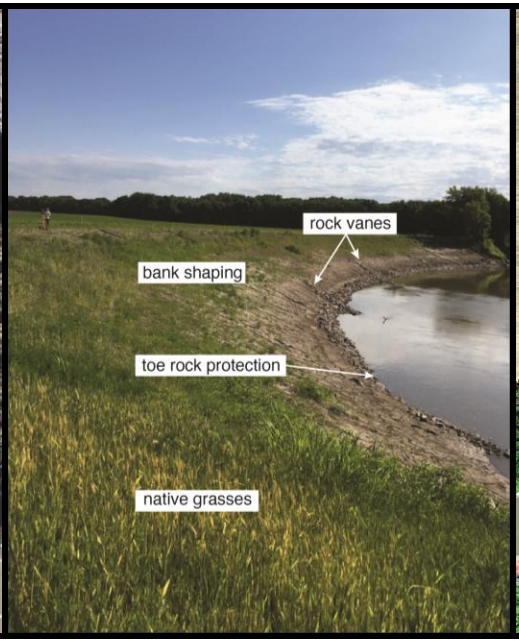
HOW EFFECTIVE ARE STREAMBANK STABILIZATION PROJECTS?



Tony Layzell, Kansas Geological Survey

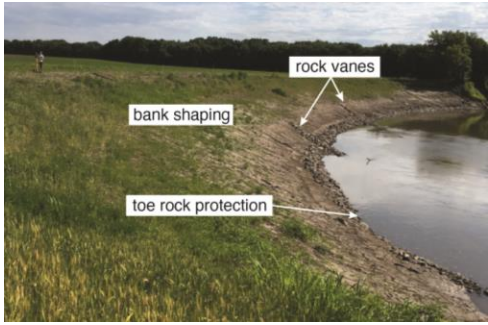
Stream restoration

- Stream restoration projects typically include components such as **streambank stabilization**, alteration of both flow regimes and sediment supply, floodplain reconnection, adjustments to channel morphology, riparian zone management, and in-stream habitat improvement.

- Variety of scales (i.e., site-specific, reach, and basin scale), most projects are small scale and **executed without an overarching framework, including plans for long-term monitoring.**

- Resulted in a poor understanding of the effectiveness of different types of restoration methods in varying locations and over time.

Pierce, 2012

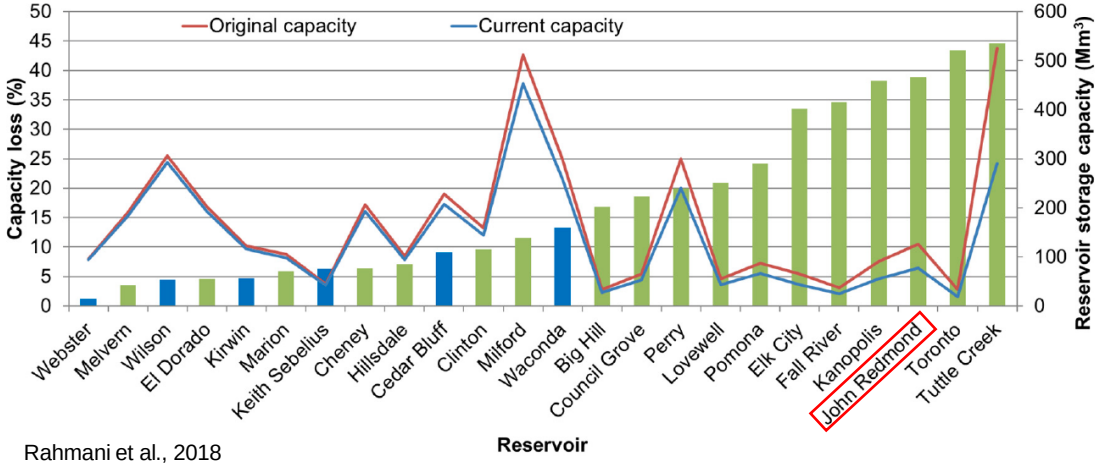


Layzell et al. 2022

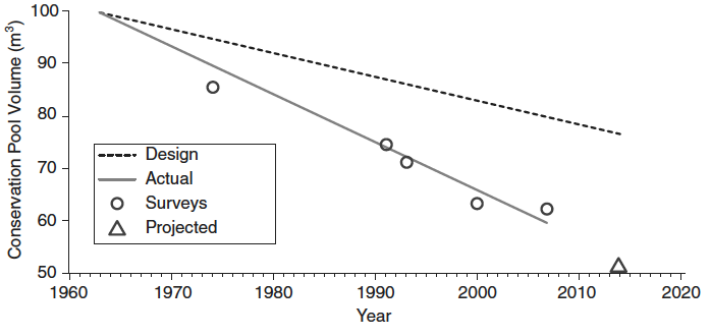
Wohl et al. 2015

The problem (in Kansas)

Reservoir sedimentation



Rahmani et al., 2018

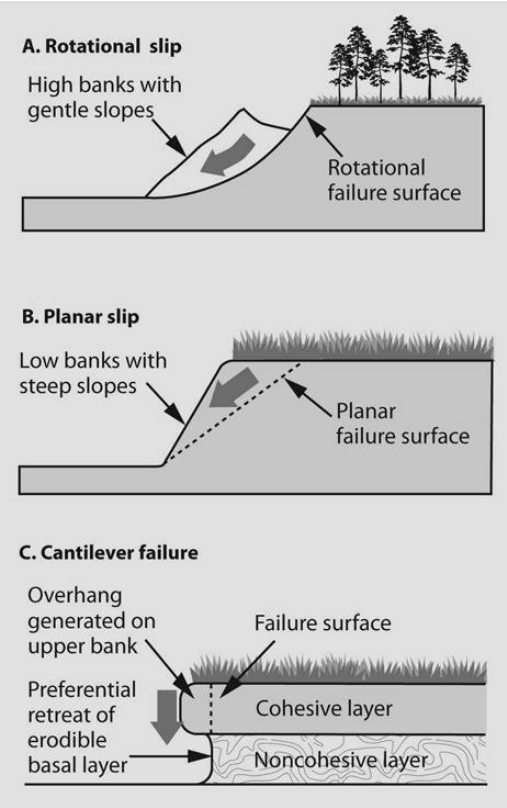


Podolak and Doyle, 2015

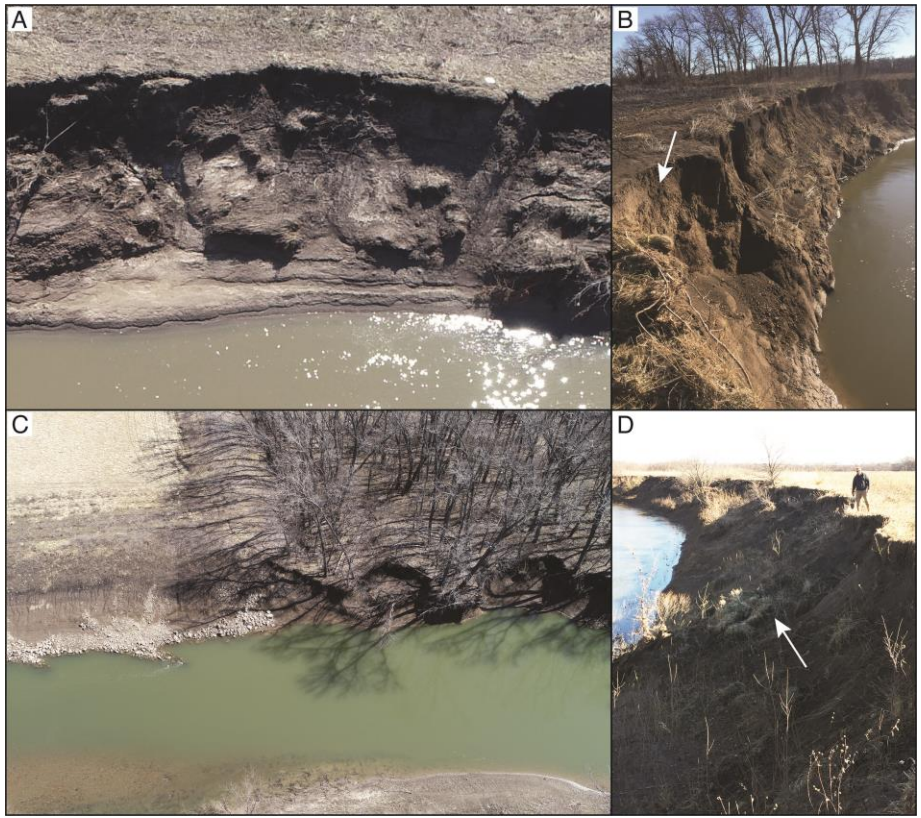
- $20 million dredging operation in 2016
- 2.3 million m^3 removed

The problem

Where does the sediment come from?



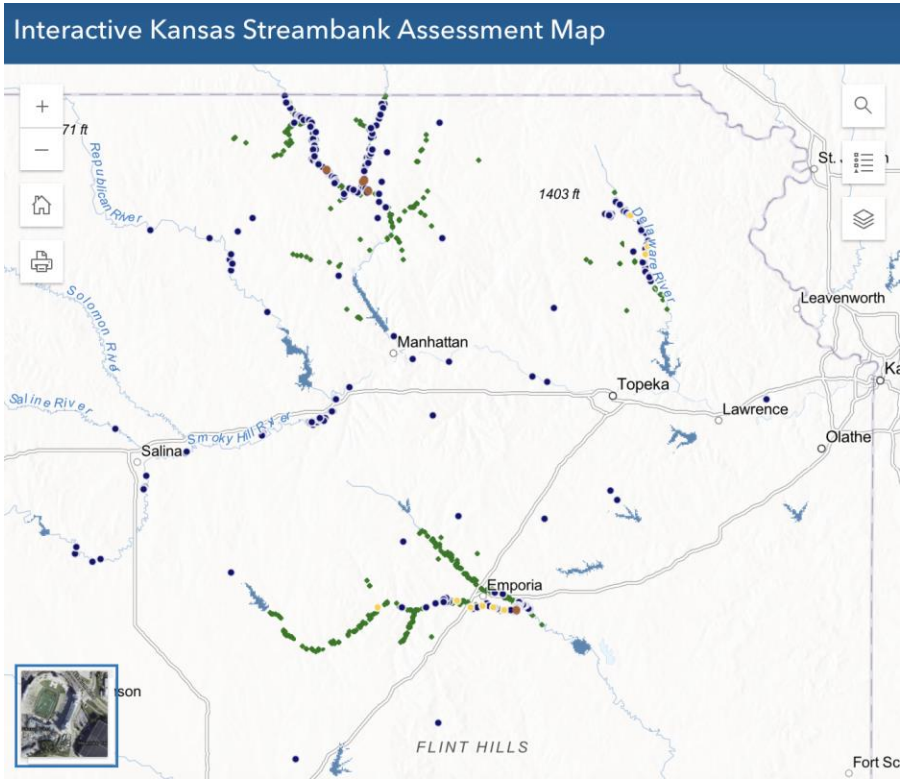
Thorne, 1978

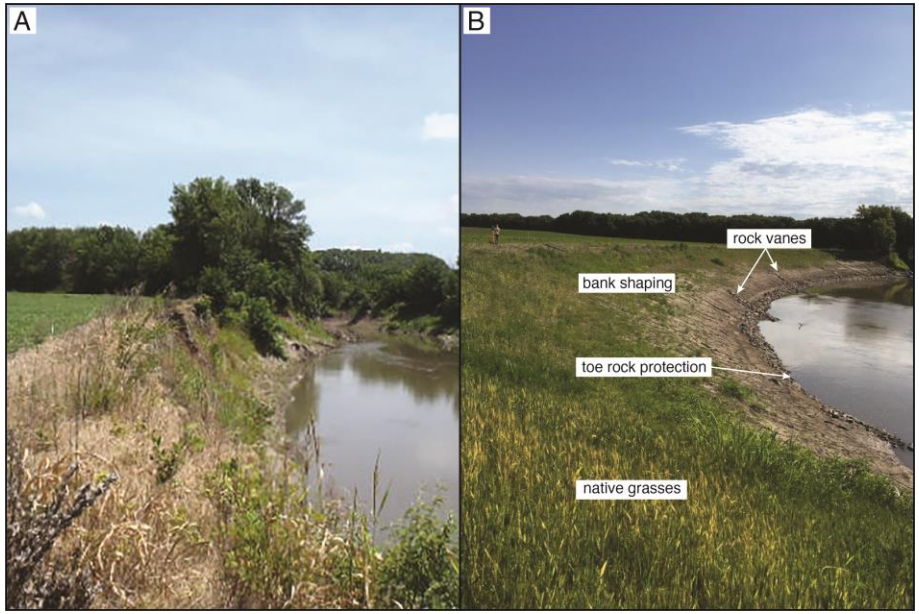


Layzell et al., 2022

The solution (?)

Streambank stabilization (upstream)

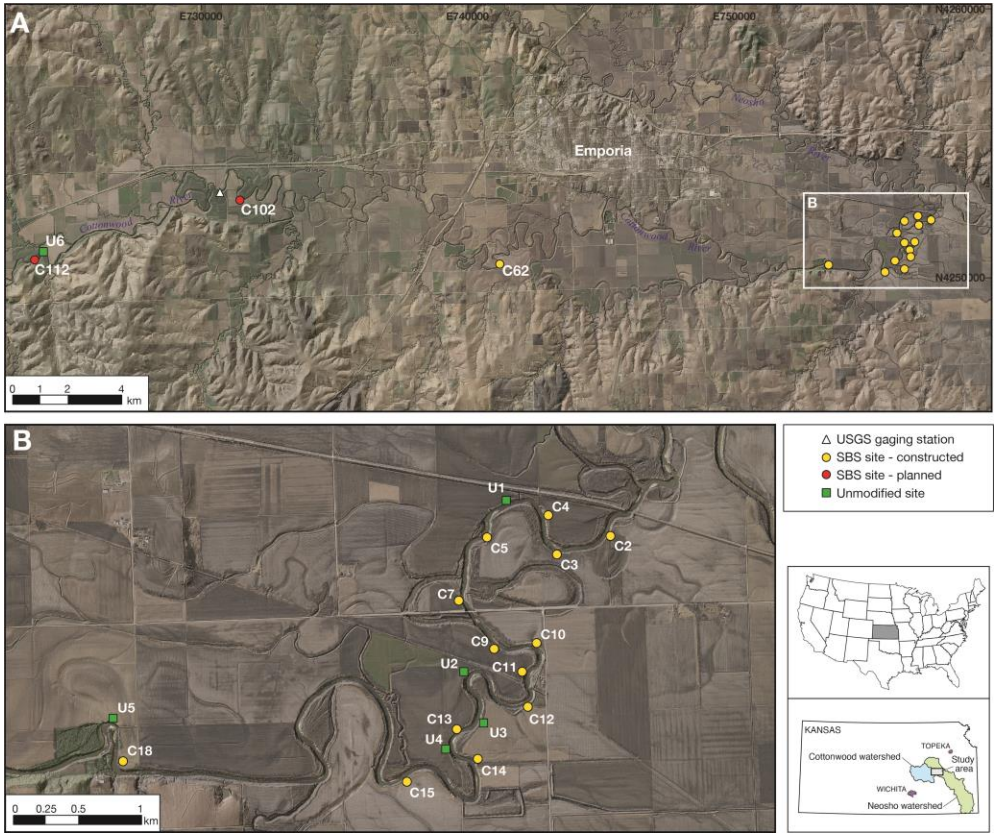




Do these stabilization efforts work?
A question of scale

Site-specific scale

Cottonwood River

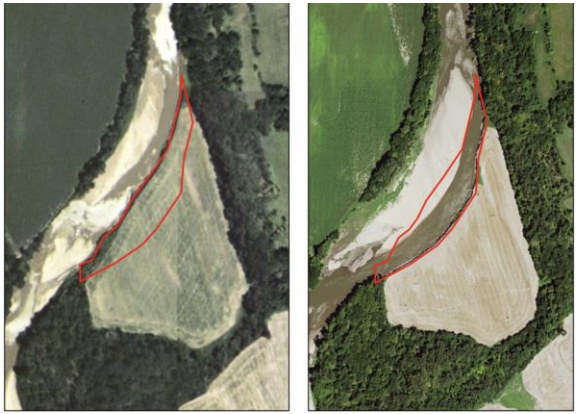


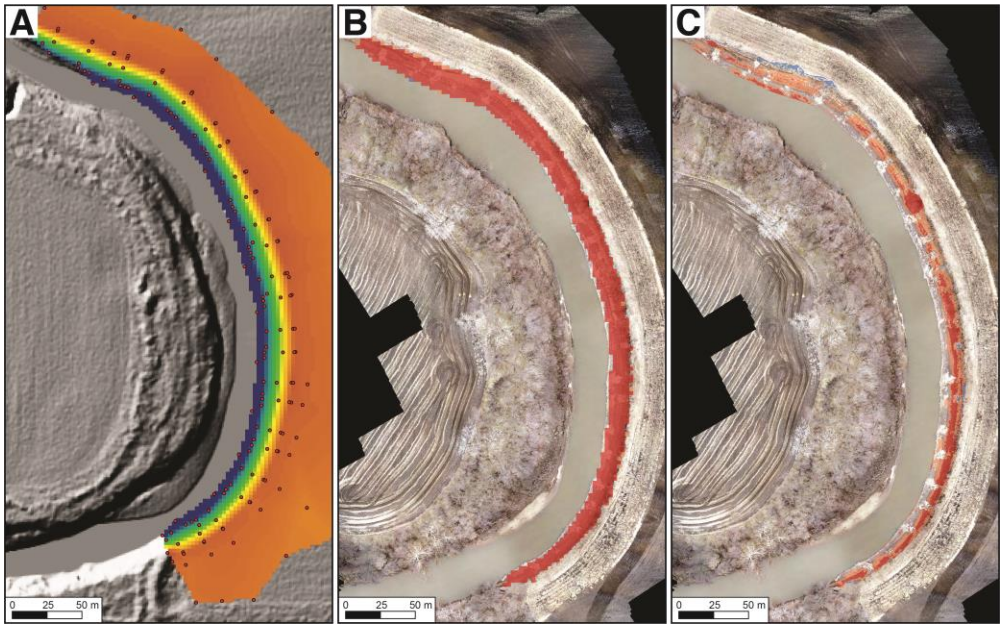
Methods

- Multiple UAS flight surveys over three separate campaigns (2019, 2020, 2021).
  - DJI Phantom 4 Pro platform.

- Calculating the volume of material eroded at each SBS site:

(1) A historical assessment of bank erosion prior to SBS construction (1992-*2015*).
(2) Erosion between the construction date and the first UAS flight survey (*2015*-2019).
(3) Erosion between subsequent repeat UAS flight surveys (2019-2021)

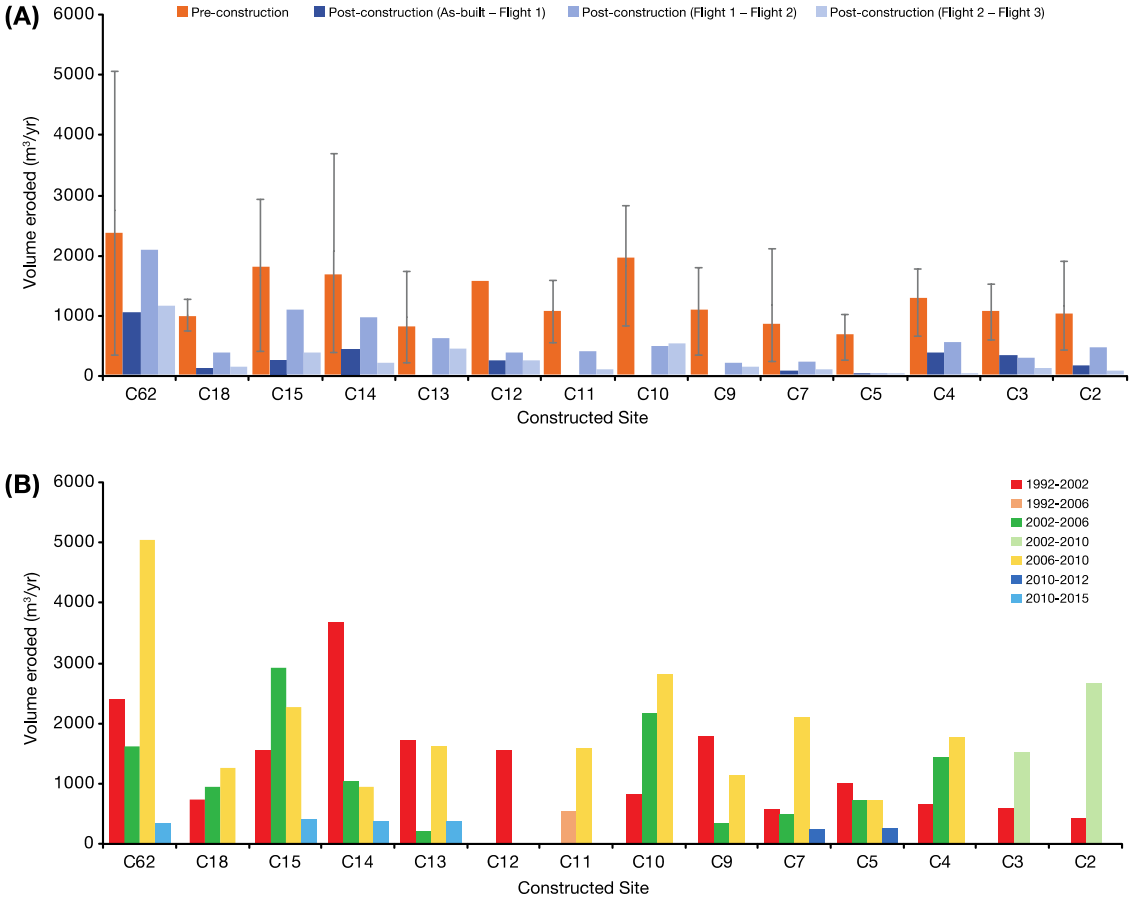




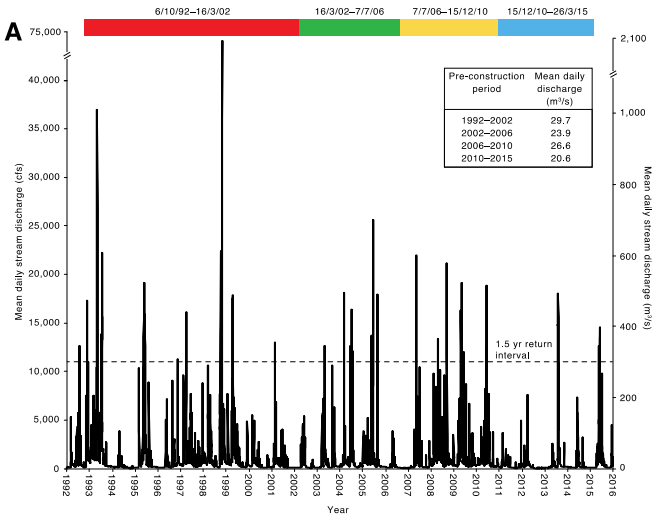
Results

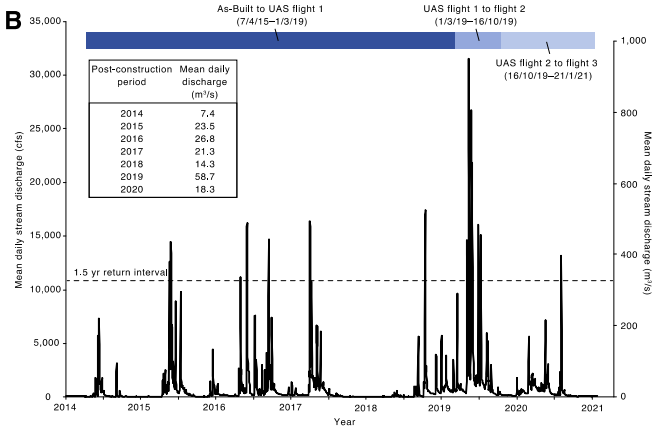
- Post-construction erosion rates are consistently lower than pre-construction values, indicating that SBS projects have successfully reduced erosion locally at each SBS site.

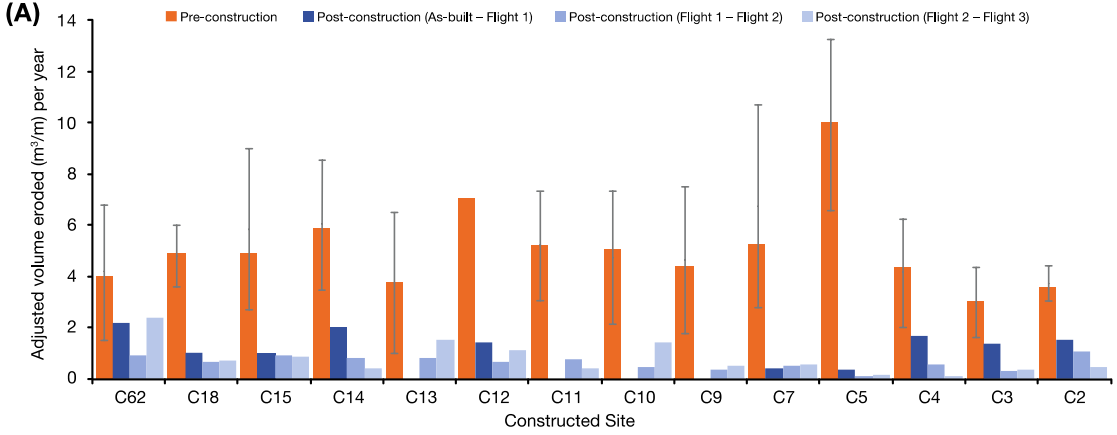
- The observed variability in both pre- and post-construction erosion rates at each site is likely related to differences in stream discharge between survey periods.

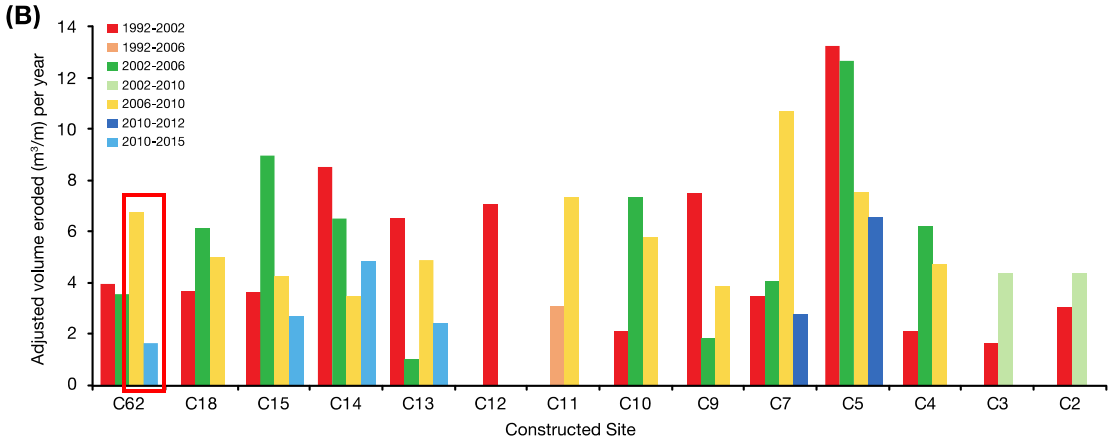


62-94% decrease in sediment yield on average

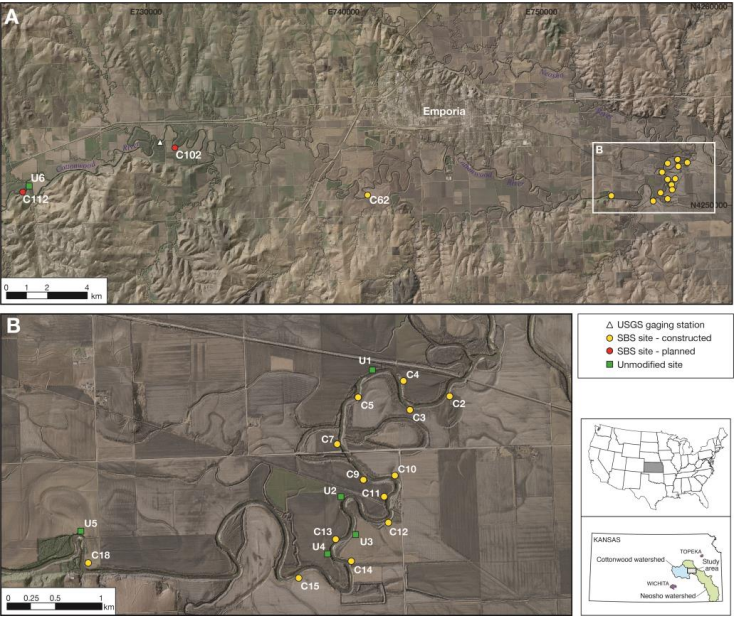


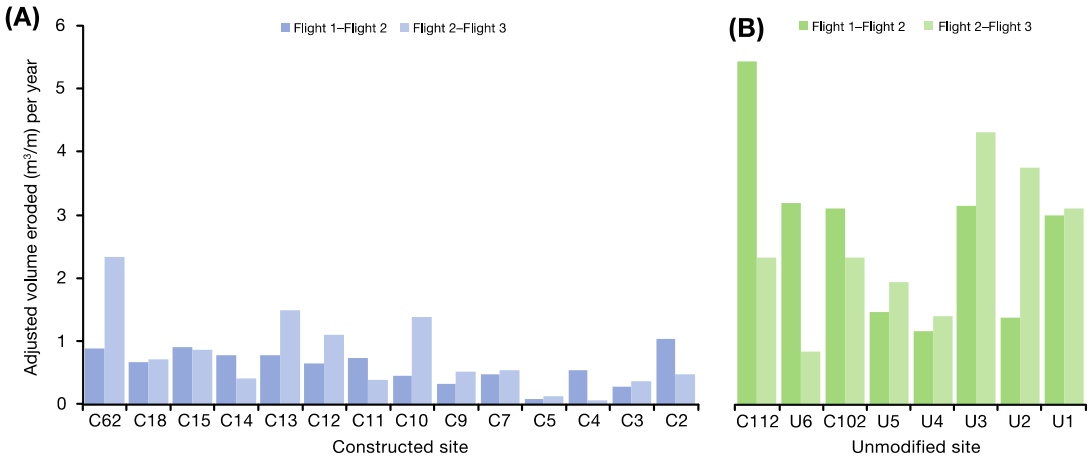






Need accurate and representative baseline data





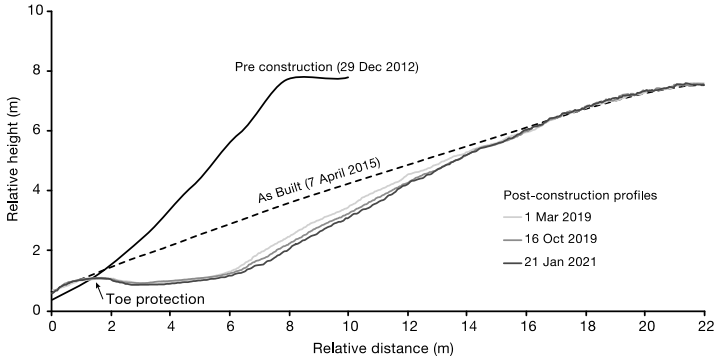
Average = 0.6 m^3/m Flight 1-2
Average = 0.8 m^3/m Flight 2-3

Average = 2.7 m^3/m Flight 1-2
Average = 2.5 m^3/m Flight 2-3

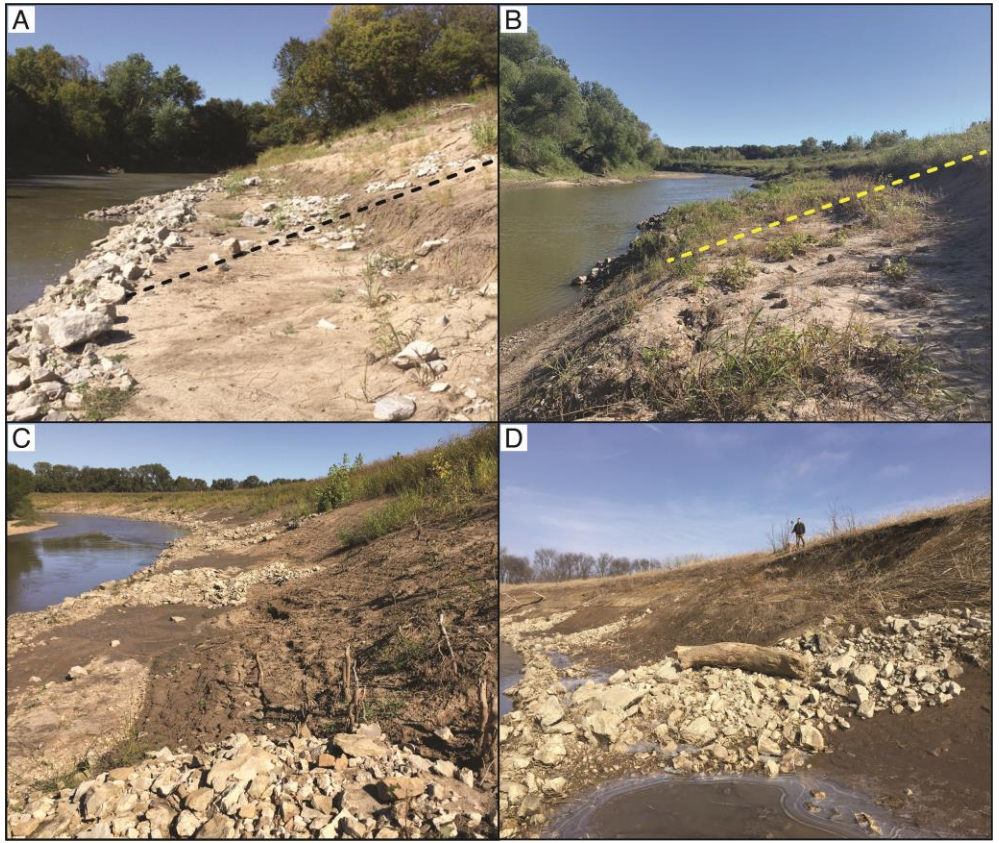
68-78% decrease in sediment yield on average

Post-construction erosion processes

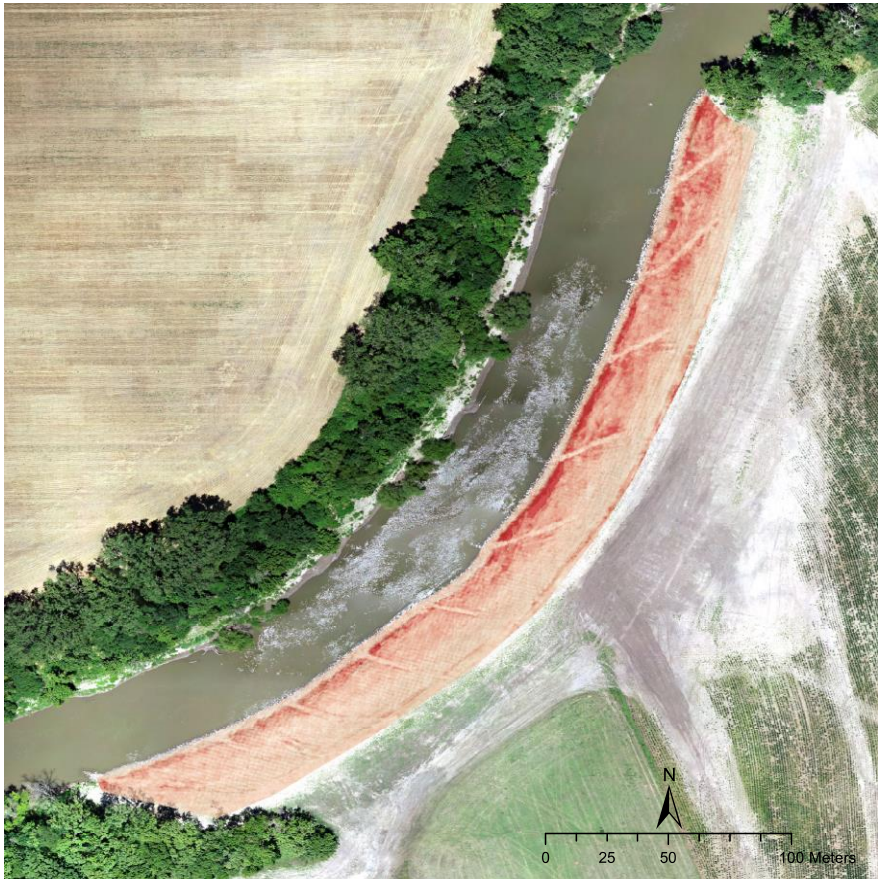
- Erosion of lower streambank
- Rotational failures



Up to 4.5 m lateral retreat, 1.8 m vertical erosion

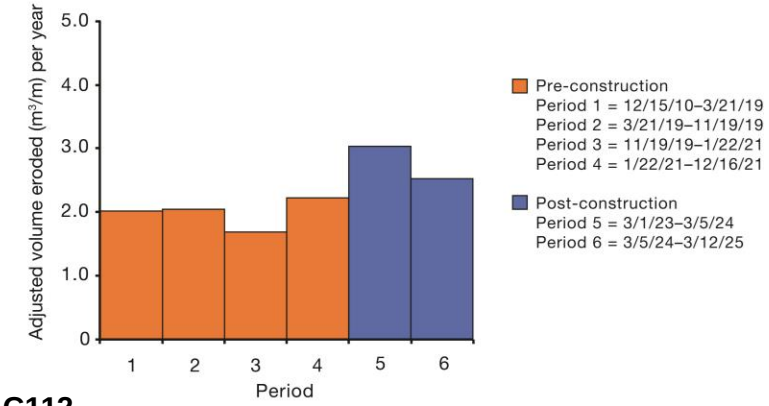


Layzell et al., 2024

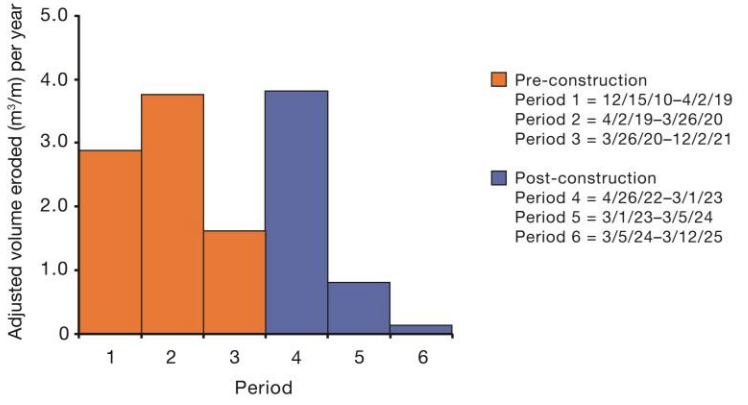


Timing of first flood event

C102



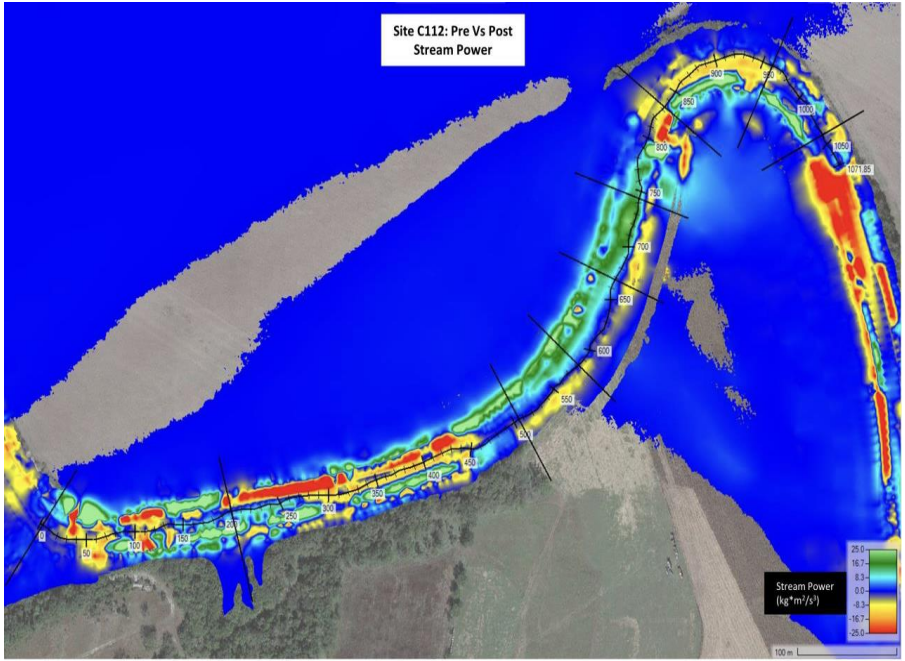
C112

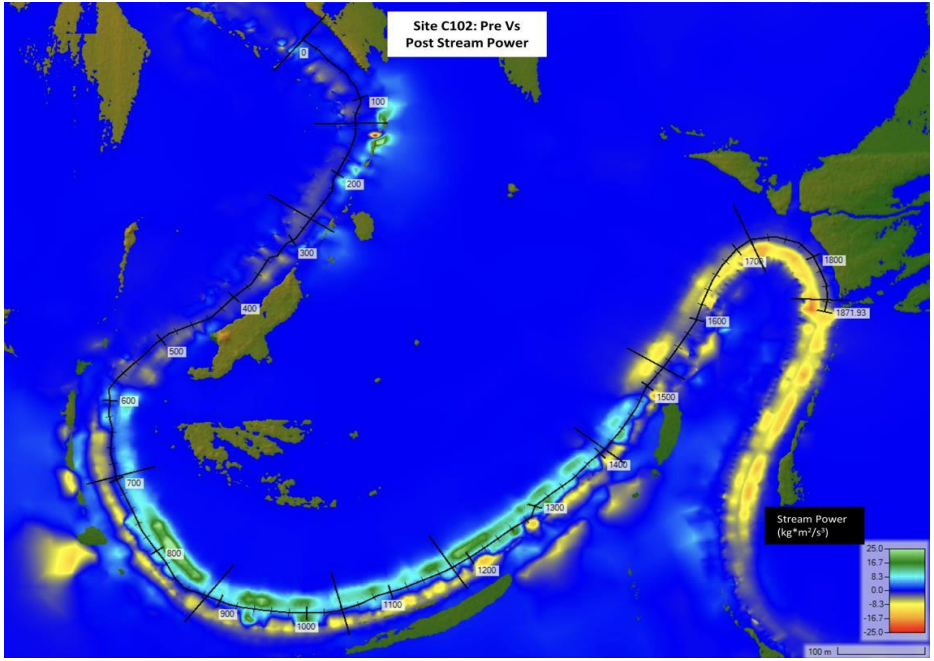


“Break in” period = 1-3 years

Reach scale

Trisha Moore, Kari Bigham, Corben Monzon

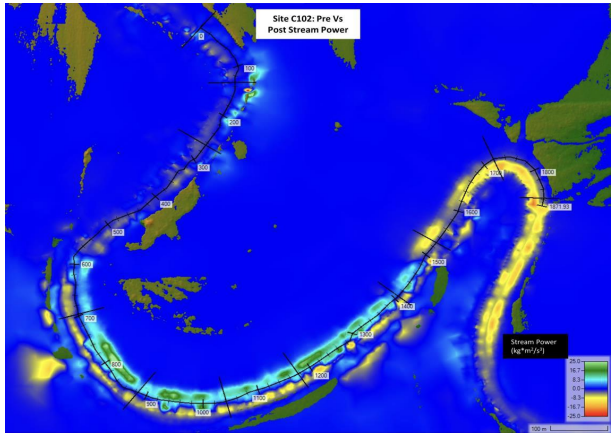


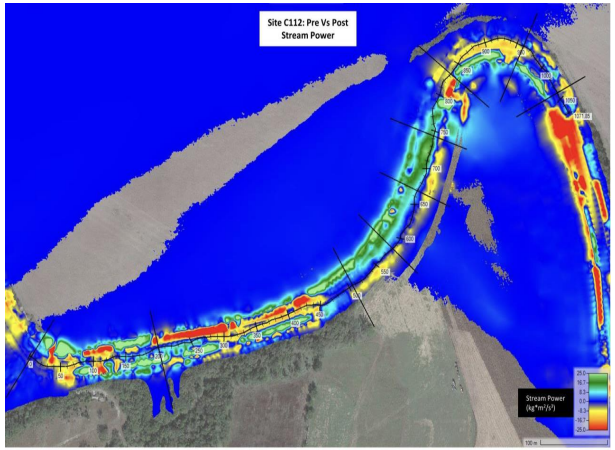


Monzon, 2024

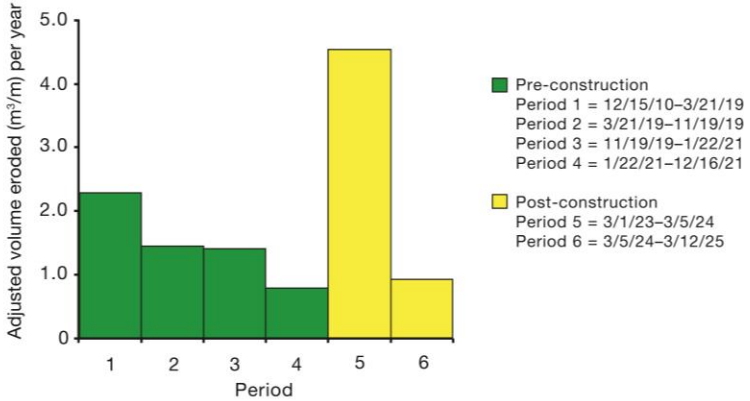
Reach scale

Temporary effect? = 1-2 years

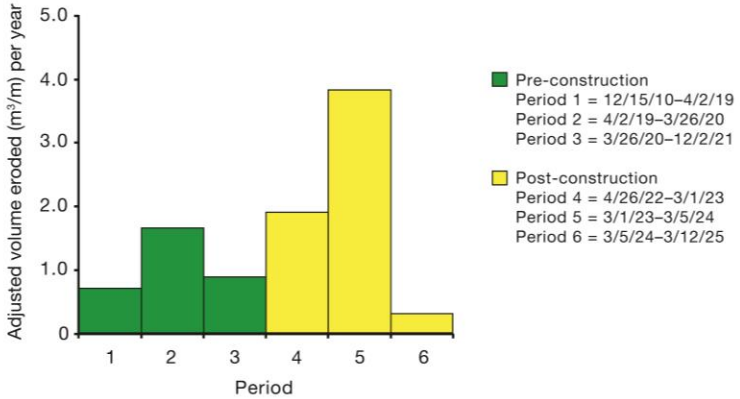




Downstream of C102

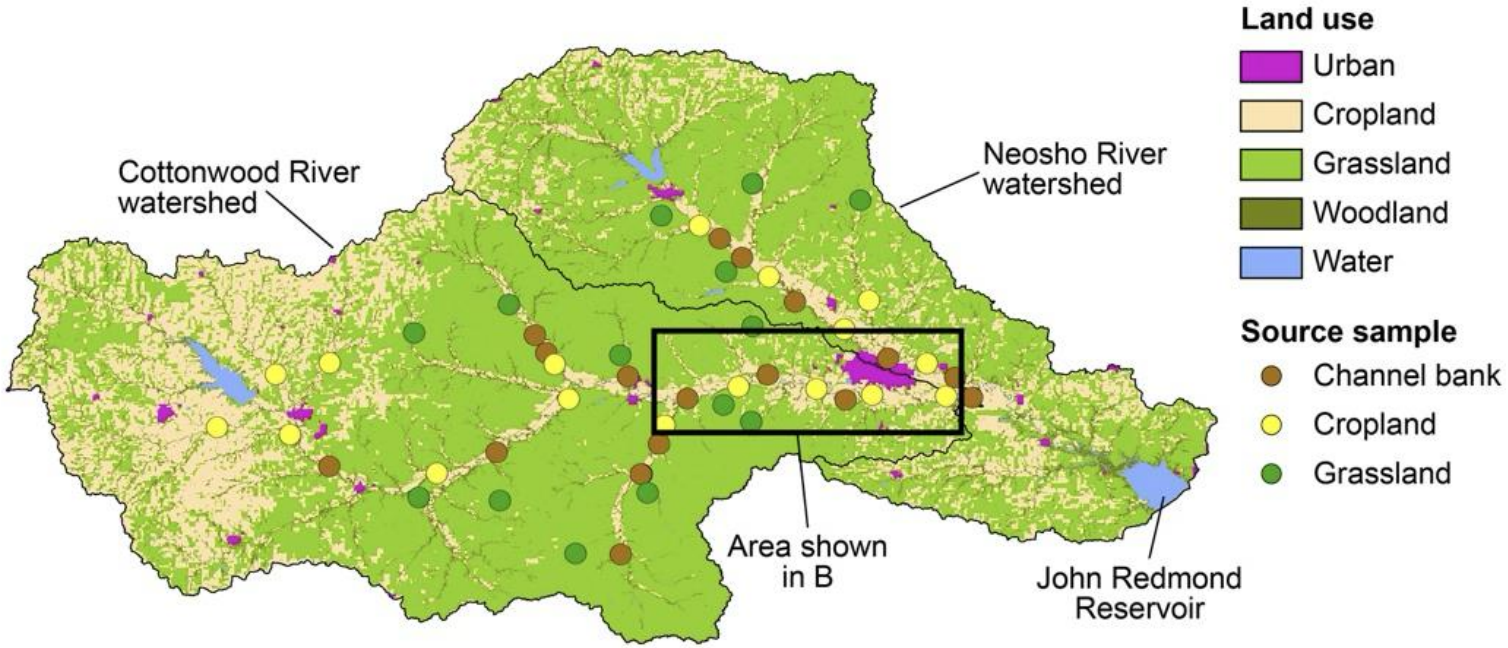


Downstream of C112



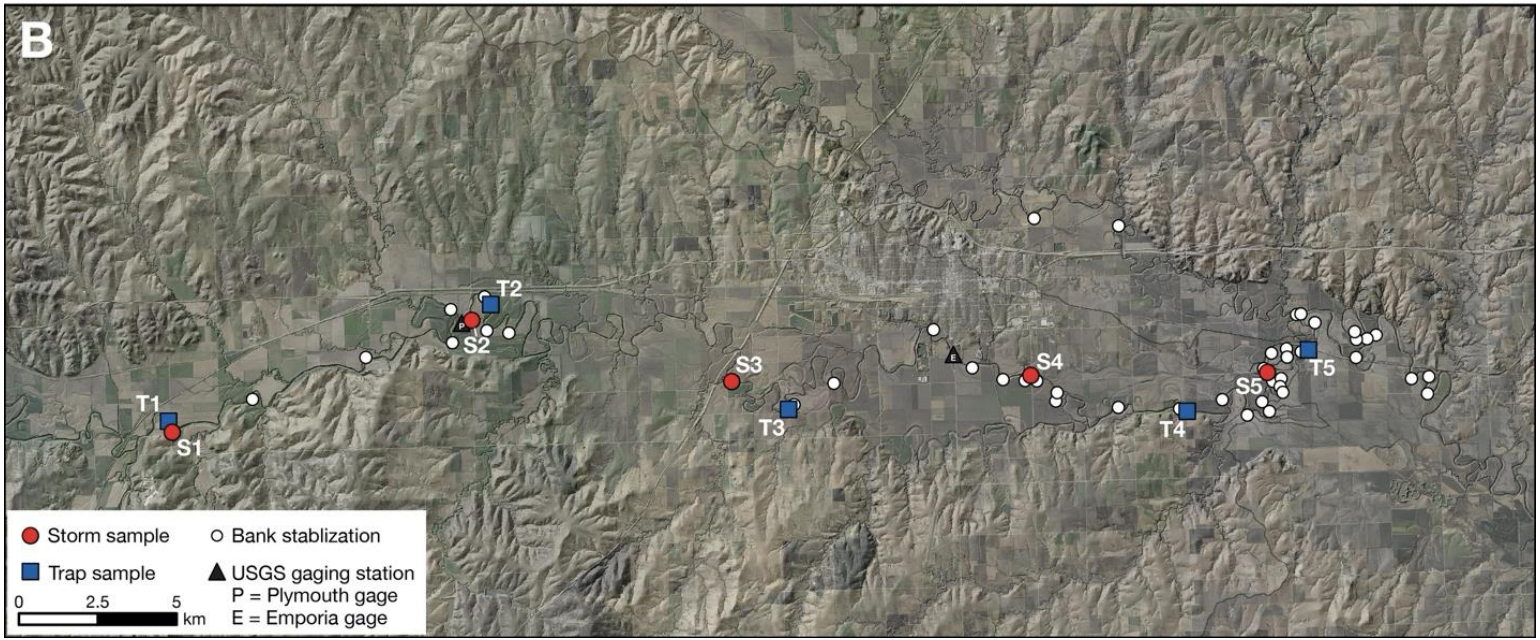
Watershed scale

- Where does the sediment in the Cottonwood River come from?
- Sediment fingerprinting - a modeling tool that can “unmix” a composite sediment sample into its constituent source fractions



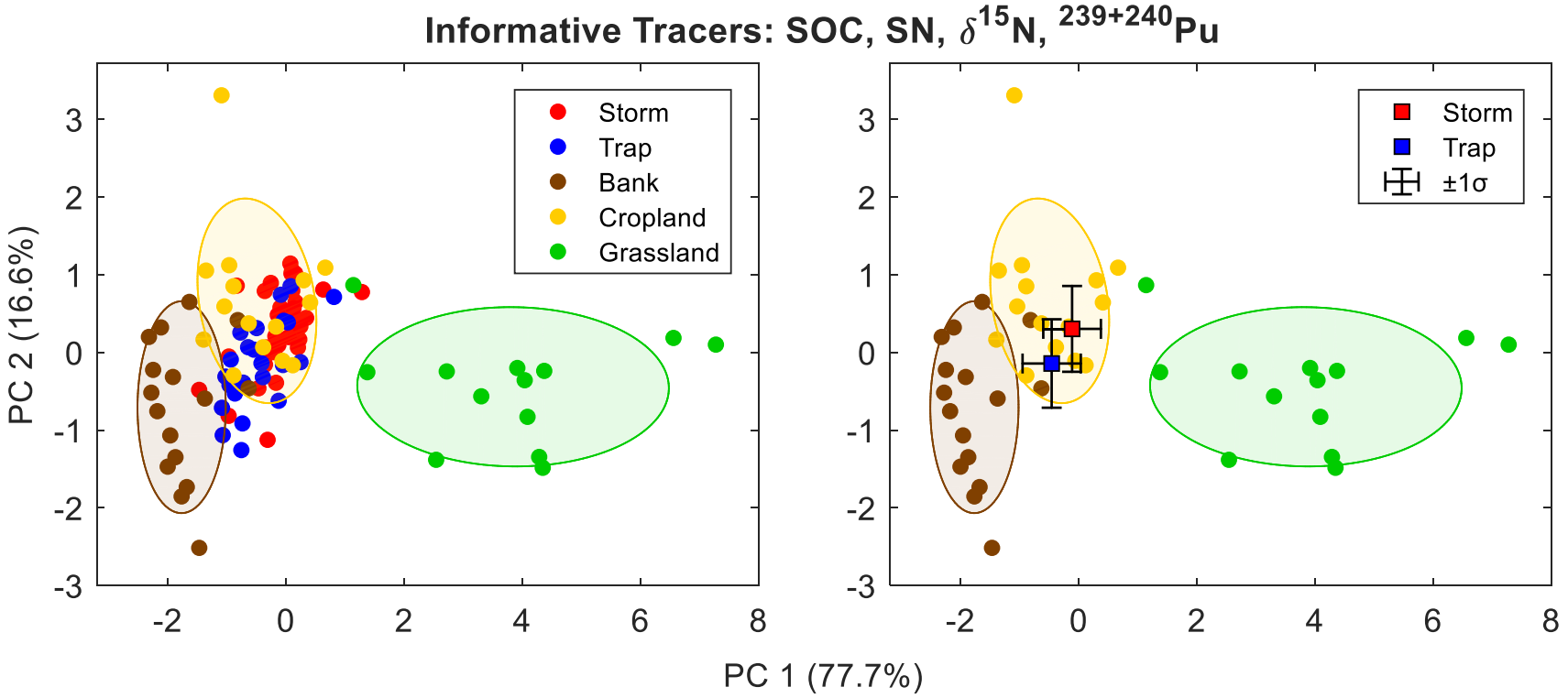
Watershed scale

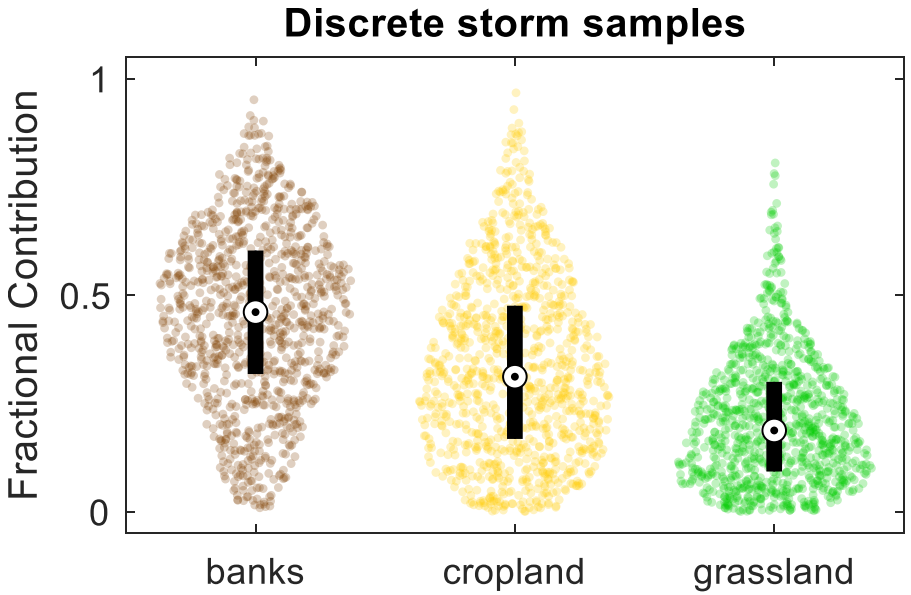
- Where does the sediment in the Cottonwood River come from?



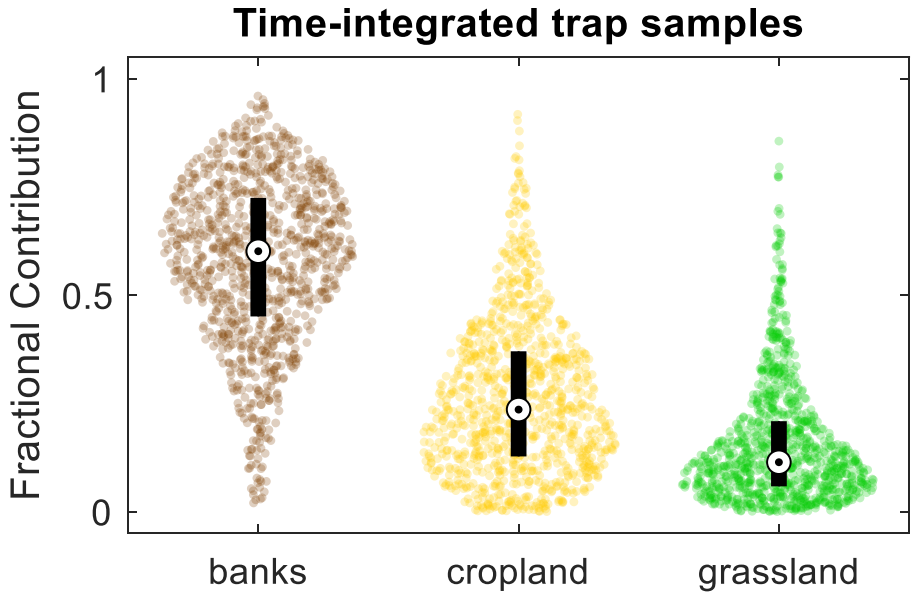
- Assess the utility of sediment fingerprinting to inform on the efficacy of streambank stabilization projects in reducing sediment loads at the watershed scale.


(A)
(B)


Informative Tracers: SOC, SN, δ15N, 239+240Pu
Storm
Trap
Bank
Cropland
Grassland
Storm
Trap
±1σ
PC 2 (16.6%)
PC 1 (77.7%)
3
2
1
0
-1
-2
-3
-2
0
2
4
6
8



45% mean bank fraction

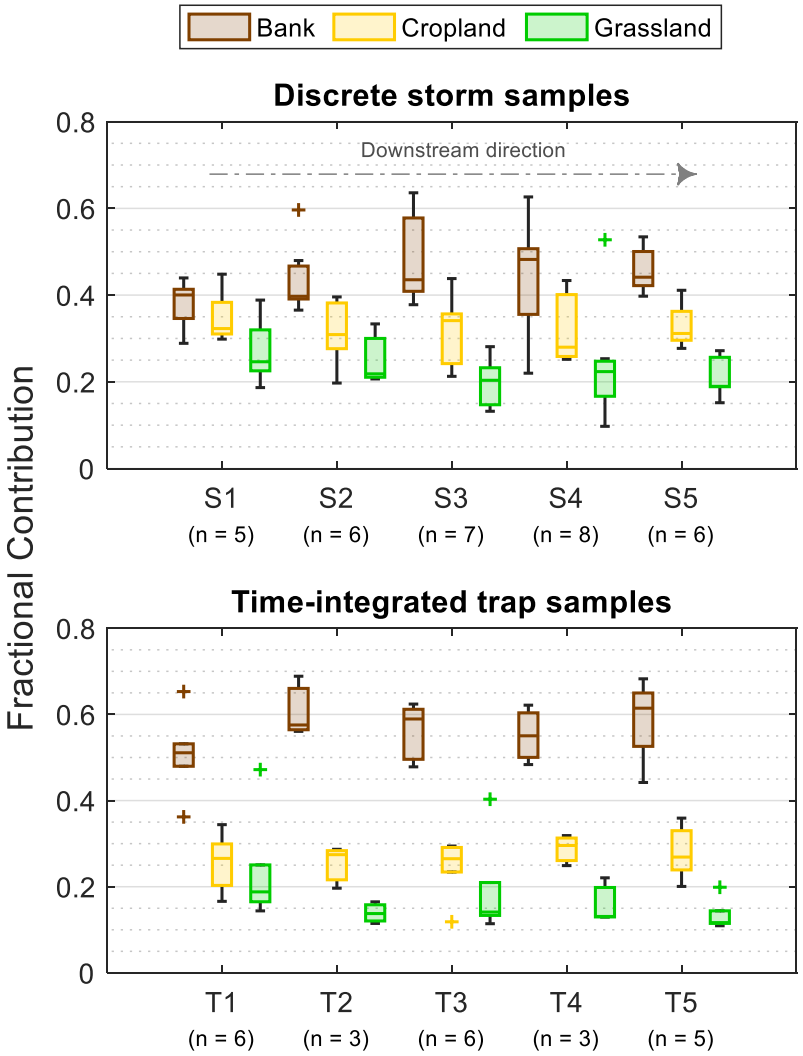


58% mean bank fraction

- Disproportionally large sediment loads occur during high-magnitude flood events.
- Targeted management should include not only streambank stabilization, but also practices aimed at reducing upland erosion, particularly cropland.

S1 = 38% ➡ **S5 = 46%**

T1 = 51% ➡ **T5 = 59%**



Increase in bank erosion along the study reach, despite the implementation of numerous stabilization projects.

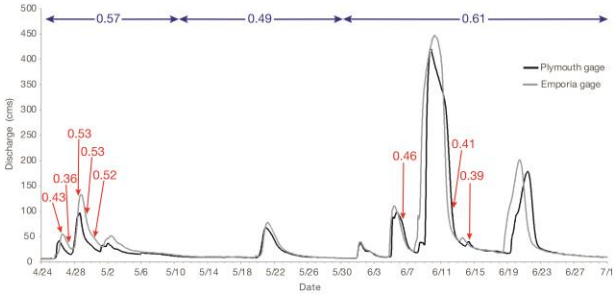
BUT no counterfactual scenario.

Highlights the importance of baseline data.

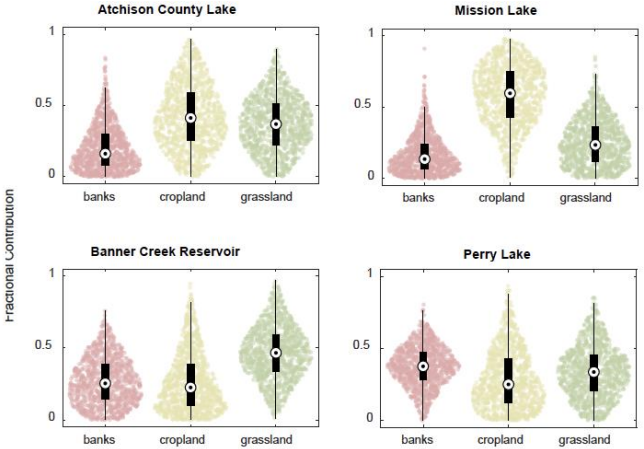
Ongoing & future work

John Redmond cores

Hydrograph



Perry Lake (2004-2024)

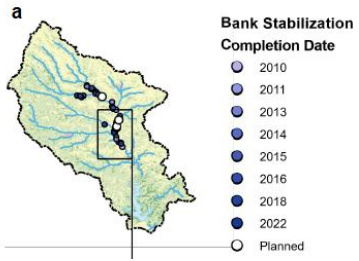


6/30 tracers statistically informative

- TN, TOC, TC, Sr, Ti, Cs-137

Sediment sourcing mainly function of land use

- Except Perry Lake – 38% channel banks



45/81 SBS projects completed

Conclusions

Site-specific scale

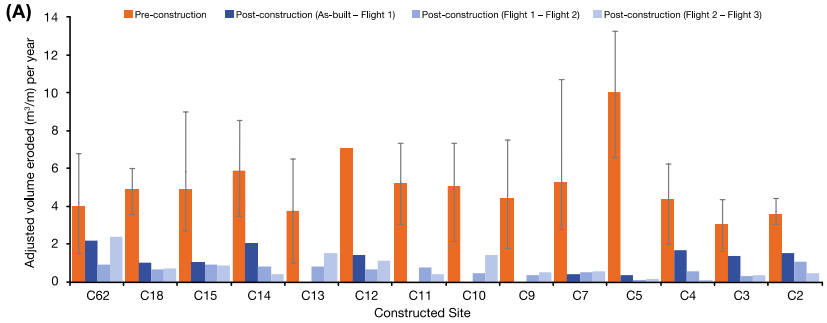
- SBS projects **appreciably reduced local-scale erosion at the stabilized sites** (62-94% reduction in sediment load).
- Need accurate and representative **baseline data**.
- Evidence of erosion of the lower bank above toe protection.
- Effectiveness is subject to a **“break-in” period** (1-3 years).

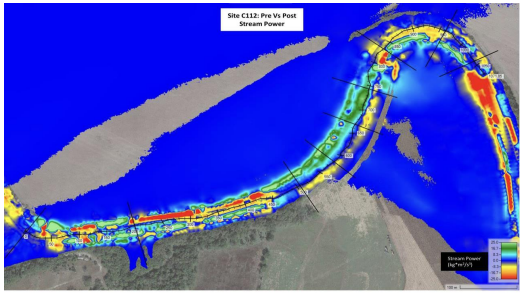
Reach scale

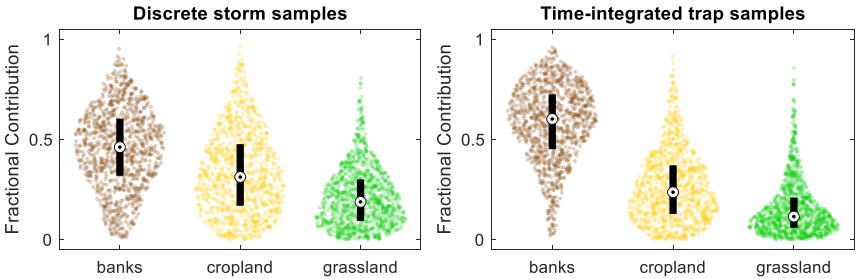
- HEC-RAS modeling indicates **increase stream power** at downstream meander bends.
- Model results confirmed in the field.
- Downstream meanders appear to adjust after 1-3 years.

Watershed scale

- Banks contribute **45% of sediment load** during storms
- Targeted management should also include practices aimed at reducing upland erosion.








Feb 2018 - Mar 2019
Mar 2019 - Nov 2019
Nov 2019 – Jan 2021
Jan 2021- Jan 2022
N
0
50
100
200 Meters

Clements Bridge