Study Design and Project Status: Hydrological and Water Quality Monitoring from Bioenergy Crop Lands

SWAT Model Data Calibration/Verification Support for Watersheds near Vonore, Tennessee

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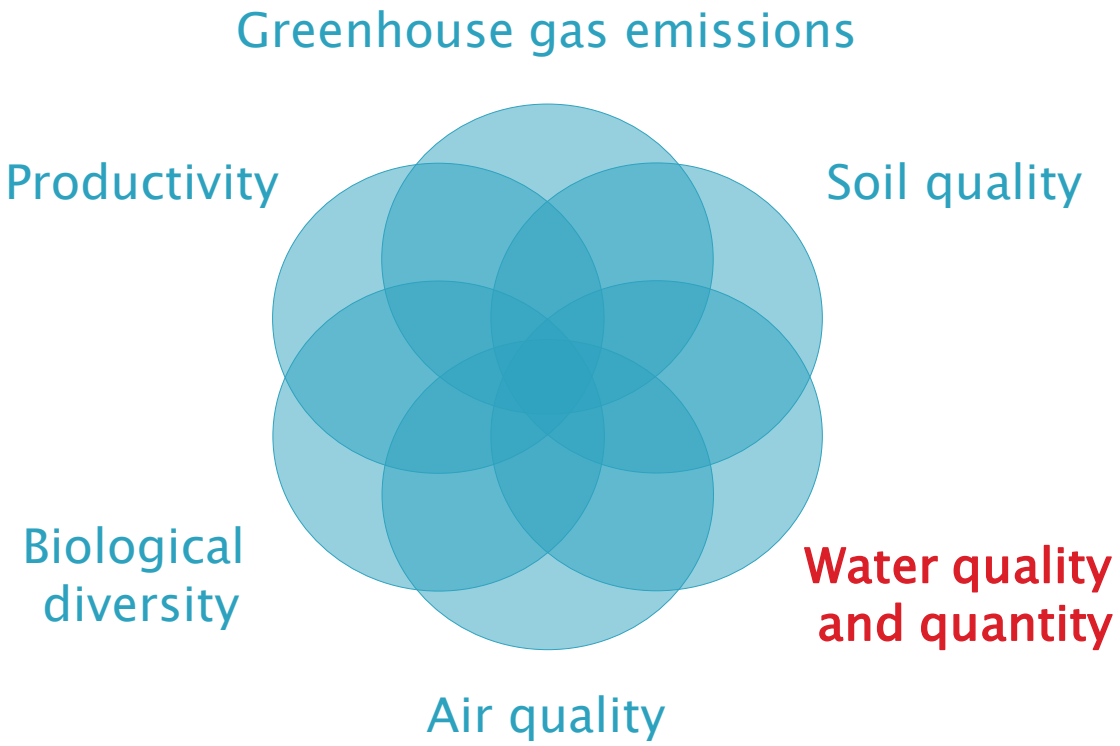
Project Background

- USDA Funded: Southeast Partnership for Integrated Biomass Supply Systems (IBSS)
- Previous ORNL Research
  - SWAT Modeling (Baskaran *et al*. 2010; others)
  - BLOSM Model (Parish *et al*. 2012; others)
- ORNL Research Goals
  - Sustainability: Water Quality vs Ag Profits
  - Develop a Suite of Environmental Indicators

CBES
Center for BioEnergy Sustainability

Environmental Indicators of Bioenergy Feedstock Sustainability

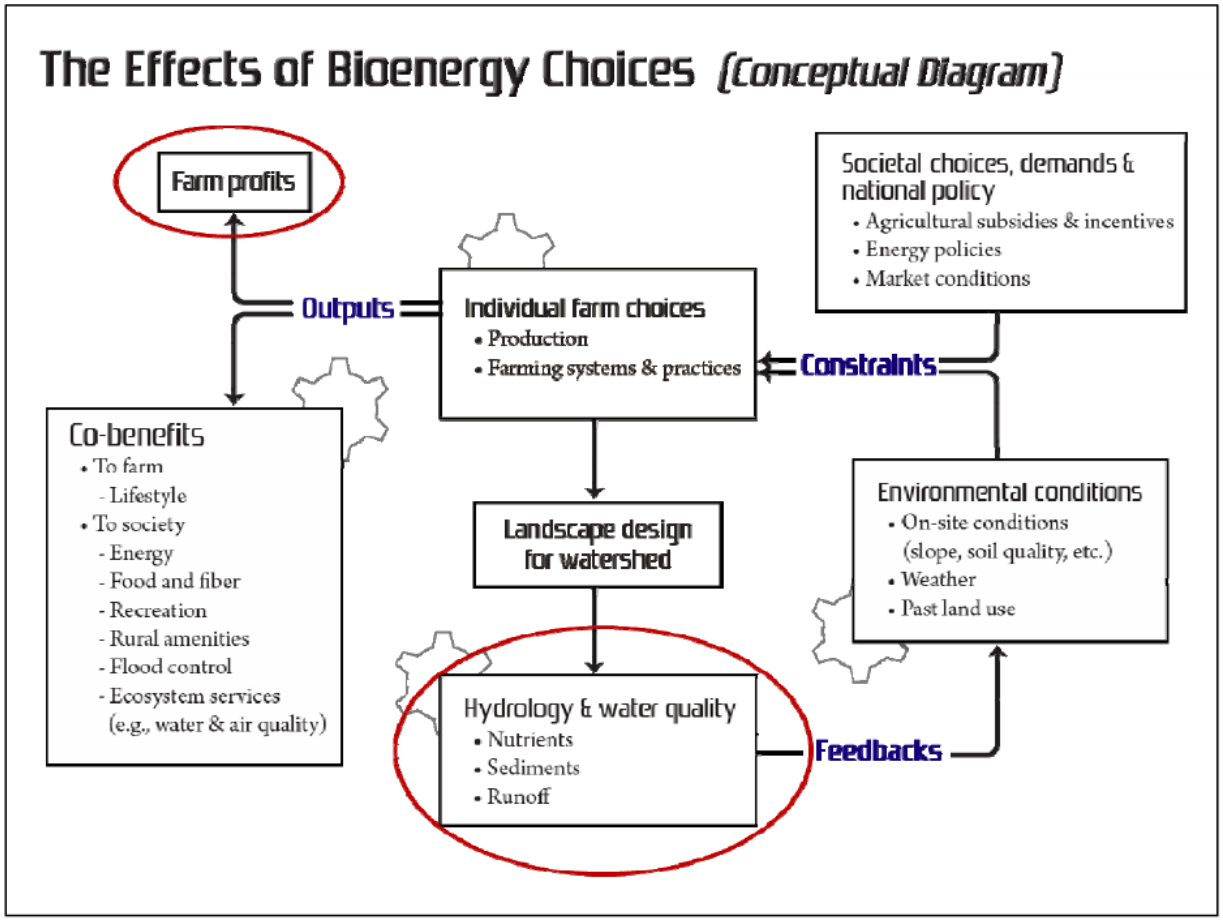


McBride et al. 2011. Indicators to support environmental sustainability of bioenergy systems. *Ecological Indicators* 11(5) 1277–1289.

Slide for V. Dale

Testing a Landscape Design for Watershed-Scale Bioenergy Sustainability

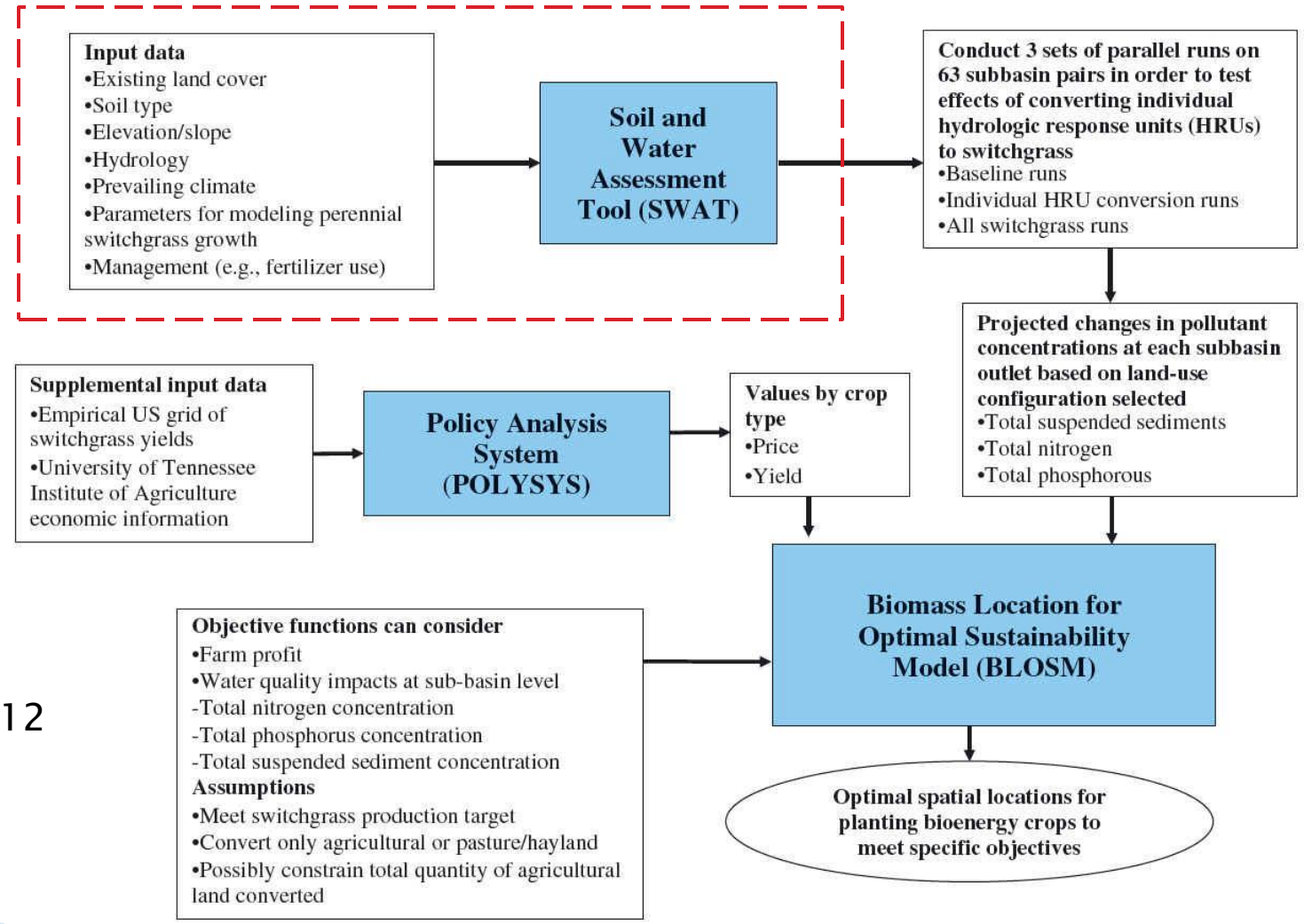
- Optimizing Bioenergy Crops Across a Watershed



Parish, Dale

Testing a Landscape Design for Watershed-Scale Bioenergy Sustainability

- BLOSM



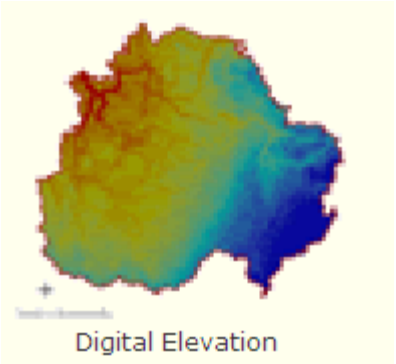
Lower Little Tennessee River

Parish et al. 2012

Hydrology and Water Quality Modeling

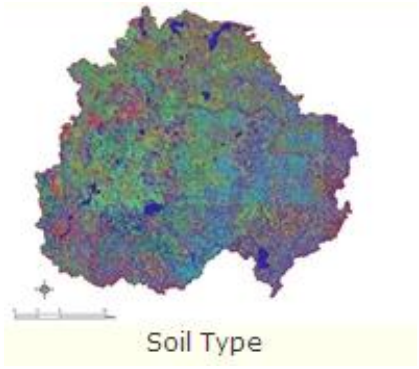
- Soil and Water Assessment Tool (SWAT) Model
  - Quantify runoff sediment, nutrients (total nitrogen and phosphorus), and other chemicals from watersheds in terms of daily loads.
  - Evaluate the effectiveness of alternative best management practices (BMPs) at reducing pollutant loads from watersheds.
  - Assess impacts of climate on agricultural production.

Spatially-explicit Model using 4 base GIS layers:


Digital Elevation


Land Use


Rivers


Soil Type

SWAT Model Input Parameters for Switchgrass Land Cover

- Hydrology: Curve Number (measured or estimated from table)
  - Other hydrological variables.
- Revised Universal Soil Loss Equation (RUSLE) is used to estimate sediment yields by erosion.
  - $A = R \cdot K \cdot LS \cdot C \cdot P$
    - A = Annual Sediment Loss (computed t/ha/yr)
    - R = Rainfall Erosivity factor (measured per rainfall gauge)
    - K = Soil Erodibility factor (measured or standard from table based on soil type)
    - LS = Slope Length / Slope Steepness factor (from DEM)
    - C = Cover Management factor (measured or estimated from table)
    - P = Support Practice Management (estimated)

SWAT Model Input Parameters for Switchgrass Land Cover

- C-Factor
  - Used to describe the effects of plants, soil cover, biomass, and soil disturbing activities (C-Factors)
  - Unknown – how to handle rill/gully development
- C-Factor for Switchgrass
- C-Factors for other vegetation types form various states and regions:
  - Michigan (grass/hay): 0.005 (C-Factors)
  - Ohio (wheat): 0.006 (RUSLE Erosion Prediction)
  - North Carolina (vegetated): 0.004 (JFIC, 2006)
  - Georgia (vegetated): 0.002 (2000)
  - Alabama (winter rye): 0.006 (Nyakatawa)

Switchgrass Effects on Water Quality

- Switchgrass is known to improve water quality, particularly by lowering nutrient levels in runoff.
- Perennial nature means less fertilizers (Blanco-Canqui)
- Once established, has a lower water requirement (Blanco-Canqui).

UTK Project Objectives

- UTK-CEE Objectives
  - Provide hydrological, erosion, and water quality monitoring data for SWAT model verification.
- Water Quality Study design & Site Selection
  - 21 watershed initially selected for 4 paired watershed study.
  - Design modified from paired study to include:
    - i.) catchment sites with near 100% switchgrass land cover; and
    - ii) watershed-scale sites with approximately 10% switchgrass land cover.
- Geomorphological Study Design
  - Assess any downstream channel erosion affects from switchgrass land conversion and estimate sediment yield contributions from channel.
  - Assess land management quality and the formation of field rills/gullies
  - Generate a sediment budgets for watersheds subjected to switchgrass land conversion.

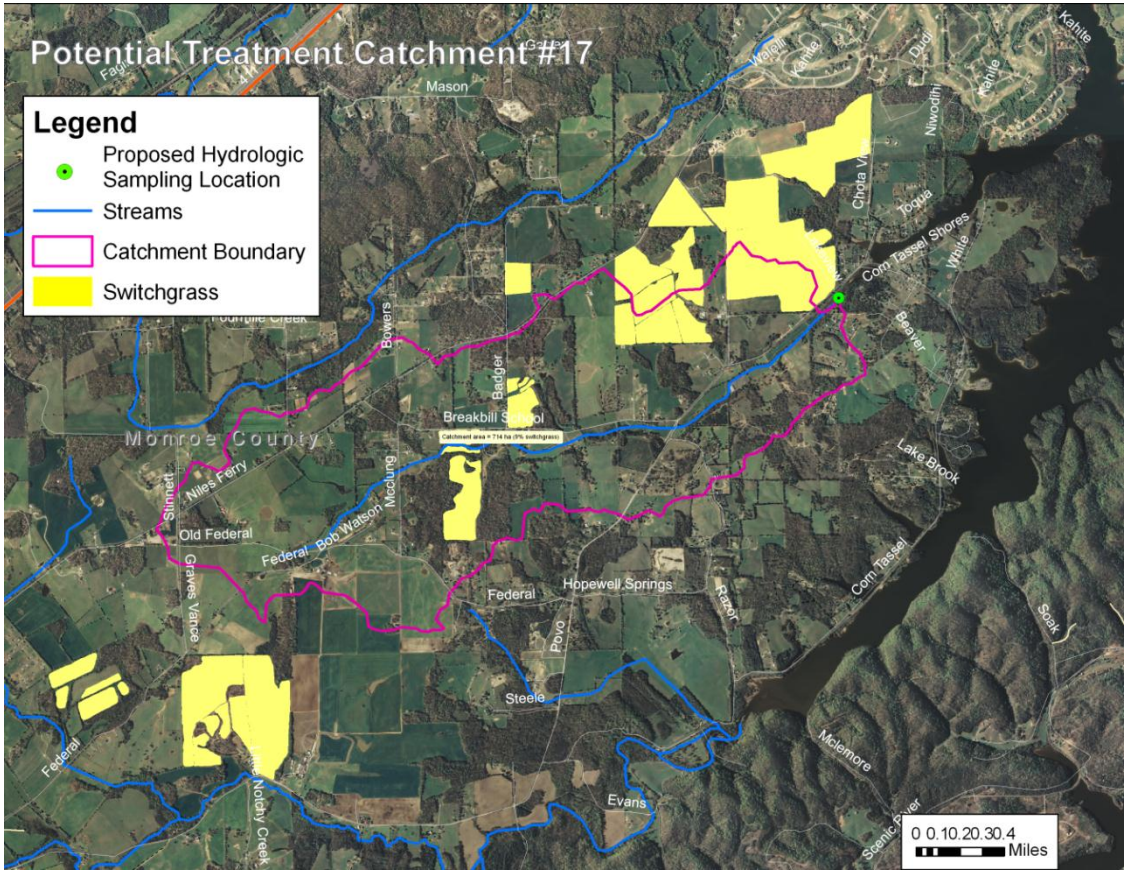
Project Schedule

- Five-year Work Plan

Subtask: Hydrology and Water Quality Project — Year:	1	2	3	4	5
Installation of equipment and instruments, instrument tests	♦				
Field data collection		♦	♦	♦	
Integration of model and field data, synthesis			♦	♦	♦

Proposed Initial Study Sites

- 21Sites will be selected within 50 mile radius from Vonore, Tennessee.
- October 2011; E. Parish, S. Jackson, J. Schwartz, Z. Seiden met to discuss sites.
- Sites filtered based on UTK contract with farmer to grow switchgrass.
- 7 sites remained.
- Paired watershed concept to achieve on the ground; too many potential pollutant sources to obtain statistically relevant data.

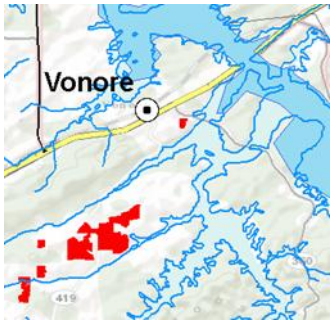


Cornteasel Creek, Vonore, TN
714 ha, 9% switchgrass

Catchment Sites – Study Design

- Catchment Site Measurements
  - Measure runoff, TSS, TN, TP from seven (7) catchments with switchgrass.
  - Two site characteristics:
    - *a.*) 4 land erosion without rills, and
    - *b.*) 3 land erosion with rills.
  - Determine runoff curve numbers (CN) for switchgrass plots for SWAT model for each characteristic.
  - Determine erosion C factor for switchgrass plots for RUSLE module in the SWAT model for each characteristic.
  - Rainfall measurements to estimate erosivity (R) factor

Switchgrass Catchment Locations



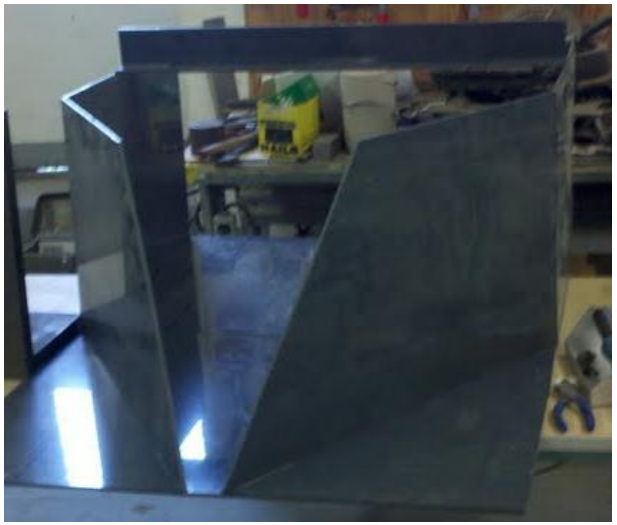
Switchgrass Catchment Locations

Rill Concentrated Flow

Land Sheet Flow

Catchment Site Monitoring Design

- 1.5 ft H-flumes will be used to measure runoff rates
- ISCO 3700 automated samplers will collect runoff water triggered by bubbler-type stage sensors
  - Runoff collected per intervals throughout hydrograph.
  - Runoff collected for water quality analysis (TSS, TN, TP) per interval to compute mass loadings per total runoff volume.
- Rainfall gauges, measure and data log volumes on 5-min. intervals.



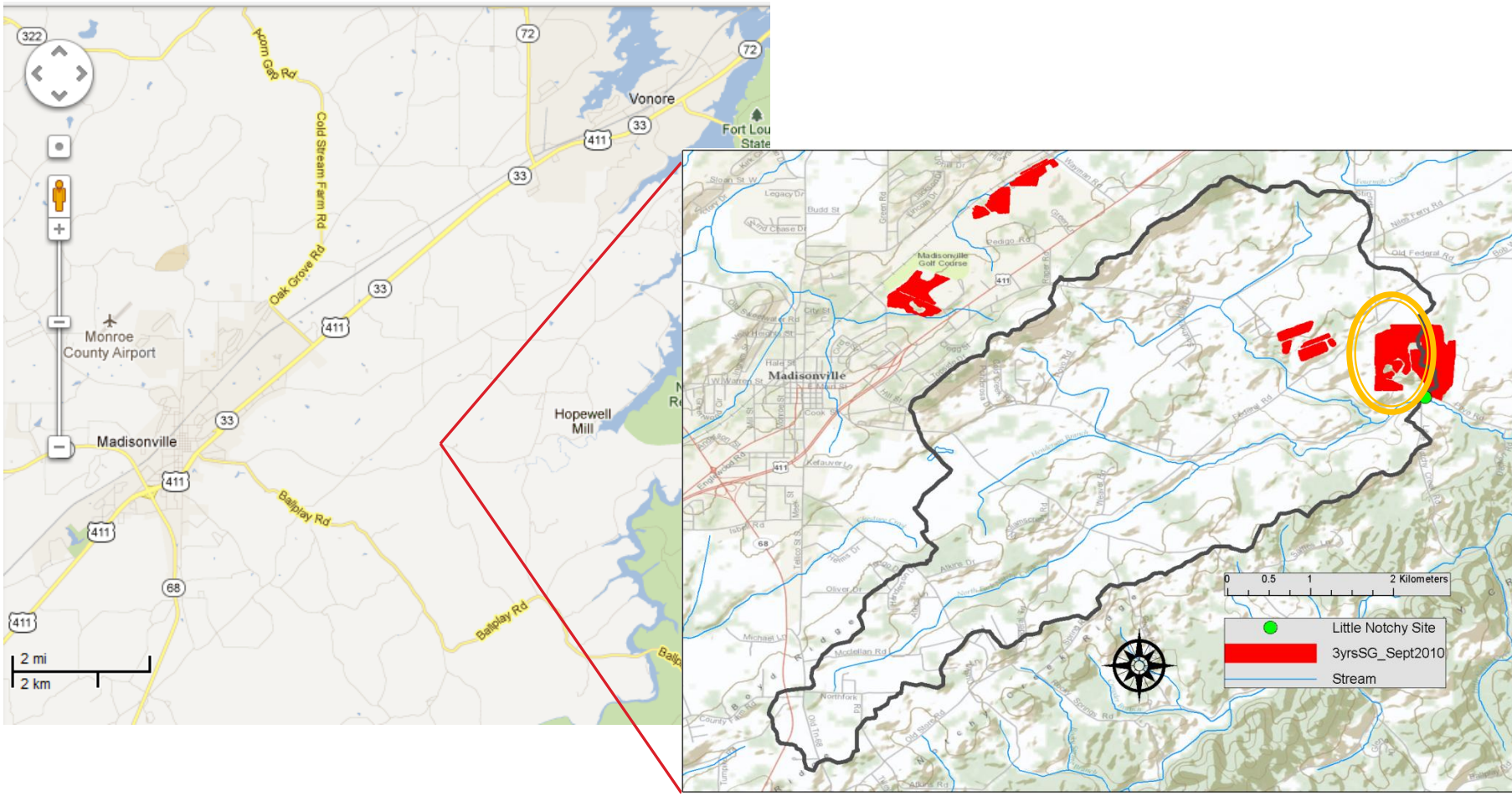
Watershed-scale Study Sites

- Two watershed stream monitoring sites
  - Tributary of the Little Notchy Creek
  - Smoke Run Creek (tentative)
- Target = 10% or more switchgrass runoff

Watershed Stream Monitoring Site Design

- ISCO 6712 automated samplers will collect water when discharge reaches a specific level.
- YSI multi-probe sondes are used to trigger the ISCO samplers during storm events.

Location: Tributary *of the* Little Notchy Creek



Tributary of the Little Notchy Creek

- ISCO Composite Sampling Station
- YSI Multi-probe sonde with turbidity, pH, conductivity, temperature, stage
- GlobalWater stage recorder

Lab Analysis: Water Quality

- Total Suspended Solids
- Ion Chromatography
  - Phosphate, Chloride, Nitrate, Sulfate, Ammonia
- Spectrophotometer
  - Total Nitrogen (TN)
- Autotitration
  - pH
  - Conductivity
- Total Organic Carbon Analyzer

Base Flow Water Quality Analysis

- Water Quality Analysis:
  - Grab samples taken from each site. Date ___.
  - Ion Chromatography (IC) for water quality analysis.
  - Total Nitrogen (TN) test per spectrophotometer.

Site	Chloride (ppm)	Nitrate (ppm)	Sulfate (ppm)	Phosphate (ppm)	Ammonia (ppm)	Total Nitrogen (ppm)
Little Notchy	3.52	5.6	2.22	n/a	0.11	5.78
Smokey Run	1.07	NA	5.39	n/a	0.08	6.72

Geomorphological Analysis

- Generate a sediment budgets for watersheds subjected to switchgrass land conversion
  - Sediment source tracking: uplands, rills, channels.
    - Measure land erosion with ISCO samplers
    - Model rill development, channel bank erosion.
  - Channel incision from land conversion
    - Conduct Rapid Geomorphic Assessments at numerous stream sites with and without switchgrass conversion in the past five years – comparative statistics.

Discussion

- Water Quality Catchment Sites: CN, C factor used in SWAT?
- Water Quality Watershed Study Sites: more sites?
- Geomorphic analysis: importance for environmental indicators?