Stream bank erosion as a sediment source from the Piedmont region

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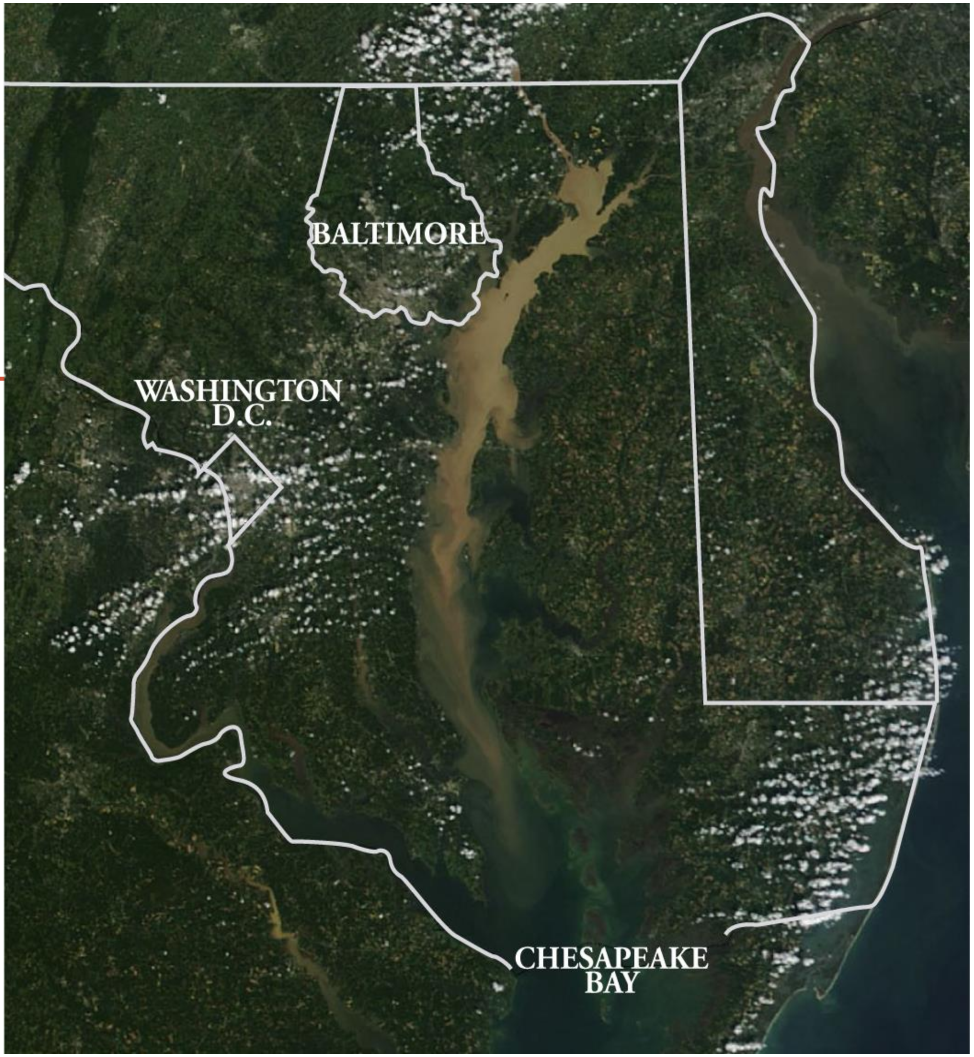

USGS science for a changing world

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Outline

- Part I- Baltimore County study

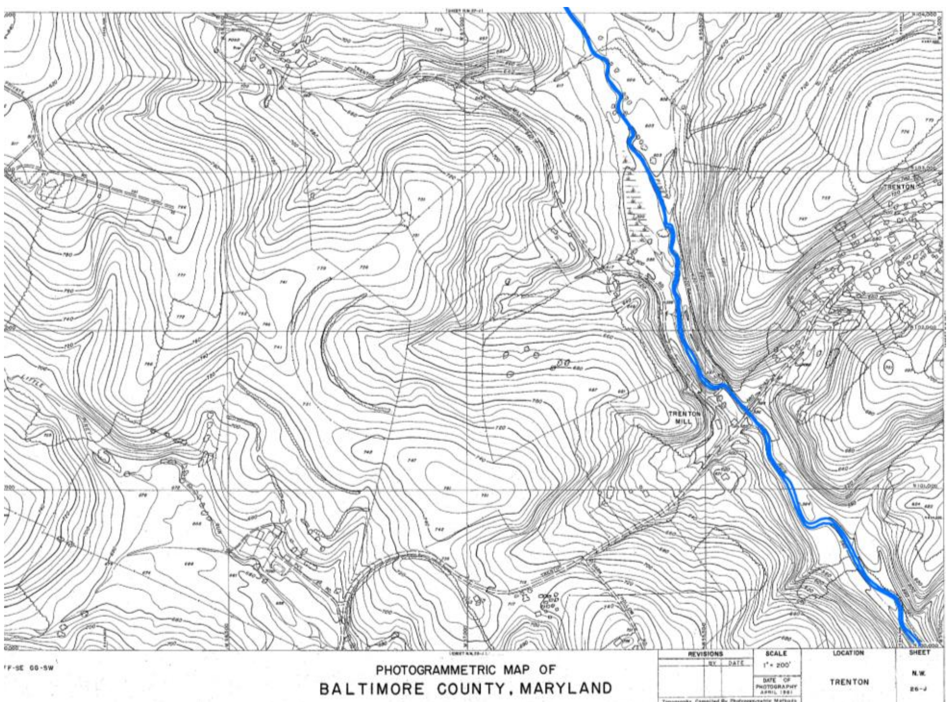
1. Methods/Approach
2. Research Questions
3. Results
    a. Mill dams
    b. Bank erosion rates
    c. Legacy sediment erosion
    d. Sediment yield & TMDL comparisons
4. Conclusions – Part I

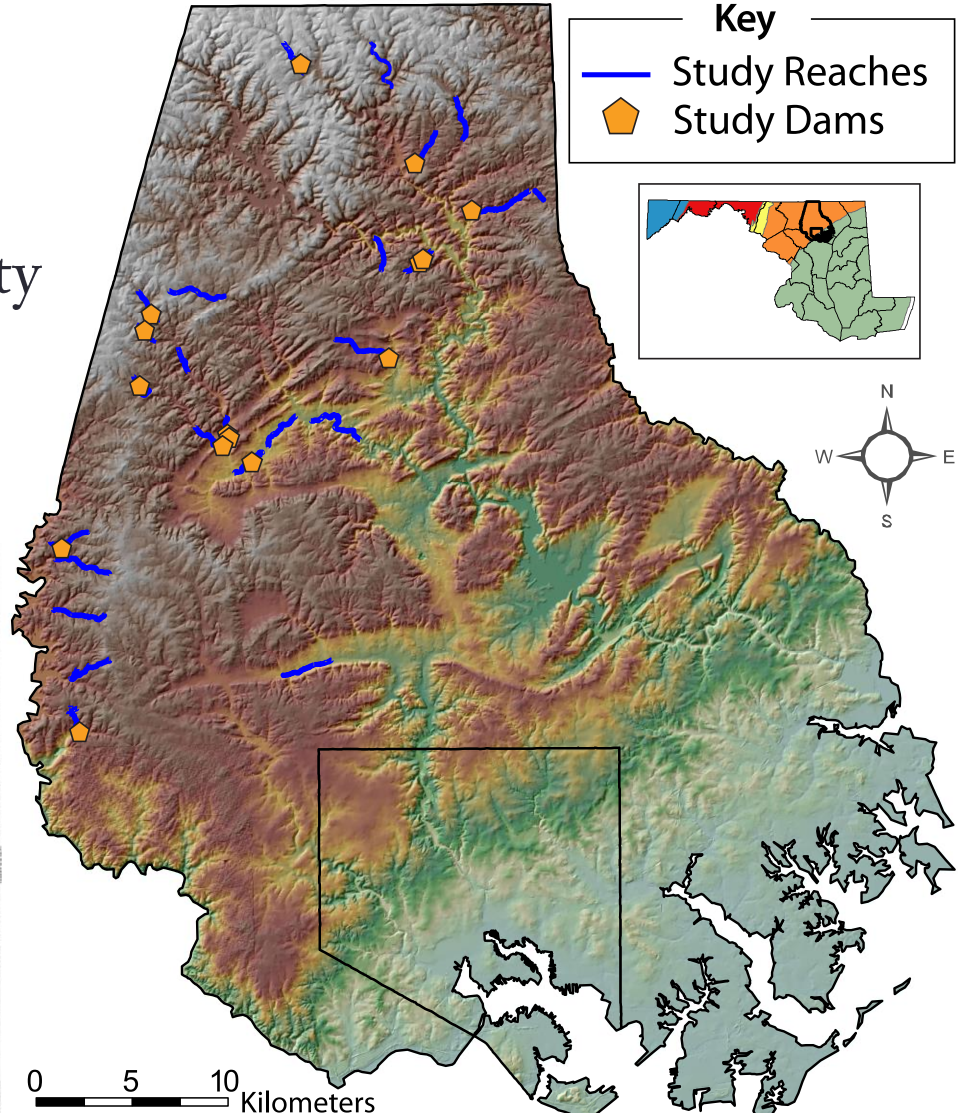
Part II- Sediment fingerprinting (A. Gellis)

5. Sediment fingerprinting
    Upland and channel sources
6. Conclusions – Part II

Methods – Approach

- 50 year record of erosion
  - Compared historic topographic maps from 1960 to LiDAR from 2005
- 25 streams across Baltimore County
  - 14 mill dams, 11 non-mill dams
  - Paired stream comparisons





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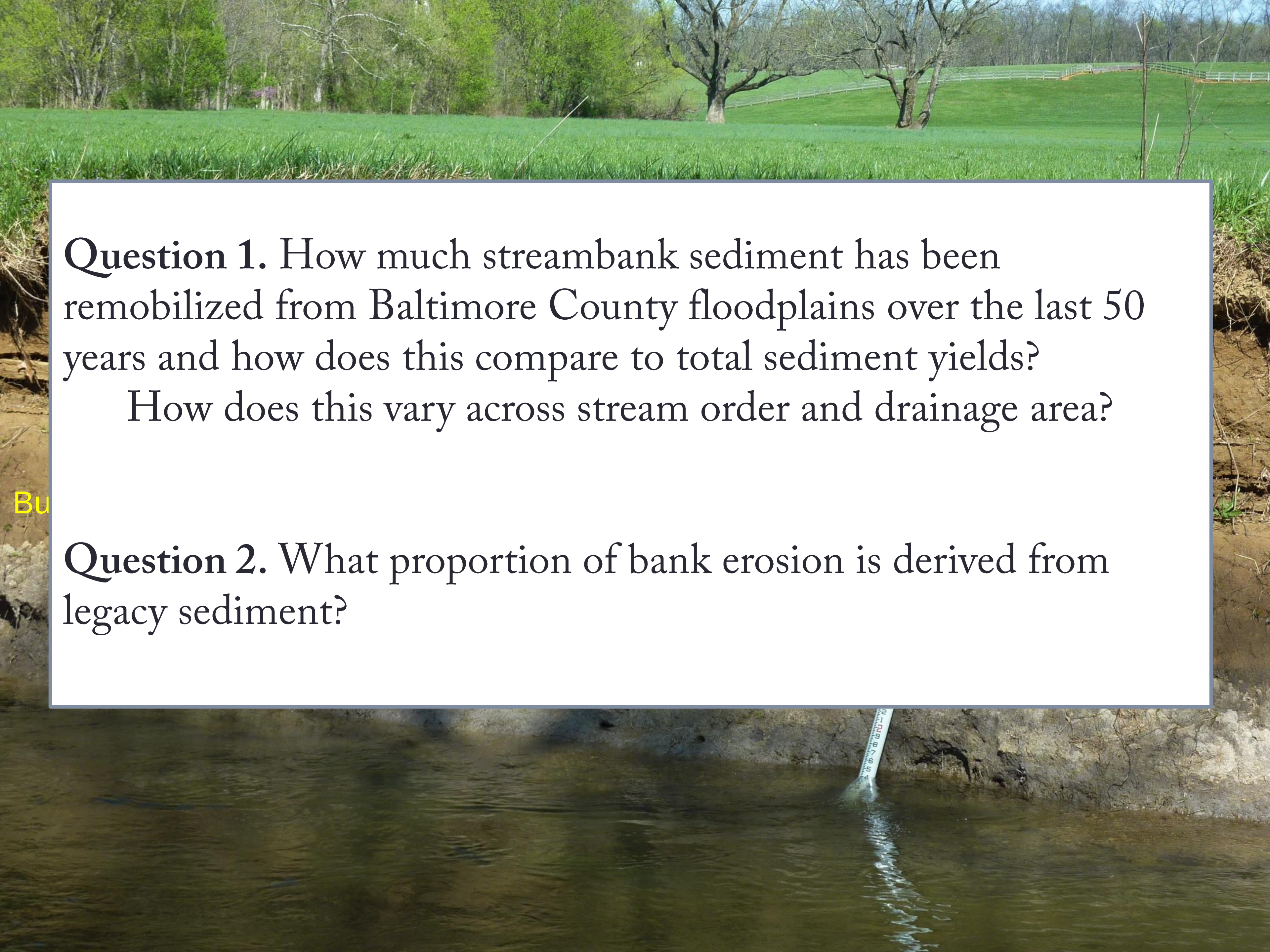


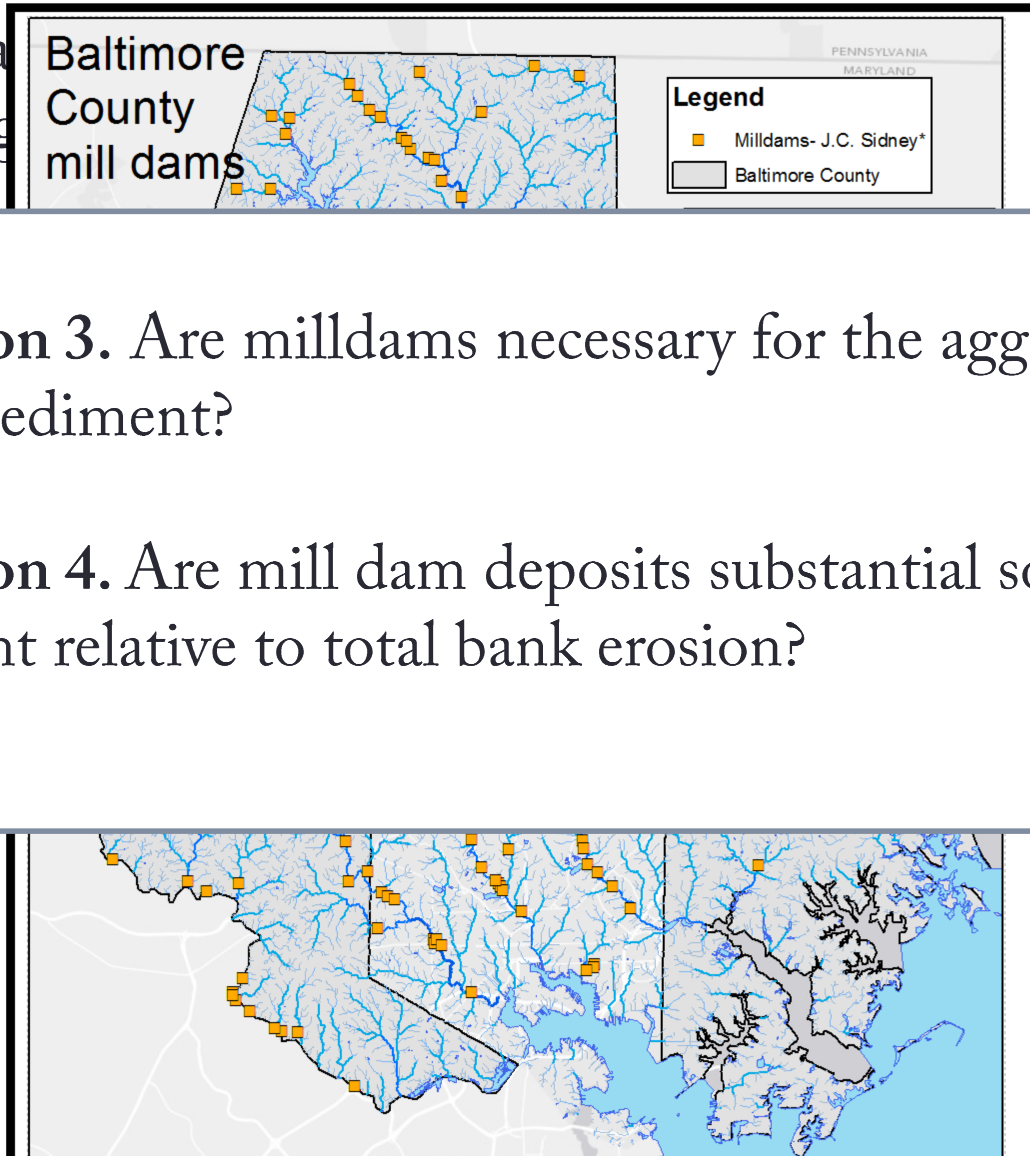
Question 1. How much streambank sediment has been remobilized from Baltimore County floodplains over the last 50 years and how does this compare to total sediment yields?

How does this vary across stream order and drainage area?

Question 2. What proportion of bank erosion is derived from legacy sediment?

Understanding the role of mill dams

- “Widesprea… …rred as a result of damming…



*Dam locations derived from a map of Baltimore County from 1857 by James C. Sidney

Question 3. Are milldams necessary for the aggradation of legacy sediment?

Question 4. Are mill dam deposits substantial sources of sediment relative to total bank erosion?

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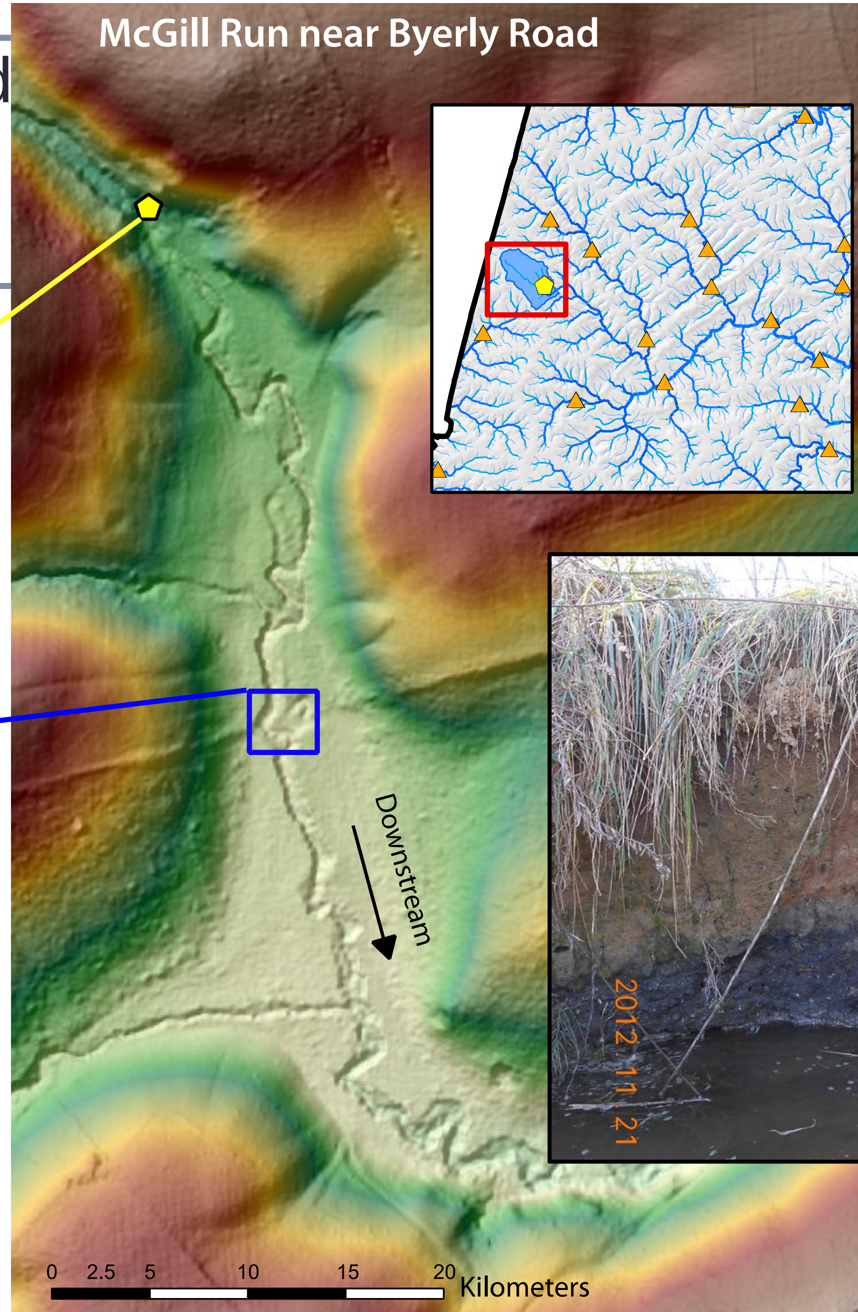
Results - Mill Dams

- **Question:** Are milld ation of legacy sediment?
- **Answer**: No



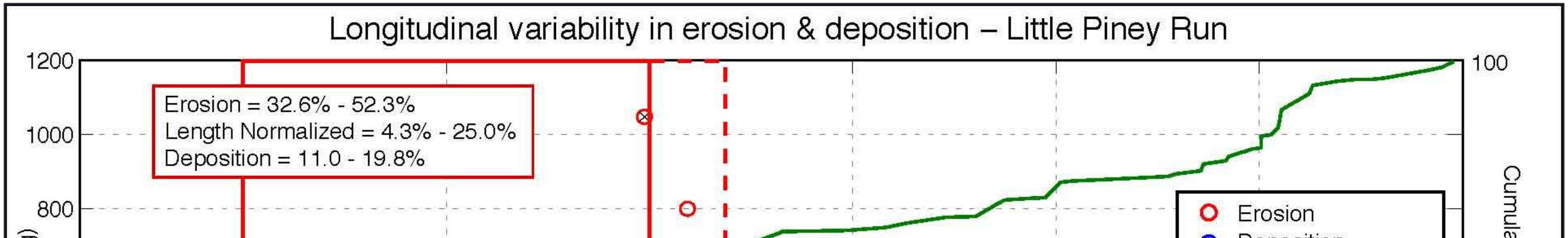
Results - Mill Dams

Question: Are mill dam deposits a substantial source of sediment?

Answer: It depends on the spatial scale…

Results – Mill dams

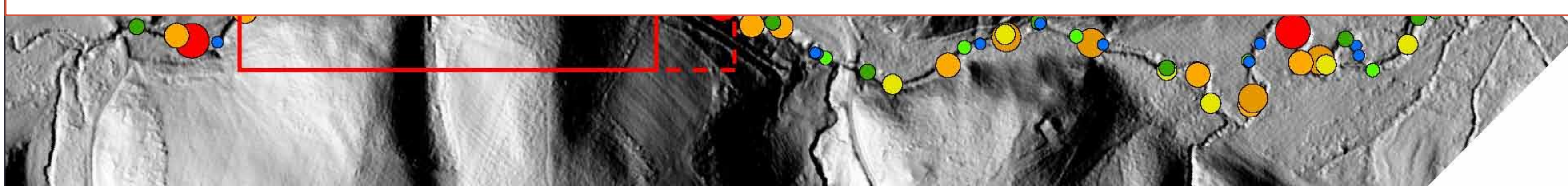
Mill dam impact within a single reach



Results for 14 streams with mill dams:

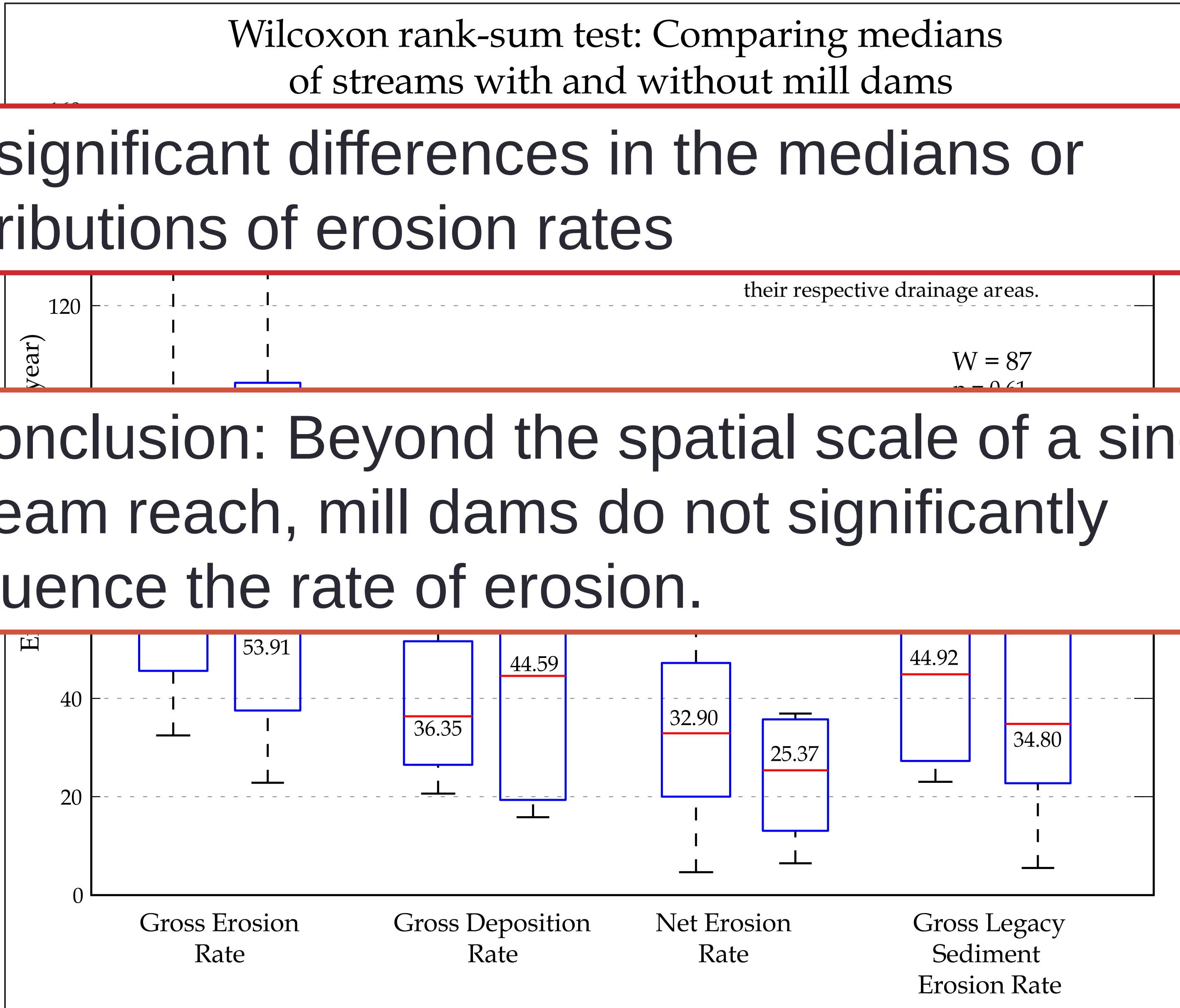
Excess erosion from mill dam deposits…

Range: 0 – 34%
Average: 14.2%



Results – Mill dams

Comparisons across all sites



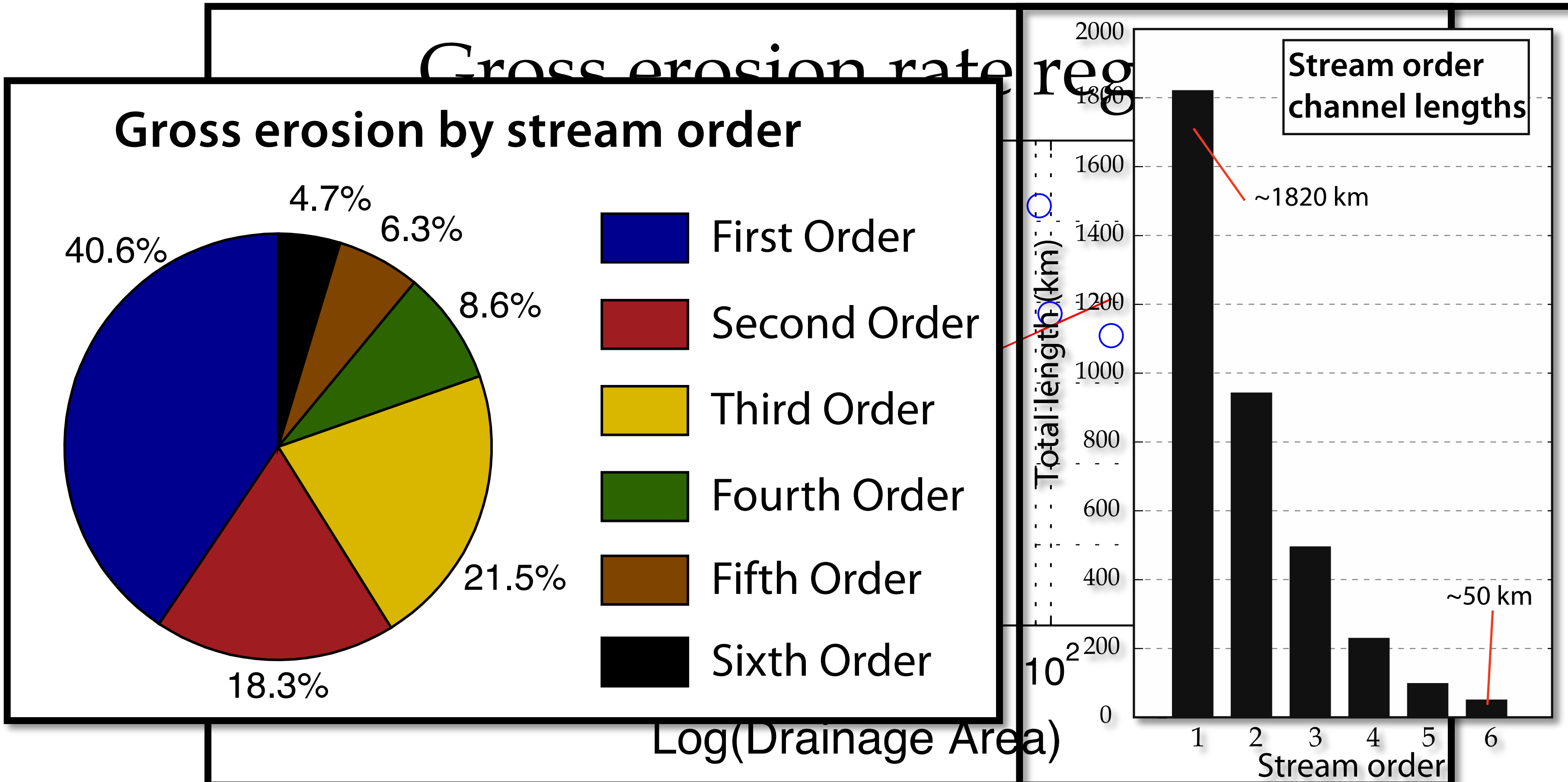
No significant differences in the medians or distributions of erosion rates

*Conclusion: Beyond the spatial scale of a single stream reach, mill dams do not significantly influence the rate of erosion.

Results – Bank erosion

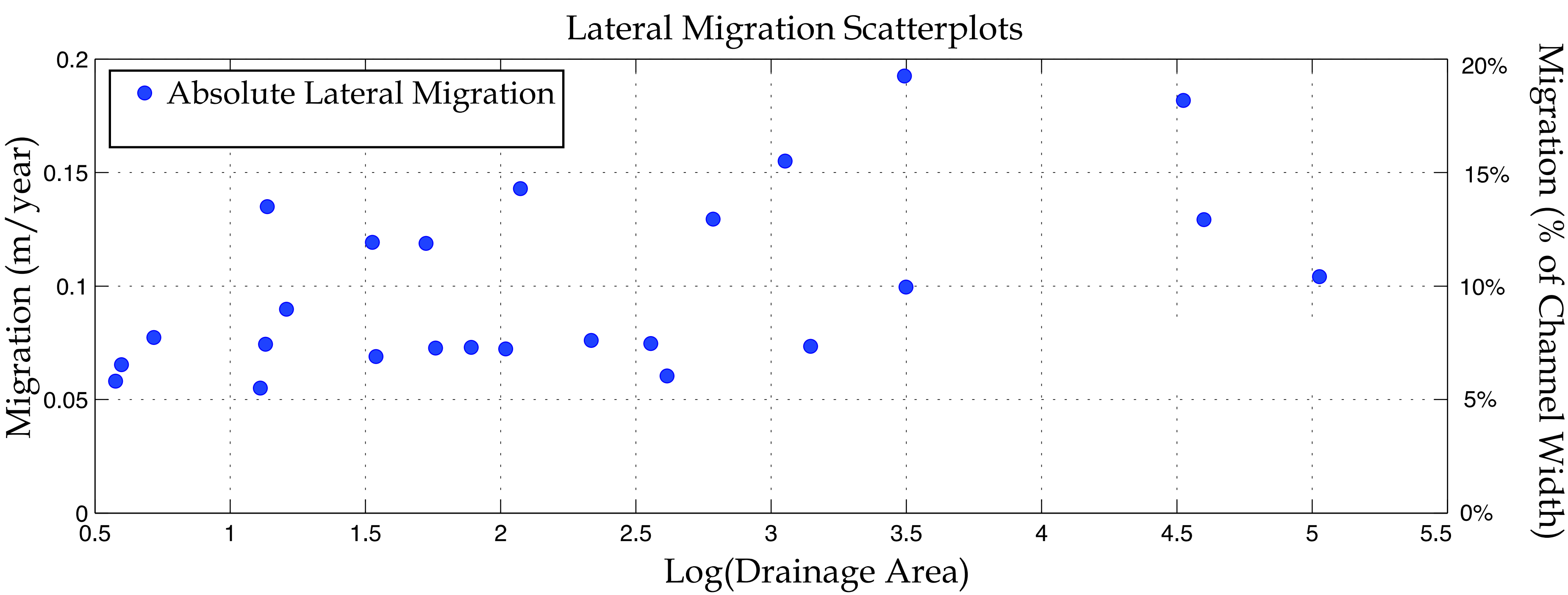
- **Question:** How does stream bank erosion vary across stream order and drainage area?
- Answer: Erosion rates increased along larger streams **however!**

Larger streams produced less total sediment load



Results – Channel migration

- Lateral migration rates - general increase across drainage area
- Absolute migration → migration as a percent of channel width
  - On average channels move 3% of channel width each year



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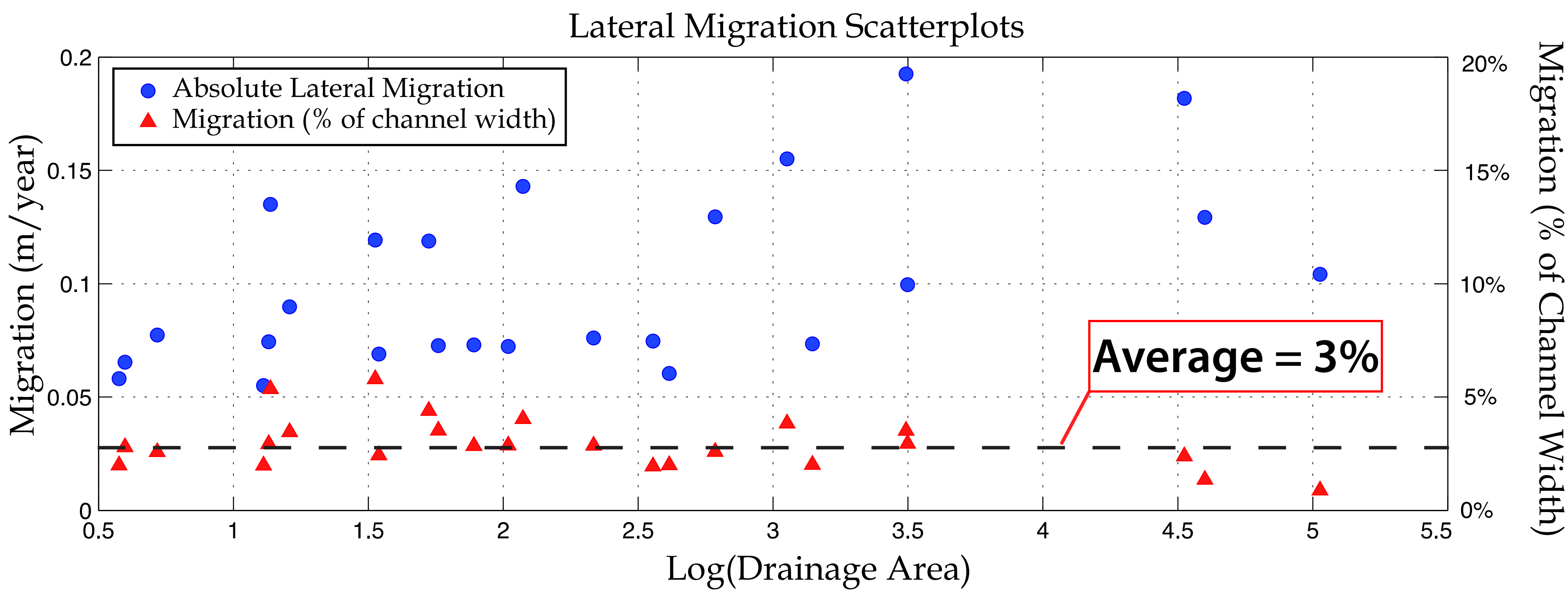
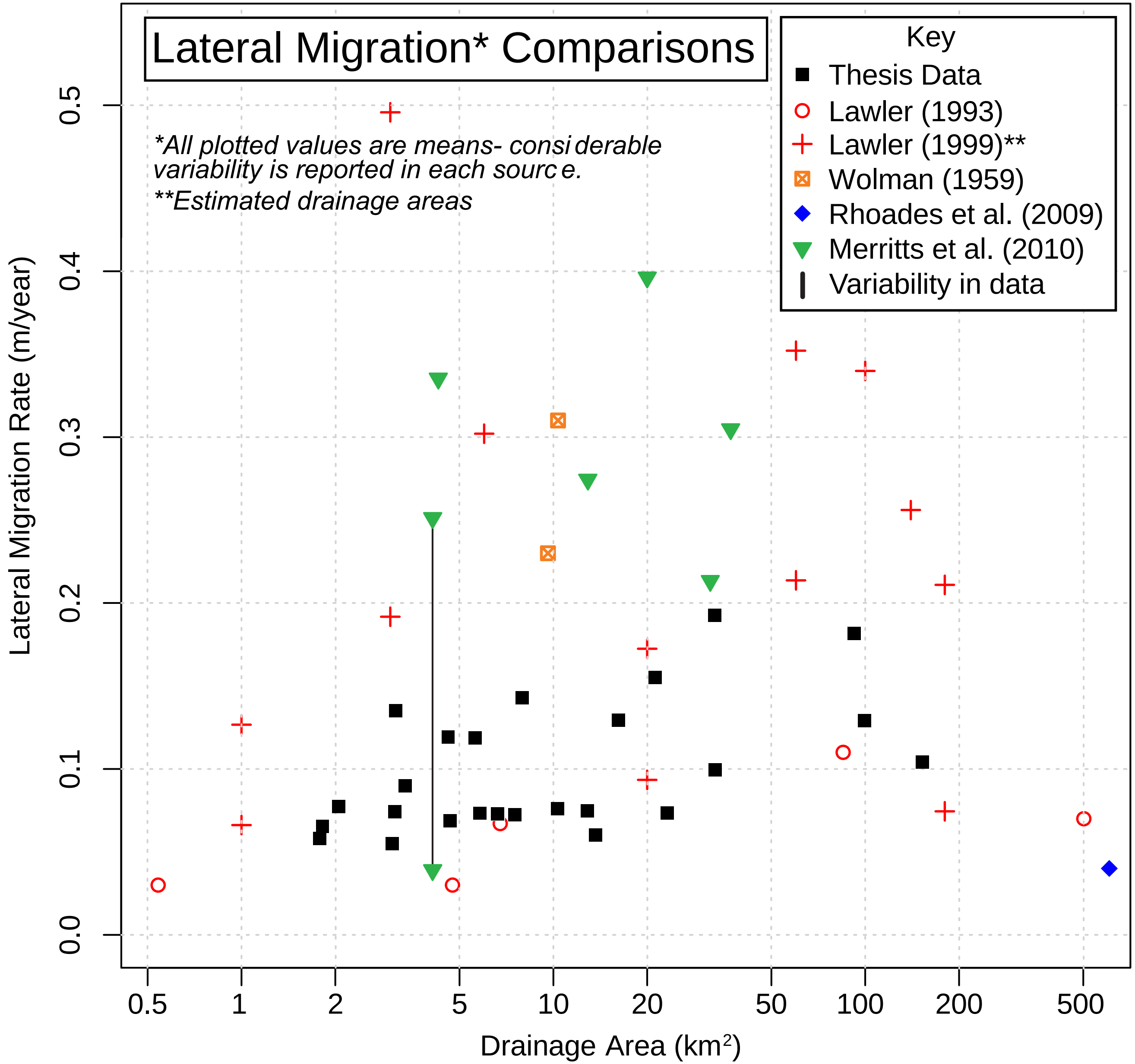


Results – Channel migration

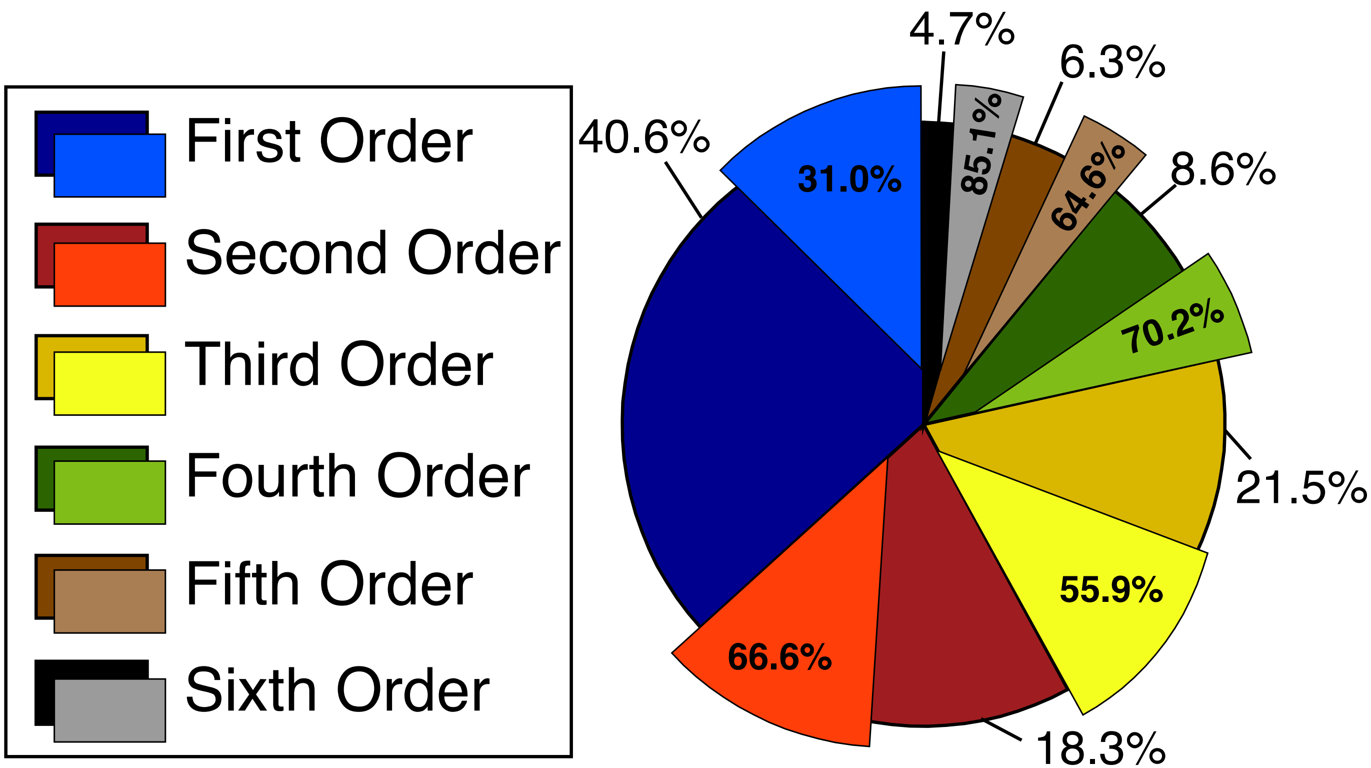
- Comparable to previously published values



Question. What proportion of bank erosion is derived from legacy sediment?

Ans … ns
ran … r
pro …

Legacy sediment erosion by stream order



**Percentages labeled on the lighter shades are the percent of legacy sediment as a fraction of the gross erosion from each stream order.*

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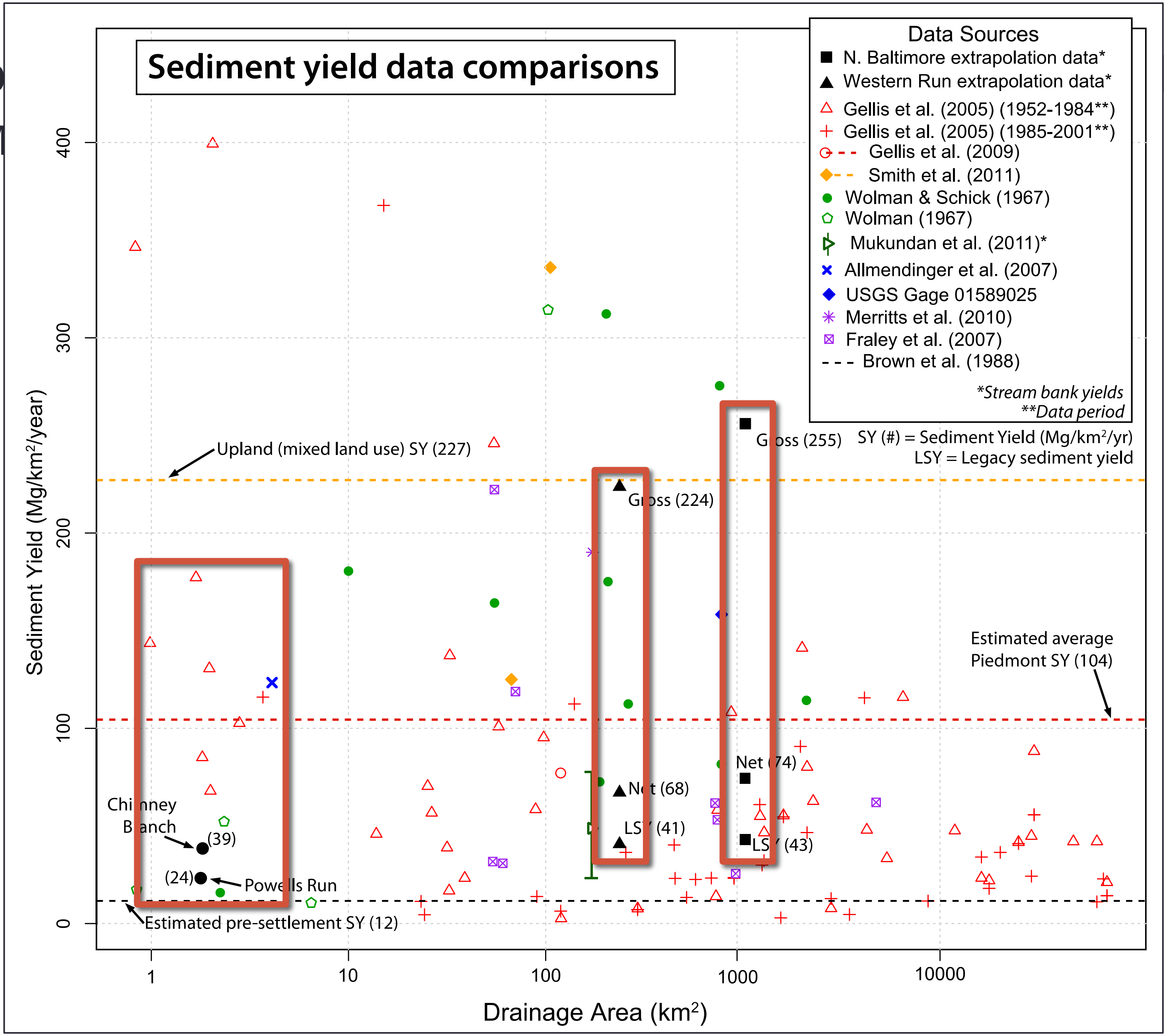
Results - Extrapolations

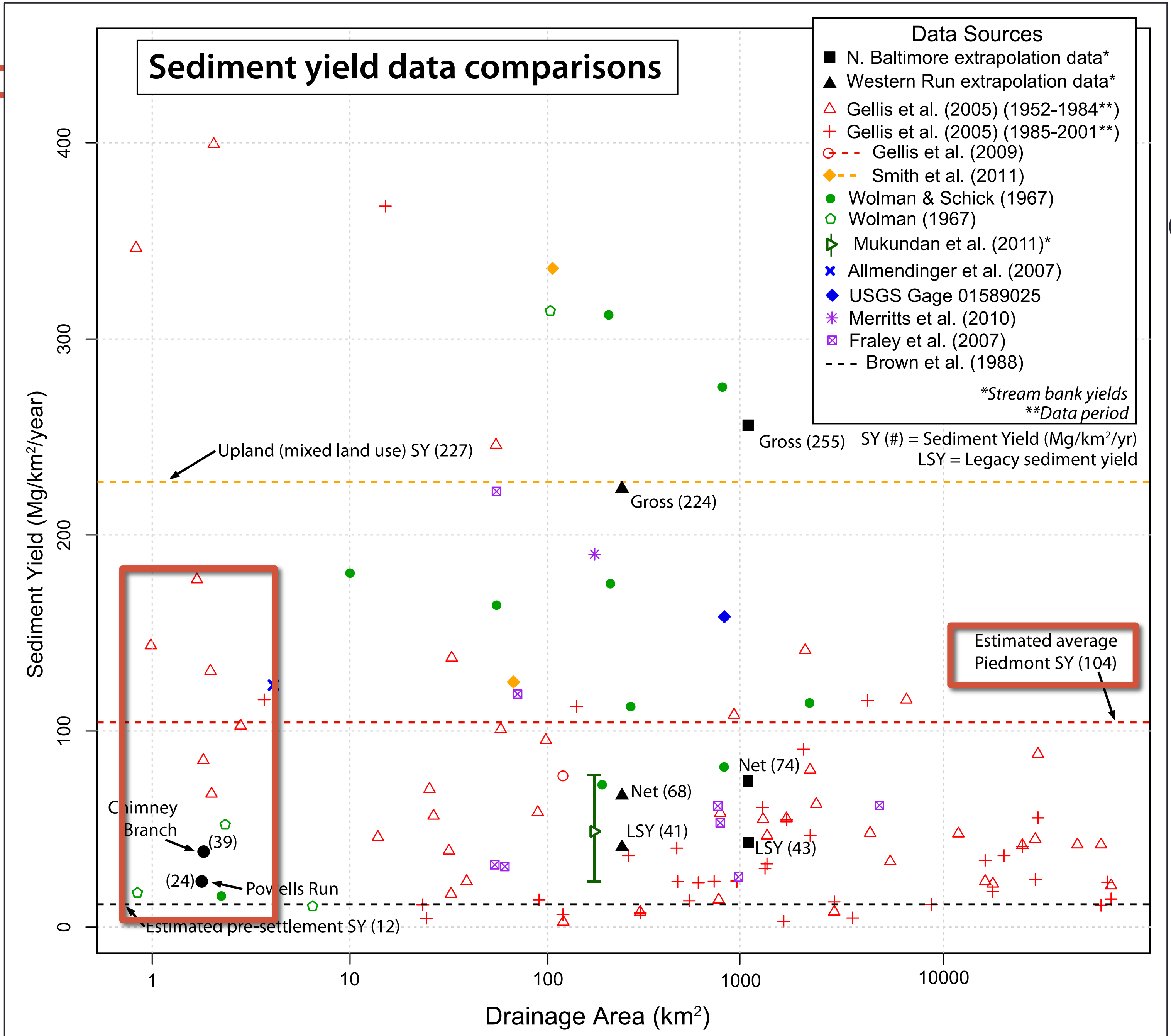
- Ero… ds
  - M…



Sediment yield comparisons

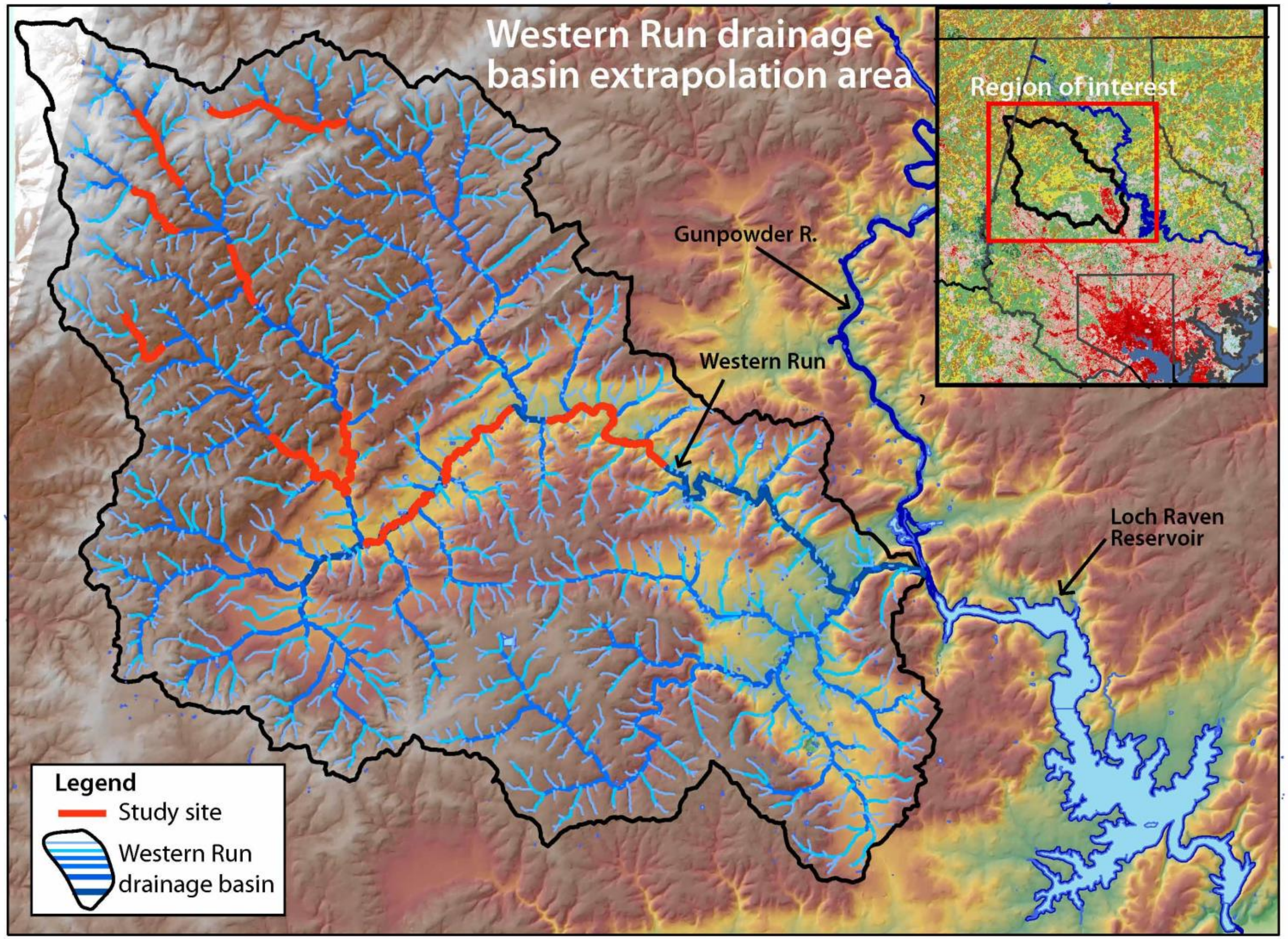
F

- elds



Stream banks & TMDLS

- Western Run (222 km^2)
  - Upstream of Loch Raven Reservoir (580 km^2)
  - Western Run = 38% of the Loch Raven Res. drainage area



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- Estimated *net* sediment load = 15,222 Mg/yr
  - This accounts for in-channel deposition and estimated floodplain dep.
- Loch Raven TMDL = 28,925 Mg/yr (MDE, 2006)
- Western Run banks contribute a minimum ~ 50%

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Conclusions – Part I

- Fine-grained stream bank sediments may account for 47-95% (mean = 71%) of sediment yields after redeposition
  - 50 - 98% → (Costa 1975; Trimble 1997; Allmendinger 2007; Schenk and Hupp 2009; Shilling 2009; Mukundan et al. 2011; Gellis and Noe 2013)
- Large proportion may be fine-grained legacy sediments
- Nutrient content of legacy material:
  - (Langland and Cronin 2003; Walter et al. 2007; Gellis et al. 2009)
- Low-order streams may be important contributors to total sediment loads
- Mill dams can contribute excess sediment, but were not the largest source of remobilized sediment in Baltimore Co. (Hupp et al. 2013; Rhoades et al. 2011)

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1. Data is not yet published, but will be available soon
2. Limited extent of observation (Baltimore County)
3. Co-authors: Exhibit caution in applying results elsewhere

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Part II – Sedimen Fingerprinting

Understanding the sources of sediment at the small watershed scale provides land-managers agencies with answer to this key question – *Is it coming from the uplands or channel?*

SEDIMENT FINGERPRINTING

Underlying principle – potential sediment sources can be characterized using a number of diagnostic physical and chemical properties

Comparison of these fingerprints with equivalent information for suspended sediment samples permits the relative importance of the potential sources

** On fine sediment – silts and clays

Walling et al., 1999

Sediment Fingerprinting

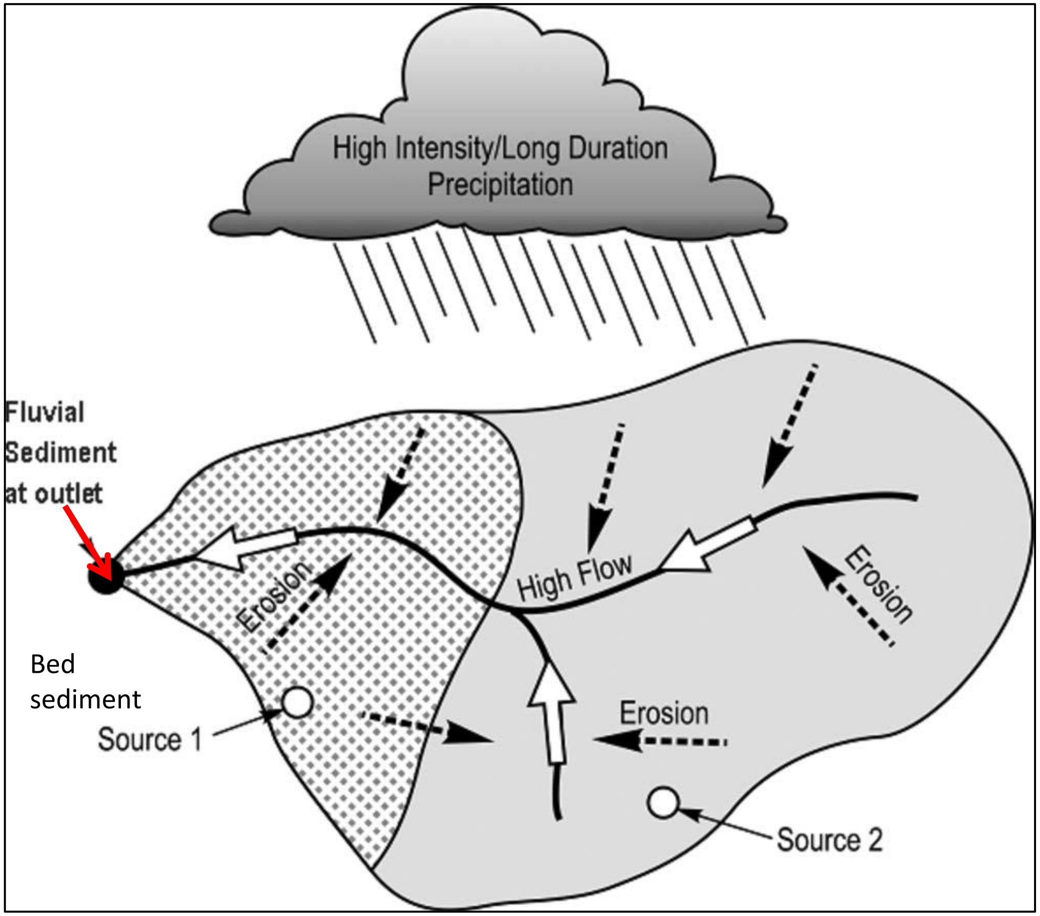
STEPS

1) Identify sources

2) Sample sources

3) Sample export – (fluvial sediment, bed sediment)

4) Determine proportion coming from each source



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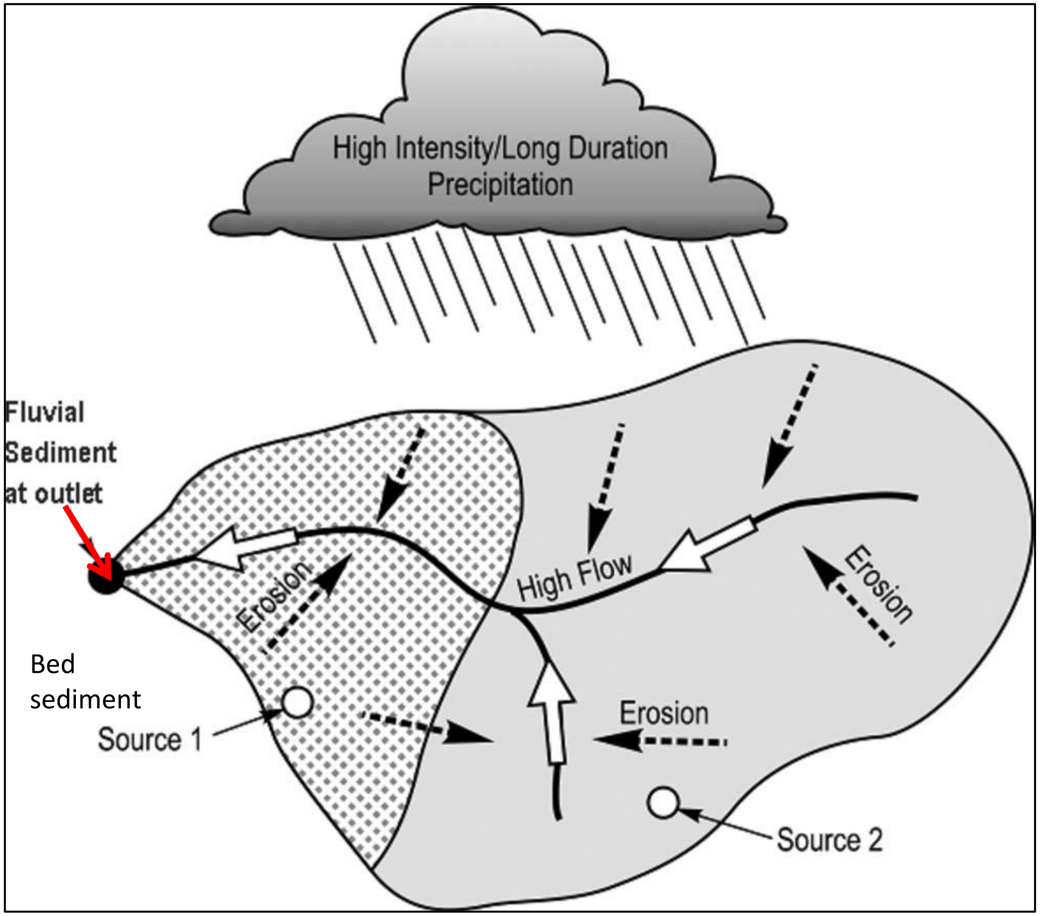
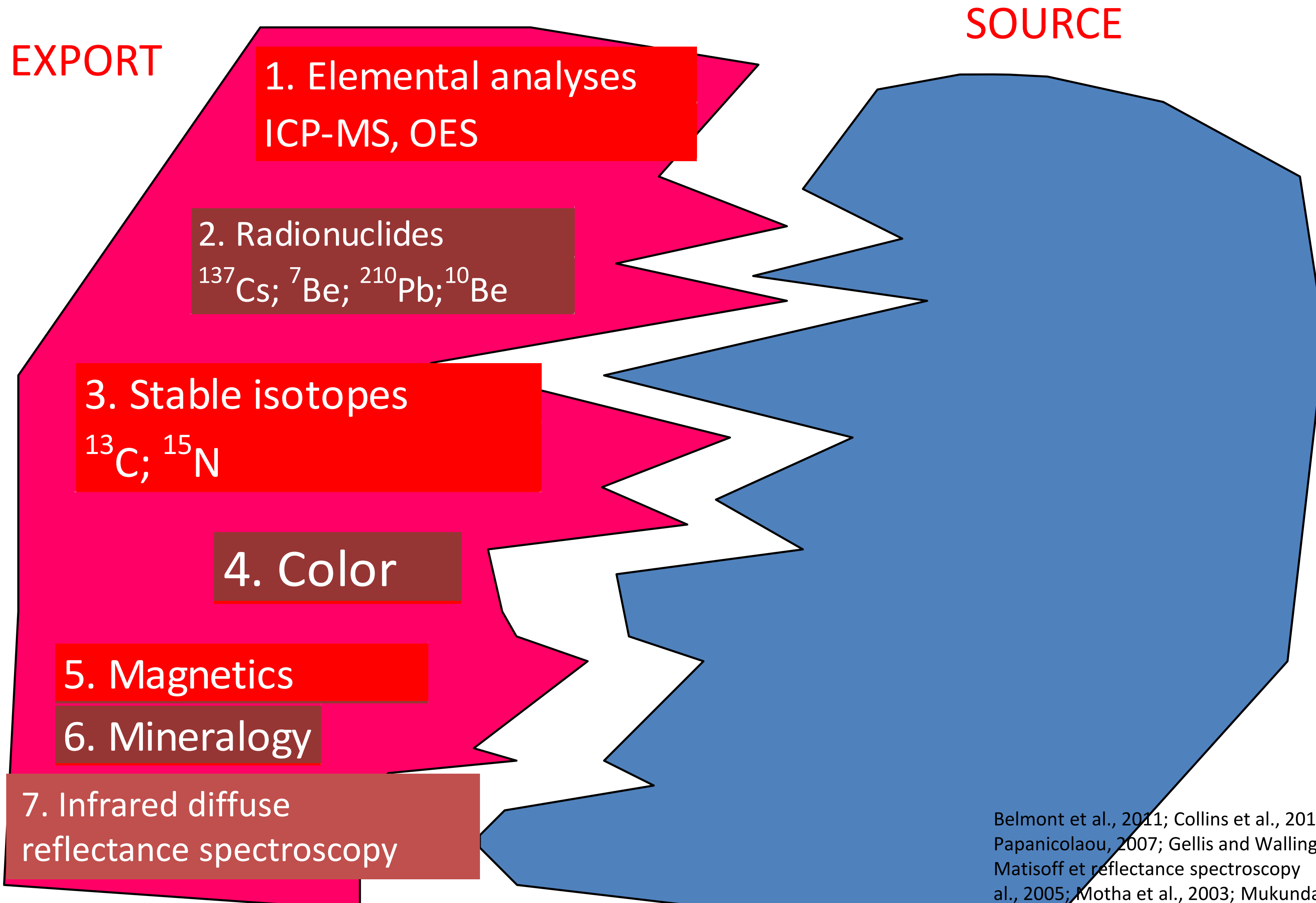


Uses soil properties as unique identifiers (fingerprints) to determine the sources of fine-grained sediment



Belmont et al., 2011; Collins et al., 2010; Fox and Papanicolaou, 2007; Gellis and Walling, 2012; Matisoff et reflectance spectroscopy al., 2005; Motha et al., 2003; Mukundan et al., 2010; Owens et al., 1999; Poulenard et al., 2009; Wilson et al., 2008

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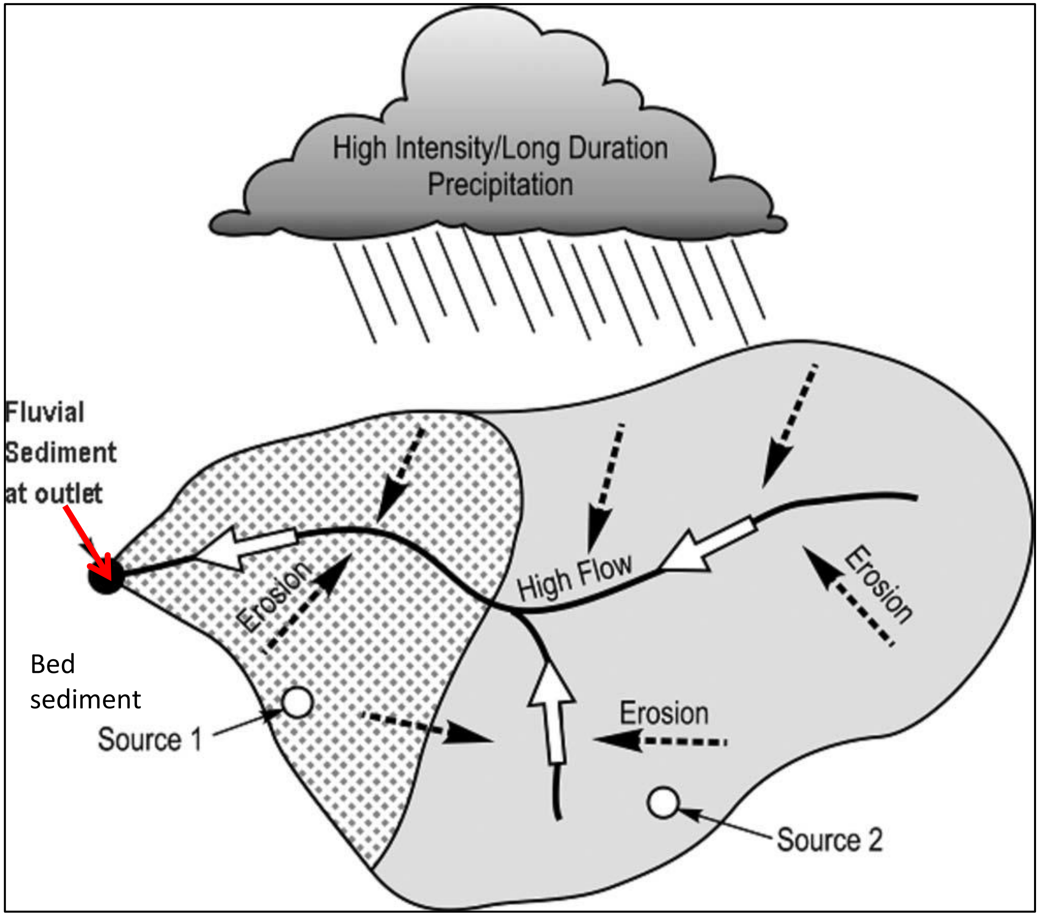

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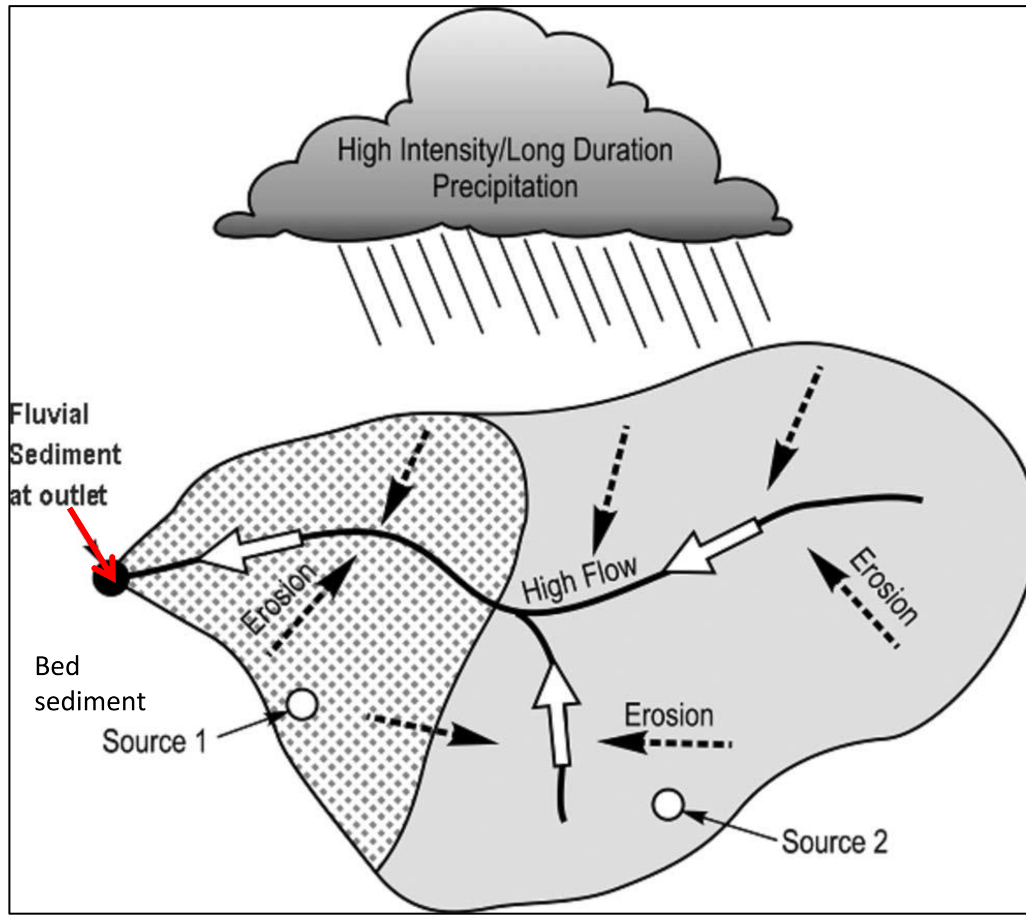
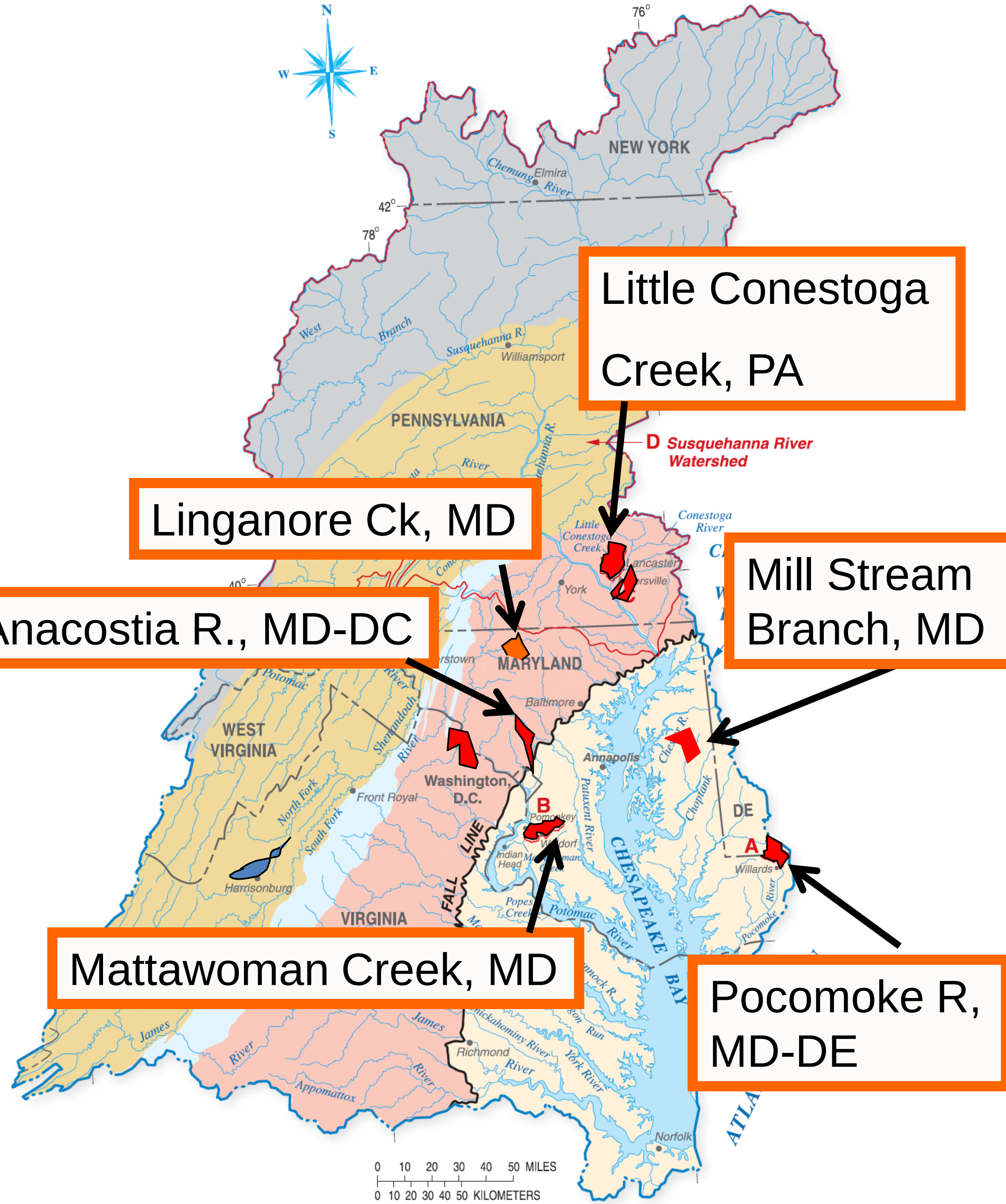


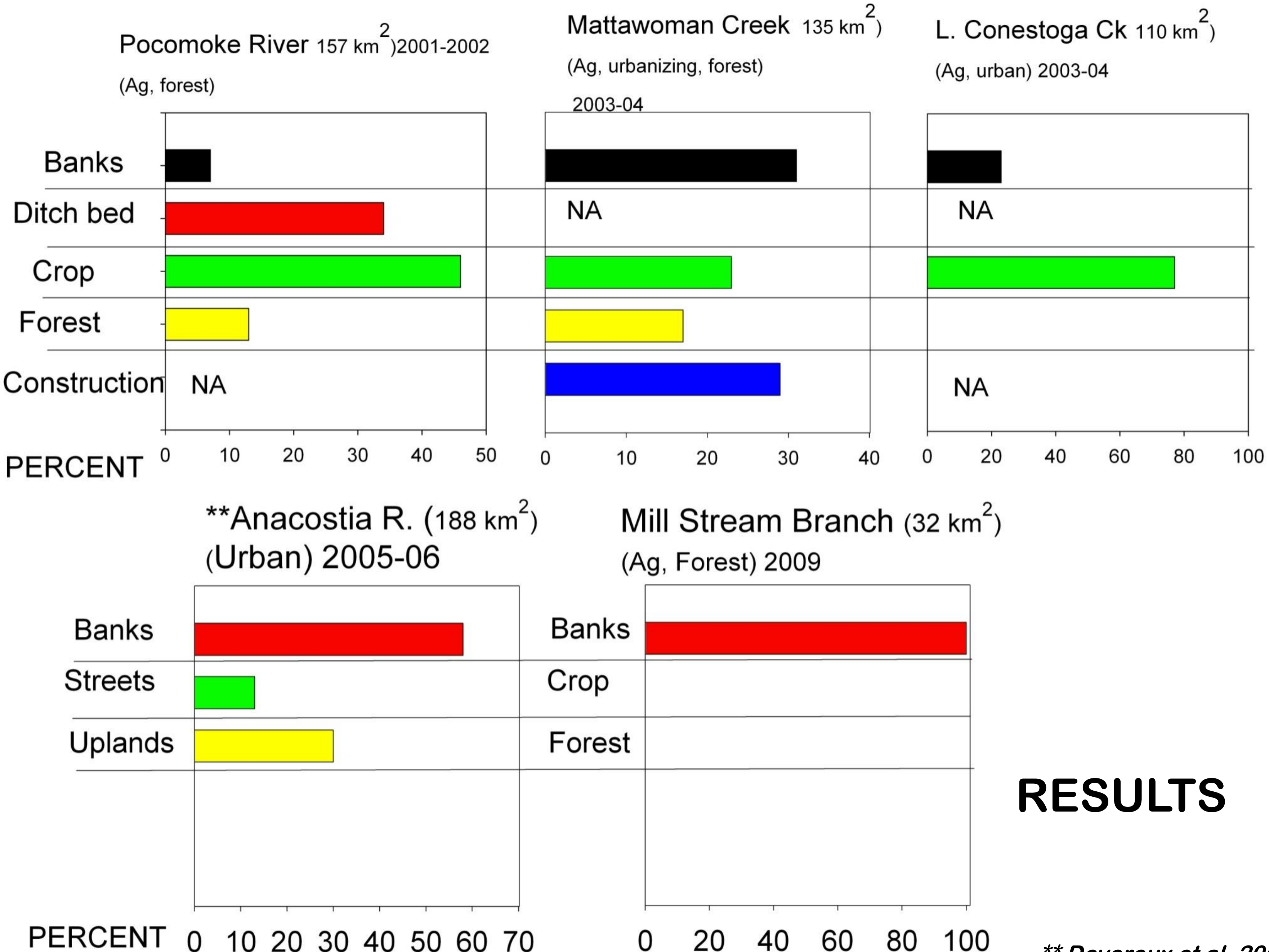
Sediment fingerprinting

Results from 6 watersheds draining Chesapeake Bay



** *Devereux, et al., 2010*

RESULTS



*** Devereux et al, 2010*

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Conclusions – Part II

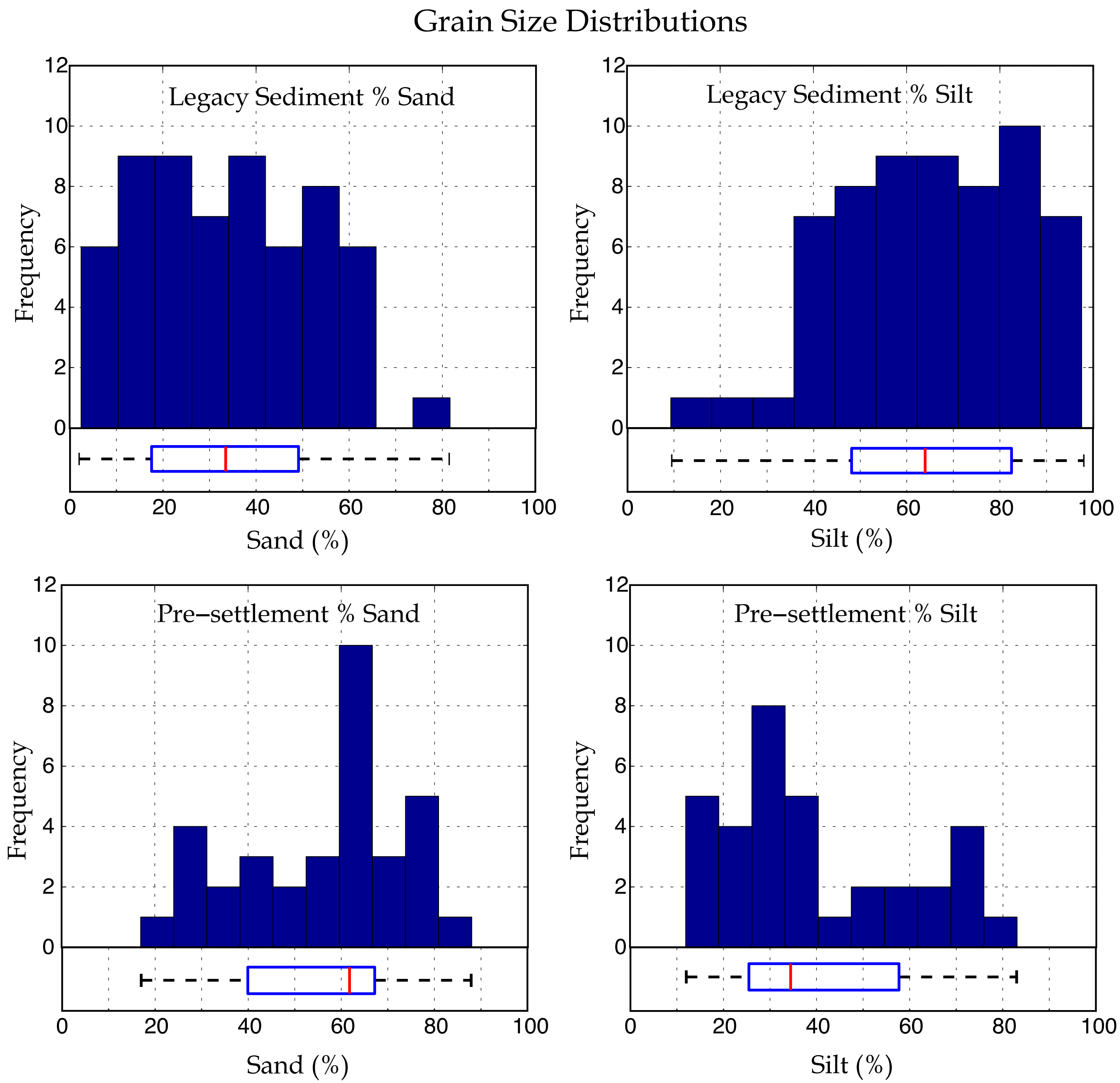
- Fingerprinting shows stream banks and upland land use are both important contributors
- Additional fingerprinting will allow us to measure what sources are leaving watersheds
- My co-authors suggest that the data presented is spatially and temporally limited, and as such is not adequate for models of erosion for the entire Chesapeake Bay watershed

Acknowledgments & Questions

- Funding provided by: Maryland Water Resources Research Center (MWRRC)
- Committee members: Andy Miller, Matt Baker, Allen Gellis
- Field and lab work → Andrew Bofto
- Other help, feedback, and suggestions:
  - Dorothy Merritts, Milan Pavich, Michael Rahnis, Sean Smith, Claire Welty, Junmei Tang, Cherie Miller, Dan Jones, Sierra Shamer, Andy Miller, Alex St. Pe, Preston Donovan, Janet Donovan, Mitchell Donovan

Contact: mdonovan@umbc.edu

Grain sizes



Grain Size Distributions
Legacy Sediment % Sand
Frequency
Sand (%)
Legacy Sediment % Silt
Frequency
Silt (%)
Pre−settlement % Sand
Frequency
Sand (%)
Pre−settlement % Silt
Frequency
Silt (%)
0
2
4
6
8
10
12
0
20
40
60
80
100