Legacy Sediment in the Piedmont: Past valley aggradation, modern stream erosion, and implications for stream water quality

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Funding provided by grants from:
NC WRRI (Grant # 2010-70254), Geological Society of America, Sigma Xi, and NCSU Undergrad Research funds

Acknowledgements

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Dr. Elena Leithold, NCSU – MEAS
Dr. Helena Mitasova, NCSU – MEAS
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What would a natural – non anthropogenically modified Piedmont stream look like?

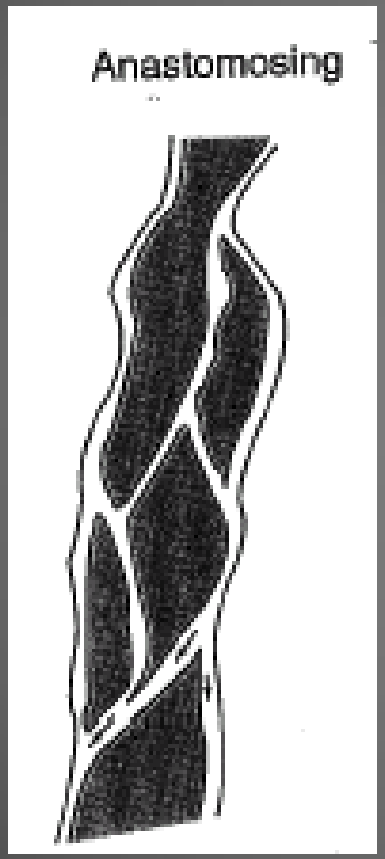
A: What we mostly see today – incised meandering streams with steep banks of fine-grained erodible sediments

What would a natural – non anthropogenically modified Piedmont stream look like?

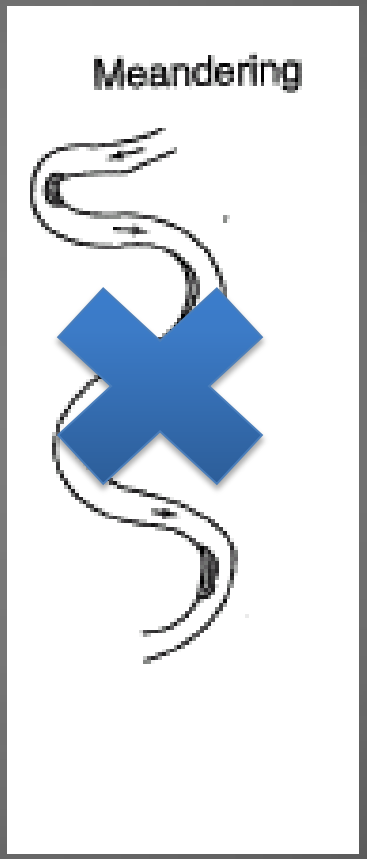
B. What I think we would like to see more of:
valley-bottom wetland complexes controlled in large part by the activates of *Castor canadensis* (North American beaver)

Holocene Streams in Low-Relief Landscapes

A



B

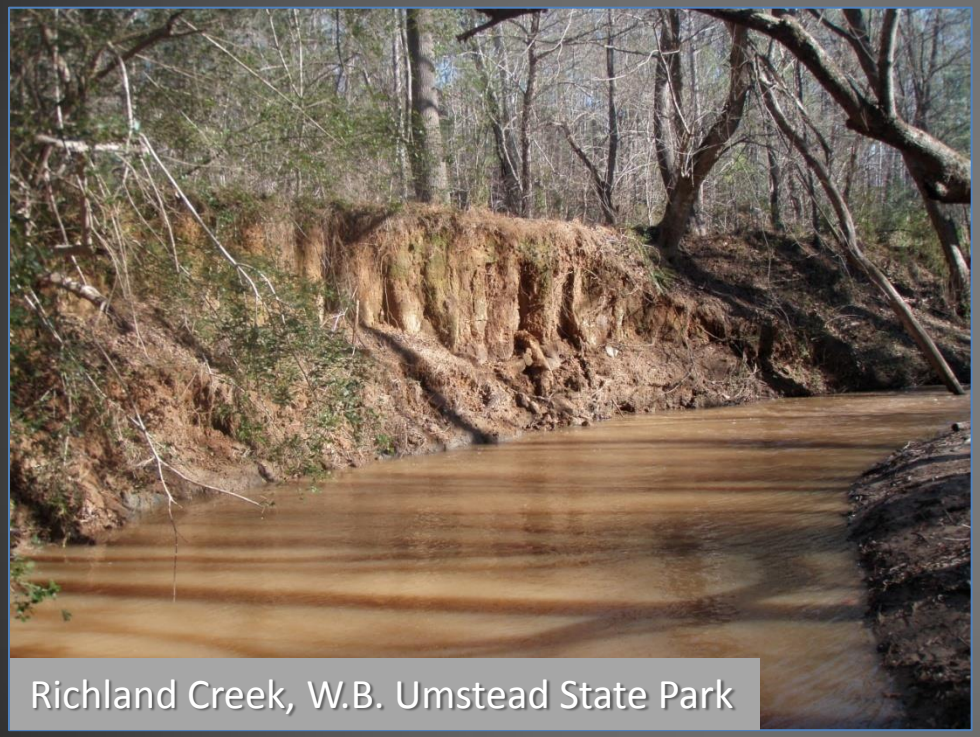


How did we get from A to B ?

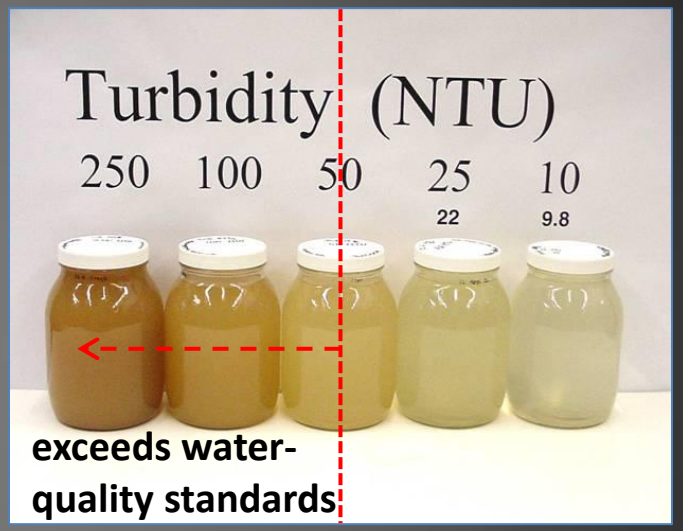
From Merritts et al, 2011, Anthropocene streams

Observation 1:

Modern piedmont Streams have high suspended sediment concentrations following precipitation events. Where is this sediment coming from?



Richland Creek, W.B. Umstead State Park



In 2007, the US EPA concluded that suspended sediment is the single largest contributor to stream water impairment across the nation with nutrient loading (N, P, and C) also of considerable concern

In urban to suburban areas, poor water quality is often blamed upon development

Observation 2:

Many Piedmont streams have tall banks of fine-grained, highly-erodible sediments

Richland Creek, Umstead State Park

Questions

- Are these deposits “natural” or anthropogenic?
- How old are they?
- Is their erosion contributing to modern water quality impairment?

Hypothesis

The modern erosion and transport of legacy sediment is a significant and persistent non-point source contributor to the TSS load of regional streams.

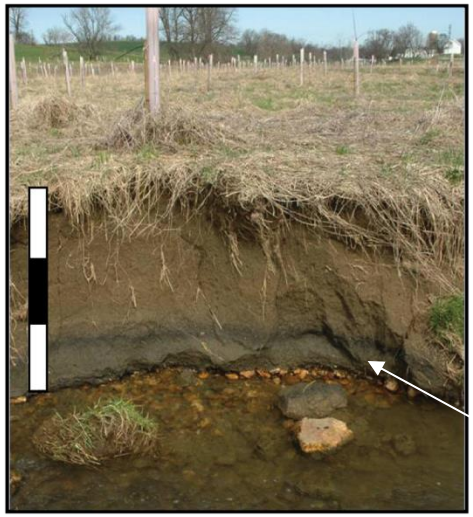
Reedy Creek – Umstead State Park: Remnants of breached milldam

Reedy Creek – Umstead State Park: upstream mill pond deposits

Conceptual Model for "Anthropocene" Channel Evolution

A

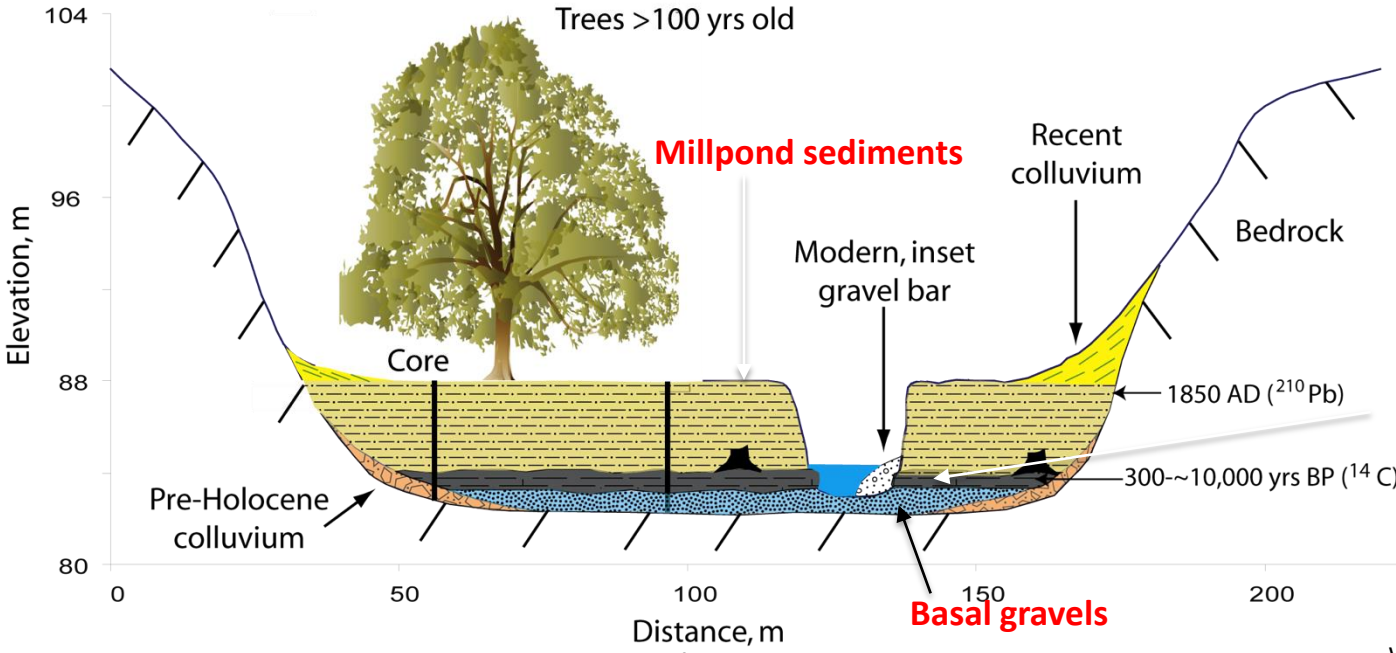
B



"Legacy" Sediments

Buried Holocene Wetland

C



7x vertical exaggeration

Walter and Merritts, 2008

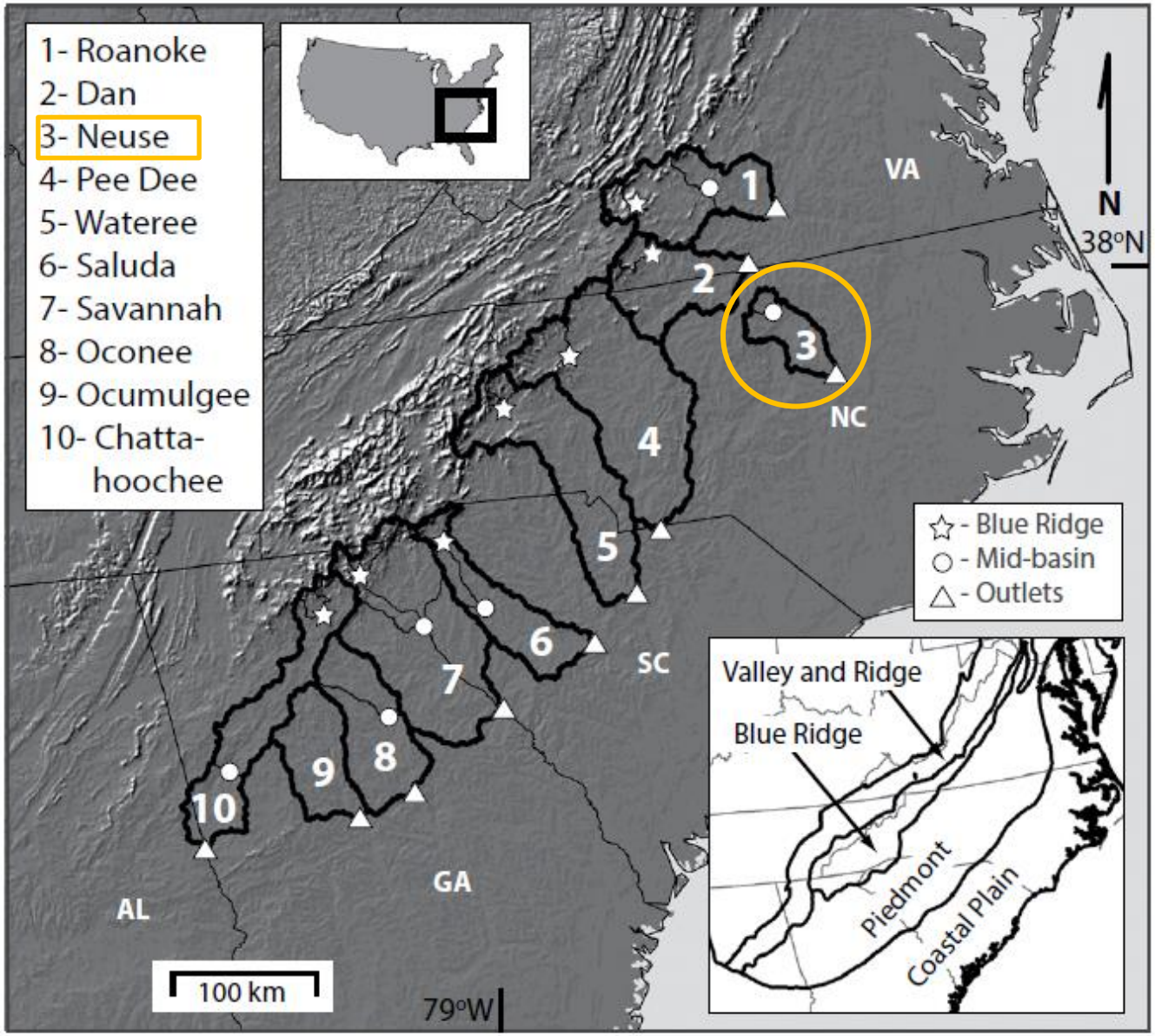


Figure 1. Map of southern Appalachian Piedmont along southeastern passive margin of North America. River basins 1–10 are those of Trimble (1977). Blue Ridge (star), mid-basin (circle), and outlet (triangle) denote locations of in situ ^{10}Be sample sites within each catchment. Insets show location of map and physiographic provinces mentioned in text. Modified from Trimble (1977, his figure 1). VA—Virginia; NC—North Carolina; SC—South Carolina; GA—Georgia; AL—Alabama.

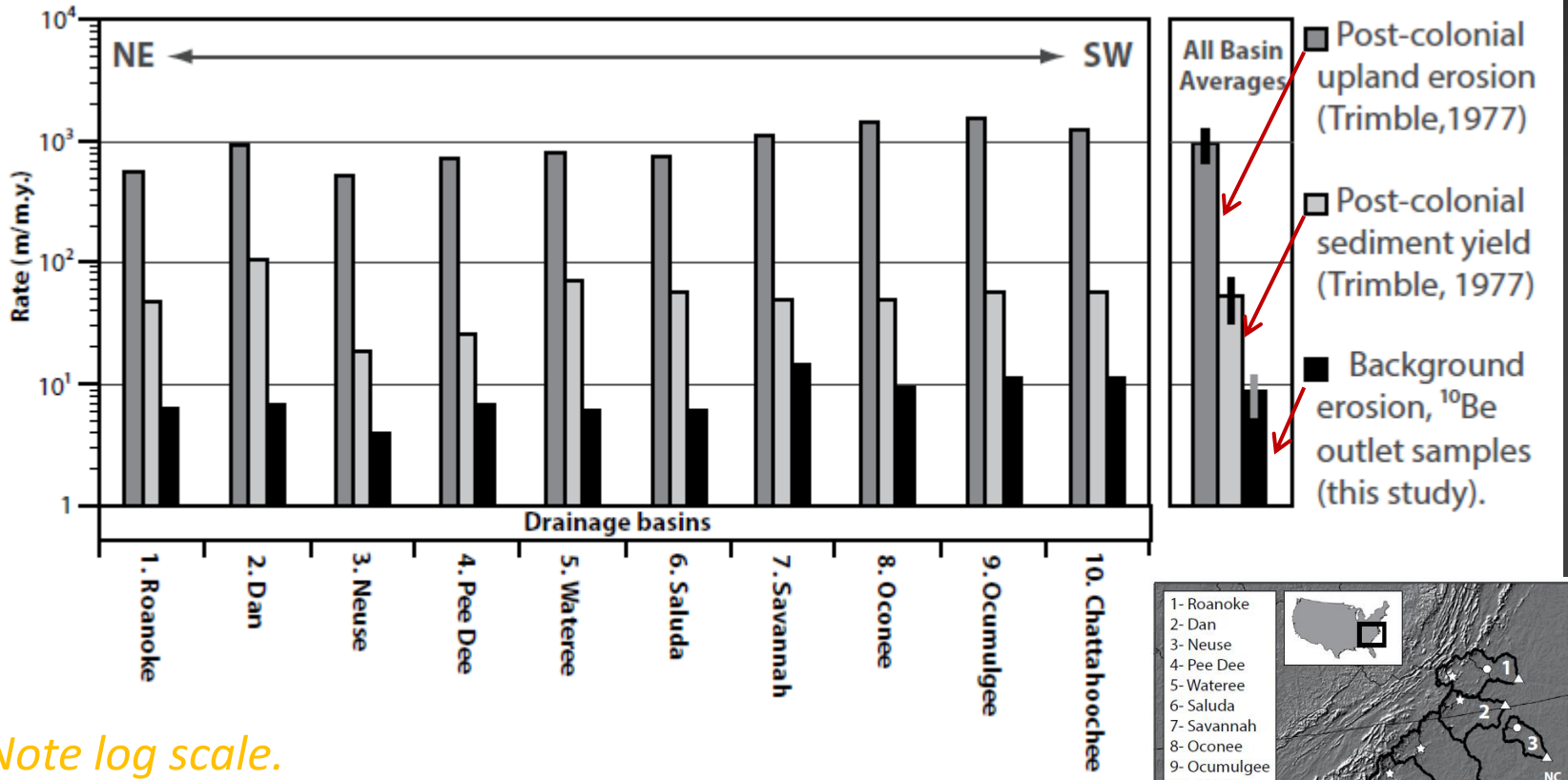
Southern Appalachian Piedmont study basins of Reusser et al. (2015)

What do we know about post-colonial agricultural practices, upland erosion rates, and lowland aggradation?

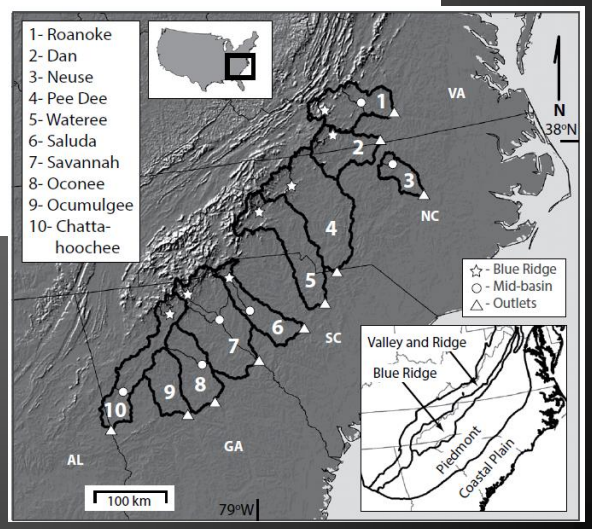
- Slash and Burn
  (increase in soil MS)
- Poor soil conservation
  (single crop rotation)
- Rapid Upland Soil Erosion
  (50 to 500x background)

  Trimble, 1974 & 1975
- 1 to 5 m of valley-bottom aggradation (legacy sediment)
- Piedmont Streams
  from AL to PA

Summary by Reusser et al. (2015) of erosion rates for large-scale catchments of the Appalachian Piedmont.

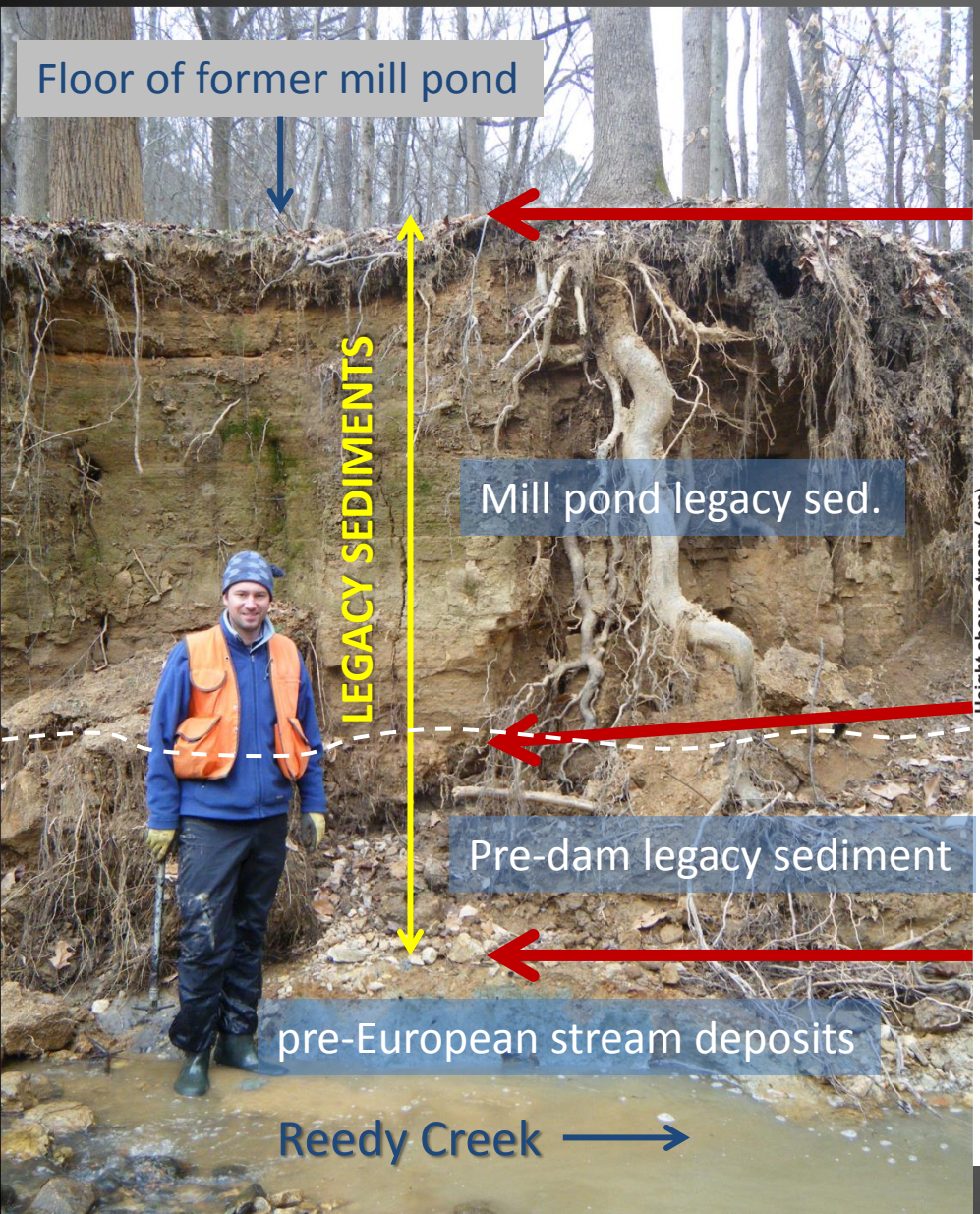


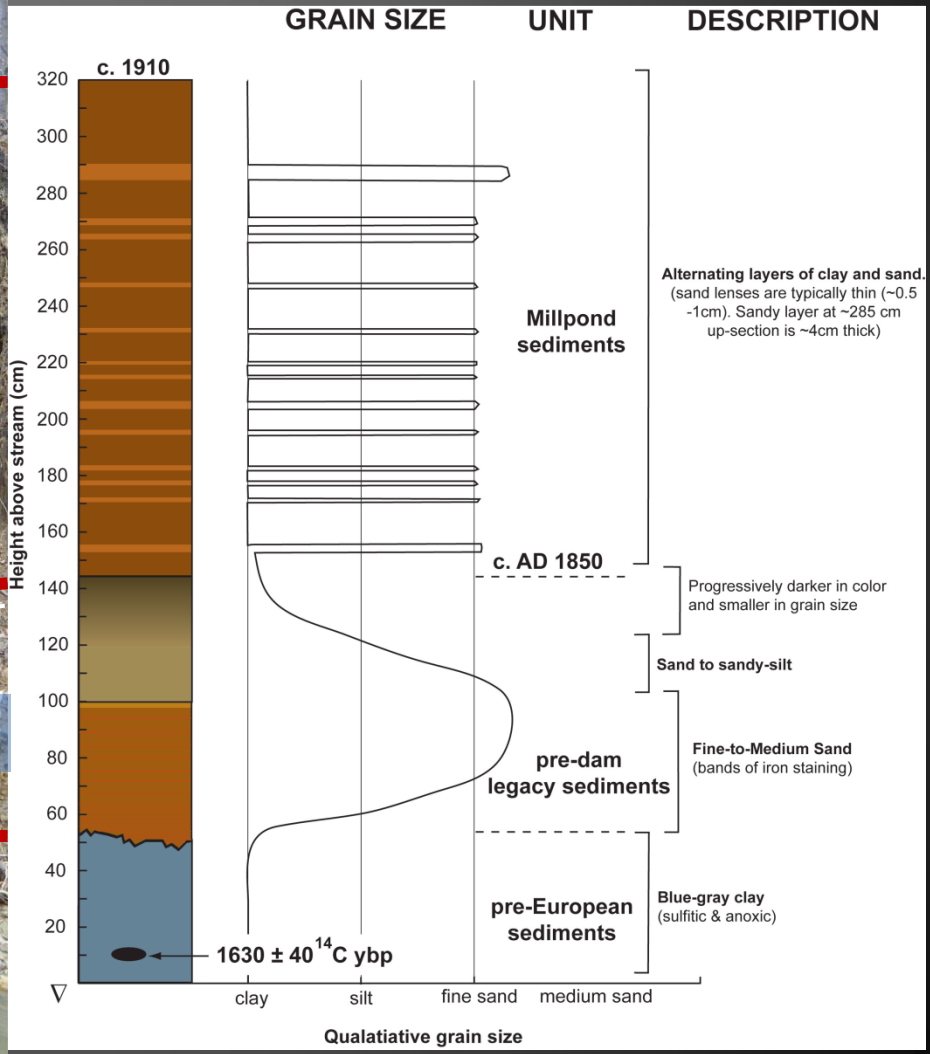
Note log scale.



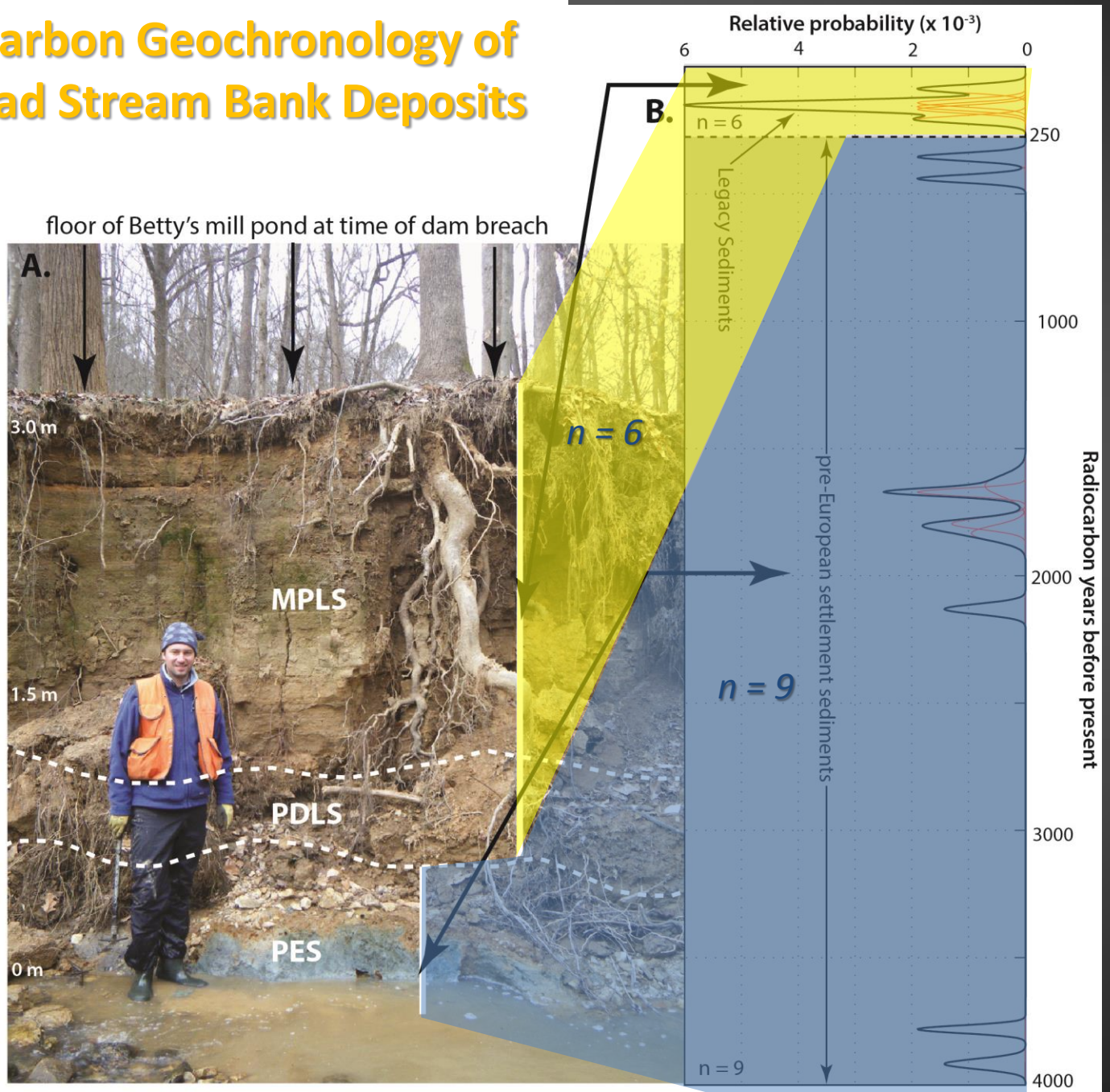
- Background (geologic) erosion rate = ~ 8 m/my
- Peak disturbance erosion rate = ~ 950 m/my
- Sediment yield 5-10x pre-settlement norms, yet rivers transported only ~6% of eroded soils

Stream Bank Stratigraphy in W.B. Umstead State Park





Radiocarbon Geochronology of Umstead Stream Bank Deposits



Quantifying the volumes of legacy sediment available for stream erosion: Richland Creek (Wake Forest) Example

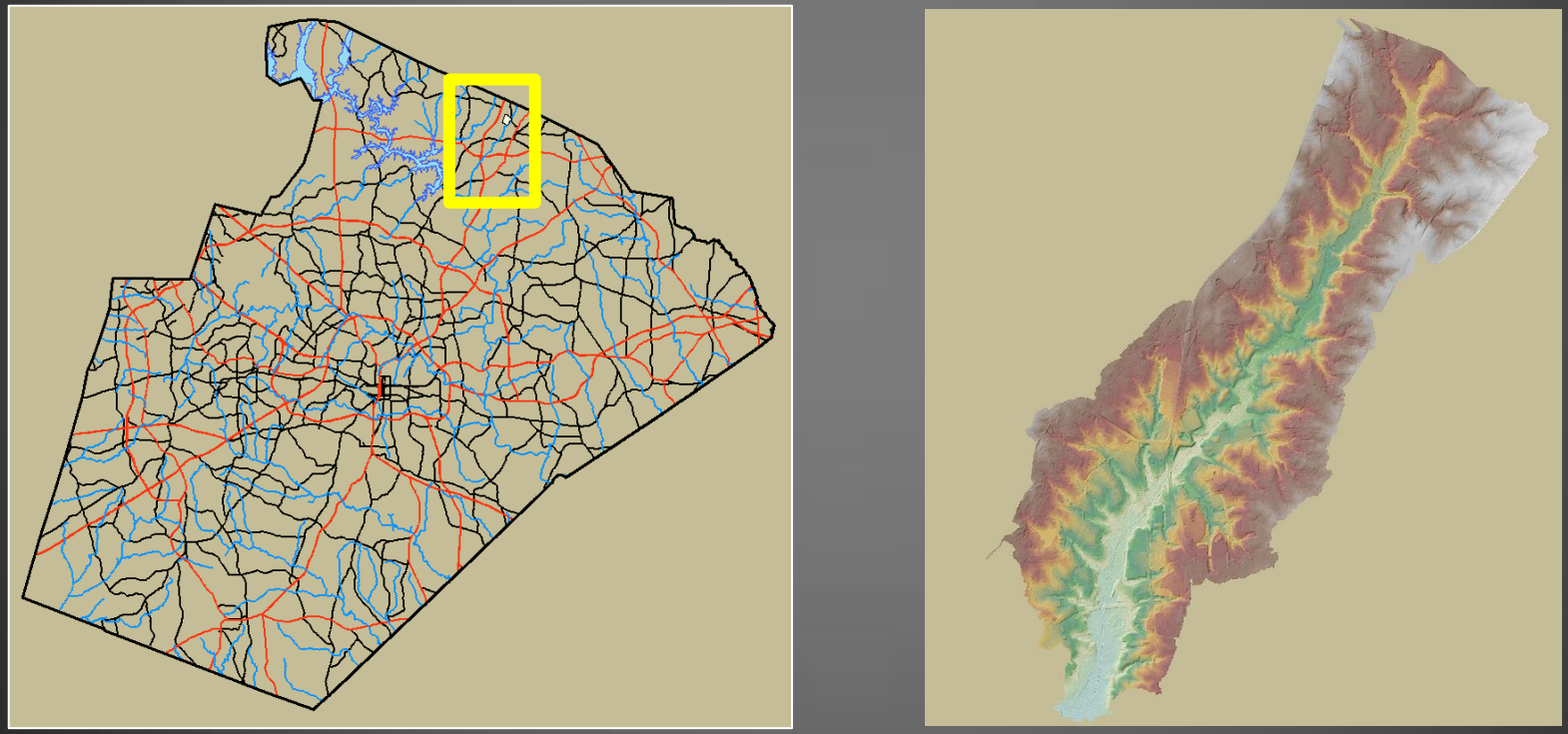
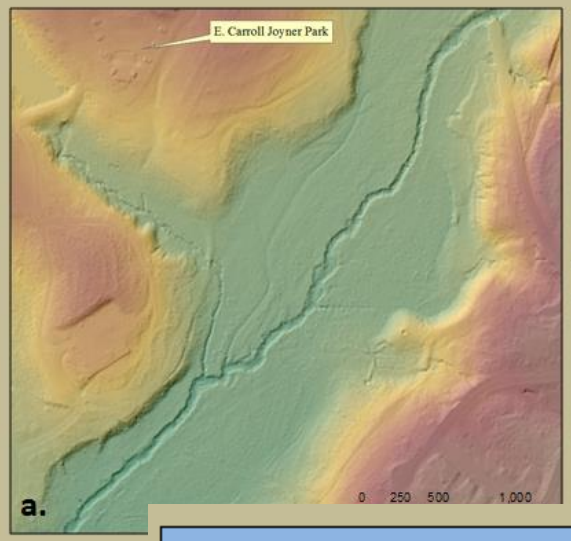


Figure 1: *a.*) Wake County, NC. *b.*) Richland Creek study area

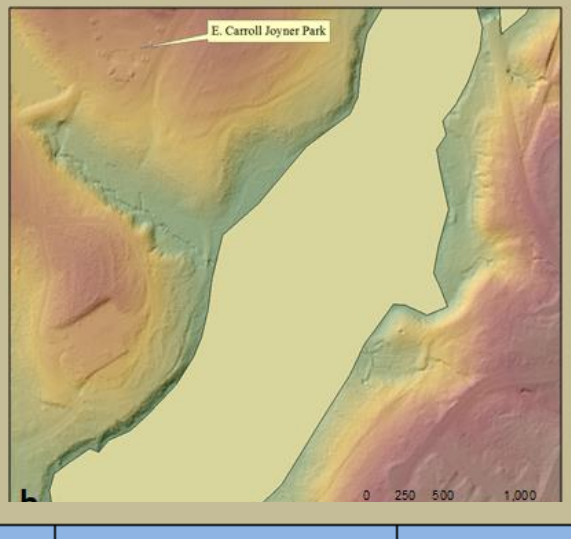
Calculating volumes

B.) DEM total volume of legacy sediment remaining

Richland Creek valley bottom



Flood Plain Vol.



Vol. removed by creek

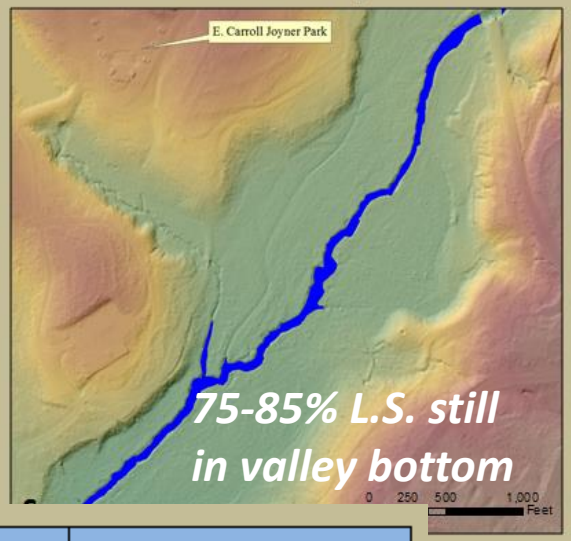


Figure 4 generat) Polygon

Sediment Depth	.5 m	.75 m	1 m
Flood Plain Vol. (m^3)	786,624	1,179,935	1,573,247
Vol. removed by creek (m^3)	180,141	180,141	180,141
Vol. of Legacy Sediment Remaining (m^3)	606,483	999,795	1,393,106

Table 1: Calculations estimating total legacy sediment remaining within the Richland Creek floodplain

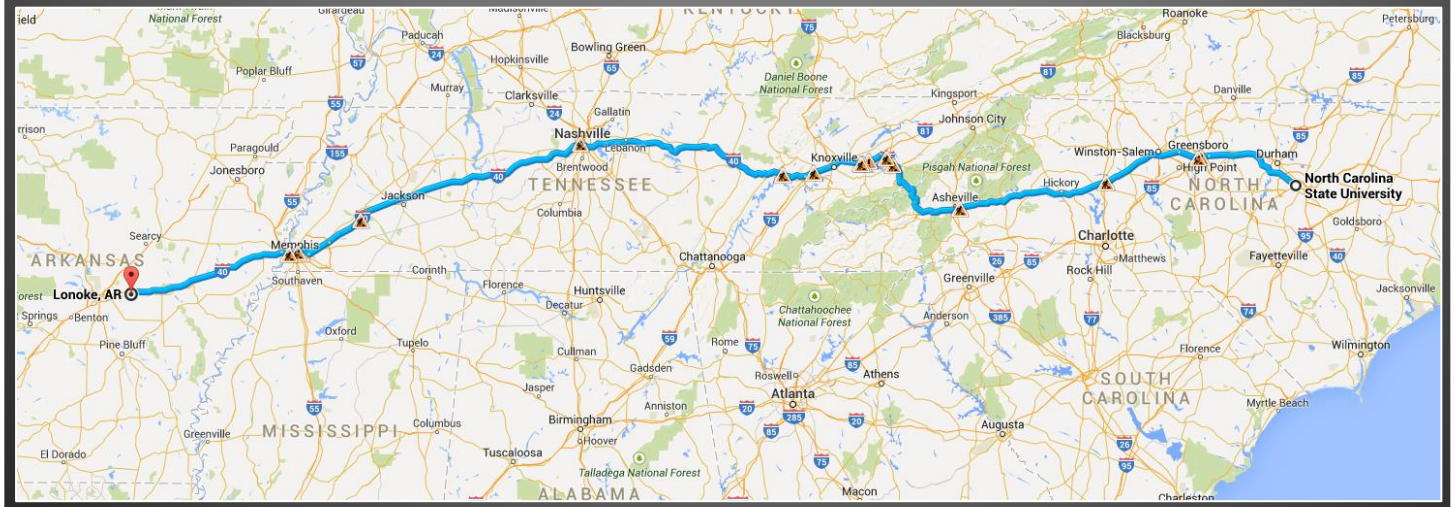
Putting this into perspective…
A standard 35-ft long, 3-axel dump truck holds 7.5 m^3 of earth materials

Photo source: http://www.lapinetrucks.com/processprodlinesearch.asp?strListedProdLines=DUM

It would require <u>130,000</u> dump trucks loads to contain the volume of Legacy Sediment still stored in the valley bottom of Richland Creek, a typical Piedmont tributary stream

Putting this into perspective…

× 130,000 Dump Trucks



Dump Truck-traffic jam on I-40 would extend from Raleigh to Arkansas

Conclusions

- Post-Colonial forest clearing and agricultural practices led to rapid erosion of upland soils, almost 100x the long-term background rate of soil production and erosion.

- Yet Piedmont streams only exported ~ 6% of the eroded upland material
  - (Trimble, 1977; Phillips, 1992, 1993; Reusser et al. 2015)

- Eroded sediments still remains as legacy sediment stored at the base of hillslopes and along valley bottoms. Locally, milldams trapped large volumes of these sediments.

Conclusions

- The present-day erosion of this legacy sediment is contributing significantly to non-point source total suspended solids loads and persistent stream water quality problems.

- At current sediment export rates, the remobilization of legacy sediment will remain a water quality problem for centuries to millennia (e.g. Jackson et al., 2005).