Water Quality Benefits of Riparian Buffers in Southern Illinois Agricultural Watersheds

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Riparian Buffer Zone

- Transitional land area between terrestrial and aquatic habitats (ecotone)
- Agricultural Watersheds
  - Riparian buffer (trees)
  - Filter strips (grasses)
- Forested Watersheds
  - Streamside management zone
- Typical Width
  - 30 – 100 feet, depending on slope of land and size of stream

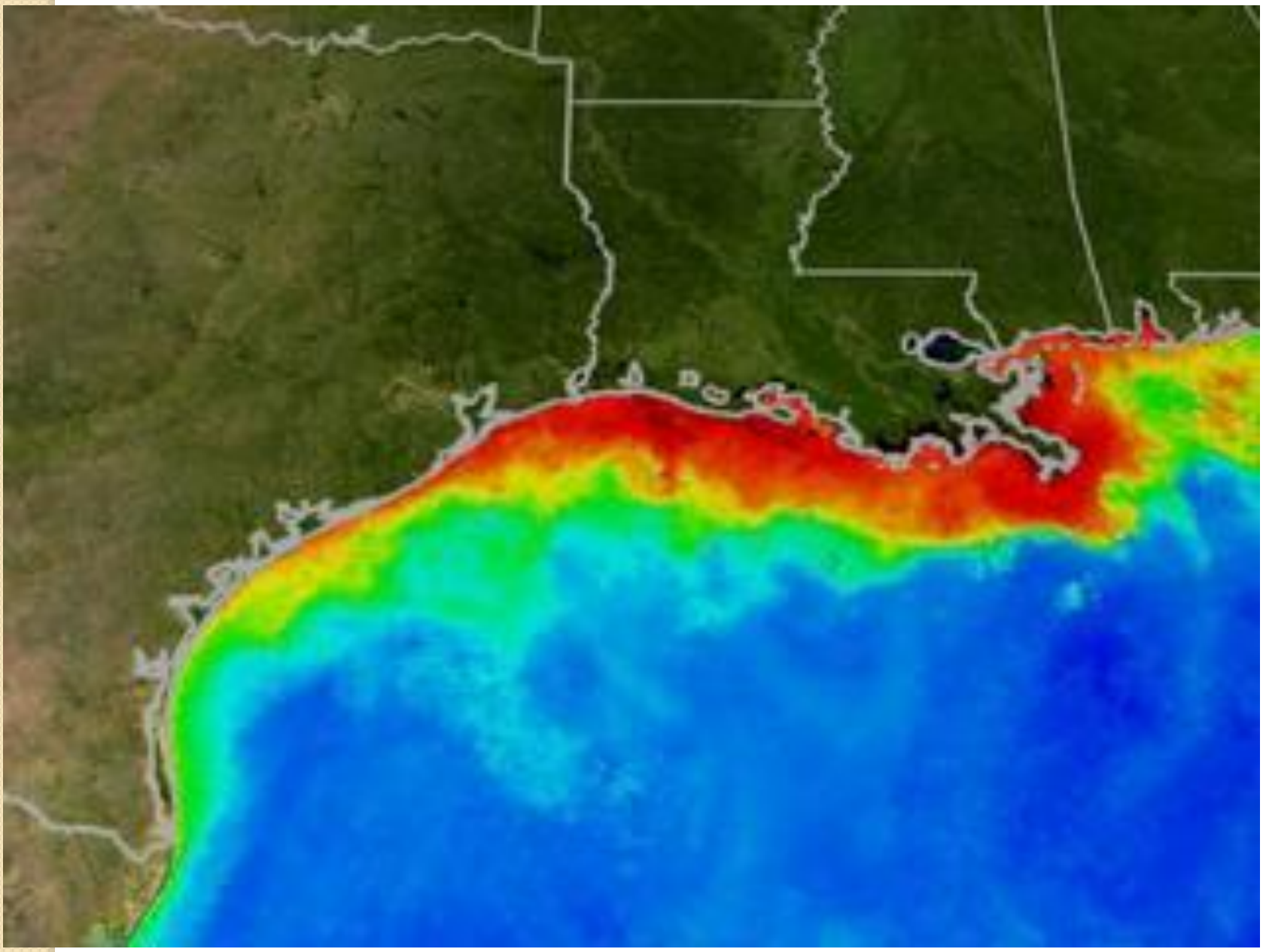
Why are riparian buffers important?

- "The last line of defense" – like having a great free safety on your football team
- Trap sediment and nutrients in surface runoff
- Process nutrients in groundwater
- Stabilize stream banks
- Shade streams
- Provide wildlife habitat
- Diversify income – hunting leases, timber

Why do we need to quantify the benefits of BMP's like Riparian Buffers?

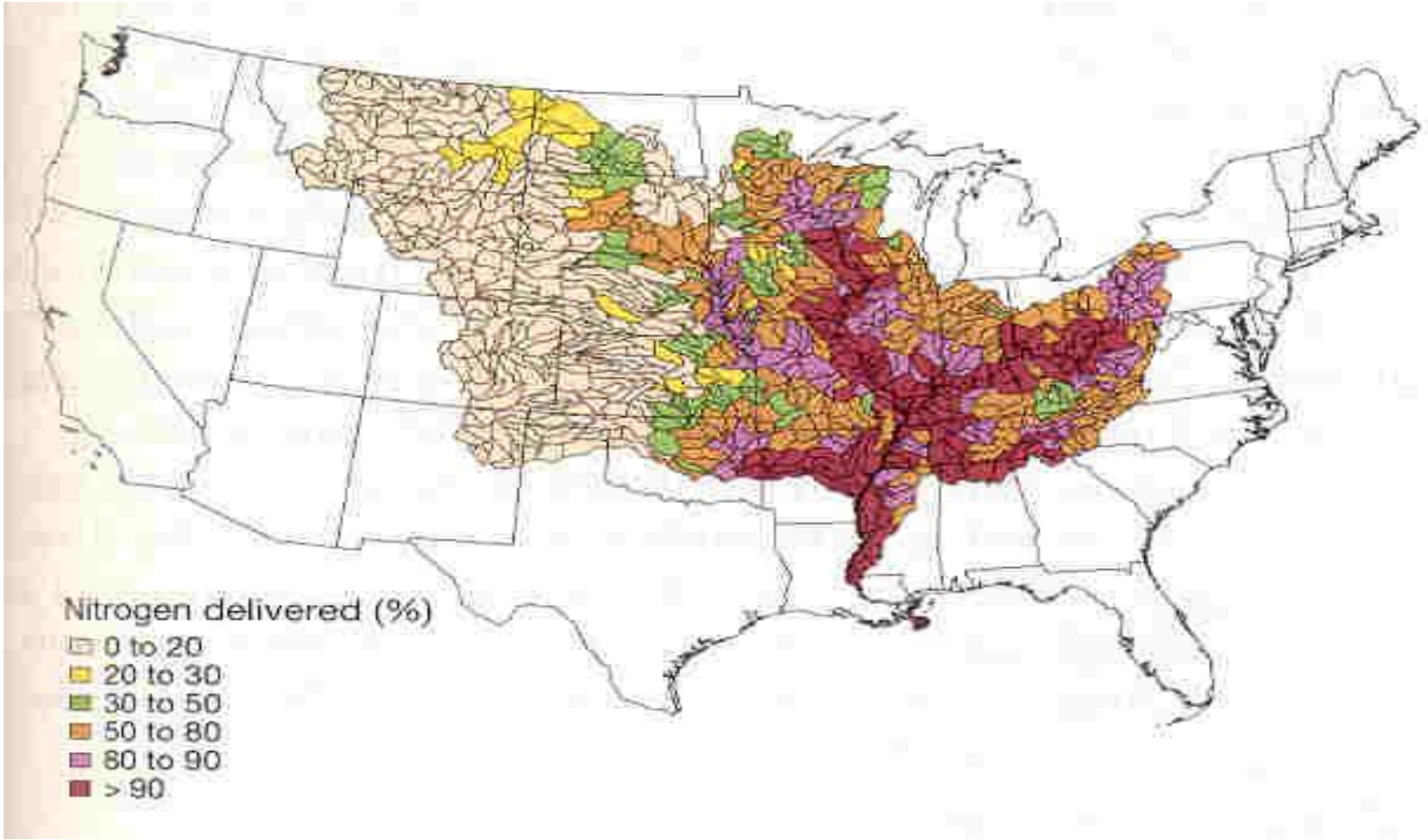
Importance of Accounting

- TMDL's
- Impending nutrient standards for all surface waters
- Hypoxia in the Gulf of Mexico



Summer phytoplankton conditions along the Gulf Coast – 2002-2004 (NOAA)

Watersheds in close proximity to the Mississippi River and its primary tributaries are important N contributors to the Gulf of Mexico (Alexander et al. 2000) - Southern Illinois



Unique Features of Riparian Areas in Southern Illinois

- Relative absence of tile drainage
- Presence of unique native species; giant cane (*Arundinaria gigantea*)

Giant Cane Distribution

Giant Cane Communities

- Formerly vast canebrakes – now small patches
- Lost due to urban and agricultural conversion
- Support a variety of unique species associates

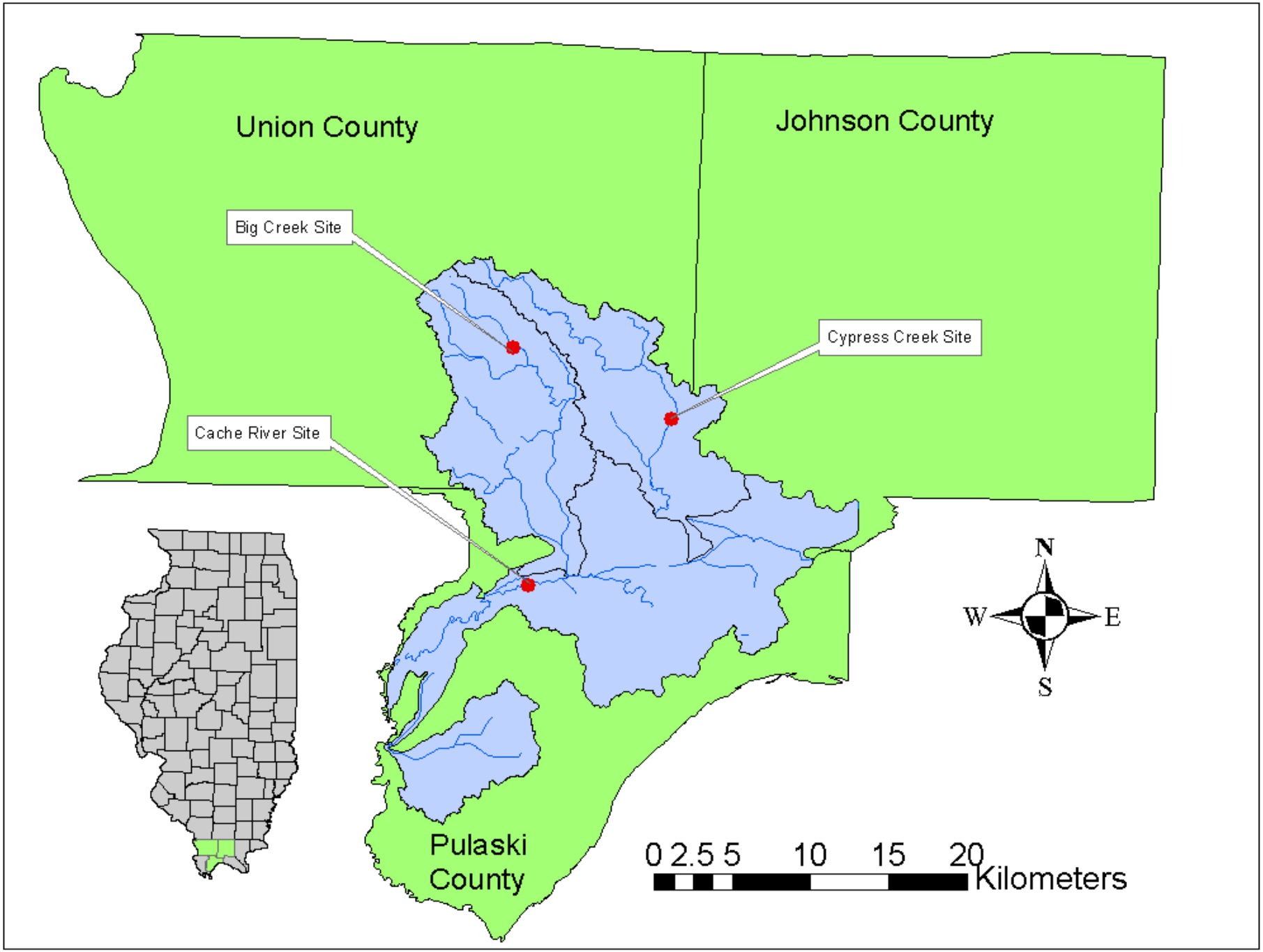
Giant Cane Associated Species

- Neotropical Migratory Birds
  - Swainson's Warbler
- Reptiles including Canebrake Rattlesnake
- Insects - moths
  - 4 new genera
  - 12-13 new species

Water Quality Benefits of Forest and Cane Riparian Buffers in the Cache River Watershed

Objective

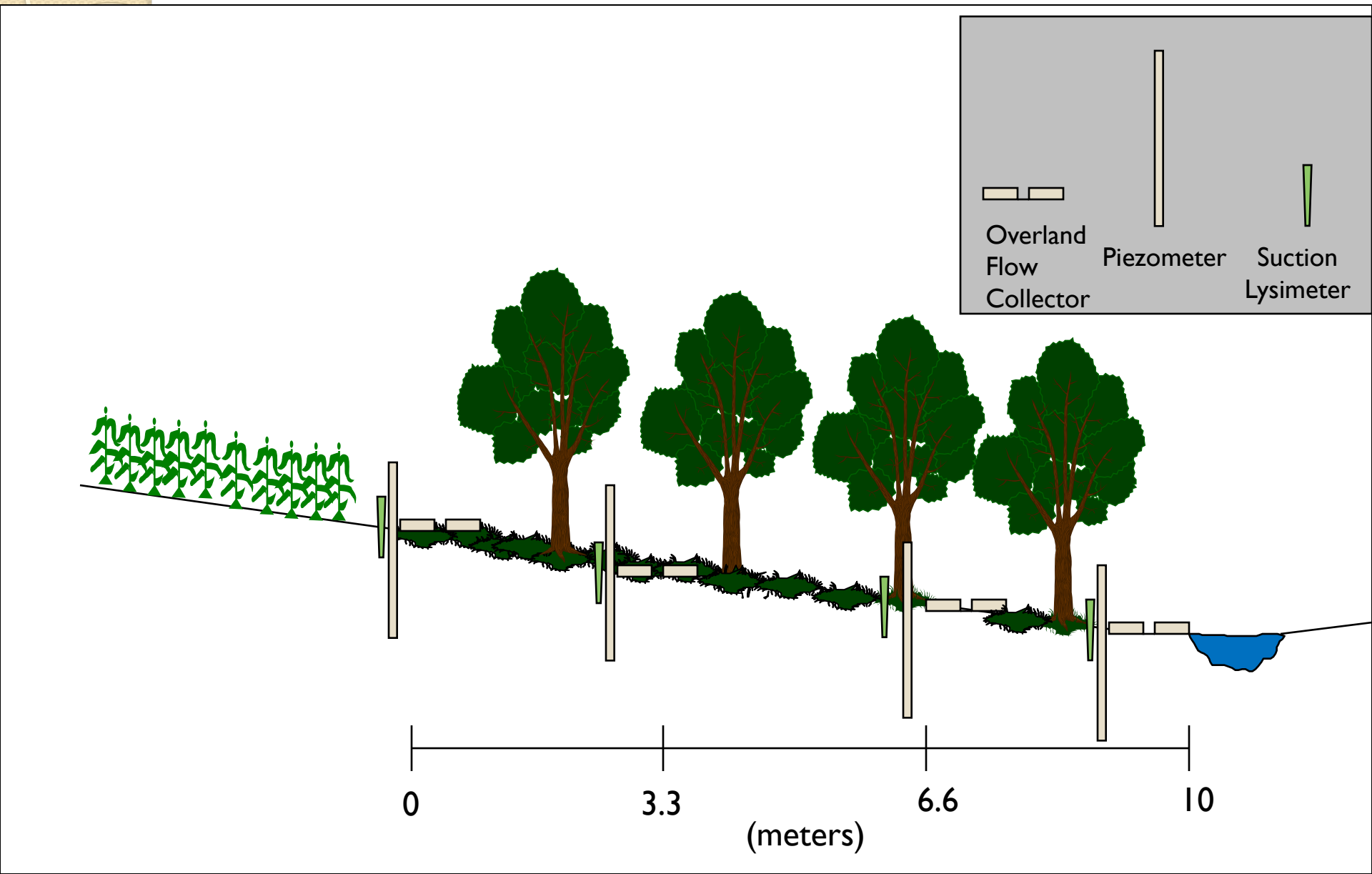
- To determine N, P, and sediment attenuation capabilities of forest and giant cane riparian zones adjacent to row crop agriculture


Union County
Johnson County
Big Creek Site
Cypress Creek Site
Cache River Site
Pulaski County
N
W
E
S
0 2.5 5 10 15 20
Kilometers

Giant cane (*Arundinaria gigantea*) (30 – 40 years old)

Mixed Deciduous Forest (30 - 40 years old)

Study Design



Overland Flow Collectors

Groundwater Wells

Suction Lysimeters

Percent Reduction of Sediment and Nutrients in the Initial 3.3 m of Riparian Buffers

Parameter	Giant Cane	Forest
Overland Flow		
Sediment	97	70
Total PO_4	80	(14)+
Total NH_4-N	81	31
Dissolved NH_4-N	80	44
Dissolved NO_3-N	68	17

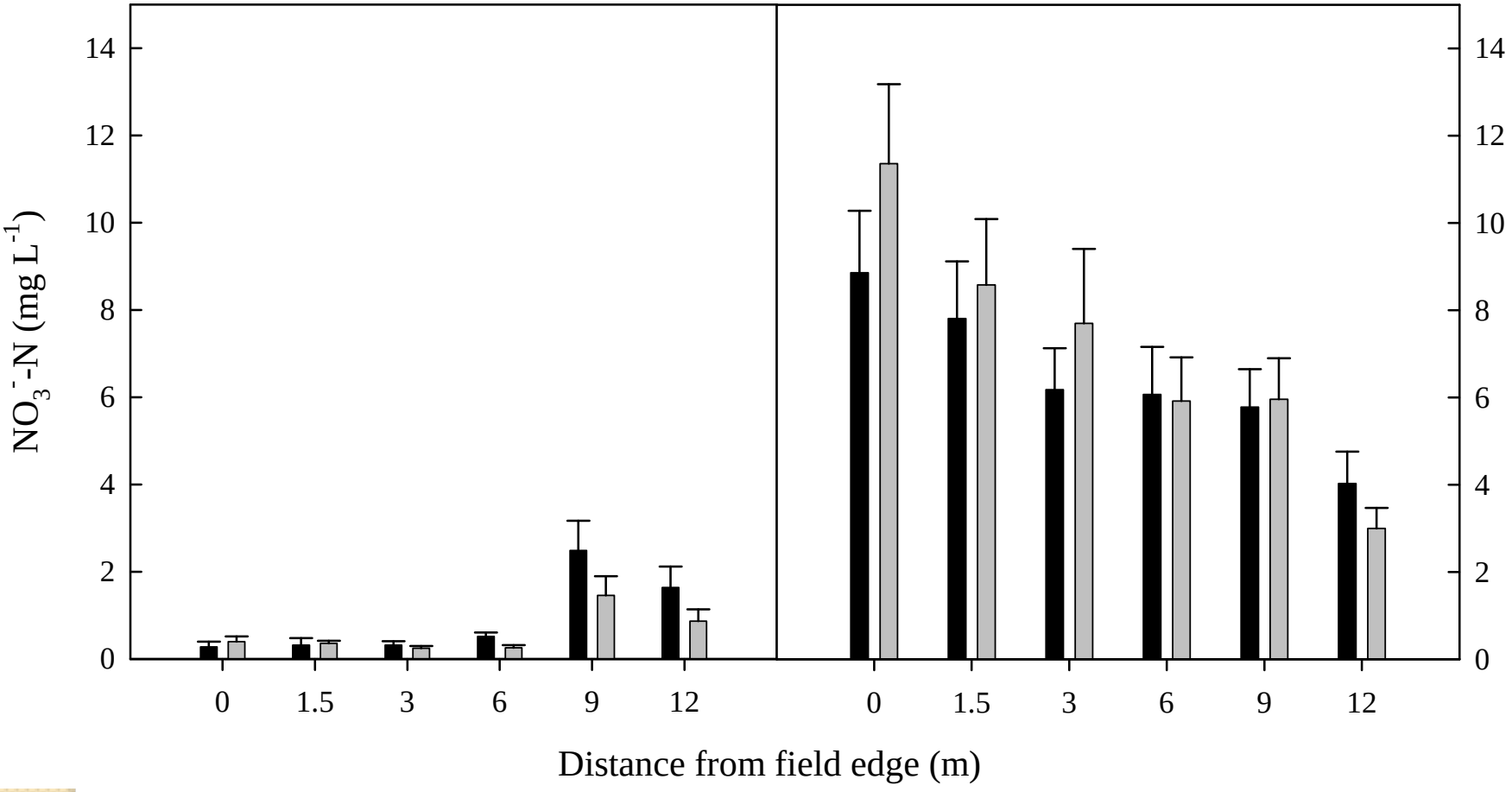
Schoonover et al. 2005, Schoonover et al. 2006

Percent Reduction of Sediment and Nutrients in the Initial 6.6 m of Riparian Buffers

Parameter	Giant Cane	Forest
Overland Flow		
Sediment	93	95
Total PO_4	79	73
Total NH_4-N	76	70
Dissolved NH_4-N	74	74
Dissolved NO_3-N	36	94

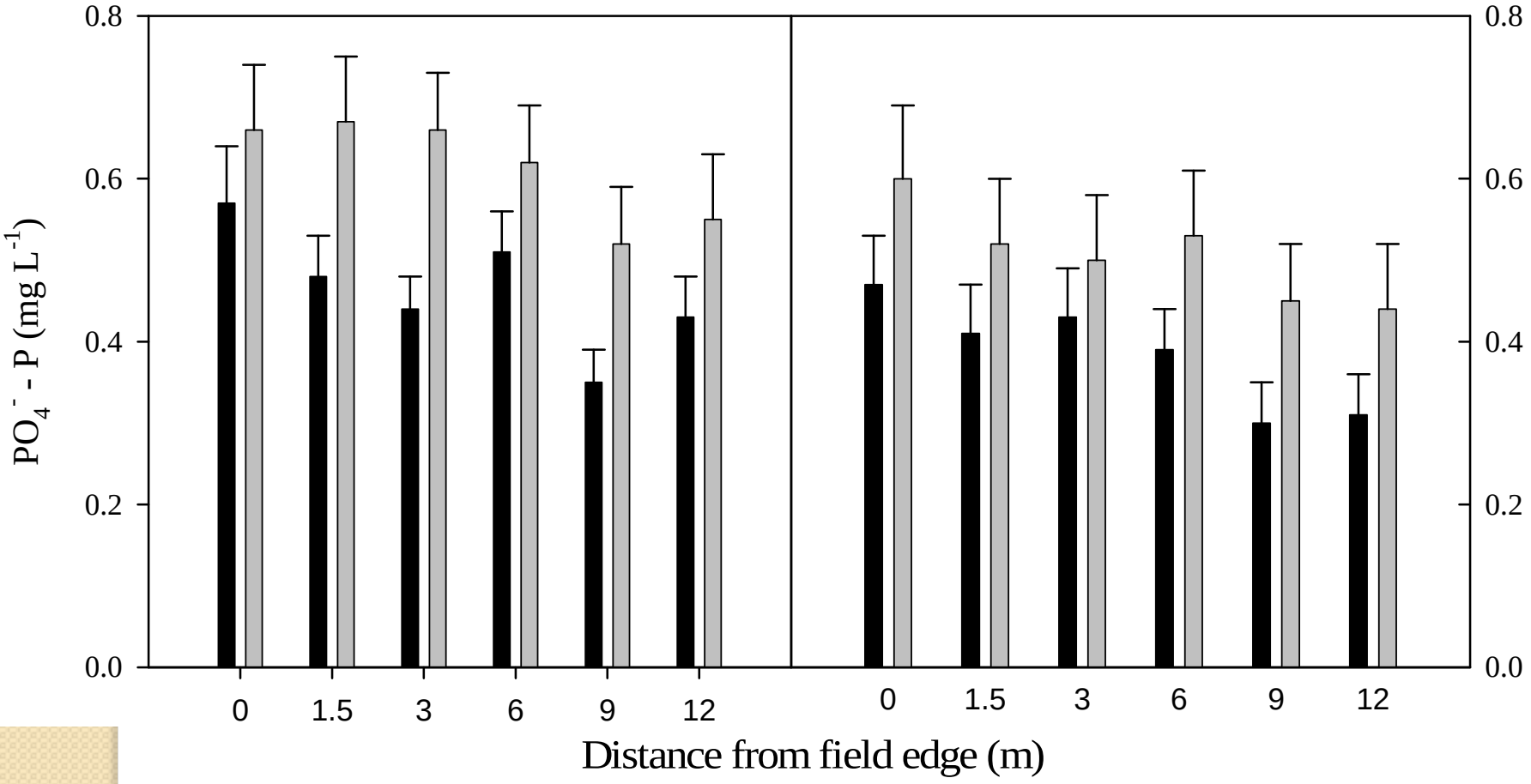
Schoonover et al. 2005, Schoonover et al. 2006

Mean Nitrate-N in Groundwater



Schoonover et al. 2010

Mean Phosphate in Groundwater



Schoonover et al. 2010

Southern Illinois

- Region with relatively high stream DRP concentrations (tributaries of the Kaskaskia and Big Muddy river basins).
- Several watersheds with mean DRP concentrations >1.00 mg L^{-1} over the past 2 decades (Short 1999).
- Mean DRP concentration of the state of Illinois = 0.25 mg L^{-1} (Short 1999).

Mean Stream Phosphate Concentrations

	Big Creek	Cypress Creek	Cache River
DRP Conc. (mg L^{-1})	0.69 ± 0.07	0.54 ± 0.06	0.65 ± 0.07

Number of samples: 12

Watershed Scale Riparian Research

- Long-Term Experimental Watersheds study, SIU Farms – initiated 2007
- Paired watersheds: giant cane and switch grass buffer, control
- 5 year calibration period; riparian restoration this spring

Concentrated Flow Paths in Riparian Buffer Zones in Southern Illinois

Objective

- To determine the importance of concentrated flow draining agricultural fields in the Cache River watershed

Introduction

- Riparian buffers have been designed to trap sediment and nutrients in shallow dispersed **sheet flow** from agricultural fields.
- Under these runoff conditions, 60 – 95% of sediment and nutrients are deposited in the buffers (30 years of riparian buffer research)

How much of an agricultural field is drained by sheet flow?

- Field observations suggest not much.
- An agricultural field is not flat, like a parking lot.
- Microtopography
  - Leads to flow concentration
  - Rills
  - Concentrated flow paths (CFP's)

Sheet Flow vs. Concentrated Flow

Sediment Berms

Concentrated Flow Path Development Model – 2 pathways (Pankau et al. 2011)

Sheet Flow
-Ideal field conditions

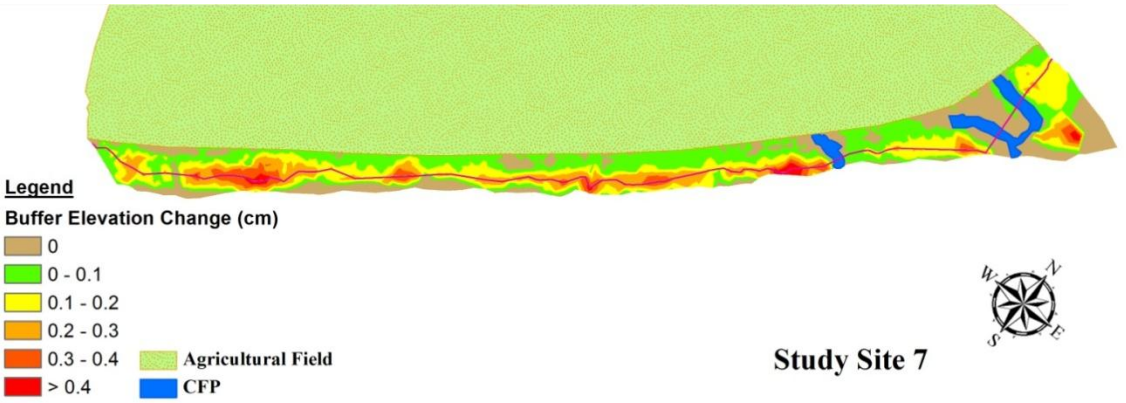
→ Deposition of sediment in vegetated riparian buffer

→ Berm Formation

→ CFP formation through buffer

→ -CFPs enlarge
-Majority of field drained by concentrated flow

Concentrated Flow
-From field



Field Study to Assess the Importance of Concentrated Flow

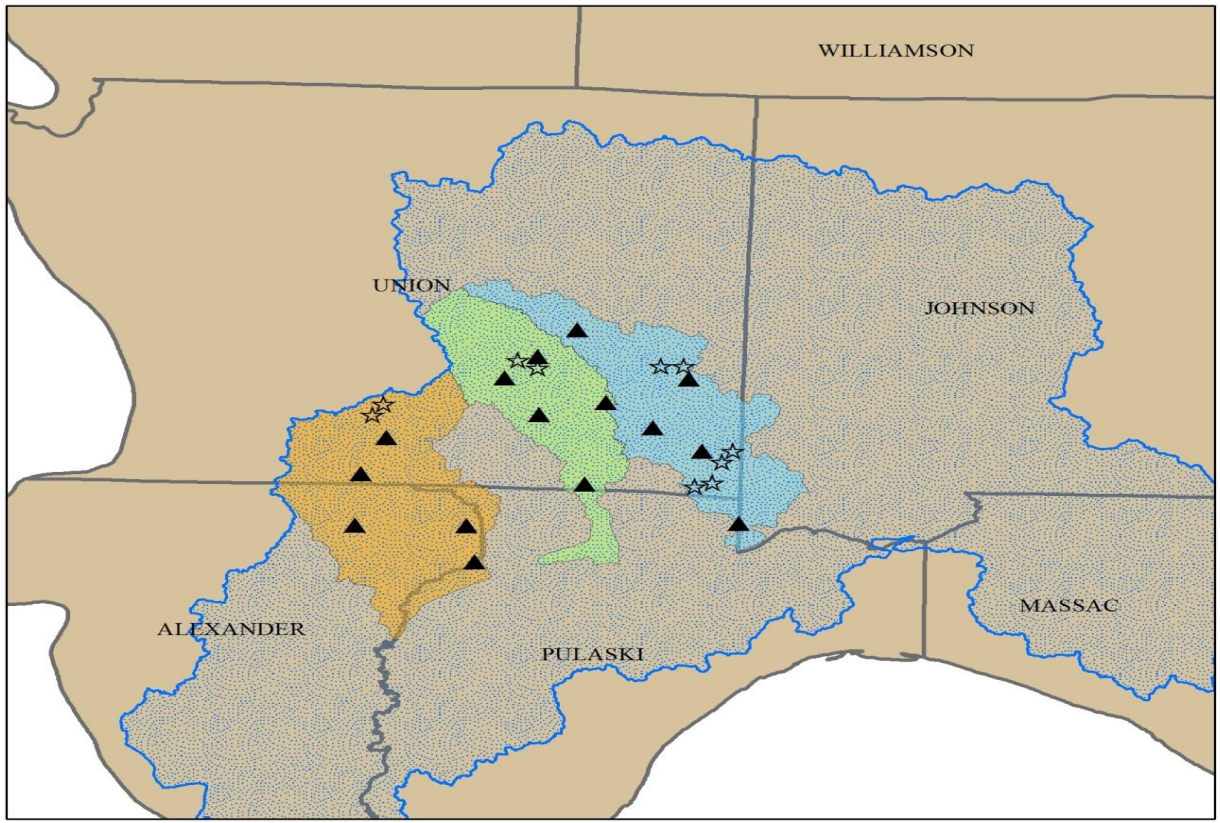
- What proportion of an agricultural field is drained by concentrated flow?
- Intensive surveying of 10 agricultural fields to create detailed digital elevation models and drainage areas of concentrated flow channels
  - Ryan Pankau – M.S. Thesis at SIUC 2010

    Pankau et al. 2011. Agroforesty Systems.

Intensive Surveying

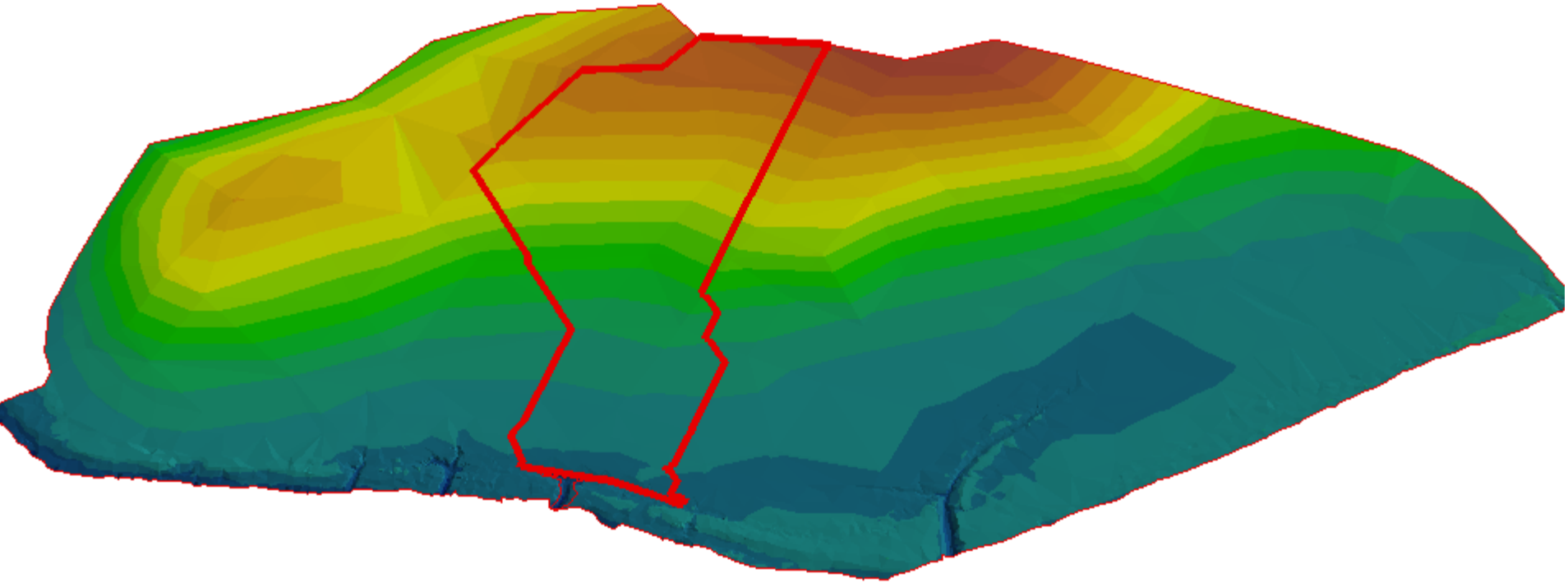
4,080 Survey Points in a field

Cache River Basin – Southern Illinois



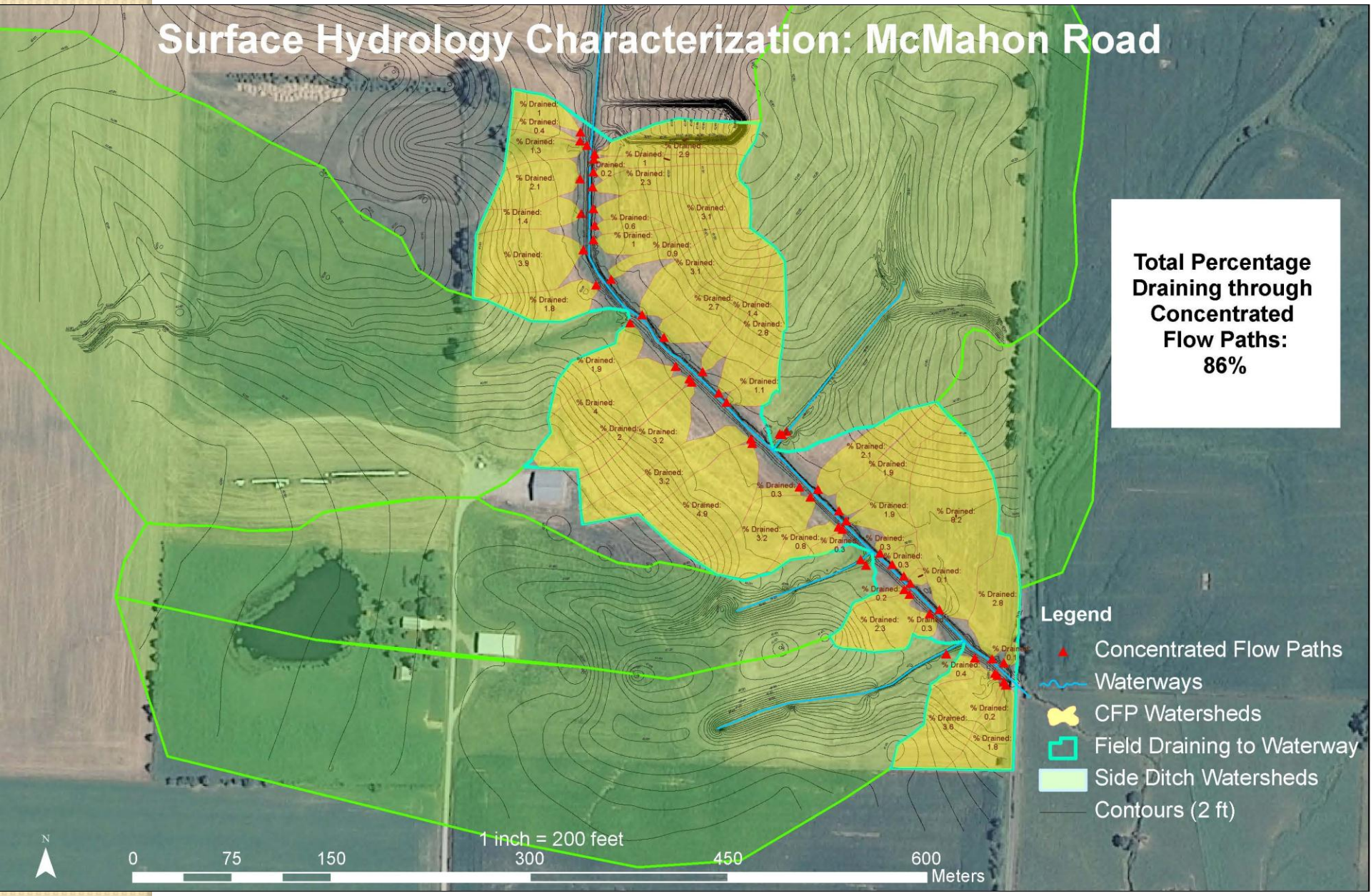
Concentrated Flow Paths: Drainage Area Calculation

- 82 – 100% of the fields were drained by concentrated flow

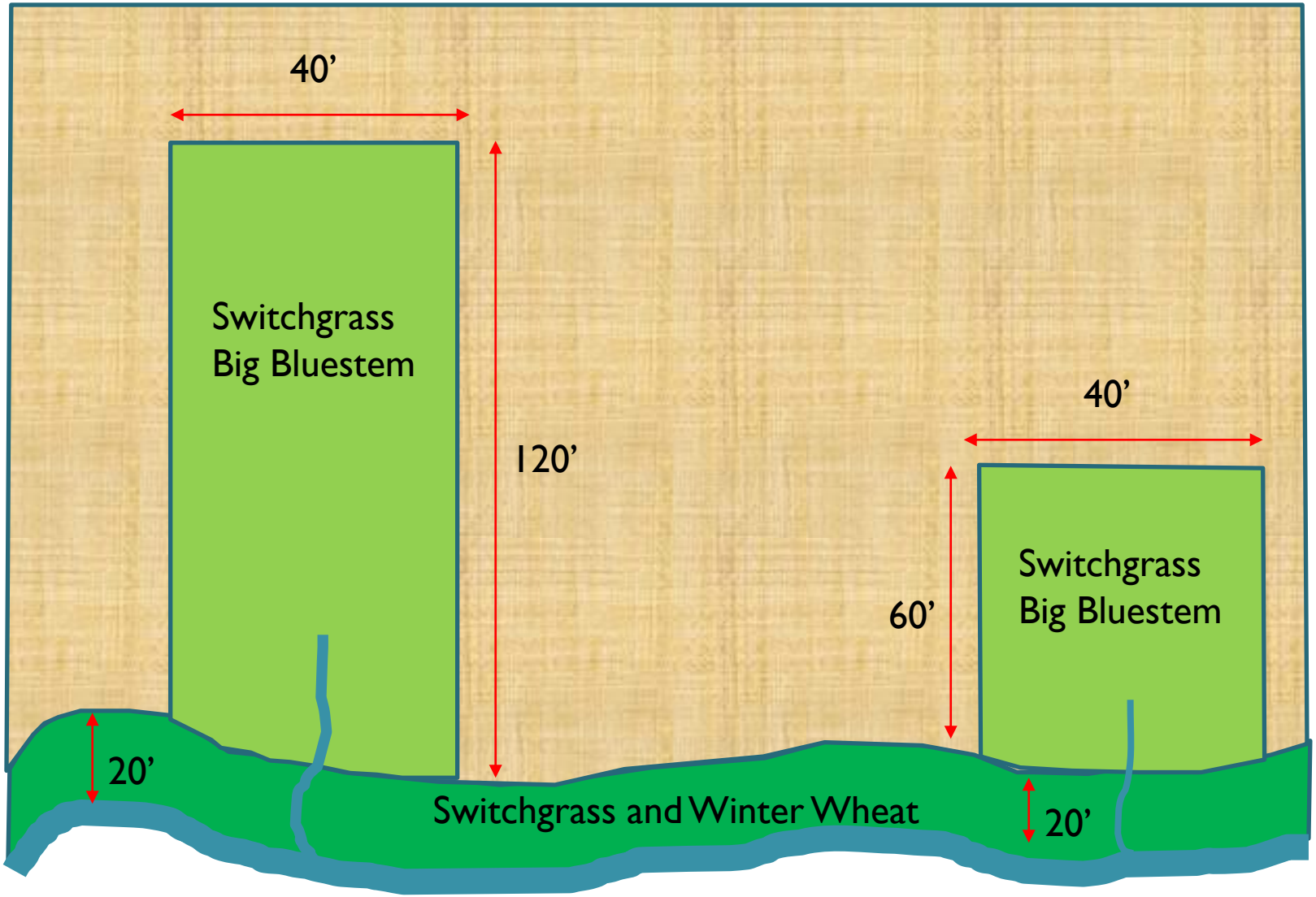


USDA NRCS Conservation Innovation Grant Project

- Research and demonstration project to address concentrated flow
- 2 headwater agricultural watersheds in southern Illinois
- Row-crop agriculture (corn and soybean rotation)


Surface Hydrology Characterization: McMahon Road
Total Percentage Draining through Concentrated Flow Paths: 86%
Legend
Concentrated Flow Paths
Waterways
CFP Watersheds
Field Draining to Waterway
Side Ditch Watersheds
Contours (2 ft)
N
1 inch = 200 feet
0
75
150
300
450
600
Meters

Variable Width Riparian Buffers



Buffer Blocks

- Stiff stemmed grasses to slow and spread concentrated flow
  - Cave-in-Rock Switchgrass, Big Bluestem
- Establish hedges
- Largest concentrated flow paths may require rock installation to help stabilize area for grass establishment
- Spring planting – Mar. , April 2012

Switchgrass

Big Bluestem

Project Summary

- Concentrated flow can be the dominant form of surface runoff entering buffers
- Traditional buffers are not designed to handle concentrated flow
- Variable width buffers with buffer blocks – equal or less area than traditional designs
- Focus vegetation where it's needed
- Designed for ease of planting and harvesting to maximize farmer acceptance

Overall Conclusions

- Relatively narrow buffers can yield significant water quality benefits.
  - Surface runoff: promotes infiltration
  - Groundwater: plant assimilation and microbial processing
- Giant cane buffers performed equally as well or better than forest buffers in terms of water quality benefits.
- In southern Illinois, P tends to be more of a stream water quality issue than N.
- Riparian buffers need to be designed to handle concentrated flow from agricultural fields.

Acknowledgements

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- USDA NRCS Conservation Innovation Grant program

Questions