Rapid Geomorphic Assessment & Sediment Source Tracking - North Fork Broad River, Georgia

Rajith Mukundan & David Radcliffe
University of Georgia

Collaborators
Mark Risse, University of Georgia
Andrew Simon, National Sedimentation Lab, MS
Eddy Langendoen, National Sedimentation Lab, MS
Jerry Ritchie, USDA-ARS Beltsville, MD

Overview

- Introduction

<u>**Rapid Geomorphic Assessment (RGA)**</u>

- Sediment source assessment
- Sediment yield estimates and regional values

<u>**Sediment fingerprinting**</u>

- Tracer selection
- Identifying sources and relative contribution
- Conclusions

Problem

- **Several streams listed for TMDL in the Georgia Piedmont and other regions in southeast are impaired because of high levels of fine sediment**

The question

- **Where is this sediment coming from?**
- **Is it coming from upland erosion sources (agrl. fields, unpaved roads, construction sites and ditches)**

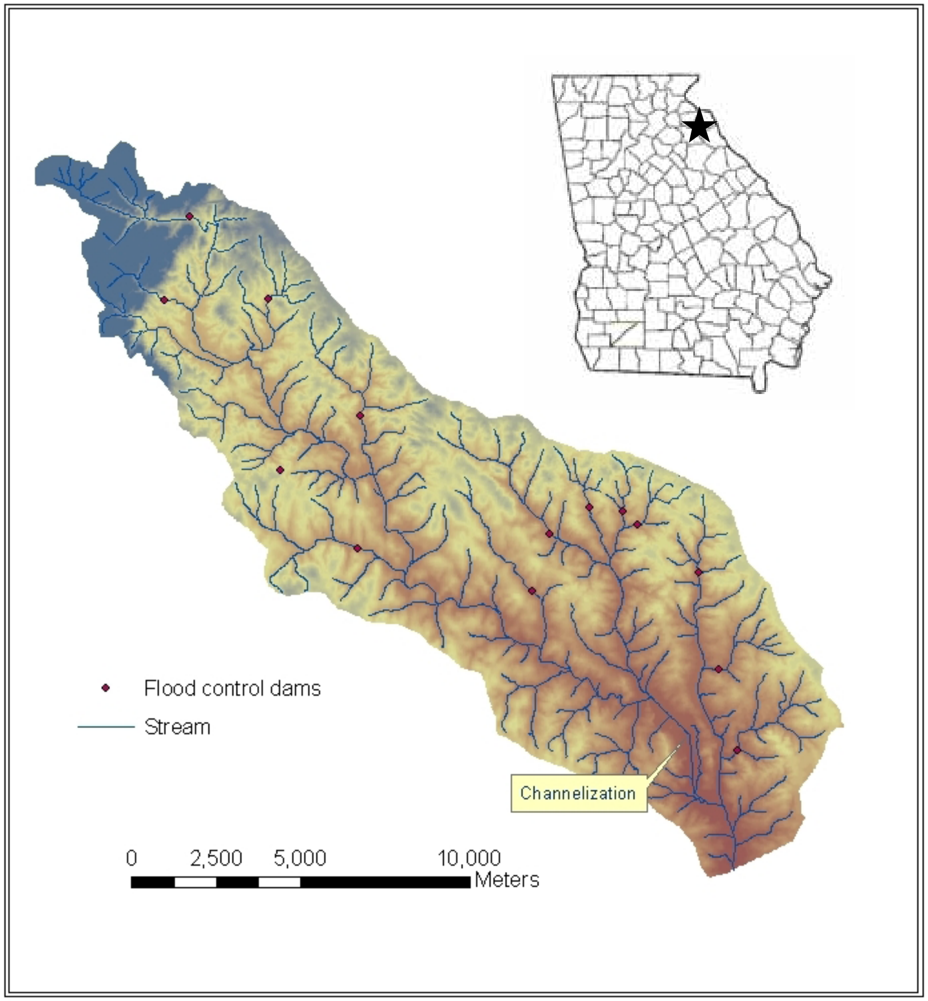
Or

- **Is it bank erosion of historic sediment deposited in the flood plains during the period of intensive cotton cultivation (1830-1930)**

Evidences of historic erosion

The North Fork Broad River Watershed

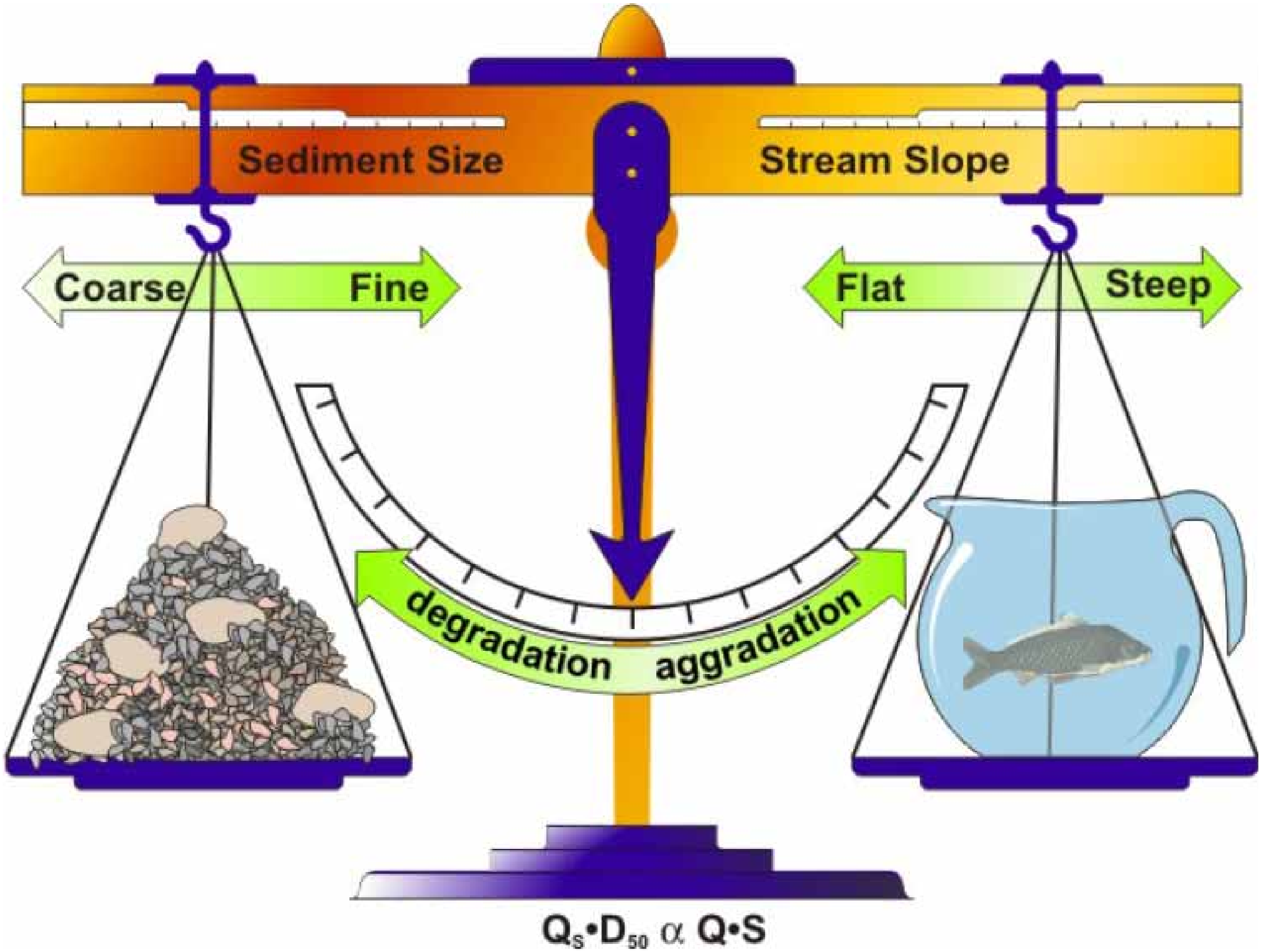
- Location- Georgia Piedmont
- Drainage area- 182 km^2
- Land use
  - Forest (72%)
  - Pasture (15%)



Rapid Geomorphic Assessment (RGA)

- **To evaluate channel stability and stage of channel evolution**
- **Utilize diagnostic criteria to infer dominant channel processes and degree of stability**

Channel stability and Lane's equation

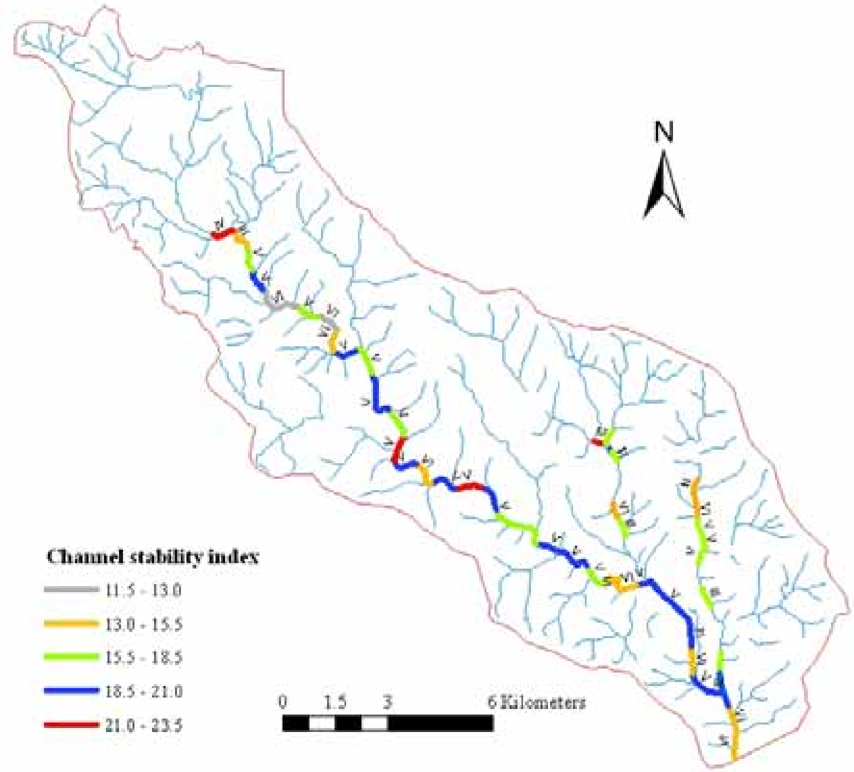


Sediment load x Sediment size α Stream discharge x Stream slope

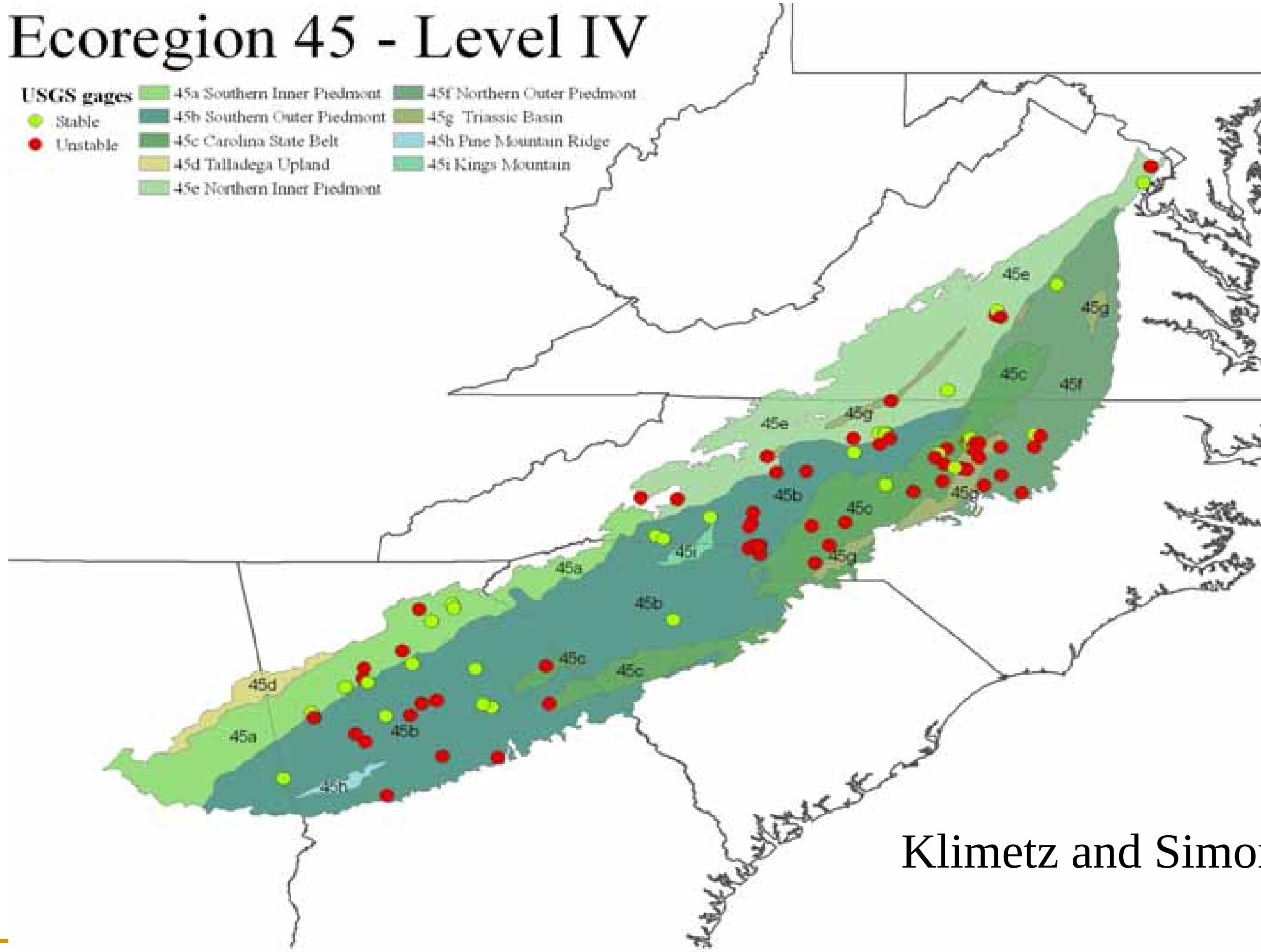
Stages of Channel Evolution

Stage – III	- 8%	- Unstable
Stage – IV	- 3%	- Unstable
Stage – V	- 58%	- Unstable
Stage – VI	- 31%	- Stable

Bank Erosion Process	**Left Bank**	**Right Bank**
Fluvial	15 (42%)	15 (42%)
Mass Wasting	5 (14%)	17 (47%)
None	16 (44%)	4 (11%)



Comparing NFBR sediment yield to values for “stable” and “unstable” sites in Ecoregion-45 – The Piedmont



Klimetz and Simon (2006)

Sediment Yield Estimates and Targets

	Mean annual yield (T ha^{-1} yr^{-1})		
	All streams	Stable	Unstable
10th Percentile	0.10	0.05	0.15
25th Percentile	0.17	0.11	0.26
50th Percentile	**0.39**	**0.19**	**0.50**
75th Percentile	0.56	0.33	0.86
90th Percentile	1.08	0.40	1.17

(From Klimetz and Simon, 2007)

NFBR ------------2.30T ha^{-1} yr^{-1} 2005

NFBR ------------0.26T ha^{-1} yr^{-1} 2006

NFBR ------------0.37T ha^{-1} yr^{-1} 2007

Average
0.91 T ha^{-1} yr^{-1}

Sediment Fingerprinting

Underlying principle

- Sediment sources can be distinguished by a number of diagnostic properties
- Comparison of the same properties in stream sediment can help in determining the relative source contribution

Fingerprint properties should be:

- **Measurable** both in source and sediment
- **Representative** of the potential sediment source and should vary substantially among different potential sources
- **Conservative** and must not undergo change in between sediment generation and delivery through reactions or by other means

SAMPLING

Upland surface sources

- Pastures
- Forests

Sub surface source

- Stream banks

Upland sub-surface sources

Unpaved roads

Road Ditches

Construction

Field gullies

Suspended sediment sampling

Sample required for lab analysis

200 g fine sediment

Manual filtering to collect 200 g require 1000L when the SSC is 200 mg/L

~ 250 x  **= 200 g**

Tracer selection

Tracers considered

Radio isotope (^{137}Cs)

Stable isotope (^{15}N)

Total C, N, P, and S

Trace elements

Steps in tracer selection

1. **Discriminant Analysis: To test the ability of individual tracers to differentiate sources**
2. **Removal of non-conservative tracers based on its concentration in sediment samples**
3. **Removal of tracers that showed redundancy (eg: C and N)**
4. **Selecting the best suite of tracers that can explain most of the source variation**

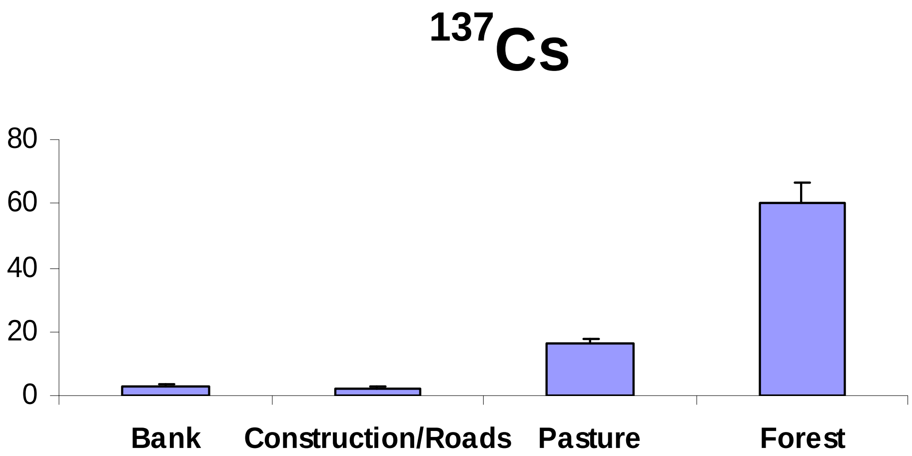
Results

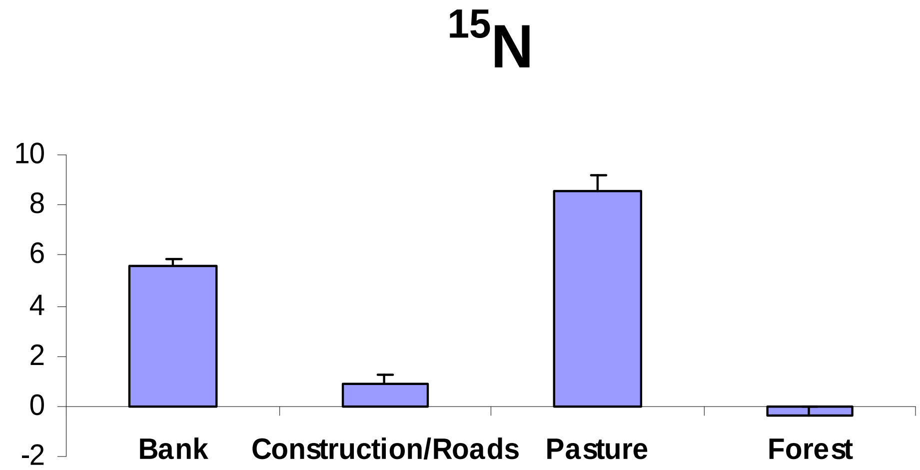
- **Total number of tracers considered- 21**
- **Number of tracers after Discriminant Analysis- 11**

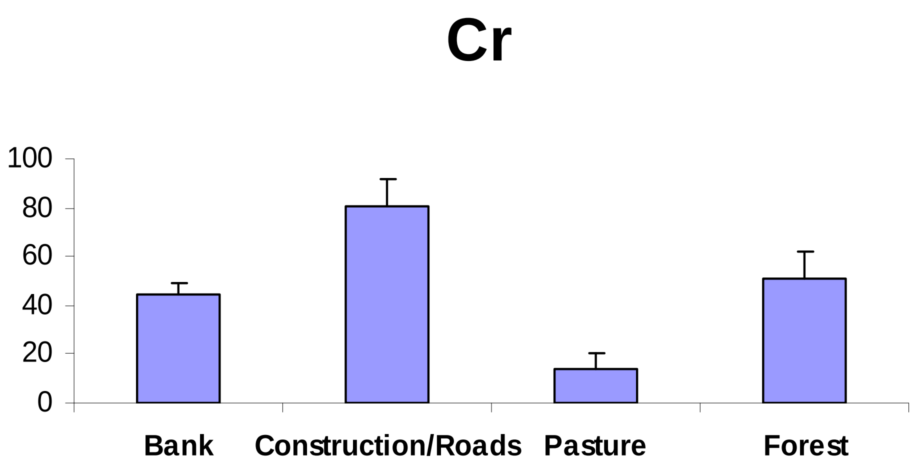
  (C, N, S, ^{137}Cs, ^{15}N, Al, Cr, Fe, Pb, Mg and U)
- **Number of tracers after removing non conservative tracers- 7 (C, N, S, ^{137}Cs, ^{15}N, Cr, and U) Al, Pb, Fe, and Mg out**
- **Number of tracers after removing redundant tracers- 4**

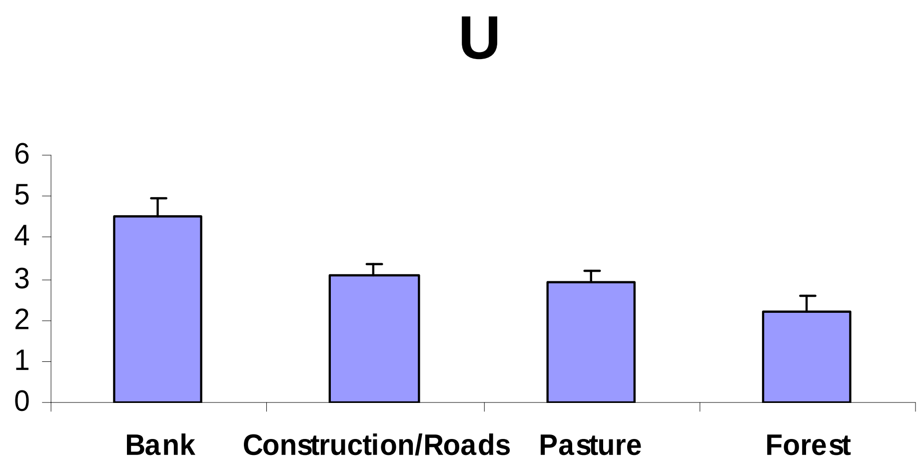
  (^{137}Cs, ^{15}N, Cr, and U) C, N, and S out

Tracer concentrations in sources









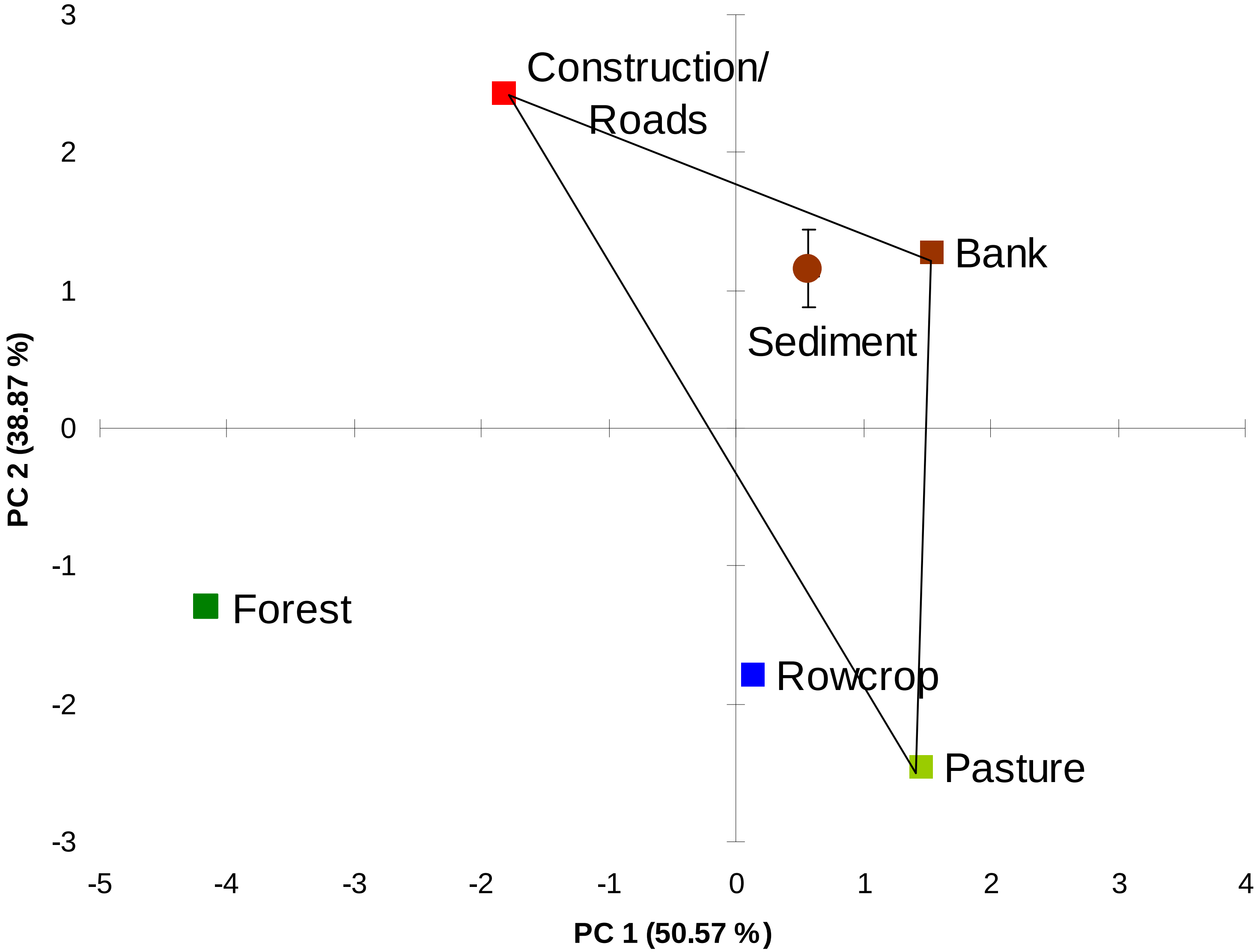
Relative source contribution

Methods

1. **Multivariate mixing model (Collins et. al 1998;Walling et. al 1999) – widely used method for sediment tracking**

2. **End Member Mixing Analysis (EMMA) (Christophersen and Hooper, 1992; Burns et. al, 2001) – widely used method for quantifying sources of stream flow**

3 End Member Mixing Model



Results

	Multivariate mixing model	EMMA
Stream bank	65 %	60%
Construction, Unpaved roads, field gullies, ditches	27%	29%
Pasture	8%	11%

Conclusions

- Stream banks contribute most of the fine sediment in this Piedmont watershed
- Scope for sediment load reduction
- Application in sediment TMDL programs
- ^{15}N – an underutilized tracer

Future research plans

- Intra-storm variability in sediment source
- Temporal variability in sediment source
- Spatial sources of sediment within a watershed
- Uncertainty in mixing models

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