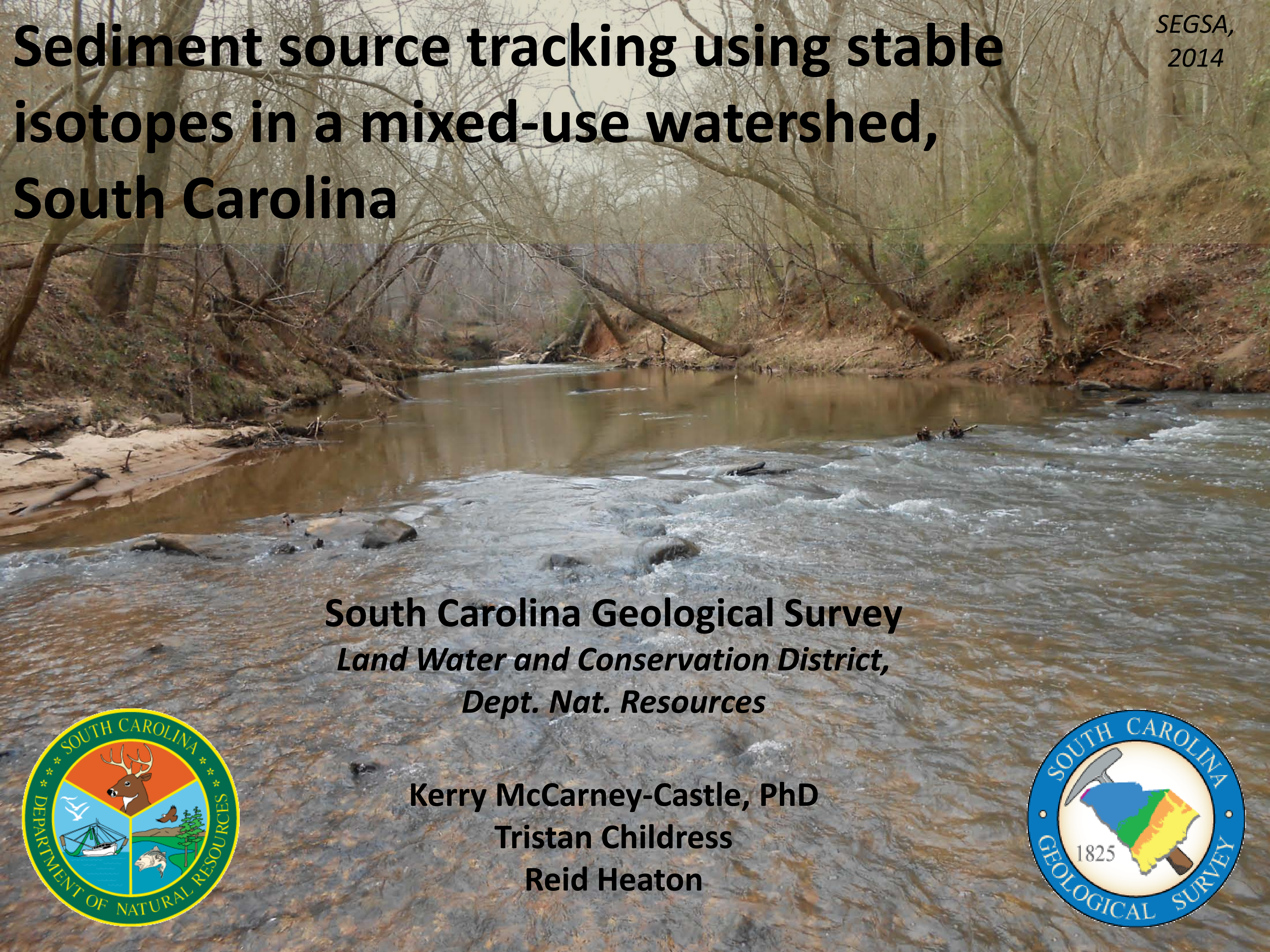


SEGSA, 2014

Sedimen source tracking using stable isotopes in a mixed-use watershed, South Carolina

South Carolina Geological Survey

Land Water and Conservation District, Dept. Nat. Resources

Kerry McCarney-Castle, PhD
Tristan Childress
Reid Heaton

Overview

- δ **Overview: sediment in streams**
- δ **Location of study**
- δ **Objectives of study**
- δ **Why this watershed?**
- δ **Hypothesis**
- δ **Methods**
- δ **Results**
- δ **Closing statement and future work**

Sediment

Excess sediment is considered the greatest pollutant in U.S. waters and is a major environmental factor in the degradation of stream habitat (EPA, 2000; Waters, 1995).

Quality

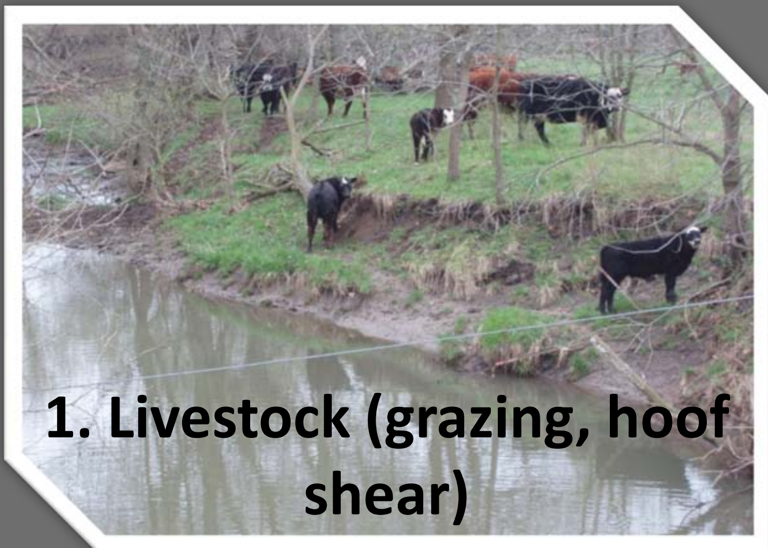
- ❑ Water chemistry
- ❑ Contaminant transport
- ❑ Fisheries and hatcheries
- ❑ Nutrient supply

Quantity

- ❑ Reservoir sedimentation
- ❑ Navigation
- ❑ Alteration of river flow/gradient
- ❑ Morphological changes
- ❑ Flooding

Present-day sediment sources

In-stream sediment: Where does it come from?



Present-day sediment sources

3. Urban storm water runoff


4. Bank erosion (gully erosion)

Present-day sediment sources

Historical (legacy) sediment

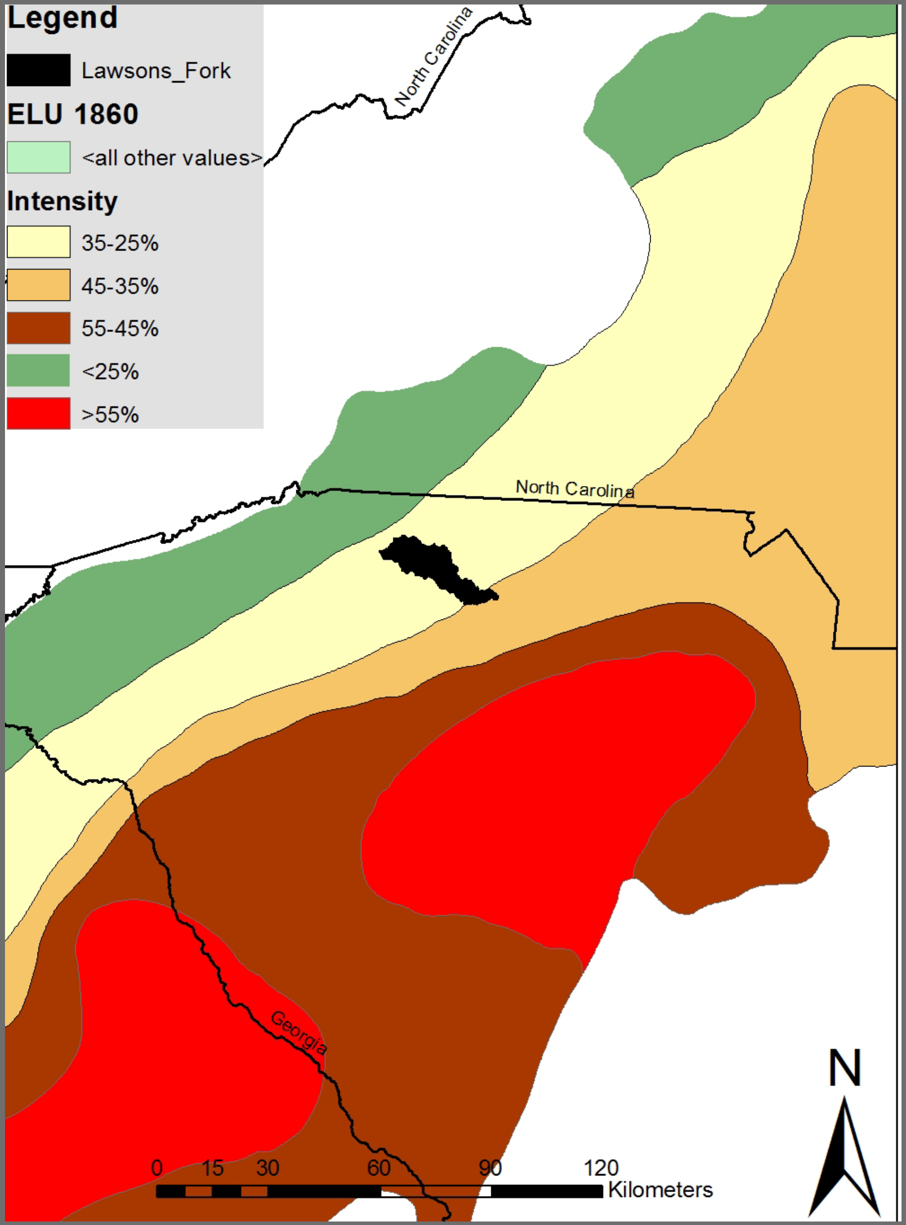
The Southern Piedmont is one of the most severely eroded areas in the U.S. (Trimble, 1974)

http://www.sseer.ca/history.htm

…..caused by widespread deforestation and subsequent cultivation plus poor farming practices from the early 1800's to 1930.

http://www.google.com/imgres?q=early+american+agriculture&um=1&hl=en&sa=N&rls=com.microsoft:en-us:IE-SearchBox&biw=1280&bih=852&tbm=isch&tbnid=zh_Yly8HWDtgtM:&imgrefurl=http://americangardenhistory.blogspot.com/2009/09/tools-john-evelyn.html&docid=bMwkChmeUK4A9M&w=284&h=400&ei=X32UTrWOOoK4twfjq435Bg&zoom=1&iact=rc&dur=281&page=1&tbnh=167&tbnw=127&start=0&ndsp=23&ved=1t:429,r:6,s:0&tx=80&ty=92

Historical (legacy) sediment



δ Rates of soil erosion due to land use change were estimated by Trimble (1974) and converted to a composite index of erosional intensity.

δ South Carolina experienced the greatest percentage of erosion than any other Piedmont state.

δ The soils lost from this intense period of erosion filled stream channels and valleys across the Piedmont.

Modified from Trimble, 1974

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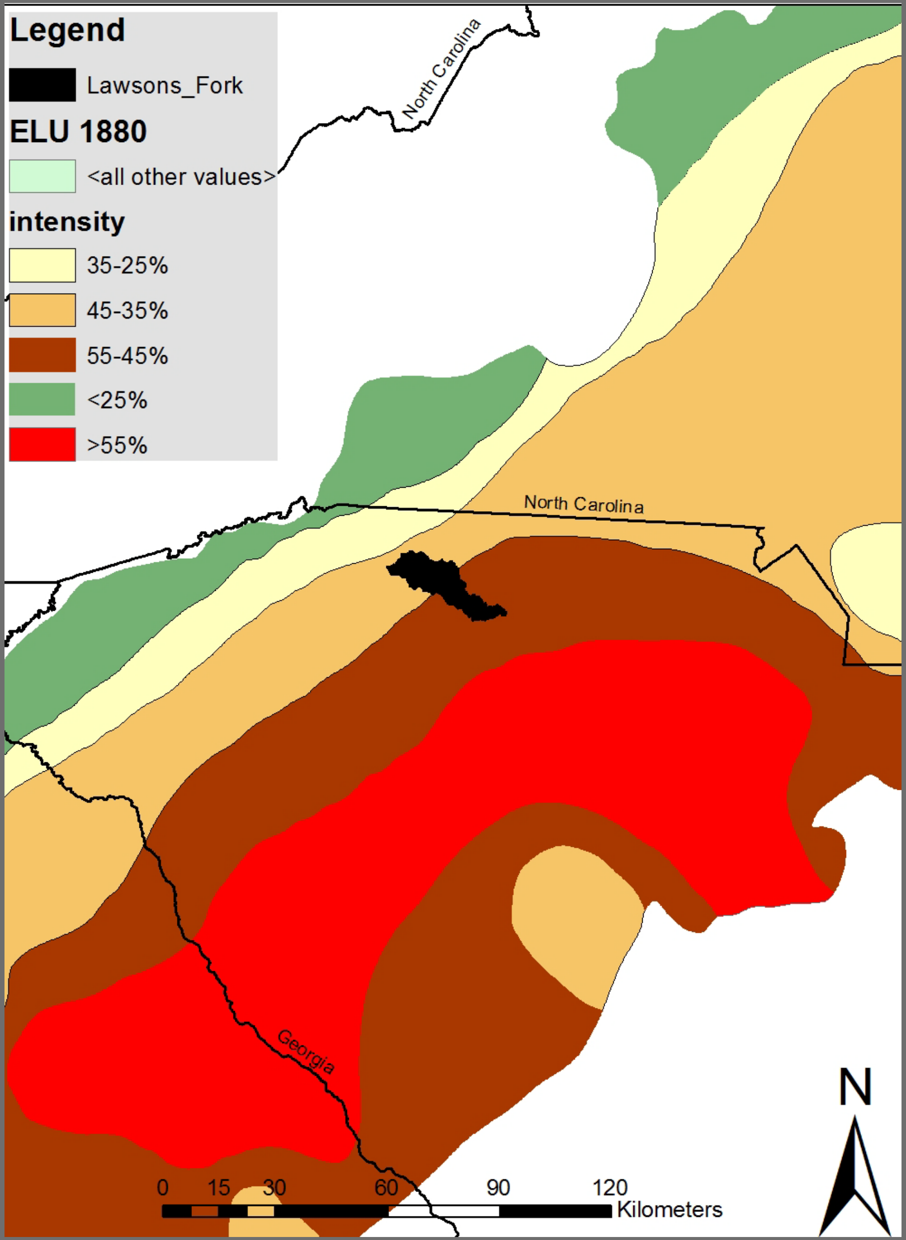

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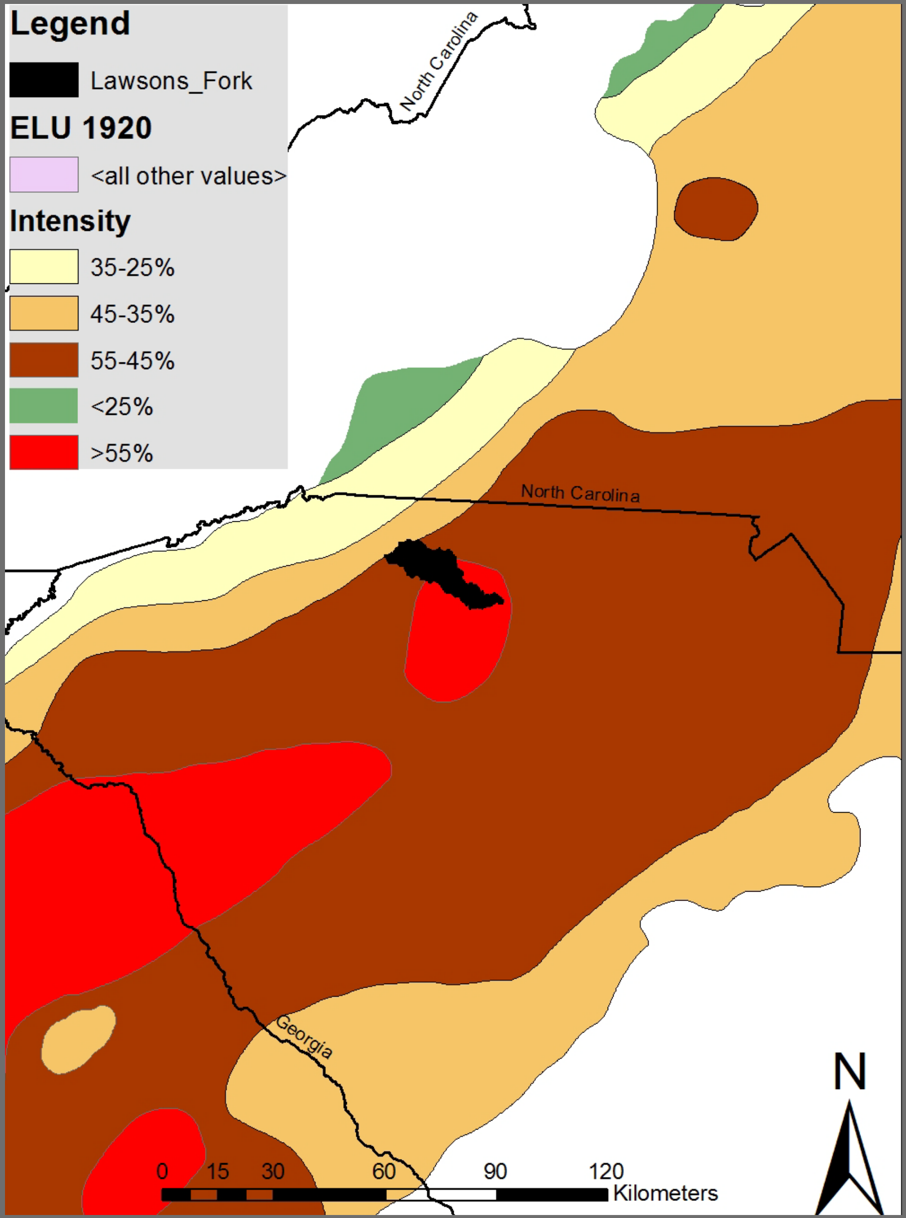

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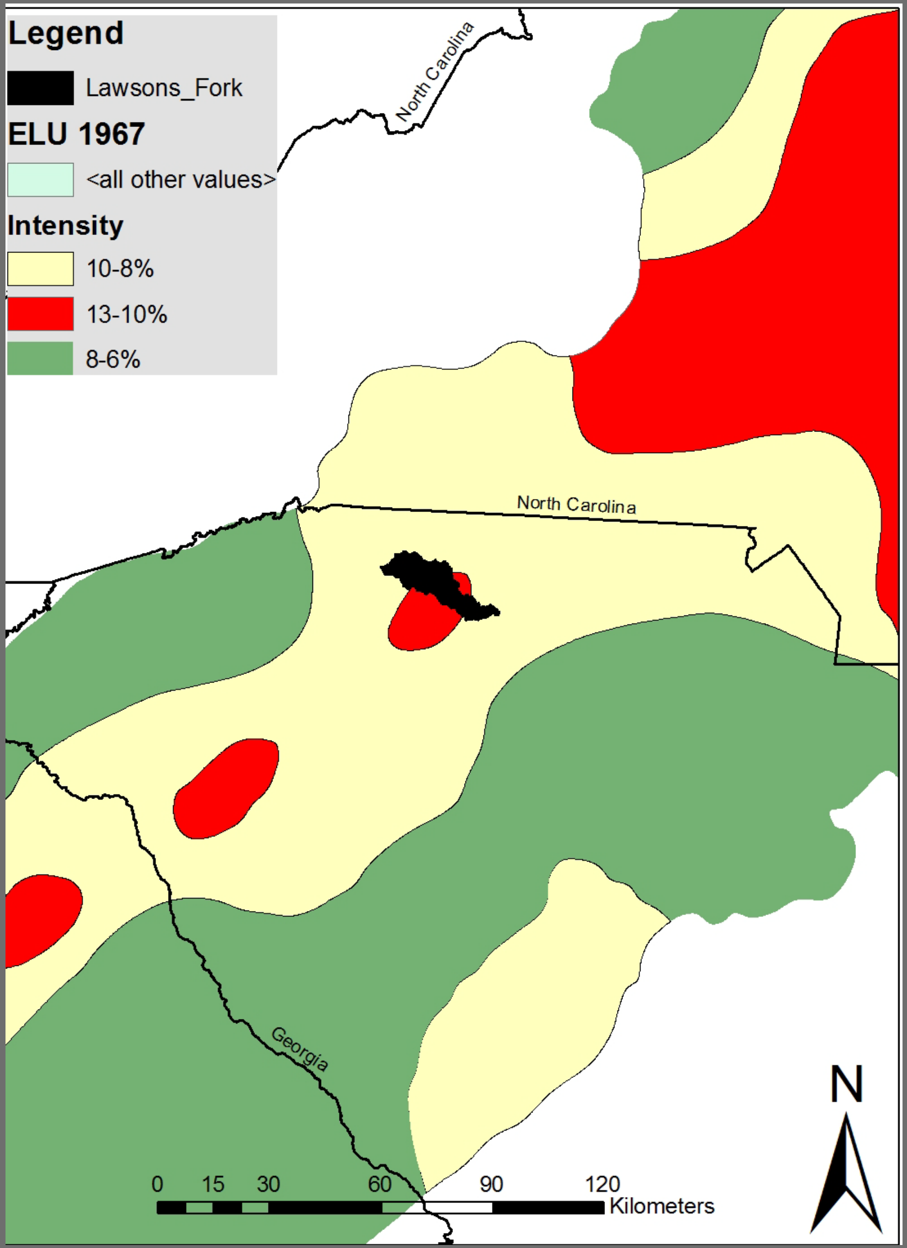

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Historical (legacy) sediment

Lawsons Fork Creek; Actively eroding bank (mass wasting)

Evidence of eroded (legacy sediment) soils overlying fluvial sediment

Photo courtesy of T. Ferguson, Wofford University

Photo courtesy of T. Ferguson, Wofford University

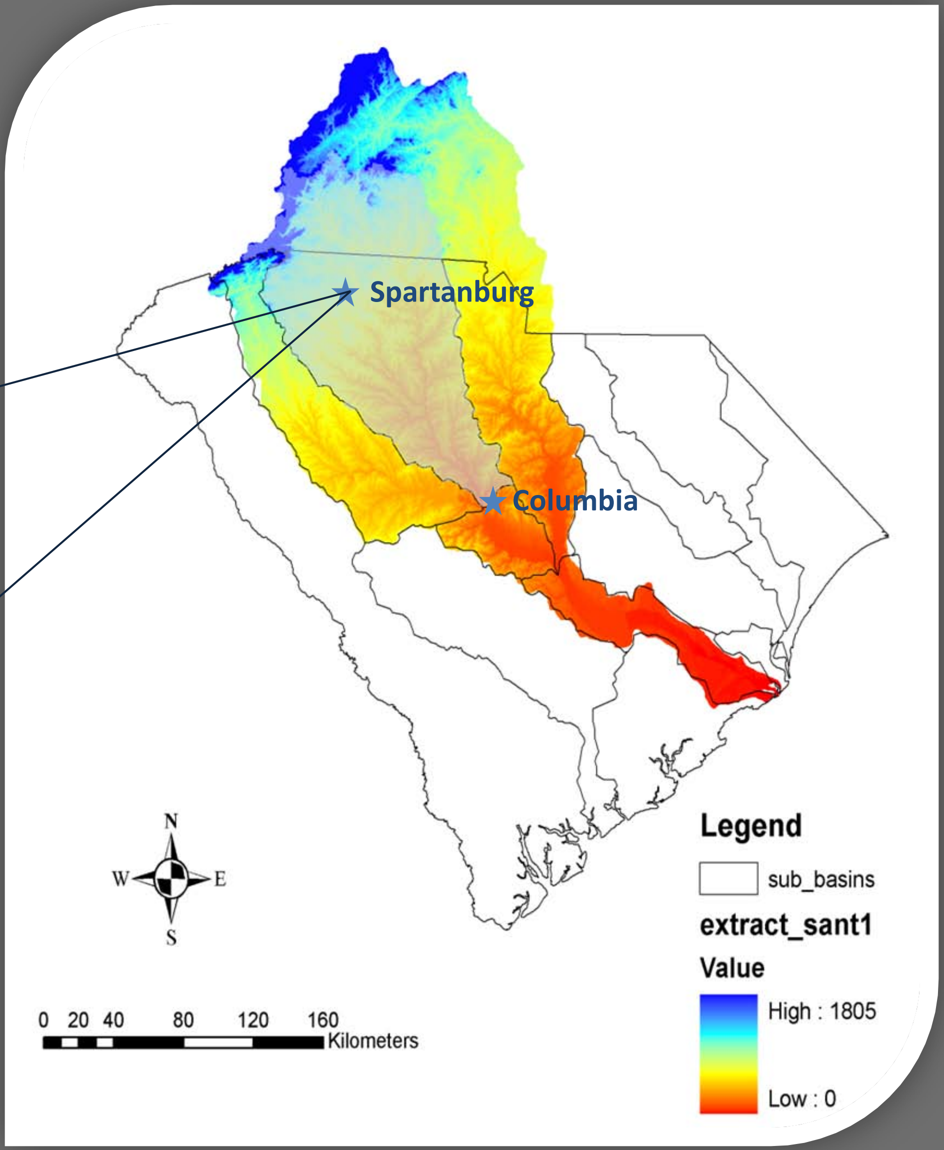
Objectives

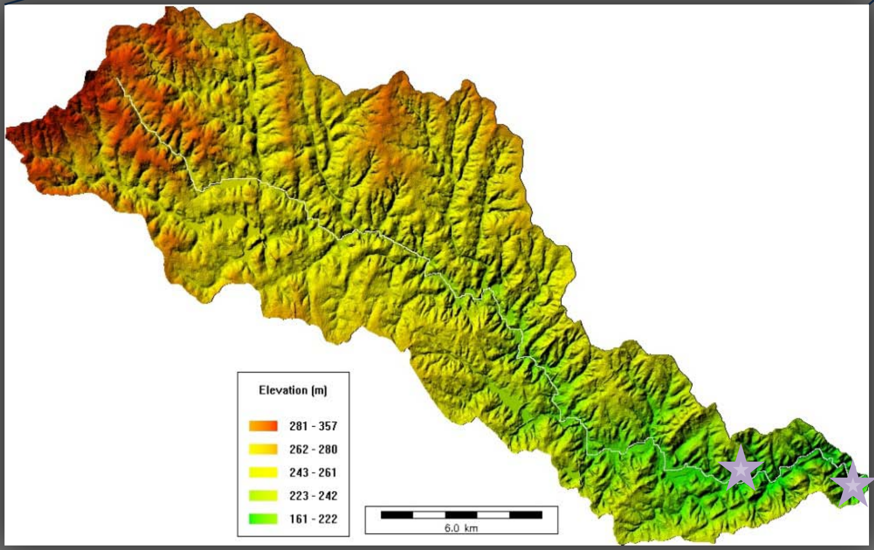
δ **Measure and assess suspended sediment loads and turbidity in the Lawson's Fork Creek watershed.**

δ **Determine the source of suspended sediment using sediment fingerprinting.**

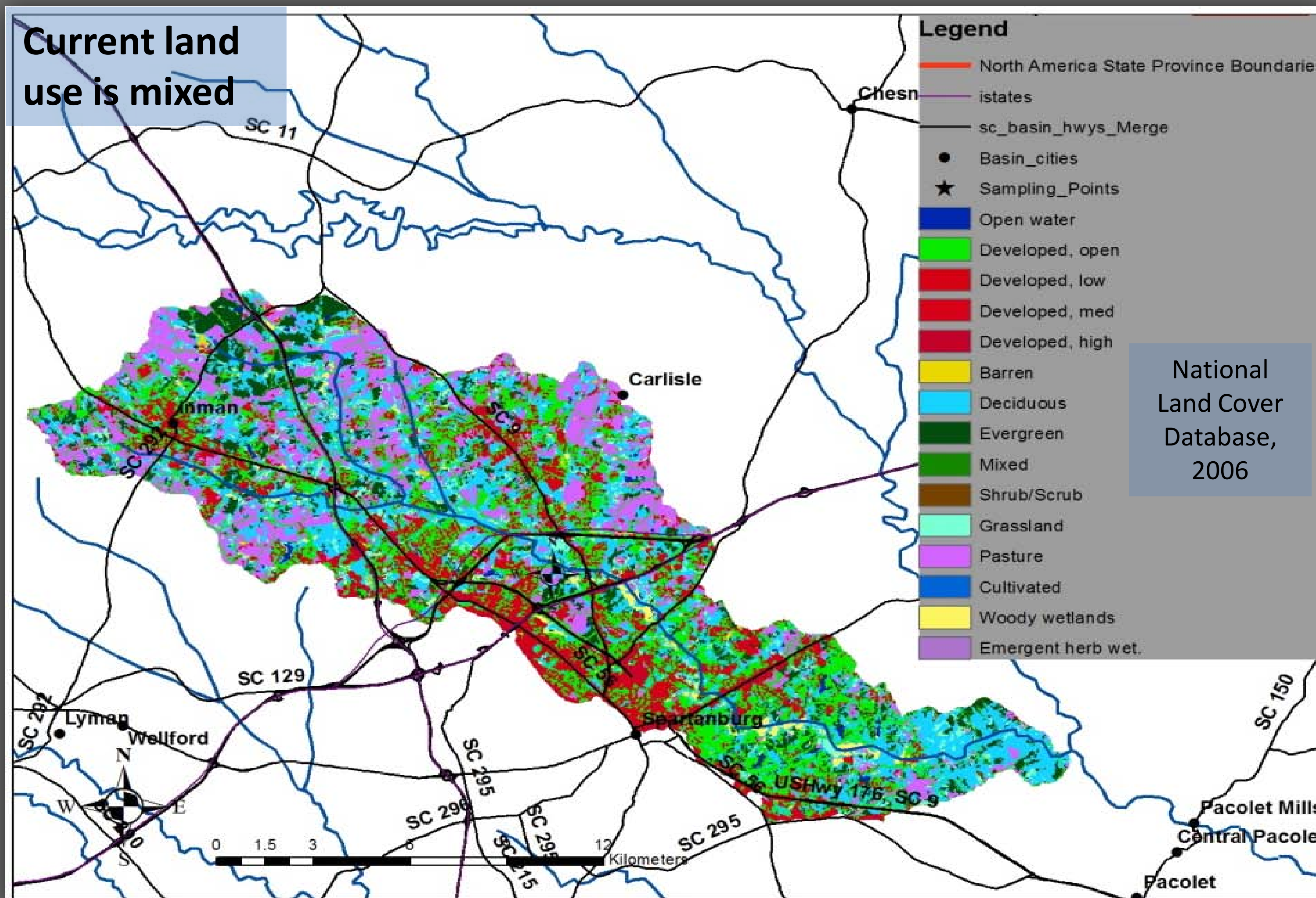
Location: Lawson's Fork Creek watershed

- Lawsons Fork Creek watershed located in the Broad River sub-basin (Santee Basin) in the Piedmont of South Carolina (HUC 03050105)
- Spartanburg Co. (288,745 pop); Population has increased ~70% over the last 40 years; this trend is expected to continue
- Basin area 217 km^2; Max elevation 357m; Min elevation 161 m





Location: Lawson's Fork Creek watershed



HUC 0305010514	Open water	Developed	Barren	Deciduous	Evergreen	Mixed	Shrub/scrub	Grassland	Pasture	Woody wetland
Area (km2)	1.35	94.18	0.91	49.76	20.75	0.90	1.13	8.62	38.07	4.50
% of basin	**0.61**	**42.74**	**0.41**	**22.58**	**9.42**	**0.41**	**0.51**	**3.91**	**17.28**	**2.04**

Why this watershed?

1. Field evidence: excessive flood deposits in the downstream reach


6/14/13 Lower right bank

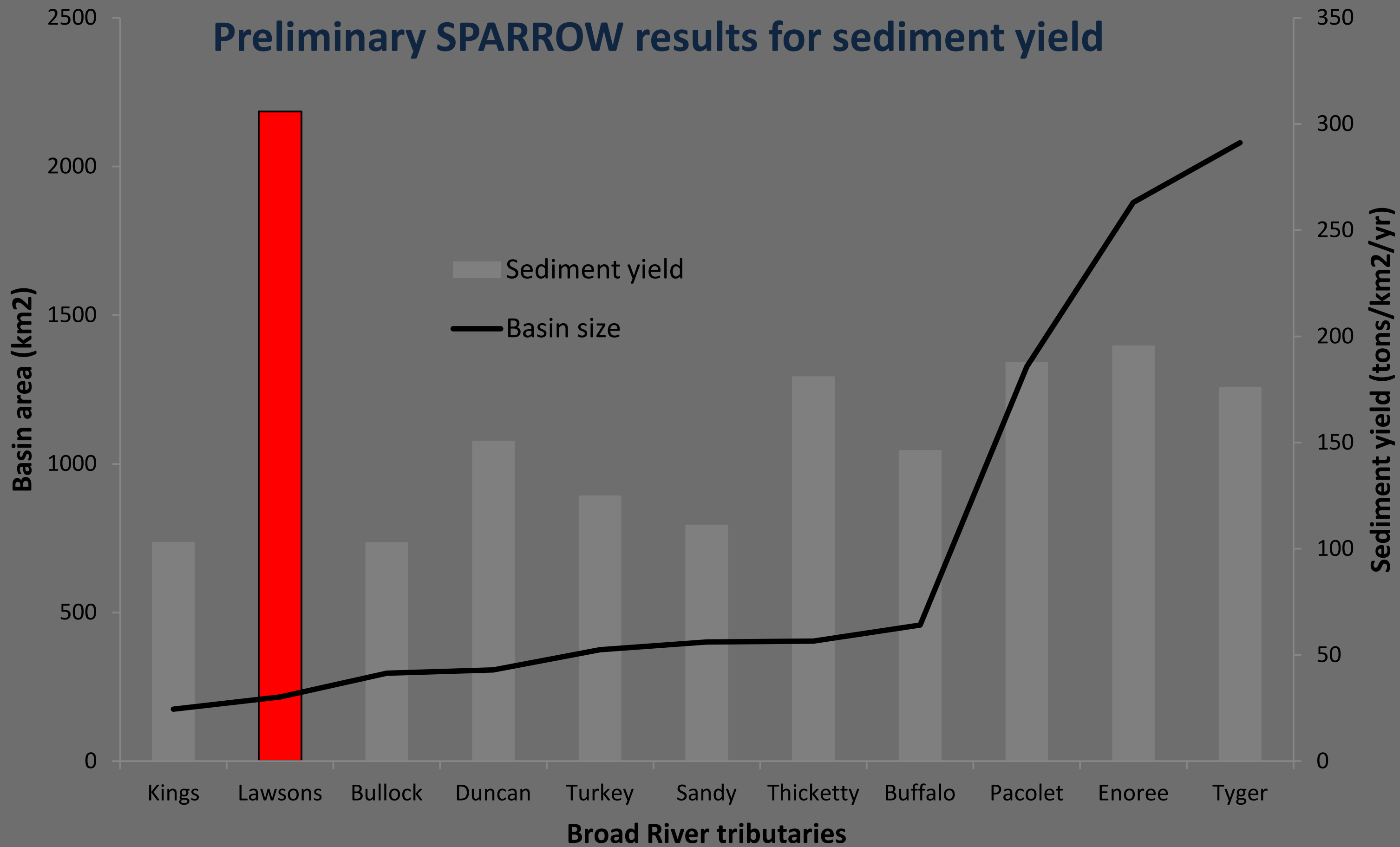

8-23-13 Upper left bank

Evidence of active erosion/high flows

Slumped bank with up to 7” of deposited sediment: 7’ above water surface

Why this watershed?

2. **Preliminary 1-D modeling:** resulted in extremely high sediment loads. SPARROW (USGS) was used to determine sediment yields throughout the Broad River basin. Lawsons Creek yielded the highest sediment load per basin area.



Why this watershed?

3. **Extremely high turbidity:** Routine basin-wide water samples yielded the highest range of turbidity (NTU) from Lawsons than in ***<u>any</u>*** stream, even the main Broad River, EXAMPLE:

5/6/2013 Flood Broad River (10,000 km^2)
Discharge = 41,200 cfs
Turbidity = <u>119 NTU</u>

5/6/2013 Flood Lawsons Fork (217 km^2)
Discharge = 4,594 cfs
Turbidity = <u>147 NTU</u>

Hypothesis

- δ **We hypothesize that urban expansion has reduced soil infiltration and increased peak flows, which has led to increased bank erosion.**

Methods: Field

Passive sediment sampler (Phillips, 2000) deployed to capture time-integrated samples during flooding events.

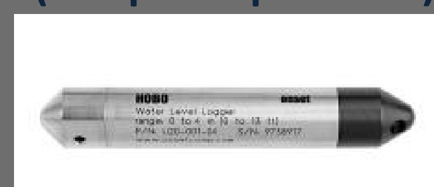
6 sets of bank pins were installed at the 2 cross-sections

YSI sonde deployed for continuous turbidity (stolen!!)

Campbell Sci. OBS-3A for continuous turbidity

Manual collection of depth-integrated suspended sediment samples and velocity profiles for two years under all flow regimes to establish sediment rating curve.

HOBO data loggers (temp and pressure)



ISCO automatic pump sampler

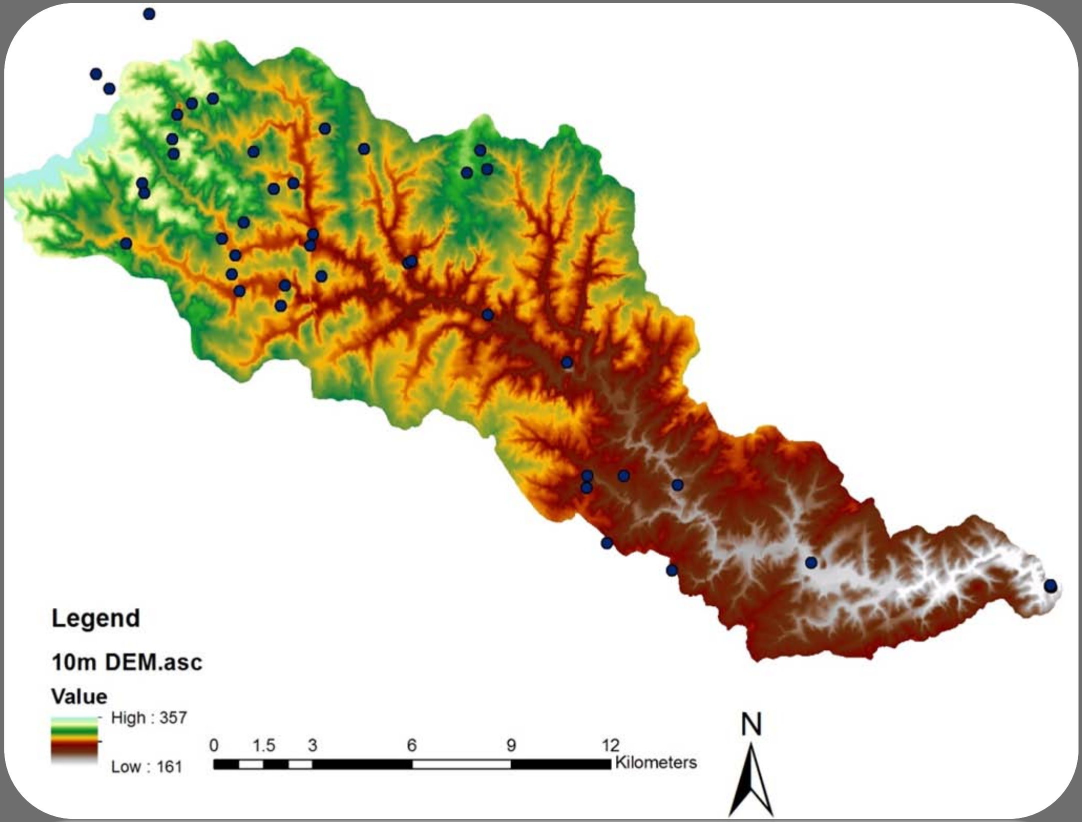
Sediment tiles

Methods: The fingerprinting approach

To determine *source* of sediment: The fingerprinting approach compares source with in-stream suspended sediment to establish relative source contribution.

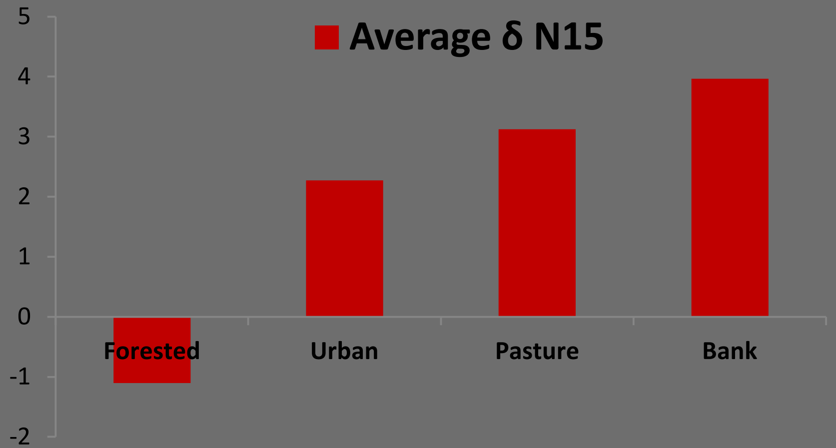
δ Nearly 100 samples were collected (stratified by land use) throughout the basin to determine isotopic ratios of $\delta^{15}N$ and $\delta^{13}C$ plus Total C and N.

δ This suite of isotopes was chosen based on Mukundan (2009), who found that these signatures were most suitable in a similar watershed in the Piedmont.



Results

Tracer concentrations



Stable isotope analysis was performed at the Stable Isotope and Soil Biology Lab at UGA.

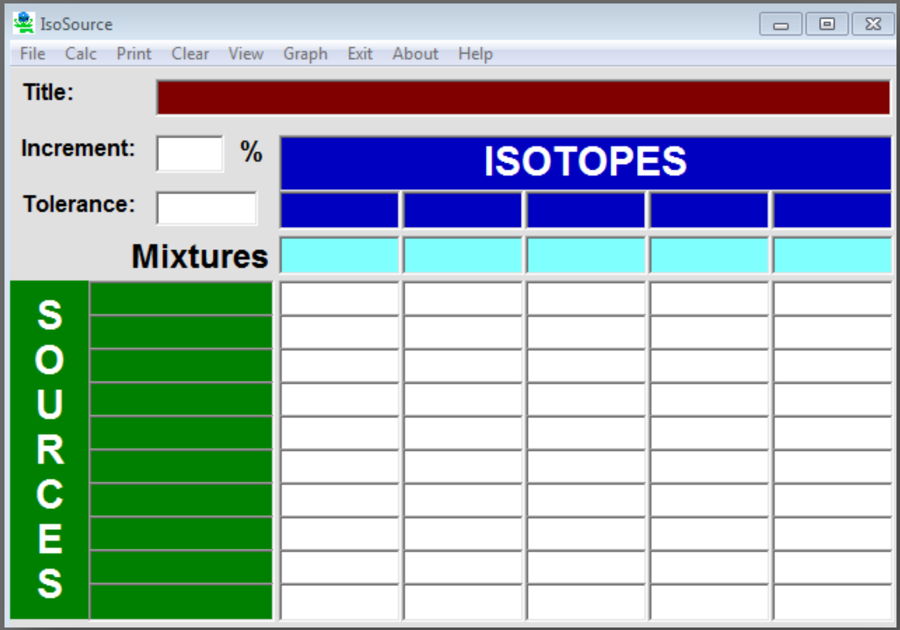
Field data collection

1. **Upland samples: collected from the upper 0-2 cm depth with stainless steel trowels, air dried and sieved to <63um**
2. **Bank samples: collected in areas of active erosion by scraping face of the bank**
3. **Suspended sediment samples: retrieved either from the passive sediment sampler (Phillips, 2000) or manually during flooding events and filtered through a 63um sieve onto pre-combusted glass fiber filter.**
4. **Analyzed the <63um fraction of both source and target samples ensured standardized particle size.**

Results

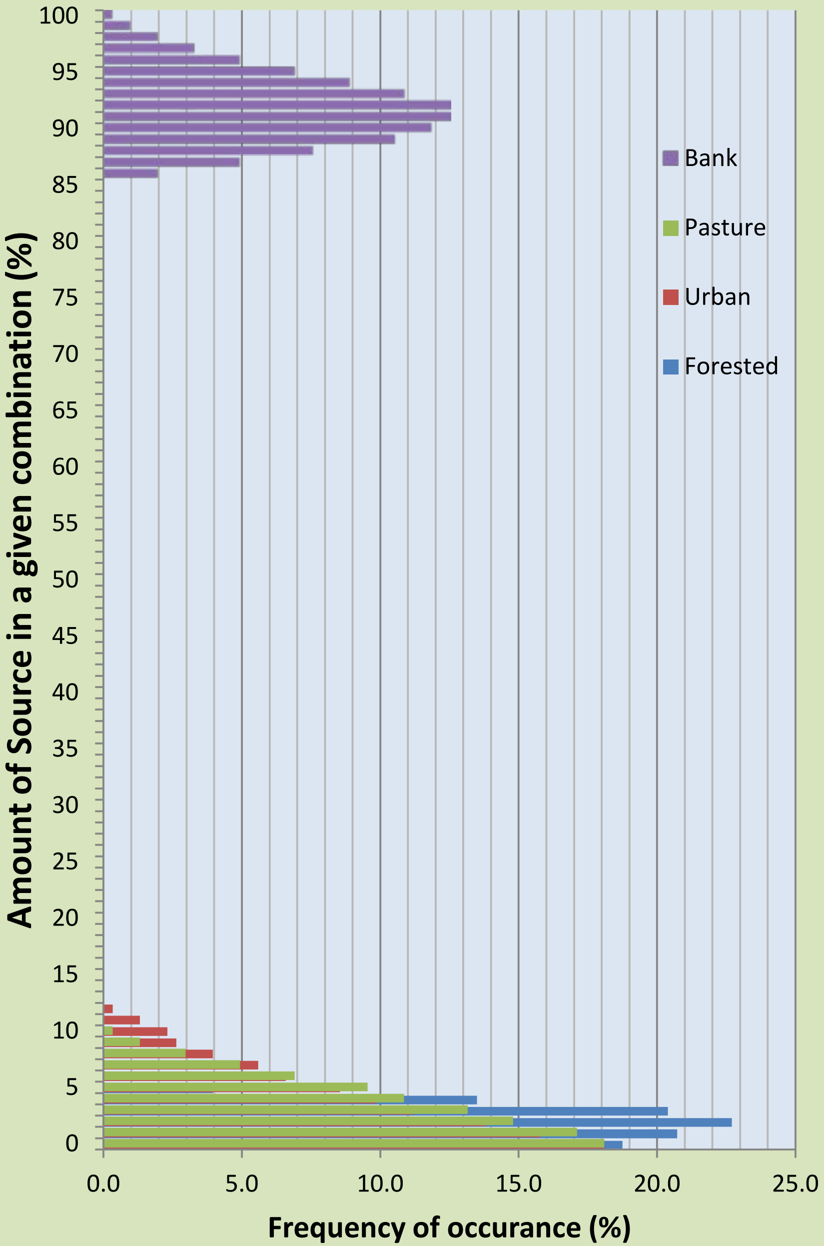
Relative source contribution of suspended sediment was estimated using the isotopic mixing model IsoSource

(Phillips and Gregg, 2001;2003)



The following potential sediment sources were analyzed:

Results



The IsoSource results estimate that bank material accounts for between 86% and 100% of mass of any given suspended sediment sample.

Urban source contributes between 0-12%

Pasture source contributes between 0-10%

Forested source accounts for the least amount of material, 0-5%, which is expected due to low erosion rates.

Contribution %	Forested	Urban	Pasture	Bank
Mean	2	3.5	3	91.5
Min	0	0	0	86
Max	5	12	10	100
1 percentile	0	0	0	86
50th percentile	2	3.5	2	92
99th percentile	5	11	9	99
StDEV	1.4	2.9	2.4	3

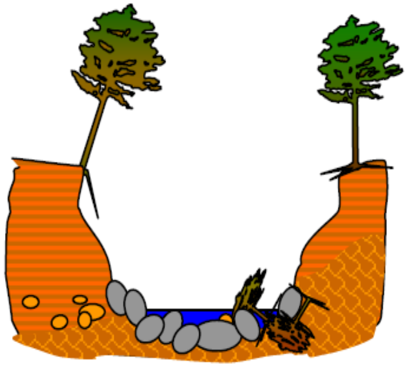
Results

- Stable isotopic results are consistent with our geomorphological field assessments where banks were noted overall as unstable.

- According to the Channel Evolution Model (Simon, 2001), the Lawsons Fork stream is at a Stage IV: Channel Widening

<u>Stage IV Channel Widening</u>

- Widespread bank failures as banks exceed critical height or were undercut by toe scour
- Channel adjusts to new flow regime
- Significant sediment loads generated; most significant erosion hazard in this phase
- Bank armoring generally ineffective



Results

Suspended Sediment Flux Results

Based on 53 depth-integrated suspended sediment samples collected over a 20 month period capturing large range of flow regimes.

Stable	• 0.20 T/ha/yr
Unstable	• 0.48 T/ha/yr
Lawsons Fork	• 2.5 – 3.8 T/ha/yr

Suspended sediment transport rates in the Piedmont for drainage basins 101-1000 km^2
(Klimentz and Simon, 2007)

In many reaches, banks are undergoing mass or rotational failure. Trees are falling into the stream or leaning sharply.

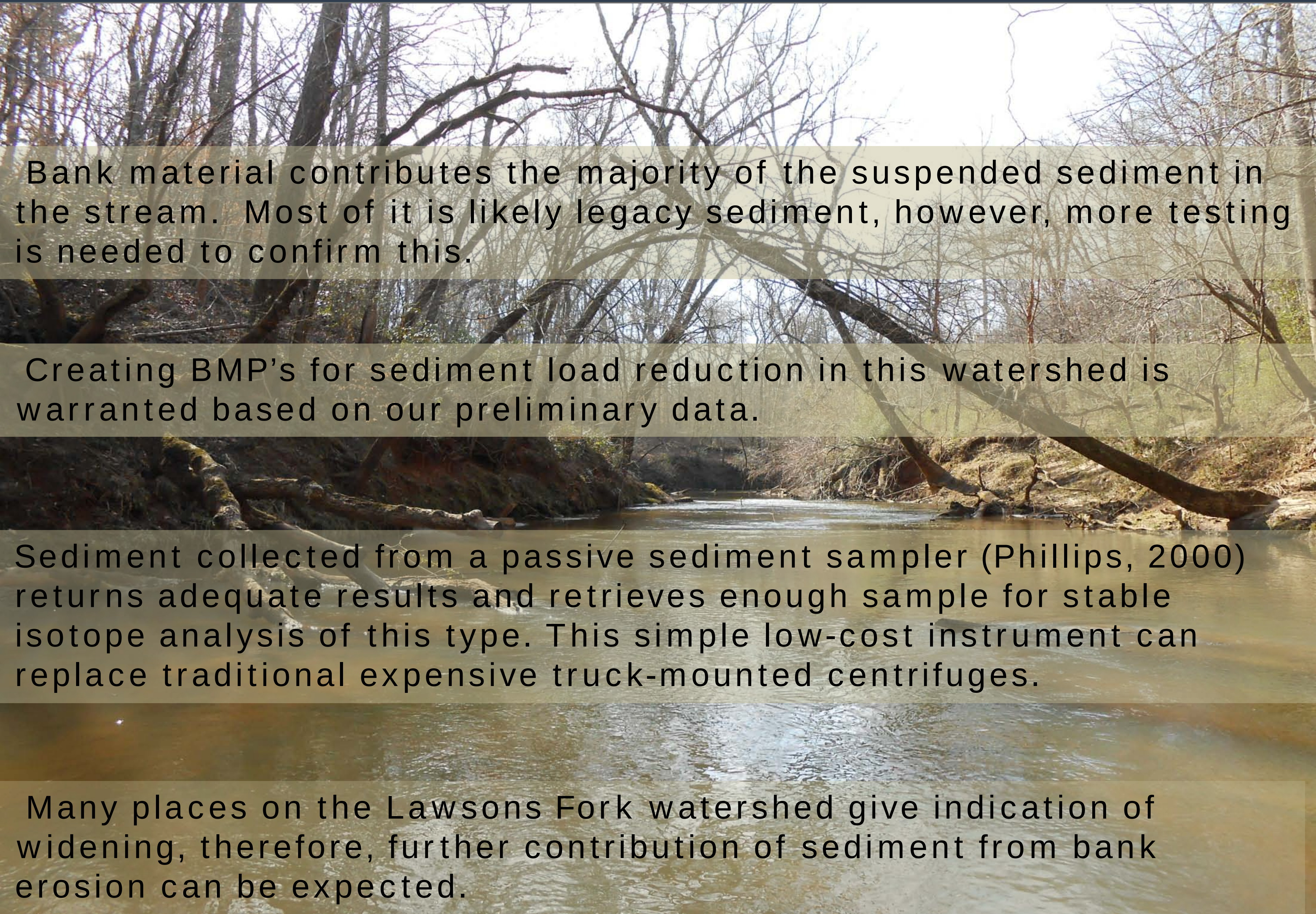
Future work

✓ During a recent flooding event (March, 2014), samples were collected with an ISCO automatic pump sampler to analyze 1) grain size distribution and 2) sediment source over different stages of the hydrograph. These results are forthcoming.

✓ Additional upland samples will be collected and analyzed to increase representation across the watershed; statistics will be run at that time (Kruskall Wallis for tracer discrimination; Monte Carlo for uncertainty)

✓ Field data collection will continue with the OBS to verify relationship between discharge and suspended sediment flux……and how sediment loads compare to others in the Broad River Basin

Closing statements



Bank material contributes the majority of the suspended sediment in the stream. Most of it is likely legacy sediment, however, more testing is needed to confirm this.

Creating BMP's for sediment load reduction in this watershed is warranted based on our preliminary data.

Sediment collected from a passive sediment sampler (Phillips, 2000) returns adequate results and retrieves enough sample for stable isotope analysis of this type. This simple low-cost instrument can replace traditional expensive truck-mounted centrifuges.

Many places on the Lawsons Fork watershed give indication of widening, therefore, further contribution of sediment from bank erosion can be expected.

Acknowledgements

- Broad River Mitigation Trustees
- United States Geological Survey
- Wofford University
- University of South Carolina
- Wildlife and Freshwater Fisheries division of SCDNR

Questions?