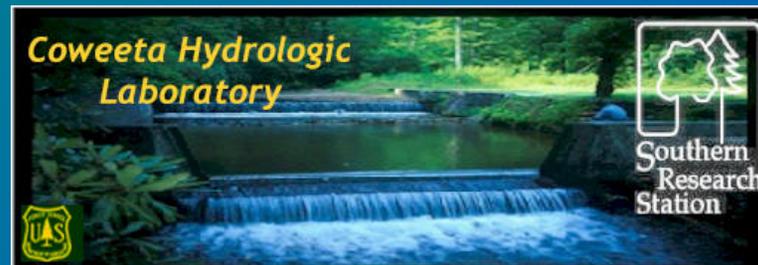


# Characterizing Hysteretic Water Quality in Southern Appalachian Streams

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Mark Riedel, James Vose & Paul Bolstad



# Introduction

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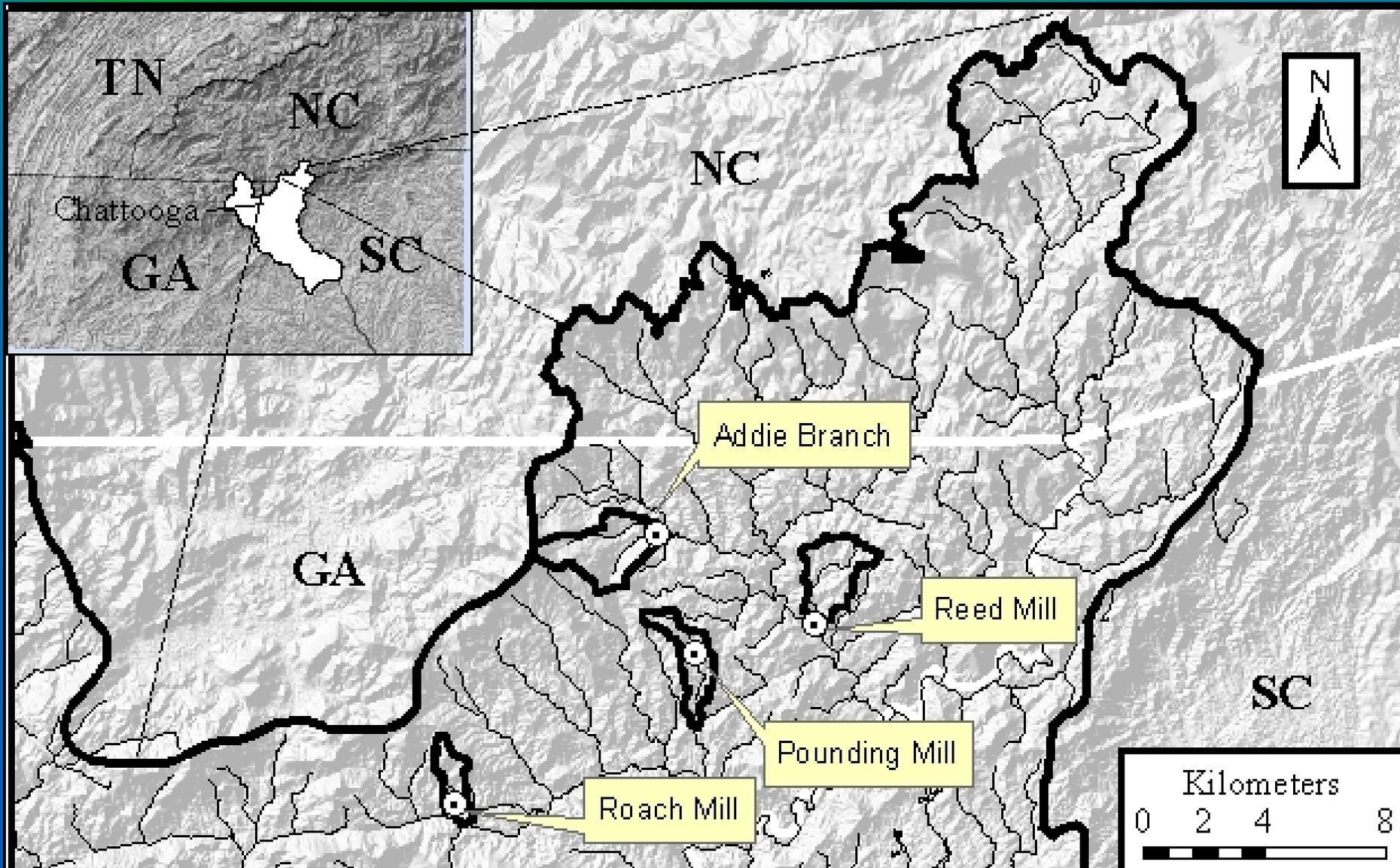
## Project Description

- Chattooga River Watershed – 450 km<sup>2</sup>
  - Blue Ridge Province - Southern Appalachian Mountain
- Wild and Scenic River
- Sediment impaired 303 (d) list (EPA, 2001)
  - Aquatic habitat and biota
- Sediment TMDLs established
  - Based on TSS

## Project Goal

- Characterize variability in water quality.
  - Compare continuous monitoring data to 303(d) status

# Introduction - Site Location



# Introduction – Study Sites

Stream	303(d)	Area (km <sup>2</sup> )	Elevation (m)	Slope (%)	Forest (%)	Roads (km / km <sup>2</sup> )	Aspect	n
Addie Branch	Unlisted	5.6	925	19	100	0.8	ENE	447
Pounding Mill	Threat.	1.3	706	14	100	2.0	ESE	511
Reed Mill	Threat.	4.4	700	14	97	1.3	S	377
Roach Mill	Impaired	0.8	712	16	100	0.0	ESE	263

# Methods - Sampling

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## Stage and discharge

- 5 - 15 minute intervals
- Flow calibrated by gauging

## Pumped Samples

- Flow proportional - baseline conditions
- Time proportional - storm flow conditions

## Grab samples

- DH-48 depth integrated samples

# Methods – Sample Analyses

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## Total Suspended Solids (TSS)

- Gravimetric to 1.5  $\mu\text{m}$  (fpom)

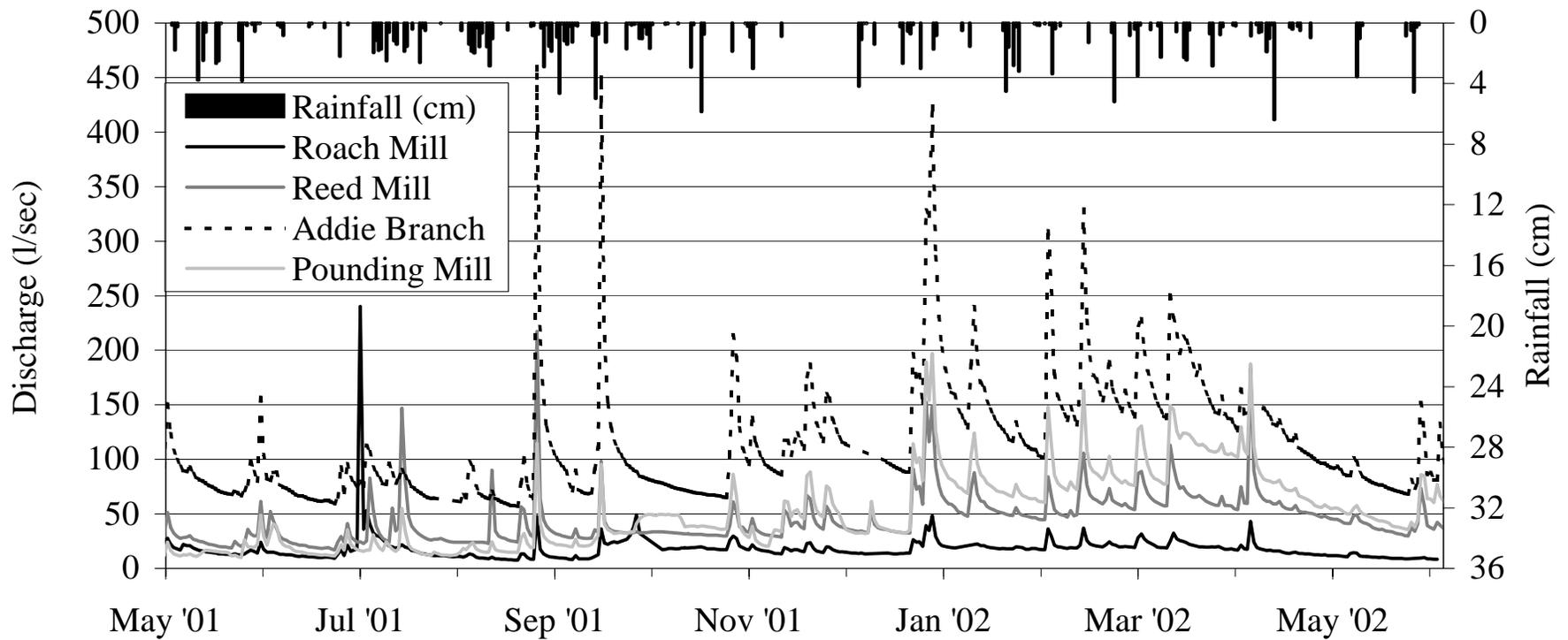
## Clastic Sediment

Ash free dry weight

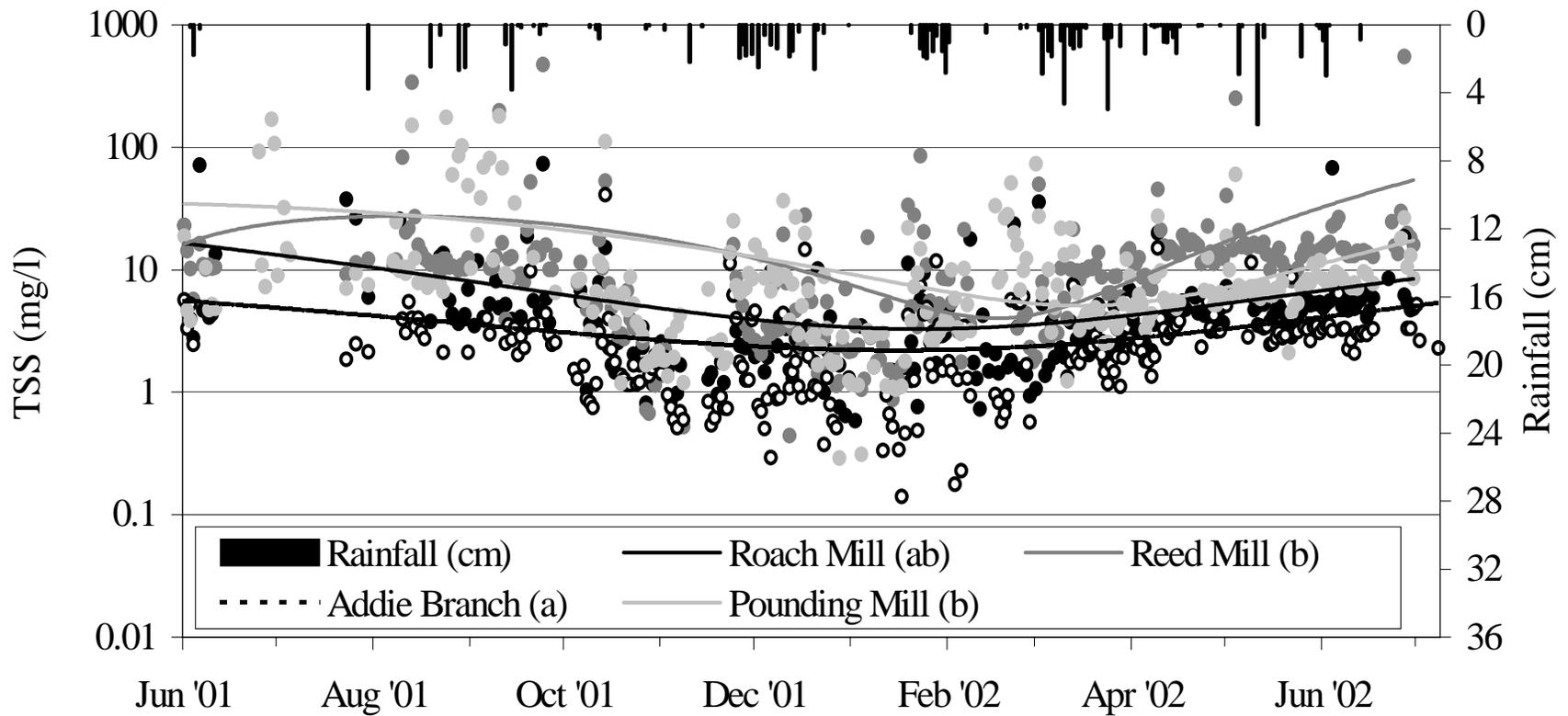
## Organic Matter

Mass conservation

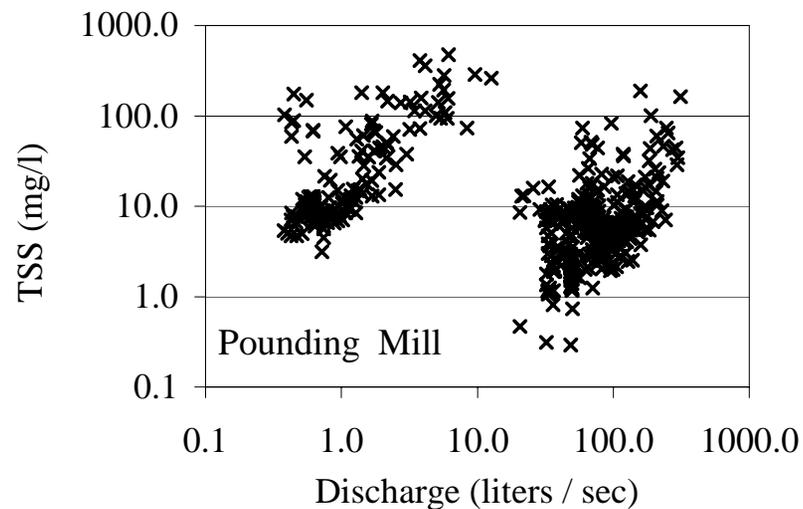
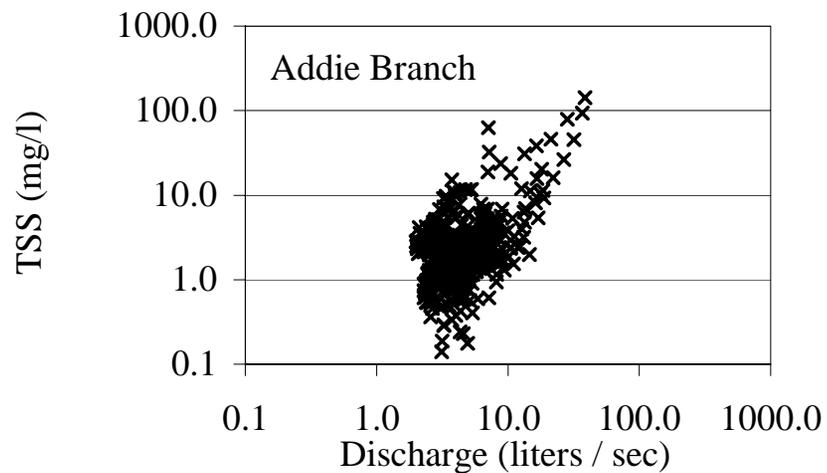
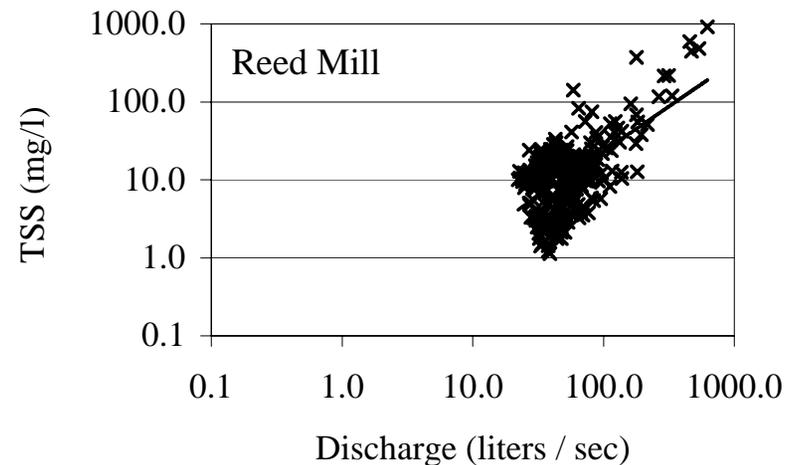
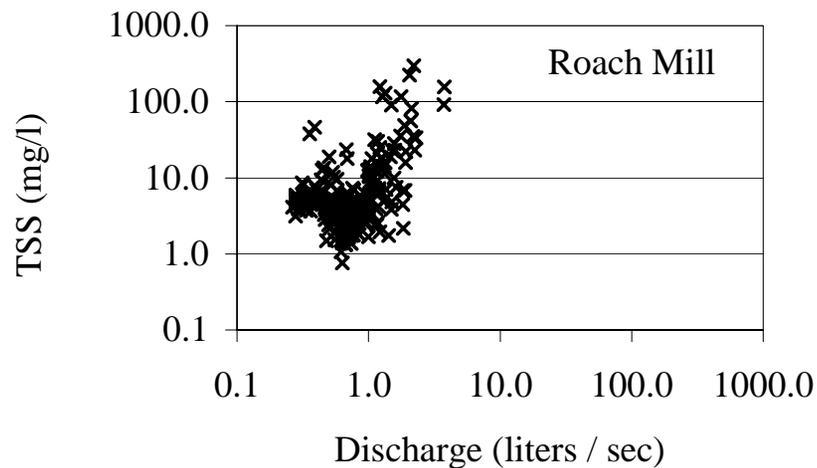
# Seasonal Flow Trends



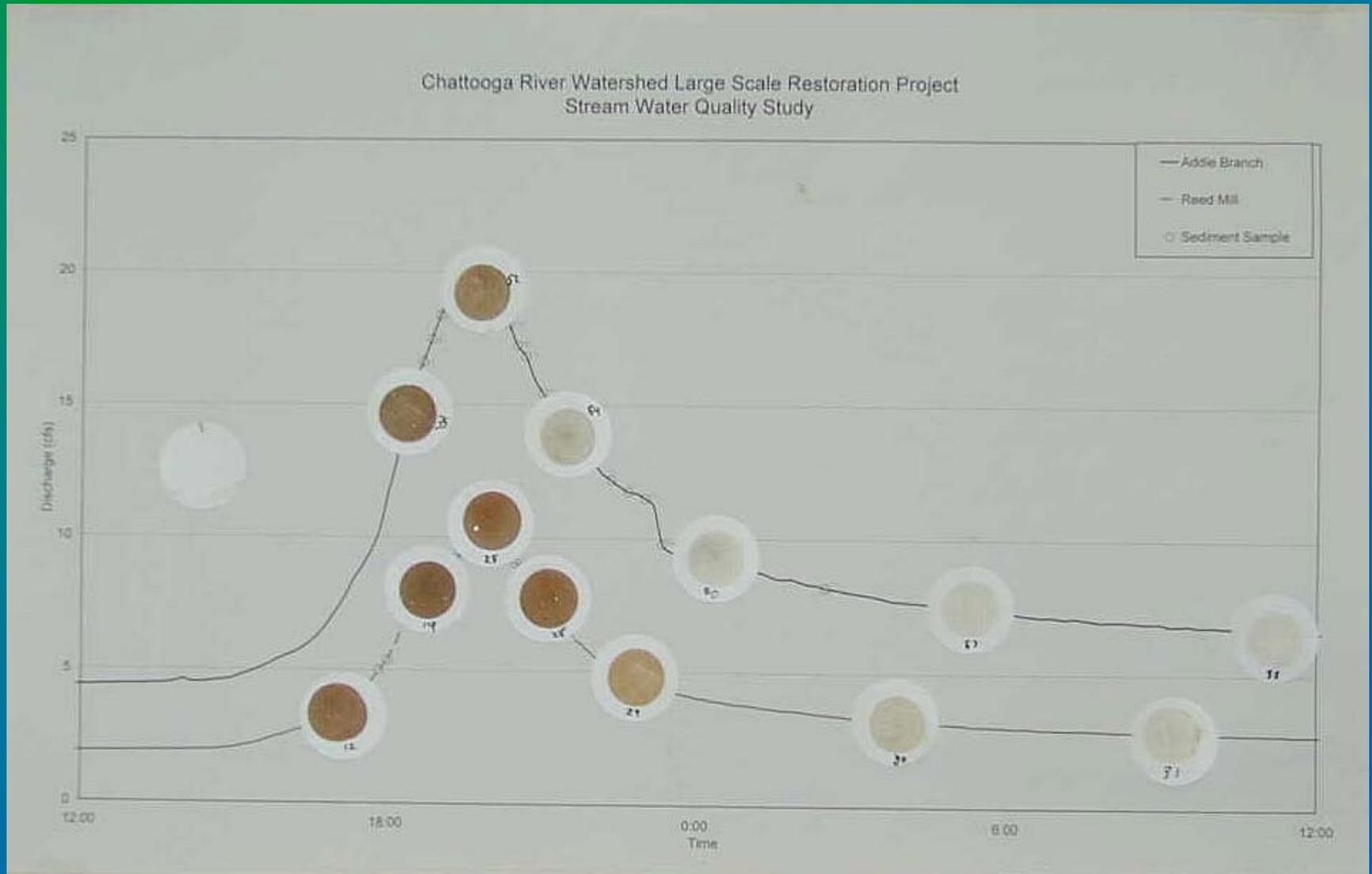
# Seasonal TSS Trends



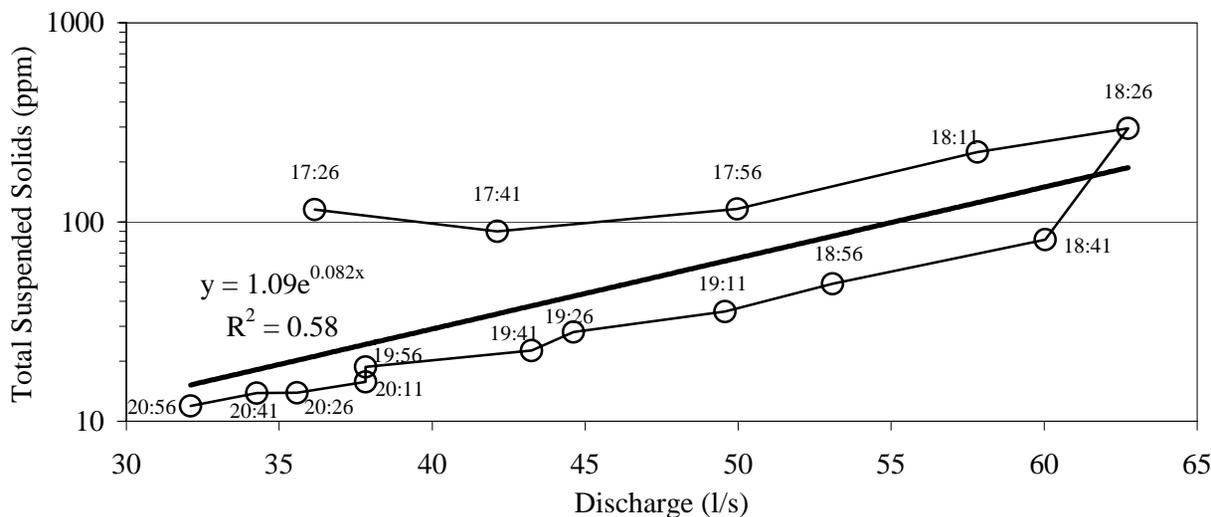
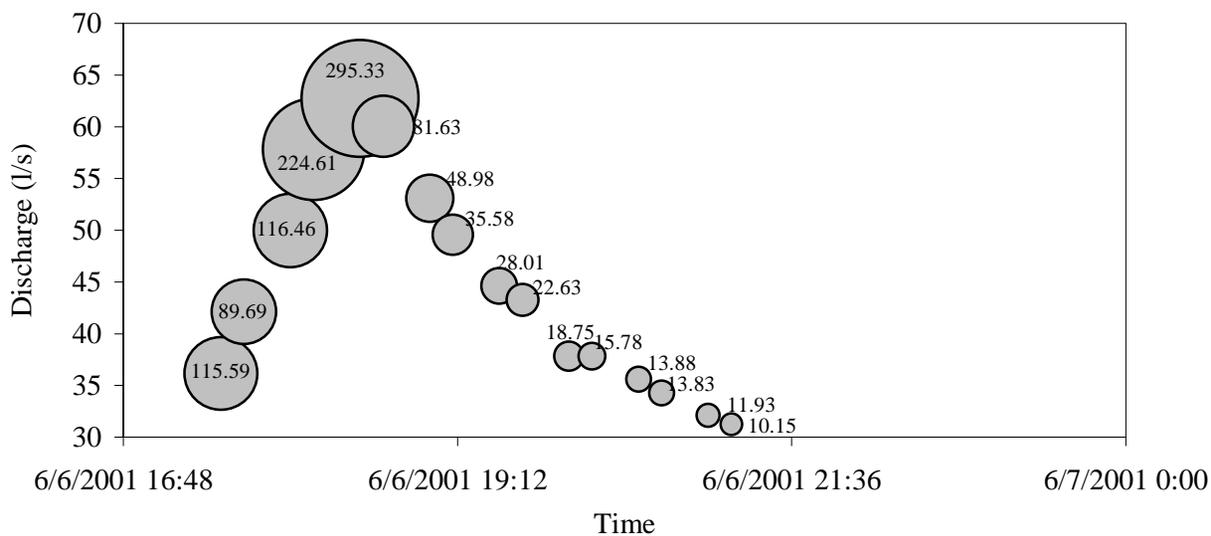
# Preliminary data



# Preliminary Data



# Preliminary Data



# Methods – Statistical Treatment

Data filtered and analyzed based upon  
“hydrograph regime” ( $dQ/dt$ )

- $dQ/dt$  computed over 3 stage intervals

% change in slope	Hydrograph regime ( $dQ/dt$ )
$dQ/dt > 1\%$	Rising Limb
$-1\% < dQ/dt < 1\%$	Baseflow
$dQ/dt < -1\%$	Recession Limb

Unique stage discharge rating curves for each regime.

Curves that were statistically “similar” were combined – ie rising limb and recession limb were the same.

# Results

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Roach Mill and Addie Branch required unique rating equations for rising limb and recession limb data

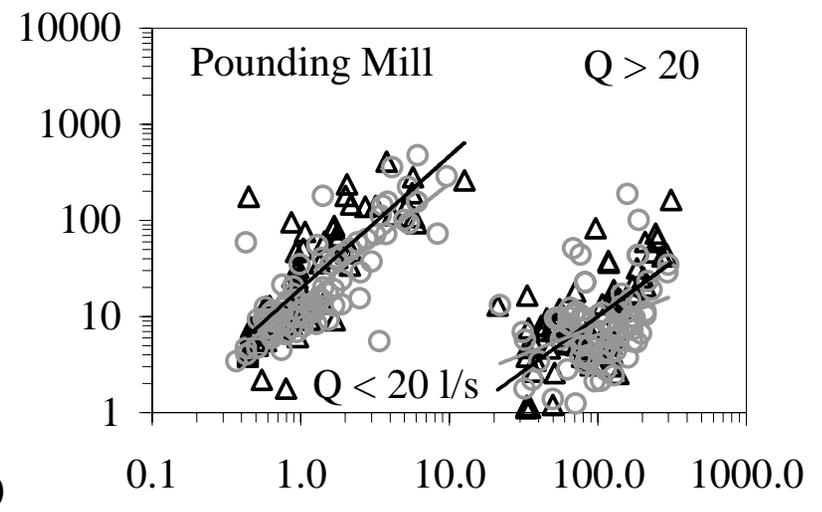
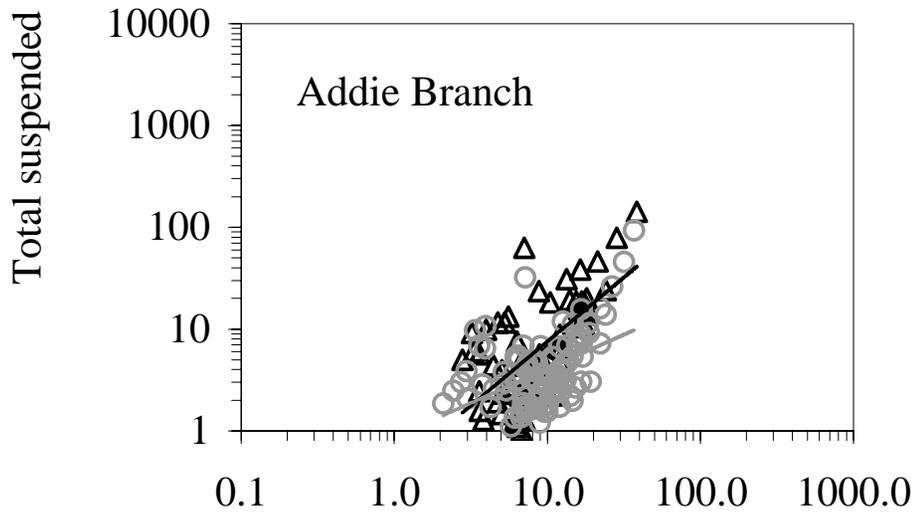
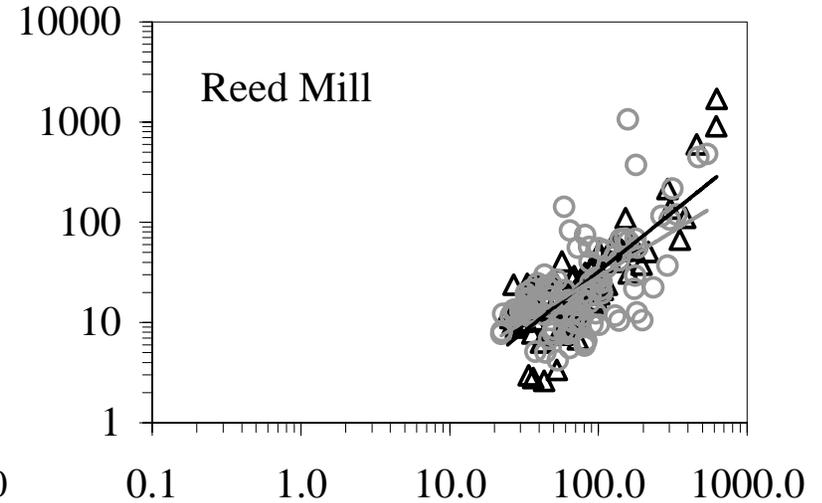
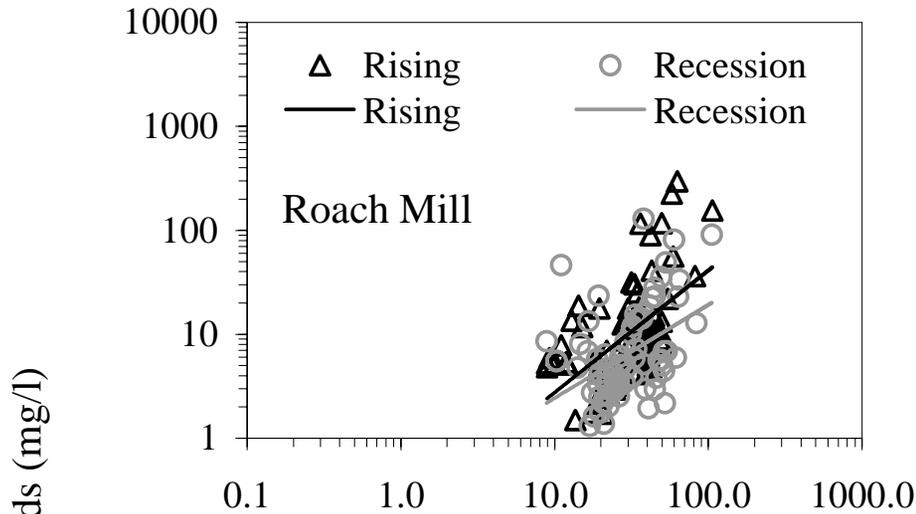
TSS rating curves for Reed Mill and Pounding Mill were the same for rising limb and recession limb data

Pounding Mill data treated separately for flows above and below 20 l/s.

# Results

Stream	Q Criteria	Hydrograph Regime	TSS Rating Equation	$r^2$	Significance	Degrees of freedom
<b>Roach</b>	<b>N/A</b>	<b>Rising Limb</b>	<b>TSS = 0.16 Q<sup>1.22</sup></b>	<b>0.28</b>	<b>p &lt; 0.001</b>	<b>76</b>
<b>Roach</b>	<b>N/A</b>	<b>Recession Limb</b>	<b>TSS = 0.31 Q<sup>0.90</sup></b>	<b>0.18</b>	<b>p &lt; 0.001</b>	<b>74</b>
<b>Reed</b>	<b>N/A</b>	<b>Combined</b>	<b>TSS = 0.25 Q<sup>1.04</sup></b>	<b>0.51</b>	<b>p &lt; 0.001</b>	<b>202</b>
<b>Addie</b>	<b>N/A</b>	<b>Rising Limb</b>	<b>TSS = 0.41 Q<sup>1.26</sup></b>	<b>0.40</b>	<b>p &lt; 0.001</b>	<b>62</b>
<b>Addie</b>	<b>N/A</b>	<b>Recession Limb</b>	<b>TSS = 0.87 Q<sup>0.67</sup></b>	<b>0.21</b>	<b>p &lt; 0.001</b>	<b>98</b>
<b>Pounding Mill</b>	<b>&lt; 20 l/s</b>	<b>Combined</b>	<b>TSS = 16.86 Q<sup>1.27</sup></b>	<b>0.63</b>	<b>p &lt; 0.001</b>	<b>155</b>
<b>Pounding Mill</b>	<b>&gt; 20 l/s</b>	<b>Combined</b>	<b>TSS = 0.15 Q<sup>0.89</sup></b>	<b>0.28</b>	<b>p &lt; 0.001</b>	<b>148</b>

# Results



Discharge (l/s)

# Conclusions

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- Strong storm flow hysteresis of TSS in Roach Mill and Addie Branch Creeks.
- TSS vs. discharge relationships are unique for rising limb and recession limb data.
- TSS increases rapidly during rising limbs then, abruptly decreases to near baseline levels with the passage of peak flow.
- There is a “supply limit” of TSS in these streams.

# Conclusions

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- No evidence of hysteresis with TSS in Reed Mill and Pounding Mill Creeks.
- TSS vs. discharge relationships are similar for rising limb and recession limb data.
- TSS increases rapidly during rising limb of hydrographs then, decreases proportionally with recession of storm flow discharge.
- There is a "transport limit" of TSS in these streams.

# Conclusions

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TSS Rating curves based on simple regression analysis do not reflect true nature of TSS loading and transport of the minimally impacted forest streams in this study.

Sediment budgets (ie TMDLs) based upon integration of hydrographs over TSS (or sediment) rating curves will be unreliable for forested streams.

# Acknowledgements

## Project coordination

- Chattooga Watershed Restoration Project Board
- USFS, Tallulah Ranger District, Clayton, Georgia

## Project funding

- USDA Forest Service Large Scale Watershed Restoration Projects

## Sample analyses & field work

- C. Marshall, P. Clinton, J. Love and K. Seader.

