Quantifying The Importance of Streambed Erosion and Failure To Total Sediment Load to Streams: Overview of the Fort Cobb Watershed Project

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USDA NIFA NIWQP Research Team

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  - Agricultural Economics
    - Tracy Boyer, Larry Sanders, and Art Stoecker
- USDA-ARS Grazinglands Research Station
  - Patrick Starks, Daniel Moriasi, and Jean Steiner

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National Institute of Food and Agriculture

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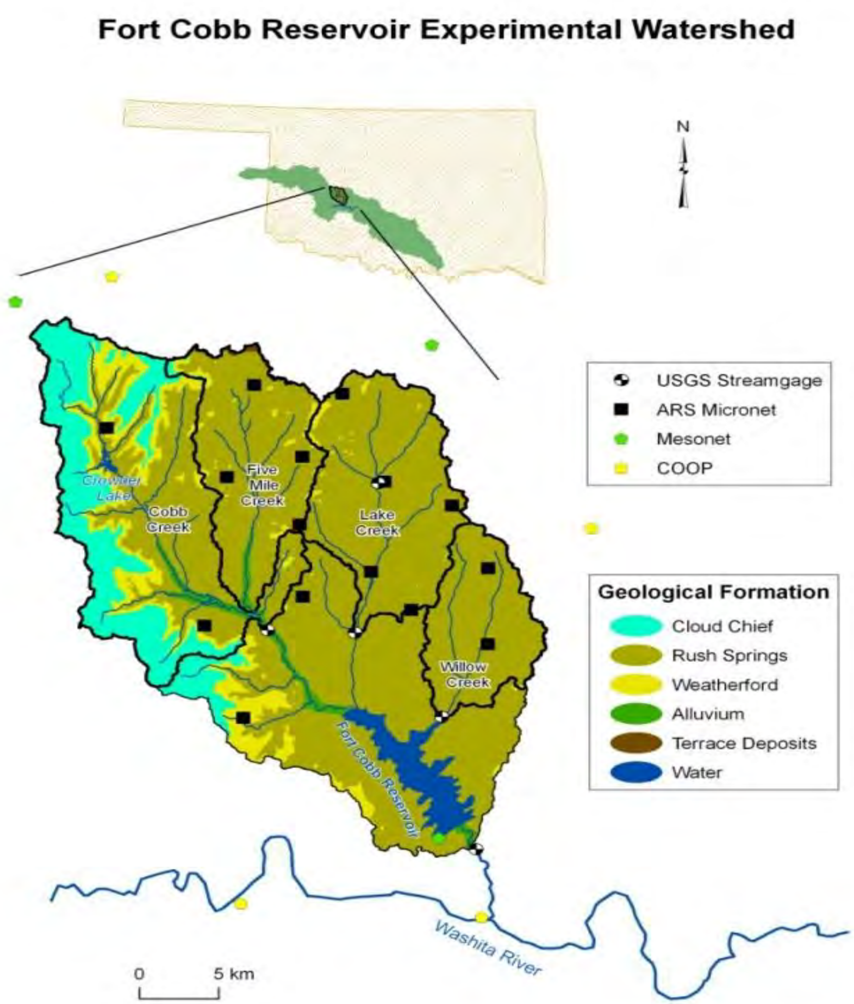
Fort Cobb Watershed

- Reservoir provides public water supply, recreation, and wildlife habitat
- Winter wheat and small grains (43%), pasture/grass (34%), peanuts and cotton (9%), forest (5%), other summer crops (4%), roads and urban (5%), and water (<2%)
- Fails to meet water quality standards based on sediment and trophic level

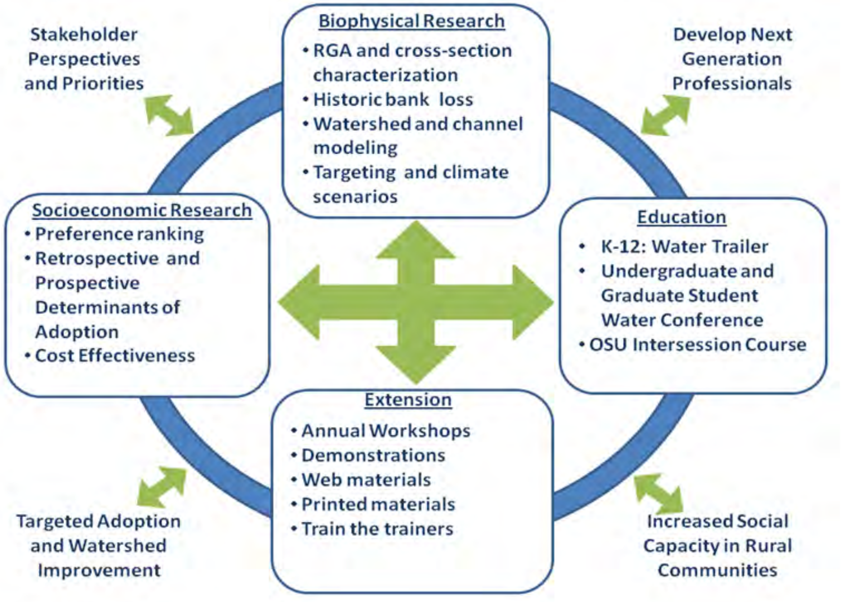


Conservation Practices

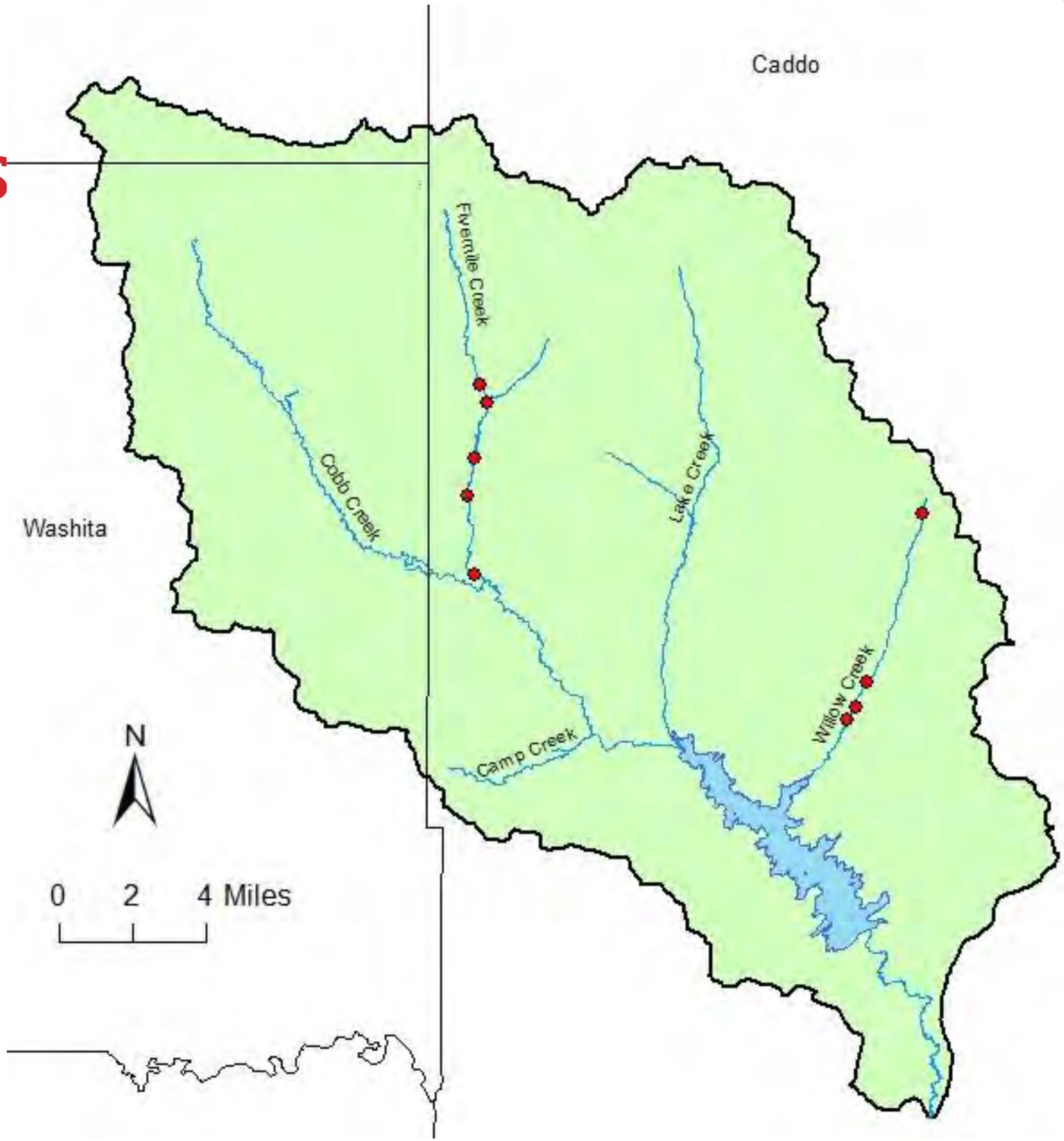
- Adoption of no-tillage management, conversion of cropland to grassland, cattle exclusion from streams
- Various structural and water management practices
  - From 1992 to 2004, conventional tillage in the watershed decreased from 71 to 44%
- Concerns about sedimentation of the reservoir persist
  - Majority of the sediment originating from streambanks and channels
  - Using ^{7}Be and ^{210}Pb as radionuclide tracers, as much as 50% of suspended sediment was from streambanks

Project Objectives

- Integrates research, extension, and education activities
- Upland, in-stream, streambank, and riparian conservation practices
- Addresses implementation relative to economic, social, and climatic considerations
    - Upcoming presentations by Drs. Boyer and Melstrom



Selected Sites

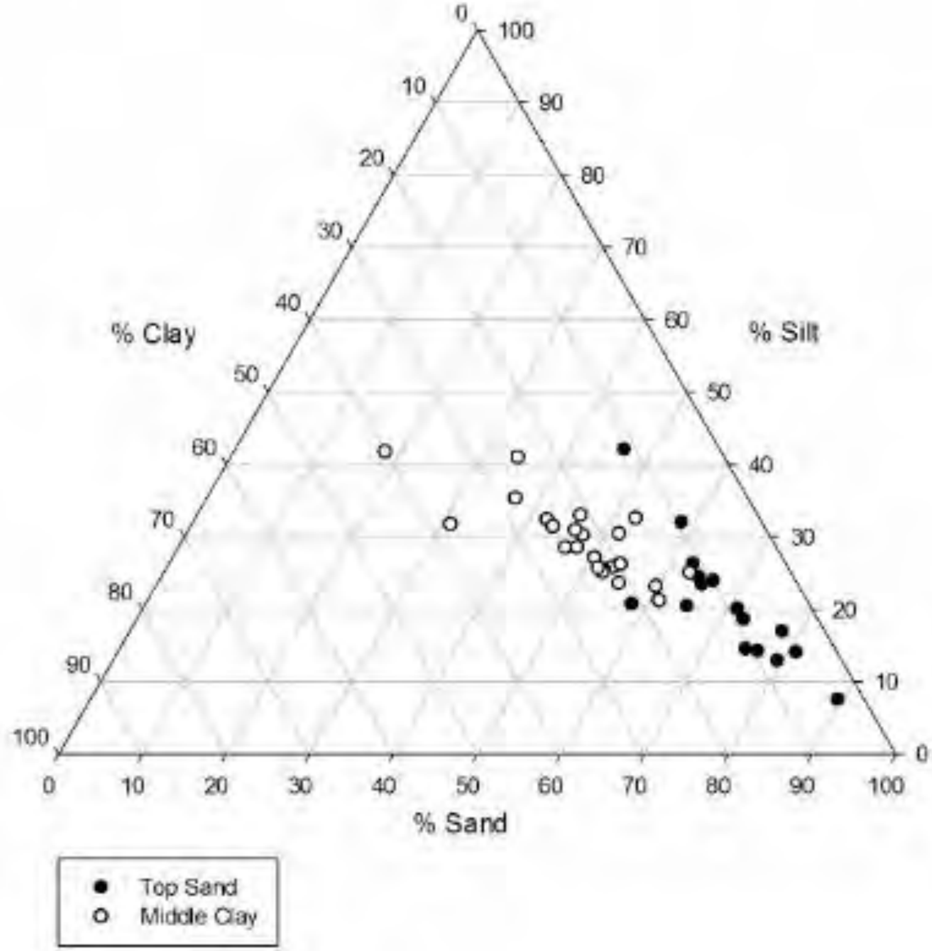


Characterizing Streambanks

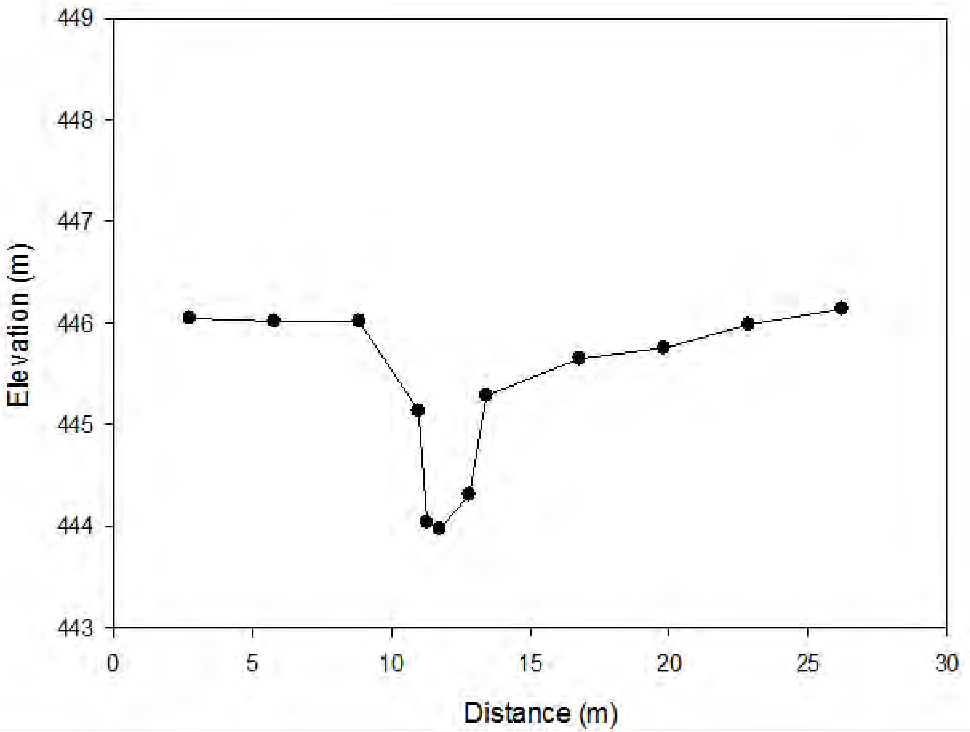
- Characterize streambeds and unstable streambanks, install water level loggers, and conduct cross-section surveys



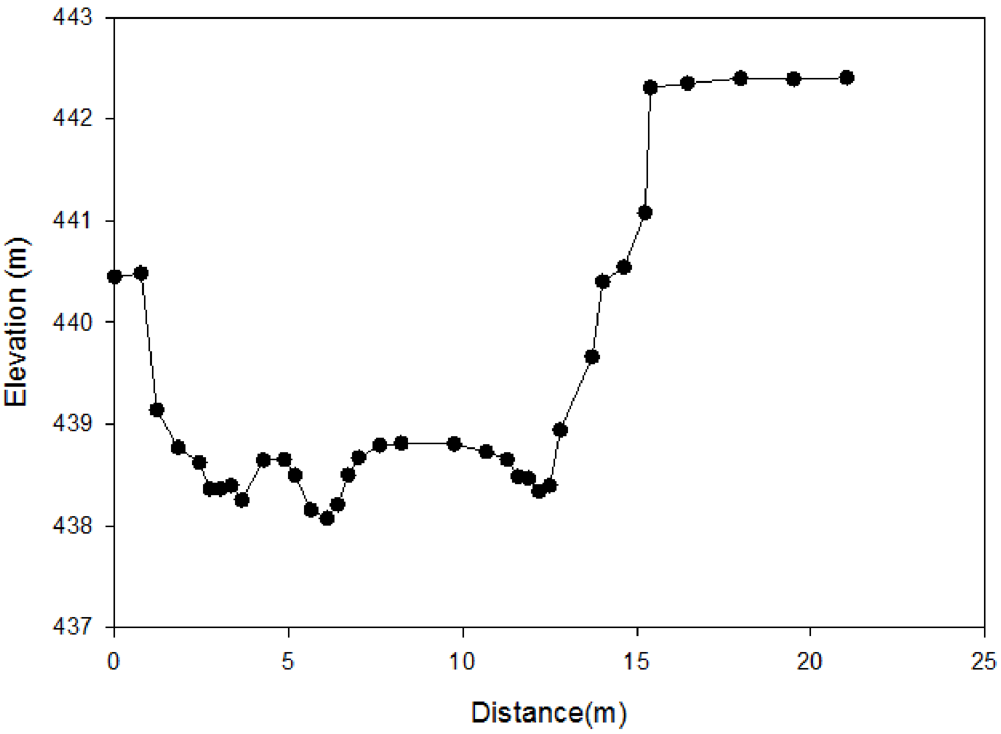
Characterizing Streambanks



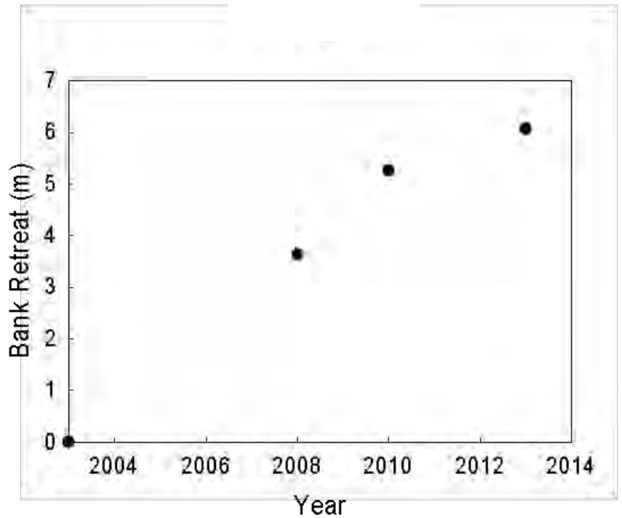
Upstream of a Headcut

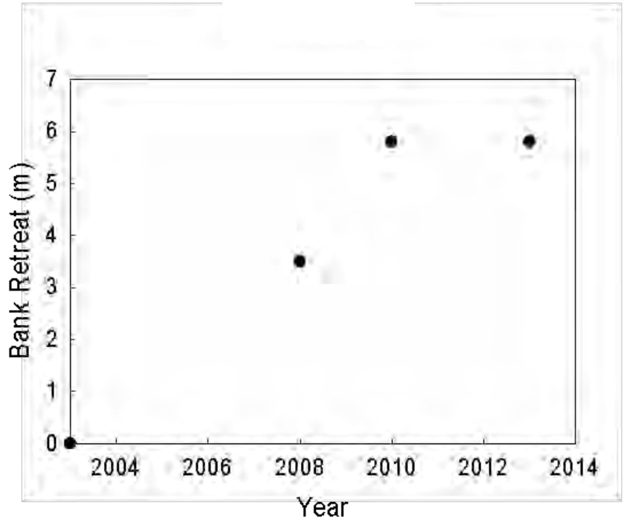


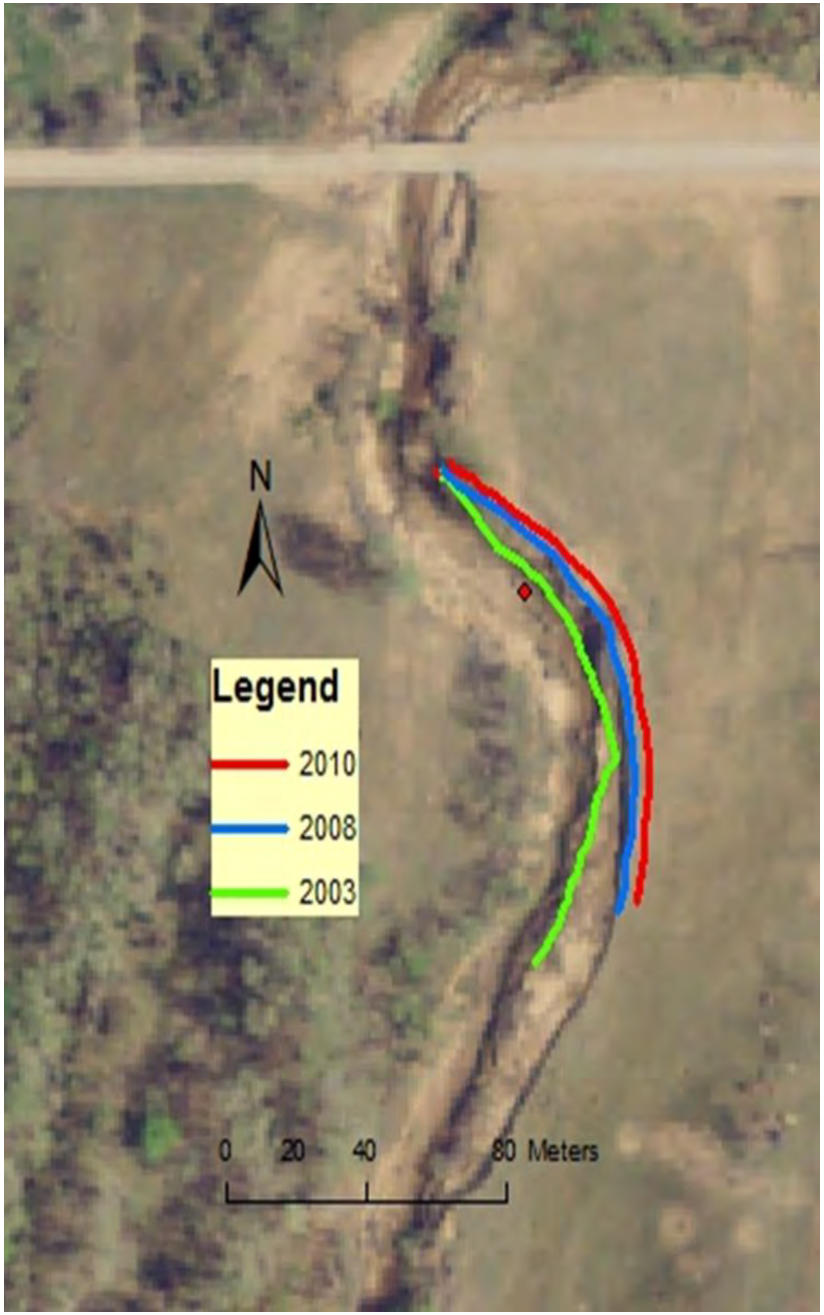
Downstream of a Headcut



Quantifying Retreat Rates







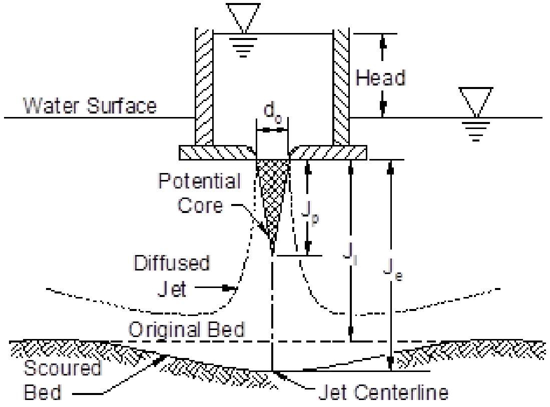
Quantifying Erodibility

- Estimate streambed and streambank erosion/failure resistance using JETs and BSTs
  - Excess shear stress equation - commonly used to model the erosion rate of cohesive soils:
    - Critical shear stress (τ_c)
    - Erodibility coefficient (k_d)

$$e_r = k_d(\tau - \tau_c)^a$$
$$a = 1$$

Quantifying Erodibility - Original JET (Hanson, 1990)

Streambed



Streambank

Laboratory

Quantifying Erodibility - Mini-JET

- A new miniature version of the JET device (Simon et al., 2010; Al-Madhhachi et al., 2013)

- Smaller, lighter, requires less water
- Easy to handle in the field as well as in laboratory

Automated Spreadsheet

- Similar in structure to the original JET spreadsheet
- Blaisdell, iterative, and scour depth solutions
- “Data Input Sheet”

JET Data Input

Site:	Site 1
Date:	11/11/2011
Test #:	1
JET #:	2
Operator:	ED
Test Location:	Barren Fork

Pt Gage Reading at Nozzle (mm):	4
Ref. Pt Gage Reading at Nozzle (ft):	0.9869
Nozzle Diameter (in):	0.125
Nozzle Height (ft):	0.1542

Initial guess* for τ_c (Pa):	1
Initial guess* for k_d ($cm^3/N \cdot s$):	1

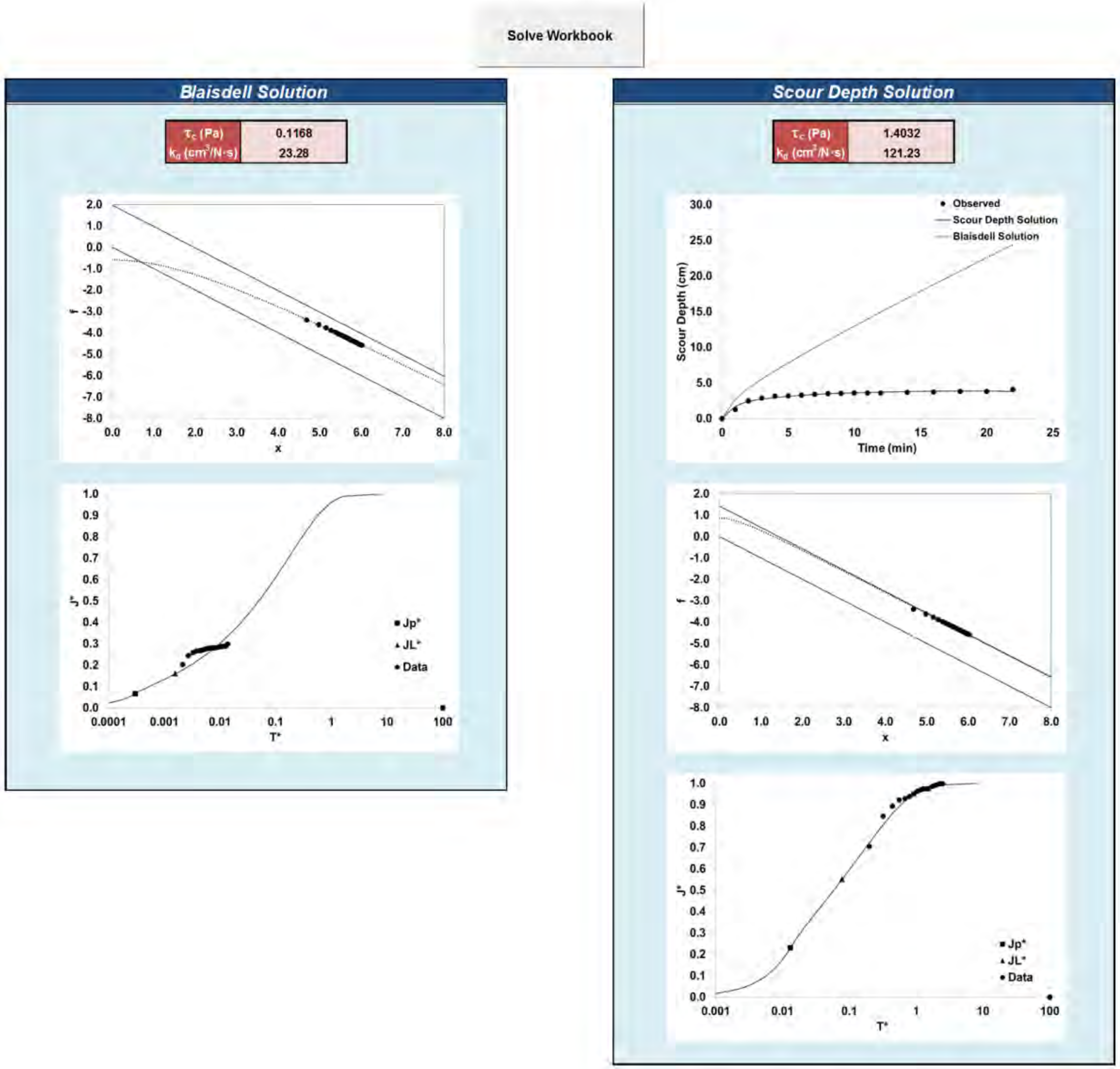
* If you do not have a guess, please enter 1.	
Suggested values of k_d as a function of τ_c:	
Hanson and Simon (2001)	
$k_d = 0.2\tau_c^{-0.5}$	$k_d = 0.2$
Simon et al. (2011)	
$k_d = 1.6\tau_c^{-0.83}$	$k_d = 1.6$
BSTEM, v5.4	
$k_d = 0.1\tau_c^{-0.5}$	$k_d = 0.1$

Scour Depth Readings					
Time (min)	*Diff Time (min)*	*Depth (mm)*	*Depth (ft)*	*Pt Gage Reading (ft)*	*Maximum Depth of Scour (ft)*
0	0	51	0.167	0.833	0.000
1	1	64	0.210	0.790	0.043
2	1	76	0.249	0.751	0.082
3	1	80	0.262	0.738	0.095
4	1	83	0.271	0.729	0.103
5	1	83	0.272	0.728	0.105
6	1	84	0.276	0.724	0.108
7	1	85	0.279	0.721	0.112
8	1	86	0.282	0.718	0.115
9	1	87	0.284	0.716	0.116
10	1	87	0.285	0.715	0.118
11	1	87	0.285	0.715	0.118
12	1	87	0.285	0.715	0.118
14	2	88	0.289	0.711	0.121
16	2	89	0.290	0.710	0.123
18	2	89	0.292	0.708	0.125
20	2	89	0.292	0.708	0.125
22	2	92	0.302	0.698	0.135

Head Setting	
Time (min)	*Head (in)*
0	22.5
1	22.5
2	22.5
3	22.5
4	22.5
5	22.5
6	22.5
7	22.5
8	22.5
9	22.5
10	22.5
11	22.5
12	22.5
14	22.5
16	22.5
18	22.5
20	22.5
22	22.5

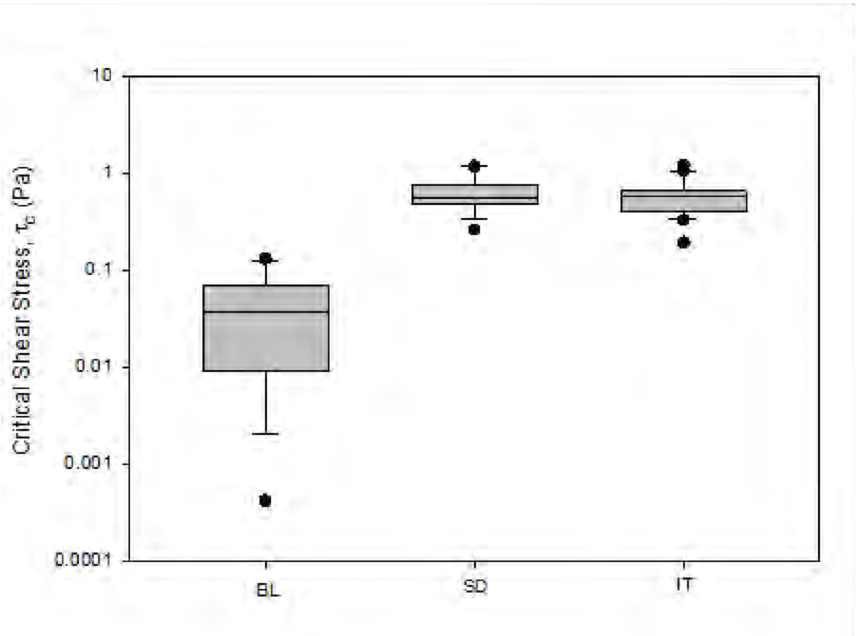
Automated Spreadsheet

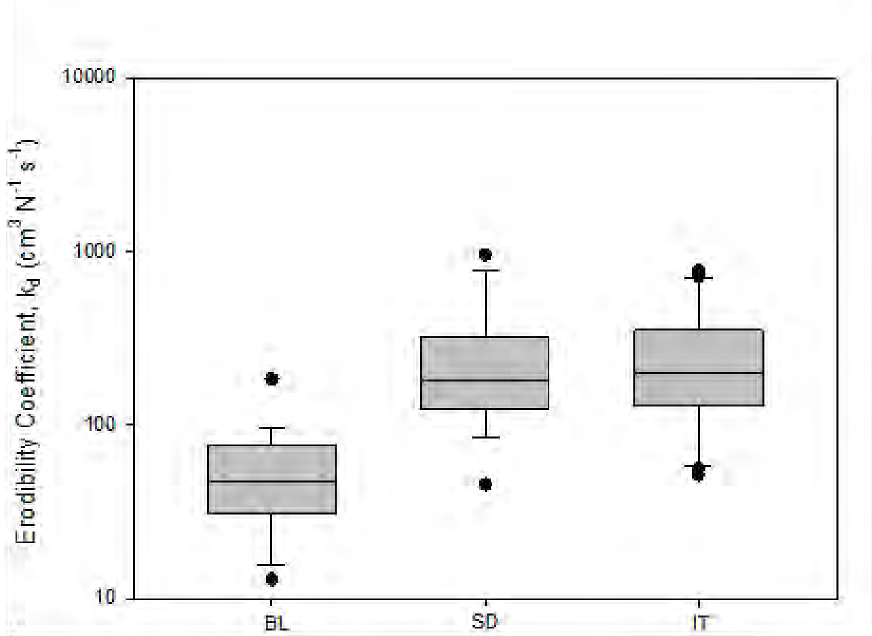
- “Solve” Sheet:



Variability in Erodibility Parameters

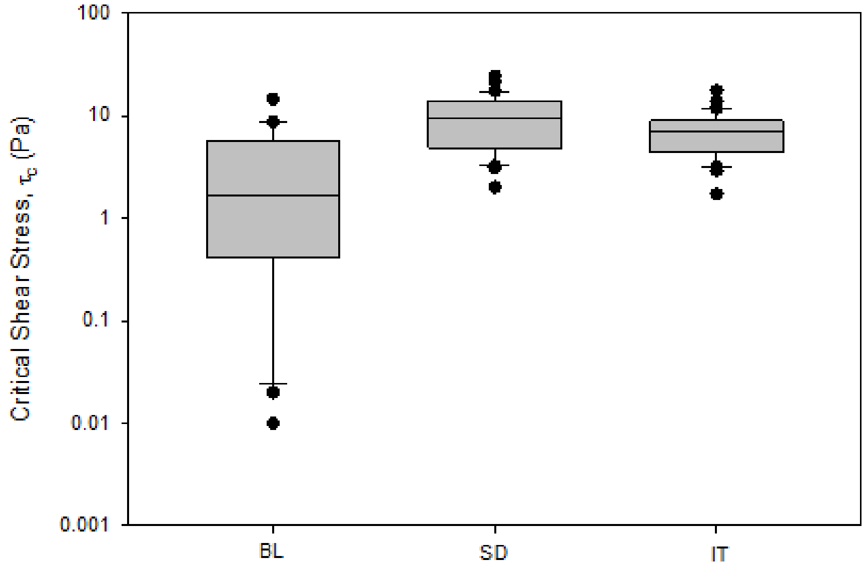
Sand Layer

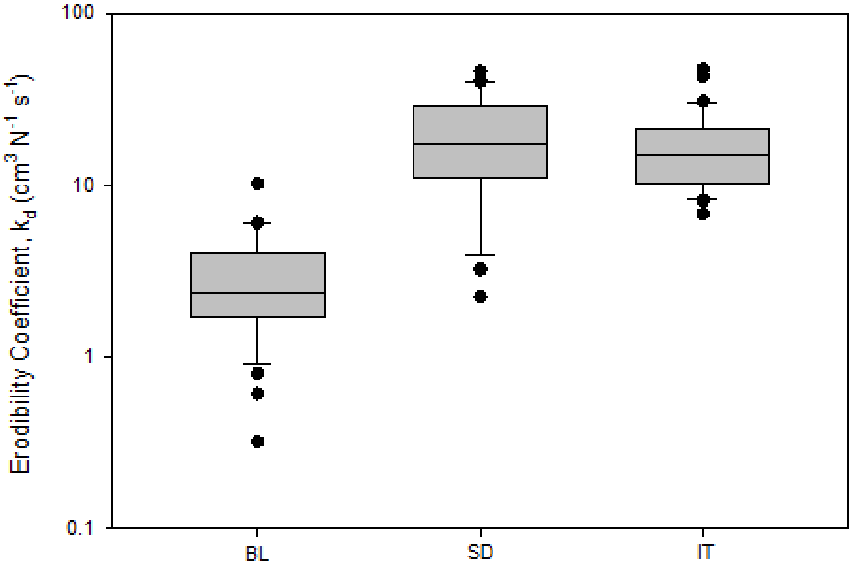




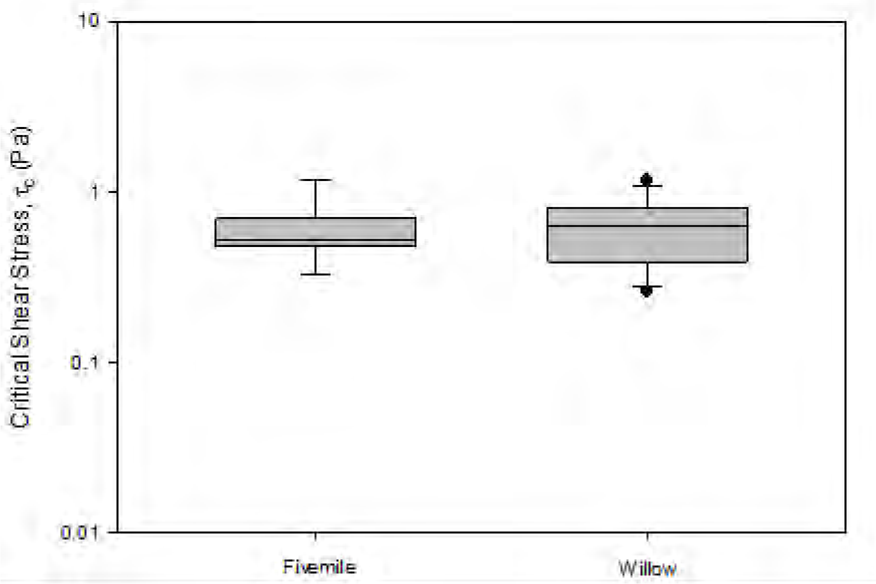
Variability in Erodibility Parameters

Clay Layer

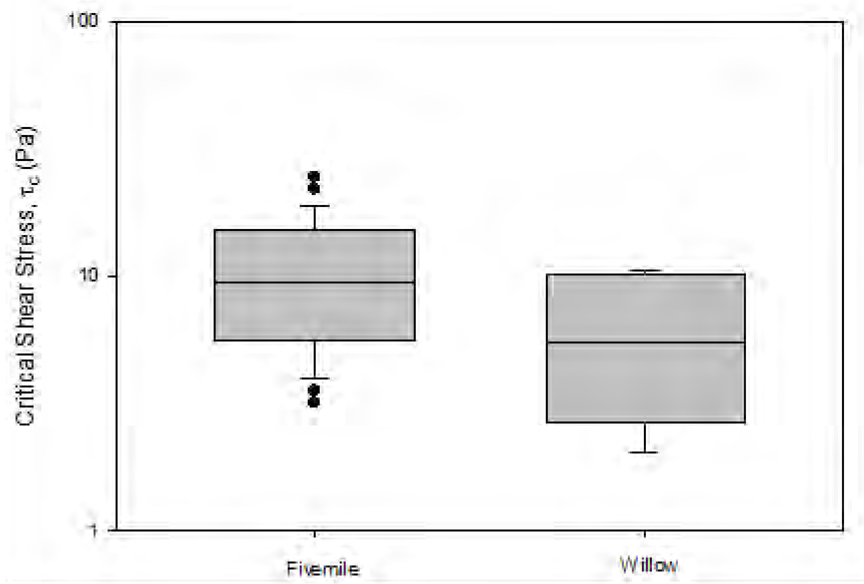




Variability in Erodibility Parameters



Sand Layer

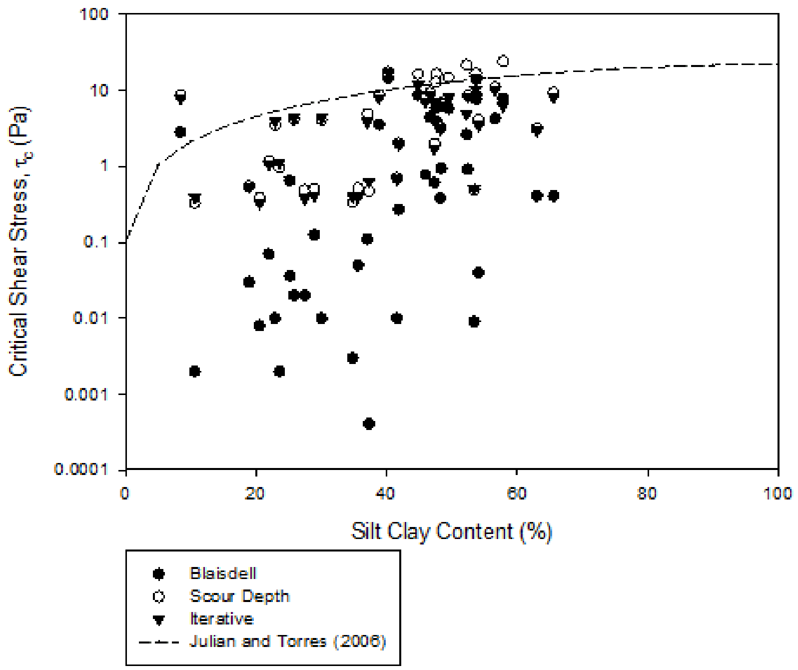


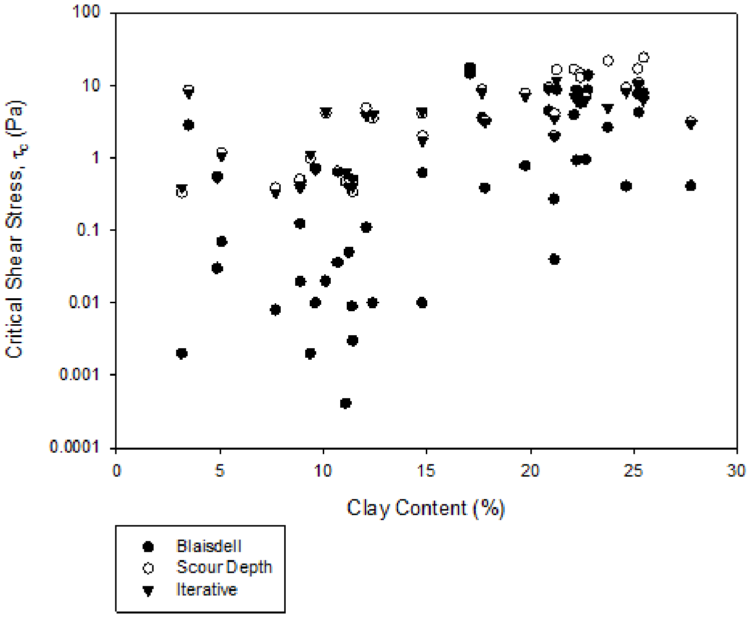
Clay Layer

Erodibility Must be Measured In Situ

- Empirical equations based on soil physical properties:

$$\tau_c = 0.1 + 0.1779(SC\%) + 0.0028(SC\%)^2 - 2.3 * 10^{-5}(SC\%)^3$$

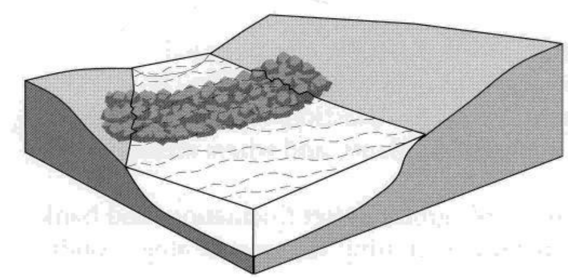




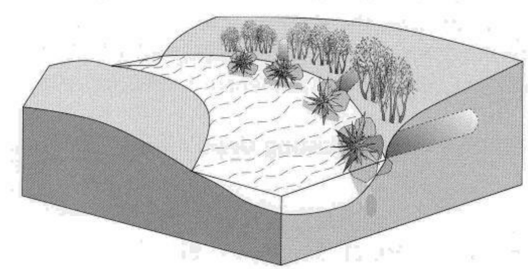
Future Work

- Water level and erosion rates monitored over the course of the next two years
- Cross-sectional surveys repeated periodically
- BSTEM and CONCEPTS models to estimate long term erosion rates and the impact of various stabilization techniques
  - Upland conservation practices using SWAT
  - Apply climate change scenarios to consider the impact of potential future climates
  - In-stream and streambank practices (grade stabilization structures, riparian vegetation, toe protection, bank sloping)

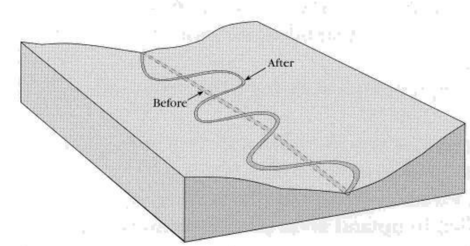
Grade Control Measures



Log, Rootwad, and Boulder Revetments



Stream Meander Restoration



Questions?