maps for Watershed

Published Studies and Documents

Journal Articles

Contact Information

Site Map



Assess Water Quality Impacts

Perform Economic Analysis

View SWAT Model Results

Resources for Educators Policy Makers

Additional Information and Resources for Producers

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Soil and Water Assessment Tool Model

- Continuous Time, daily time step model
- Distributed Parameter
  Unlimited Number of Subwatersheds
- Comprehensive – Process Interactions
- Simulate Management
- Part of BASINS suite of EPA models for TMDL development
- Model used by every state in US and 32 different countries

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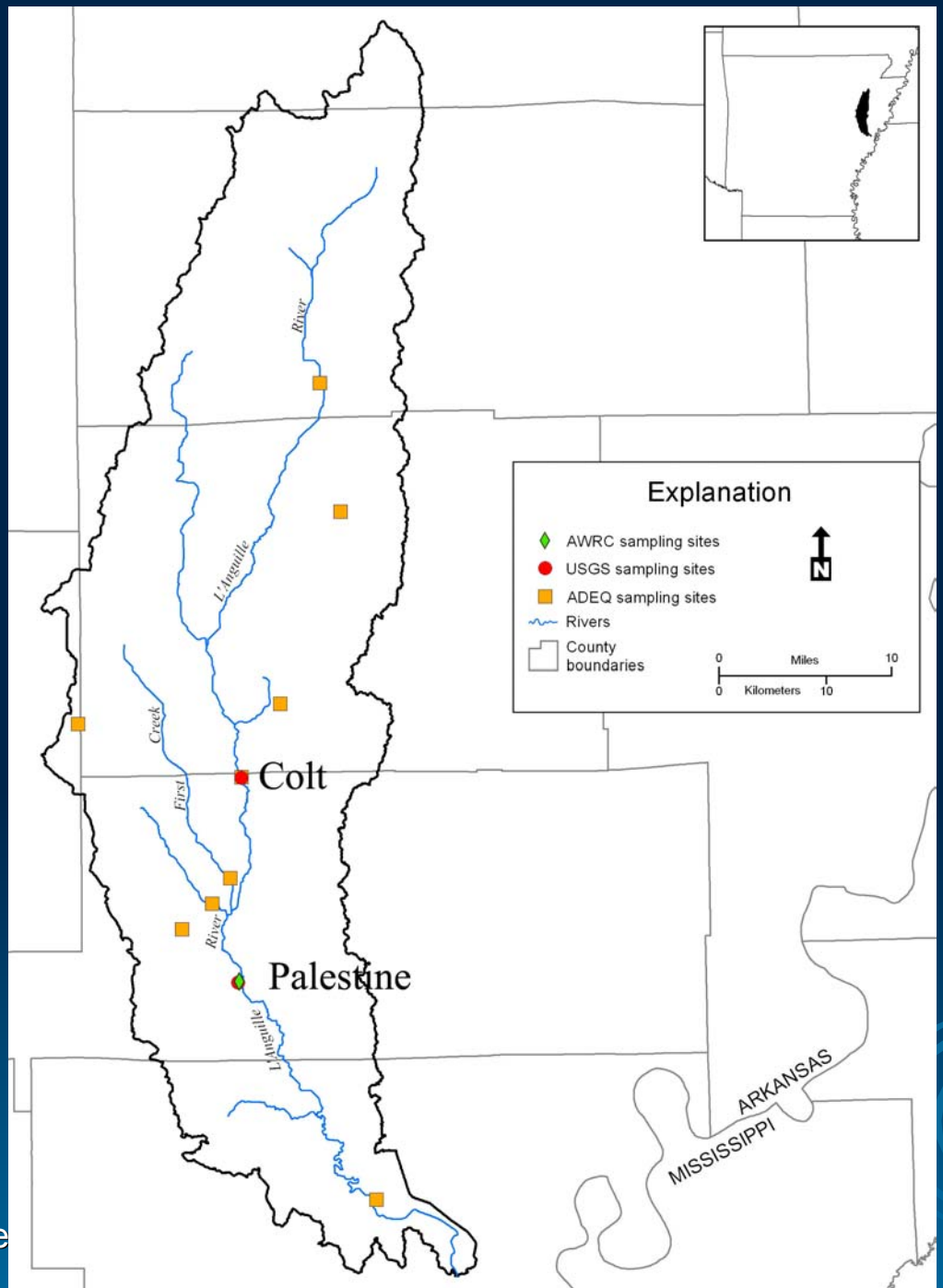

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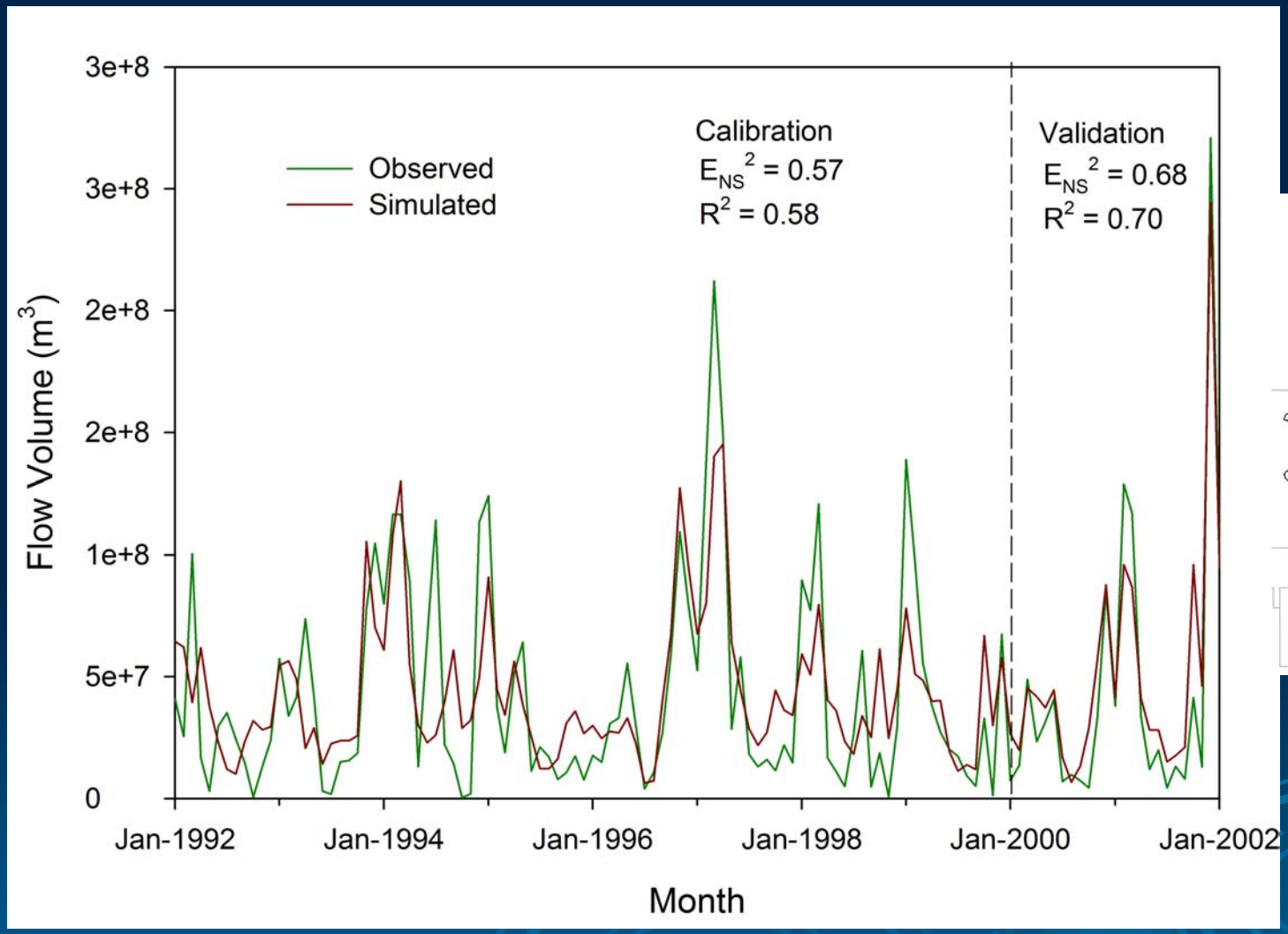
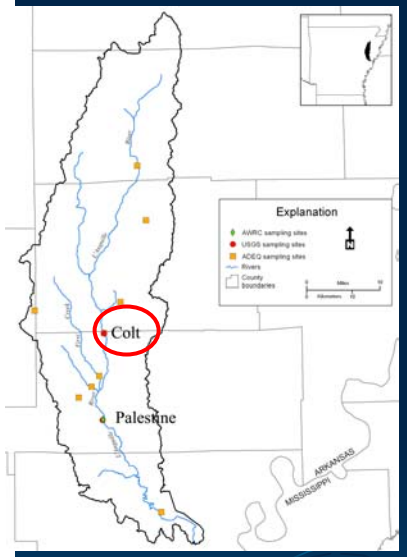
Model Results: Colt station





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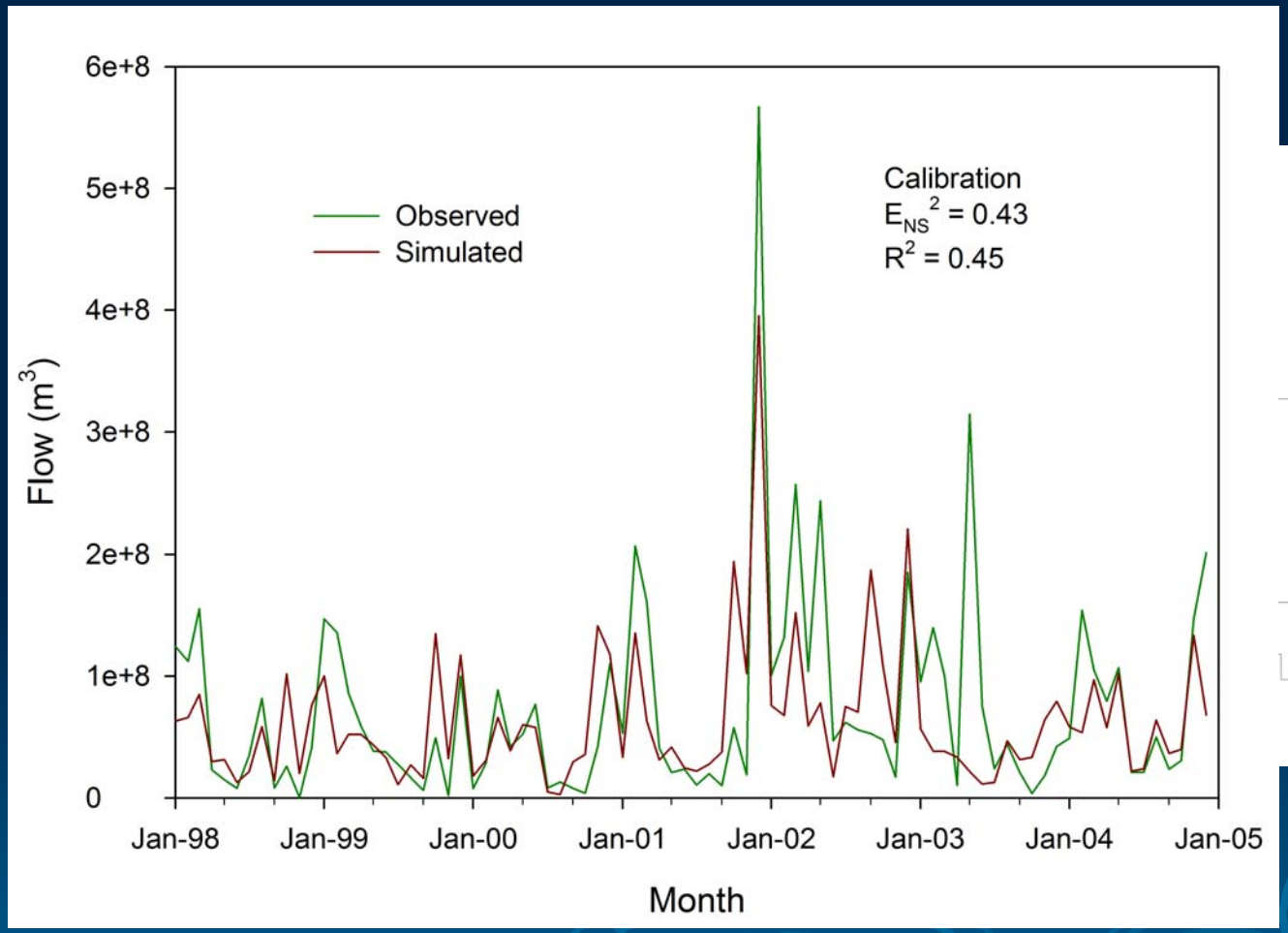
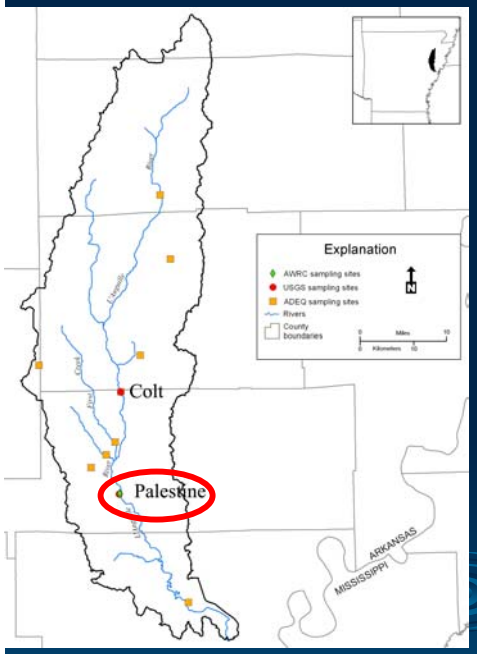
Model Results: Palestine station





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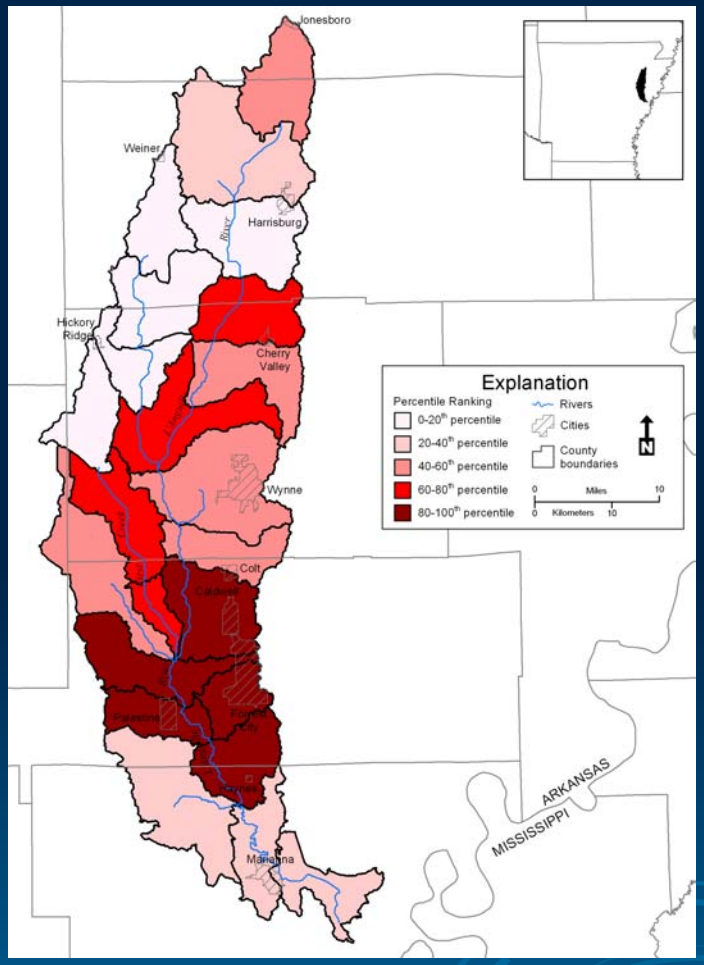
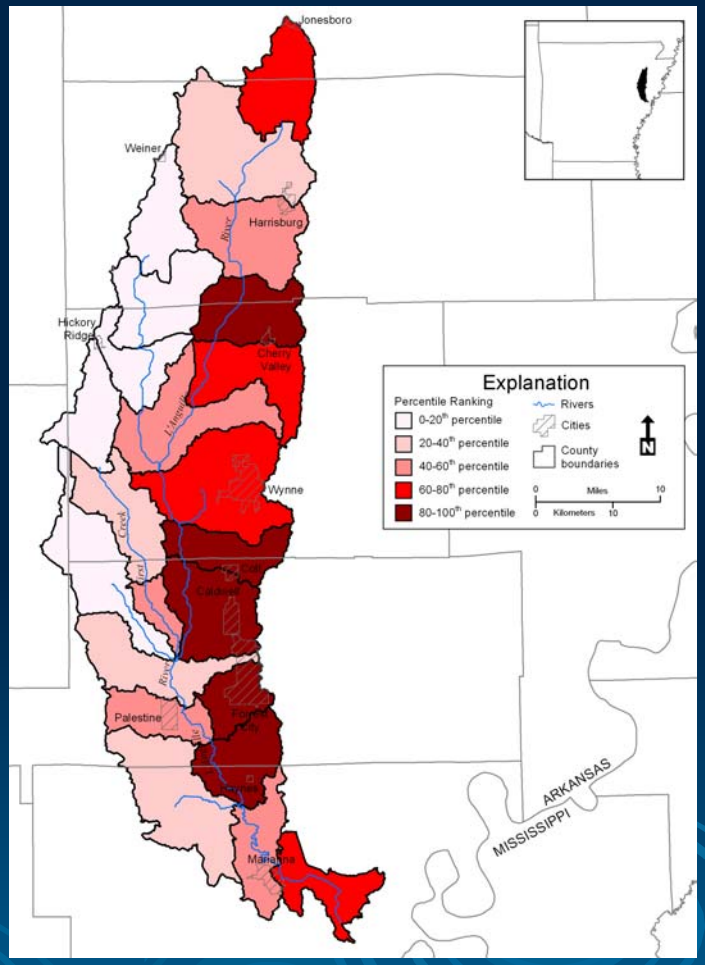
Flow



Sediment



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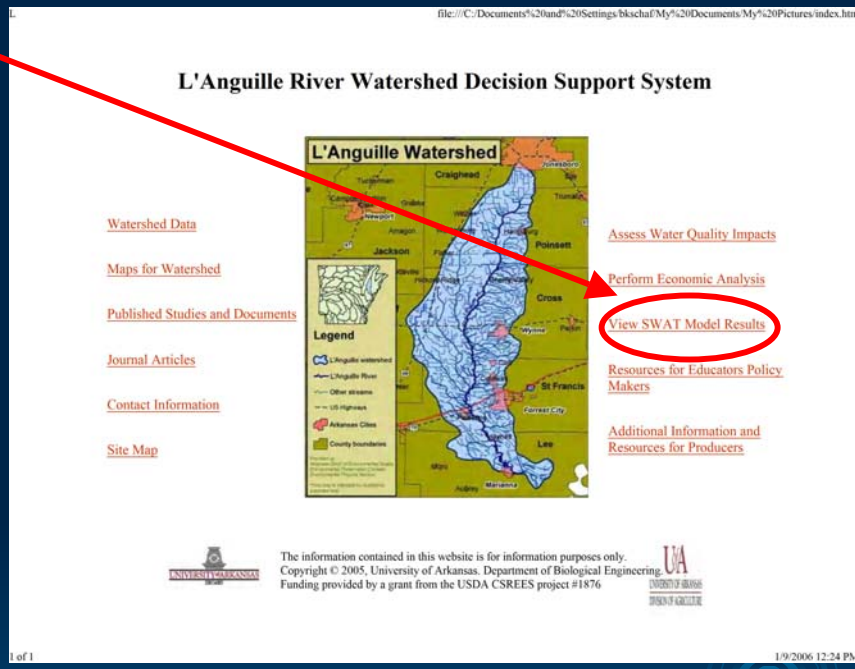
BMP Scenarios Analyzed

- 54 different scenarios
- Two Crops: rice and soybean
  - Covers 90% of the agricultural production
- Three fertilizer application rates
  - Optimal, sub-optimal, and over application
- Three tillage practices
  - Conservation, conventional, no till
- Three buffer strip lengths
  - 0, 5, 10 m



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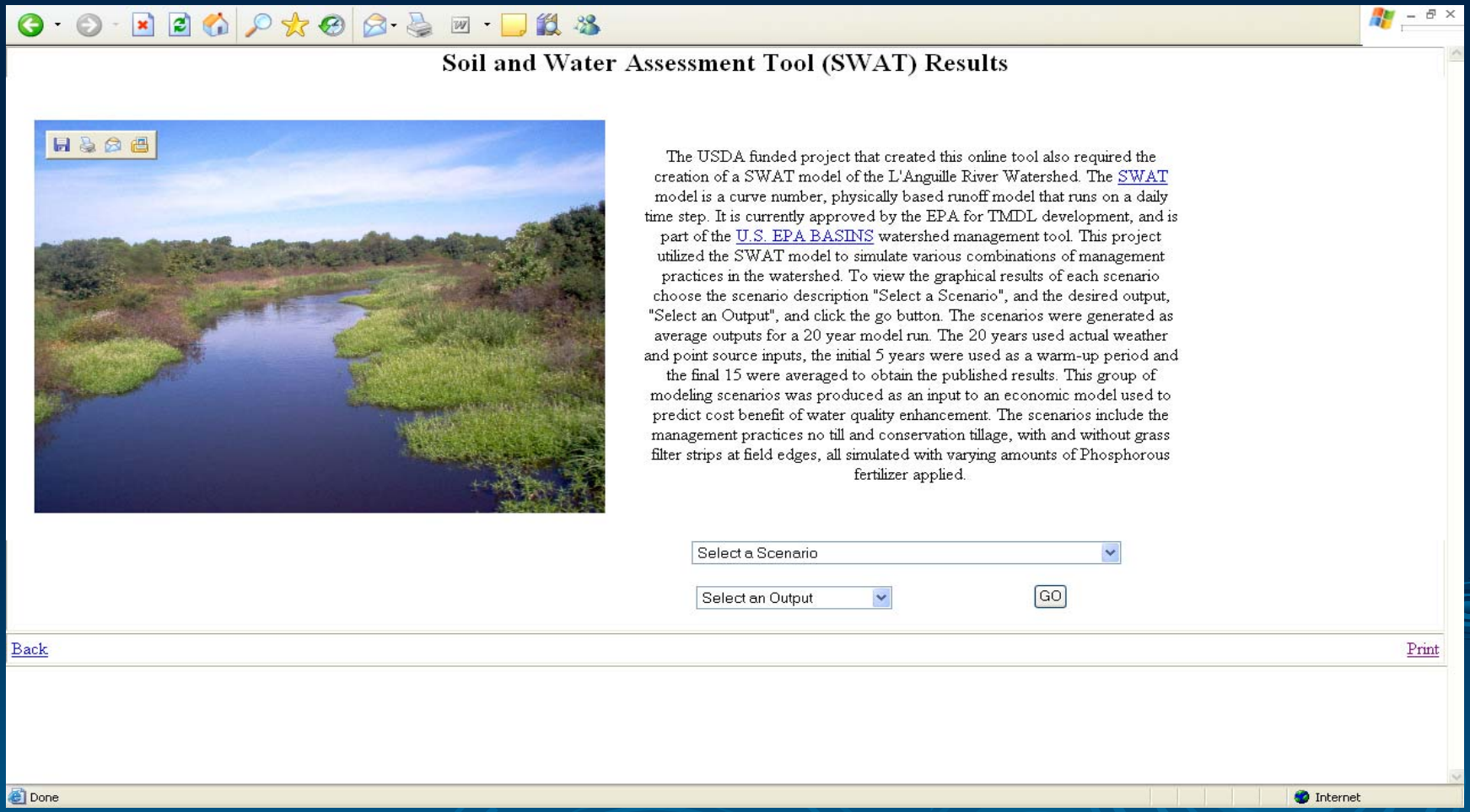
SWAT BMP Scenario Analysis



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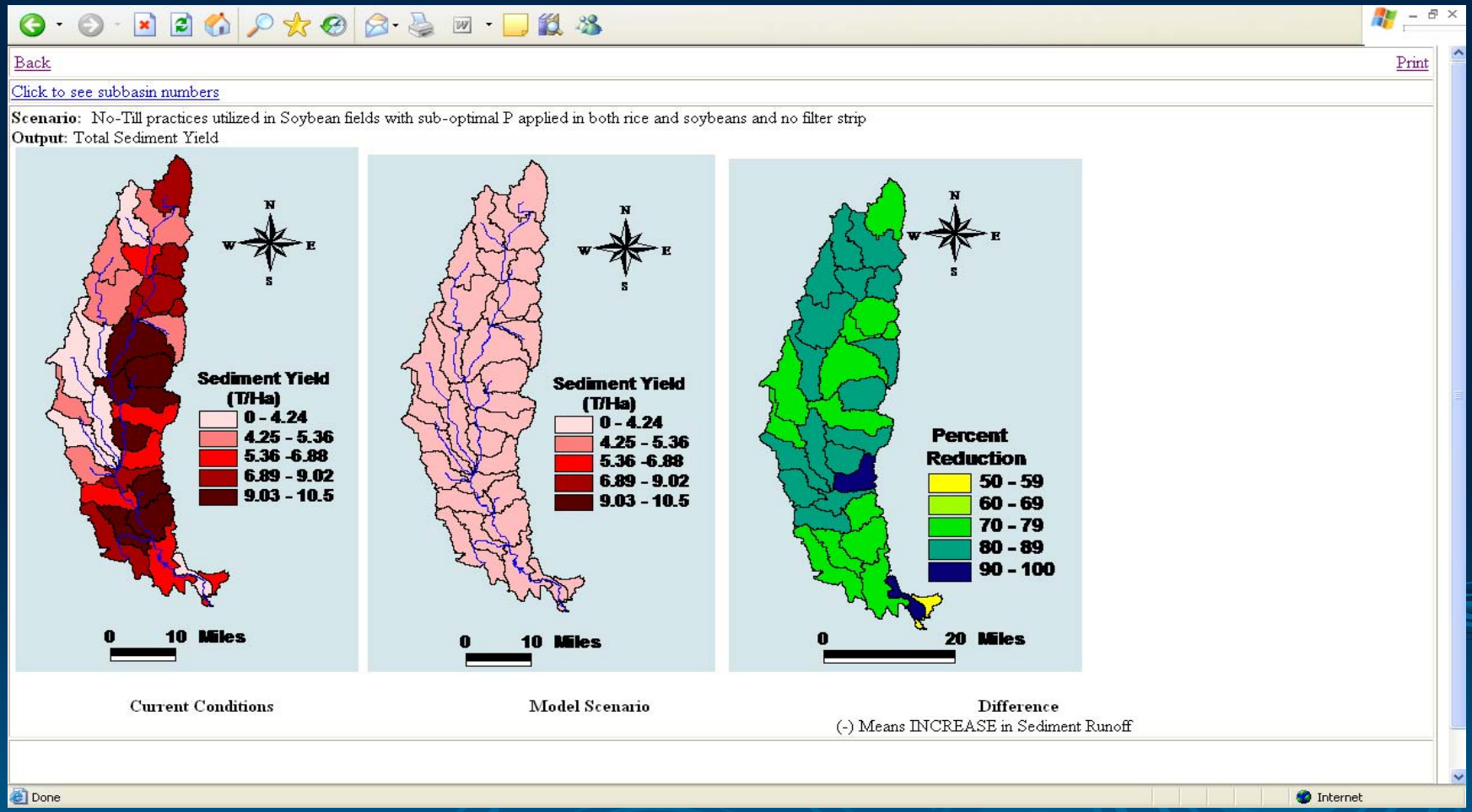
Conversion from conventional tillage to no-till



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Other BMP Evaluation Tools

Local Government Environmental Assistance Network

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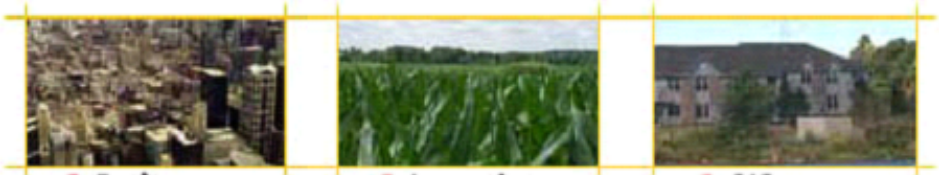
LGEAN

Land Use Impacts on Water Quality

As local land use decisionmakers, municipal and county leaders regularly measure the benefits and costs of development proposals. In addition to factors such as the extension of existing infrastructure and the delivery of government services, local officials are beginning to consider the impact that land use changes will have on a community's water quality.

Land use changes can significantly impact groundwater recharge, stormwater drainage, and water pollution. The Long-Term Hydrologic Impact Assessment (L-THIA) model was developed as an accessible online tool to assess the water quality impacts of land use change. Based on community-specific climate data, L-THIA estimates changes in recharge, runoff, and nonpoint source pollution resulting from past or proposed development. As a quick and easy-to-use approach, L-THIA's results can be used to generate community awareness of potential long-term problems and to support planning aimed at minimizing disturbance of critical areas. L-THIA is an ideal tool to assist in the evaluation of potential effects of land use change and to identify the best location of a particular land use so as to have minimum impact on a community's natural environment.



Basic L-THIA | Impervious L-THIA | GIS L-THIA

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RWDSS

STEPL Model

U.S. Environmental Protection Agency

STEPL - Spreadsheet Tool for Estimating Pollutant Load
Region 5 Load Estimation Model

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EPA Home > STEPL

Home

Access STEPL Data Server for Input Data

Models and Documentation

Frequently Asked Questions

Welcome to STEPL and Region 5 Model

Spreadsheet Tool for Estimating Pollutant Load (STEPL) employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs).STEPL provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS) Excel. It computes watershed surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD5); and sediment delivery based on various land uses and management practices. For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies.

Region 5 Model is an Excel workbook that provides a gross estimate of sediment and nutrient load reductions from the implementation of agricultural and urban BMPs. The algorithms for non-urban BMPs are based on the "Pollutants controlled: Calculation and documentation for Section 319 watersheds training manual" (Michigan Department of Environmental Quality, June 1999). The algorithms for urban BMPs are based on the data and calculations developed by Illinois EPA. Region 5 Model does not estimate pollutant load reductions for dissolved constituents.

Questions? Please contact:
STEPL E-mail support
Telephone support (EPA and EPA clients only): (703)385-6000 (Ting Dai or Henry Manguerra)
Developed for EPA Office of Water
Grants Reporting and Tracking System
By Tetra Tech, Inc.
Last revised: 7/3/2003

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Irrigation and Pump Efficiency Assessment

C18

	A	B	C	D	E	F	G	H	I
1				**Calculating Irrigation Pumping Costs**					
2	**Instructions:** Put a value in the outlined boxes. Most boxes have a pop-up help box and pull down arrow for selecting the entry.								
3	Blue values are calculated, intermediate values. **Energy** and **Operating costs** are in **$ per ac-in** and **$ per ac-ft of water pumped**.								
4	Click the **Glossary** tab at bottom for definitions of terms or the **Calculations** tab for a step-by-step guide to the calculations.								
5									
6									
7	**Diesel**			**Electrical, Vertical Line Shaft Pump**			**Electrical, Submersible Pump**		
8	Head	100	ft	Head	100	ft.	Head	100	ft.
9	Diesel Price	$2.20	$/gallon	Electric Price	$0.11	$/KWH	Electric Price	$0.11	$/KWH
10	Engine Power Output	18	hp-hr/gal	Motor Power Output	1.15	hp-hr/KWH	Motor Power Output	1.05	hp-hr/KWH
11	Pump Efficiency	70.0%		Pump Efficiency	70.0%		Pump Efficiency	70.0%	
12	Gear Head Efficiency	95.0%		Gear Head Efficiency	100.0%				
13	Energy Cost	$2.09	$/ac-in	Energy Cost	$1.55	$/ac-in	Energy Cost	$1.70	$/ac-in
14		$25.02	$/ac-ft		$18.60	$/ac-ft		$20.37	$/ac-ft
15	Routine Maintenance	15.0%		Routine Maintenance	3.0%		Routine Maintenance	7.0%	
16	**Operating Cost**	**$2.40**	**$/ac-in**	**Operating Cost**	**$1.60**	**$/ac-in**	**Operating Cost**	**$1.82**	**$/ac-in**
17		**$28.77**	**$/ac-ft**		**$19.16**	**$/ac-ft**		**$21.80**	**$/ac-ft**
18									
19									
20	**Natural Gas**			**Liquid Petroleum (LP. Propane)**			**Gasoline**		
21	Head	100	ft	Head	100	ft	Head	100	ft
22	Natural Gas Price	$0.77	$/ccf	LP Price	$1.75	$/gallon	Gasoline Price	$3.00	$/gallon
23	Engine Power Output	10	hp-hr/ccf	Engine Power Output	11	hp-hr/gal	Engine Power Output	12	hp-hr/gal
24	Pump Efficiency	70.0%		Pump Efficiency	70.0%		Pump Efficiency	70.0%	
25	Gear Head Efficiency	95.0%		Gear Head Efficiency	95.0%		Gear Head Efficiency	95.0%	
26	Energy Cost	$1.31	$/ac-in	Energy Cost	$2.71	$/ac-in	Energy Cost	$4.27	$/ac-in
27		$15.76	$/ac-ft		$32.57	$/ac-ft		$51.18	$/ac-ft
28	Routine Maintenance	12.0%		Routine Maintenance	12.0%		Routine Maintenance	15.0%	
29	**Operating Cost**	**$1.47**	**$/ac-in**	**Operating Cost**	**$3.04**	**$/ac-in**	**Operating Cost**	**$4.90**	**$/ac-in**
30		**$17.66**	**$/ac-ft**		**$36.48**	**$/ac-ft**		**$58.86**	**$/ac-ft**

Summary / Glossary / Calculations

Unknown Zone

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Calculations

The Basic Equation for Pumping Energy

$$(A/NPS) \times H = energy/ac-in$$

Where

A =	0.11345, Conversion Factor for Gallons/Minute to (hp-hr/ac-in)/ft
NPS =	Nebraska Pumping Standard = Engine/Motor Power Output X Pump Efficency X Gear Head Efficency, (hp-hr/unit of energy)
H =	Head (ft.)

Calculation for Conversion Factor: A

$$A = \frac{449.19}{1}\frac{gal}{min}\frac{hr}{ac-in} \times \frac{1}{7.48}\frac{ft^3}{gal} \times \frac{0.4329}{1}\frac{lb}{ft-in^2} \times \frac{144}{1}\frac{in^2}{ft^2} \times \frac{1}{60}\frac{min}{sec} \times \frac{1}{550}\frac{hp-sec}{ft-lb} = \frac{28001.426}{246840}\frac{hp-hr}{ac-in}\Big/ft = 0.11345$$

Calculation for Energy Cost, EC

$$EC = (A/NPS) \times H \times P$$

EC =	Energy Cost ($/ac-in)
A =	Conversion Factor for Gallons/Minute to (hp-hr/ac-in)/ft
NPS =	Nebraska Pumping Standard = Engine/Motor Power Output X Pump Efficency X Gear Head Efficency, (hp-hr/unit of energy)
H =	Head (ft.)
P =	Price in $ per unit of energy (i.e., gallons, KWH, ccf etc)

Calculation for Operating Cost, OC

$$OC = (1 + RM)EC$$

OC	=	Operating Cost	$/ac-in and $/ac-ft
RM	=	Routine Maintenance	(% as decimal)
EC	=	Energy Cost	$/ac-in and $/ac-ft

Summary / Glossary / Calculations

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Economic Modeling

L'Anguille River Watershed Decision Support System

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Maps for Watershed

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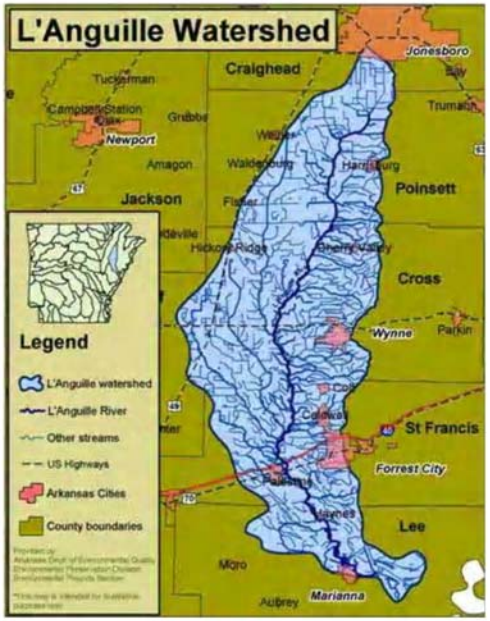

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Economic Modeling

L'Anguille River Watershed Decision Support System

Economic Decision Support

Tools for determining economic cost/benefit outcomes from implementation of various management practices.

The economic analysis spreadsheet allows user input of all variables, and facilitates the ability to estimate the cost of acceptable practices including tillage, fertilization, etc. It also provides income information based on yields and prices received, as well as government payments. To download excel version Click Here.

For instructions to use the Economic Calculation spreadsheet Click Here.

The pumping cost spreadsheet allows a producer to calculate the various costs associated with pumping groundwater for irrigation. This spreadsheet program provides information to help make informed economic decisions when selecting various types of equipment.

Open Office is a free spreadsheet program available on the internt. To Download **Open Office** Click Here

For Questions or feedback about the spreadsheet program, email hrodrig@uark.edu

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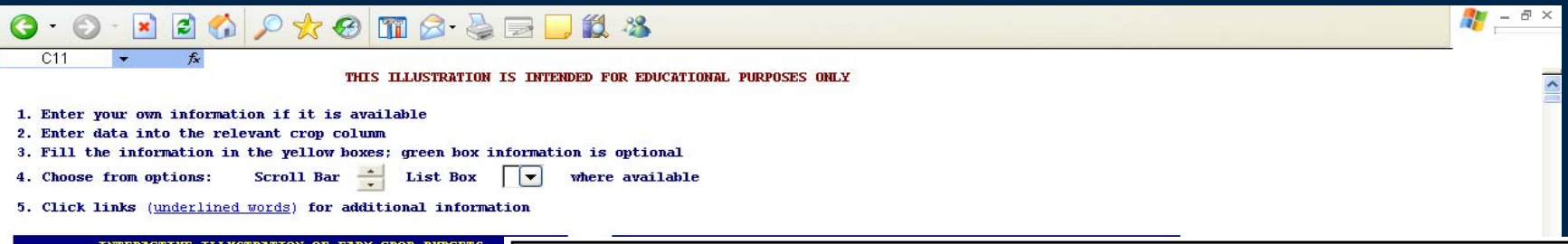
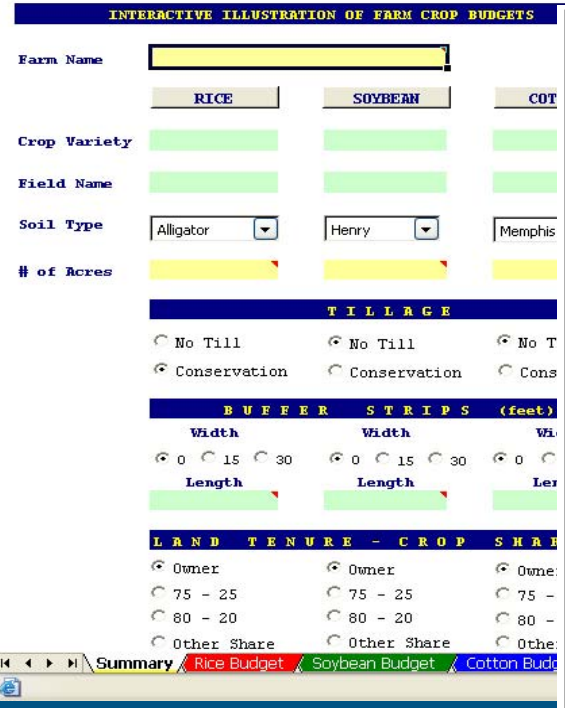




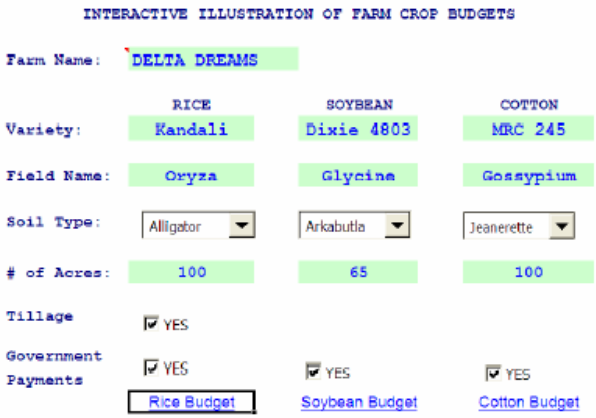
CROP BUDGETS USER GUIDE

The *Crop Budgets User Guide* covers everything you need to know to start using this application, including: (1) essential settings; (2) basic tasks to create rice and soybean budgets; and (3) help to further functions once you have learned the basics. This spreadsheet is both easy to use and highly customizable. This application can be used on your personal computer or you can access it on the web at: http://www.baeg.uark.edu/DSS/LRWDSS/perform_economic_analysis.htm

Software Requirements

The spreadsheet employs standard Windows graphical elements, so that anyone familiar with the Windows environment should find the budgets easy to navigate.

Figure 1. Getting Started: Summary Sheet



Essential Settings

Sub-basin and in-stream load reduction: example

Management Practice	Sub-Basin Yield Reduction (%)	In Stream Loading Reduction (%)
Conservation Tillage	39.3	4.3
No Till	70.1	9.2
Conservation with Filter	79.7	9.7

BMP Optimization using SWAT model and Genetic Algorithm is currently in progress

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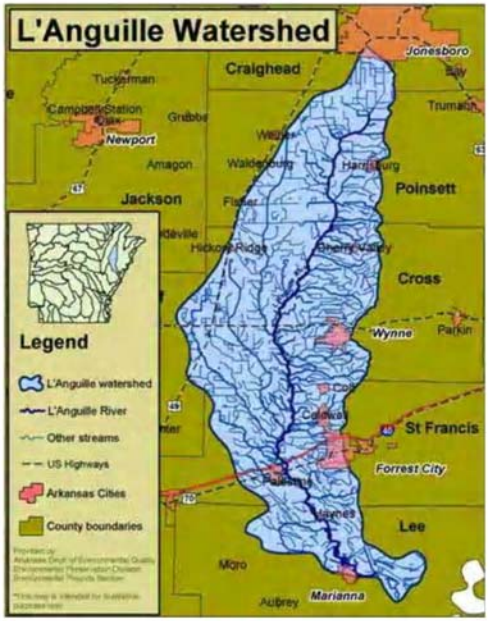

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Resources on Policies Relevant to Watershed Management

L - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://baeg.uark.edu/DSS/LRWDSS/Policyresource.htm

L'Anguille River Watershed Decision Support System

Policy Maker Resource Page

This page contains links to documents authored or recommended by project participants that contain information that may be of use to persons in positions of responsibility for making or influencing the making of water resource policy.

To Access a List of MS Power Point Presentations

Click Here

Proposed Fact Sheets (pdf)

- Water Statutes in the U.S., Bkgrnd
- History of Legislation
- Water Rights and Conservation
- Water Programs
- TMDL Process
- TMDL Litigation
- Role of Local Communities

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Fact Sheets and Educational Materials

- Water Statutes in the US – background
- History of legislation
- Water rights and conservation
- Water programs
- TMDL process
- TMDL litigation
- Role of local communities in watershed management
- Dealing with contentious issues

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Broader Impacts

- Stakeholders involved in a participatory approach to increase DSS acceptability
  - Languille River Watershed Coalition
- 10 different DSS meetings conducted
  - Attended by more than 250 stakeholders
  - Farmers, extension agents, municipality and industry personnel, and bankers
- A number of groups have indicated interest in using the DSS to make various watershed management decisions
  - Arkansas Natural Resources Commission, Audobon Society, Languille River Watershed Coalition

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