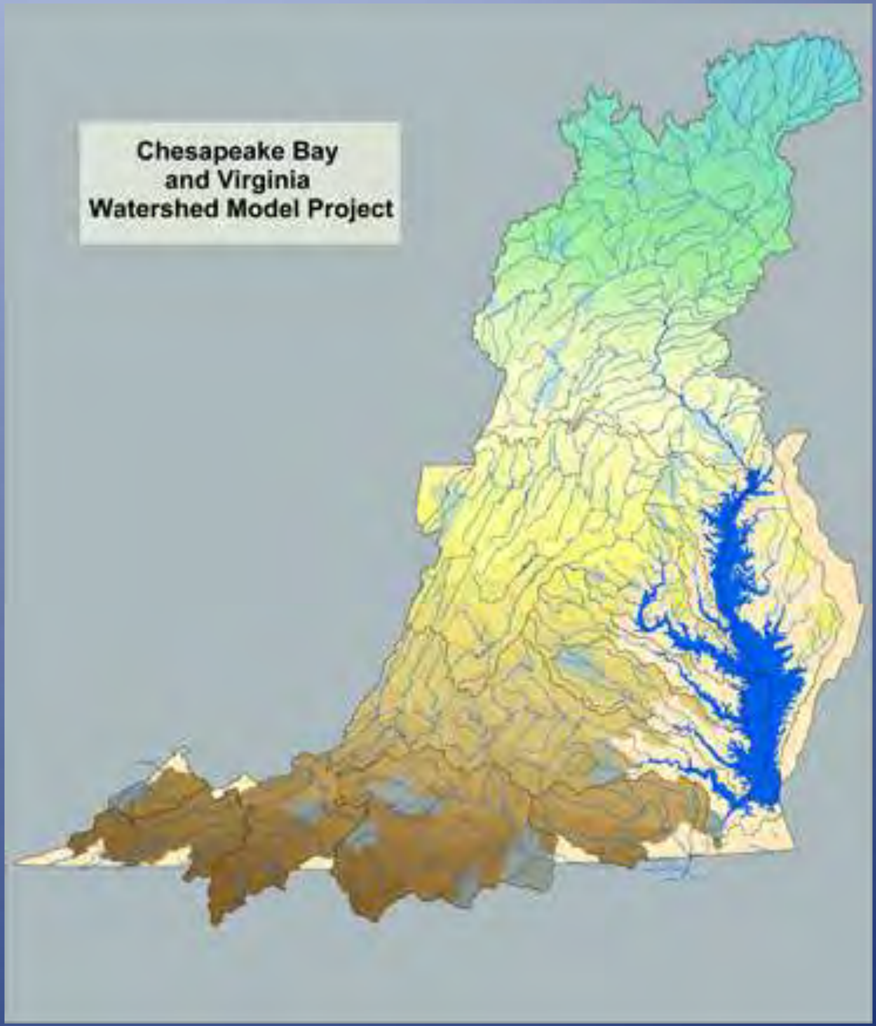
Rates and Patterns of Particle Transport in Piedmont Watersheds: Why Restoration May not Improve Estuaries Downstream

Jim Pizzuto
Michael O'Neal
Diana Karwan (NSF post-doctoral fellow)
Tobi Ackerman (PhD candidate)
Adam Pearson (PhD candidate)
Elyse Williamson (MS Candidate)
Dept. of Geological Sciences
University of Delaware

Rolf Aalto
University of Exeter, UK

The Research Question

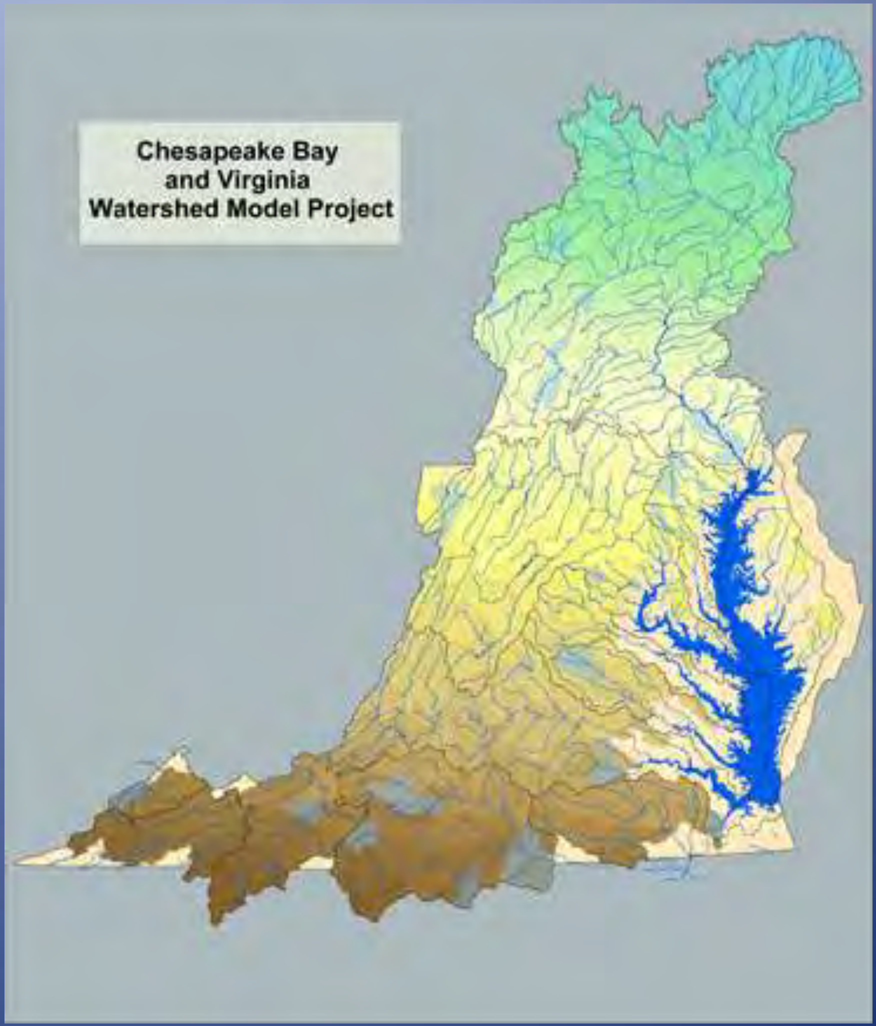
How do particles supplied from hillslopes to stream channels move through watersheds to estuaries downstream?



Why is it Important?

How long does it take for "upland" best management practice to make a difference downstream?

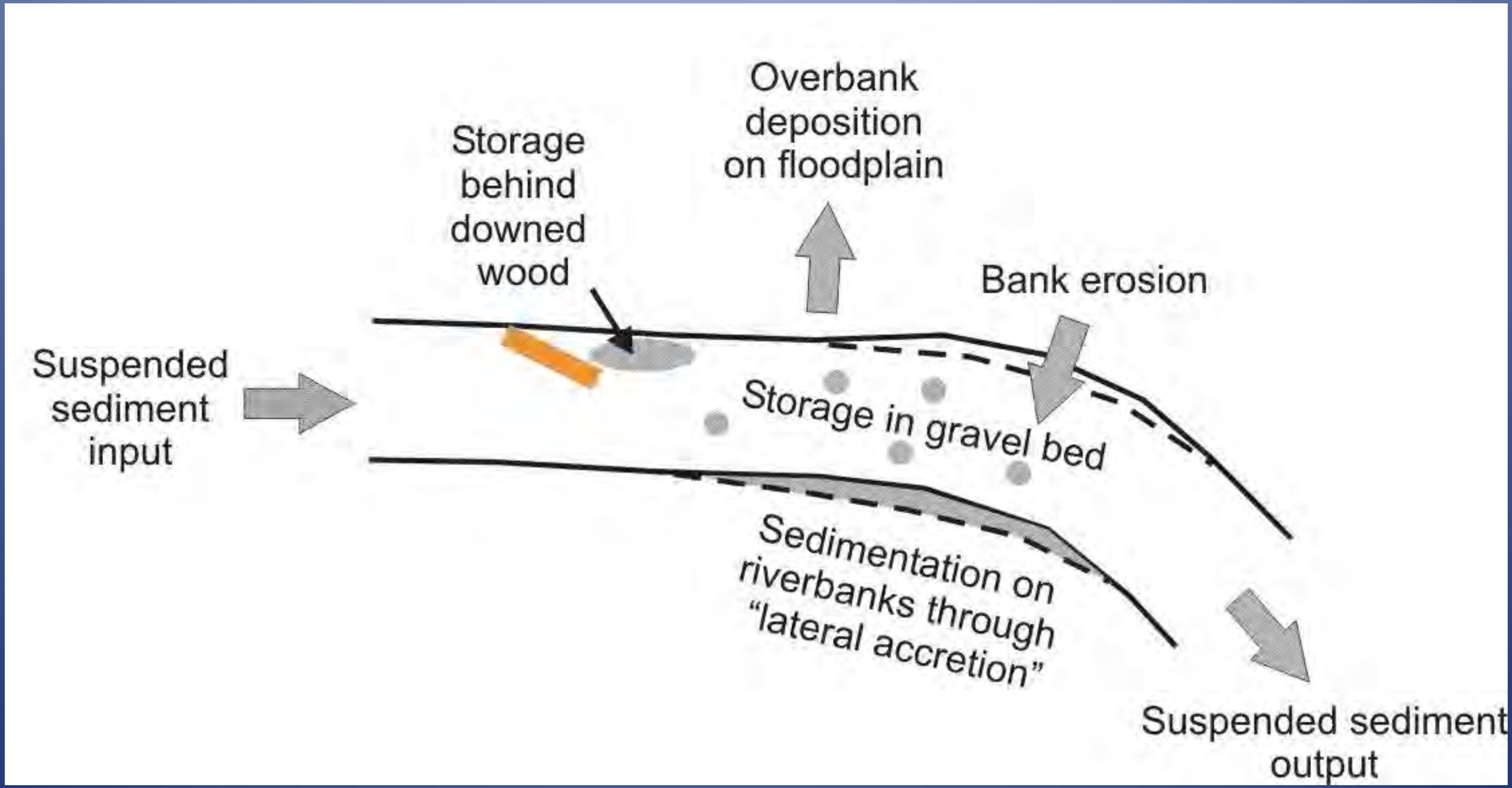
Example: efforts to reduce nutrient (P) and sediment loading to the Chesapeake Bay through best management practices on agricultural fields



Fate of Particles in Transport

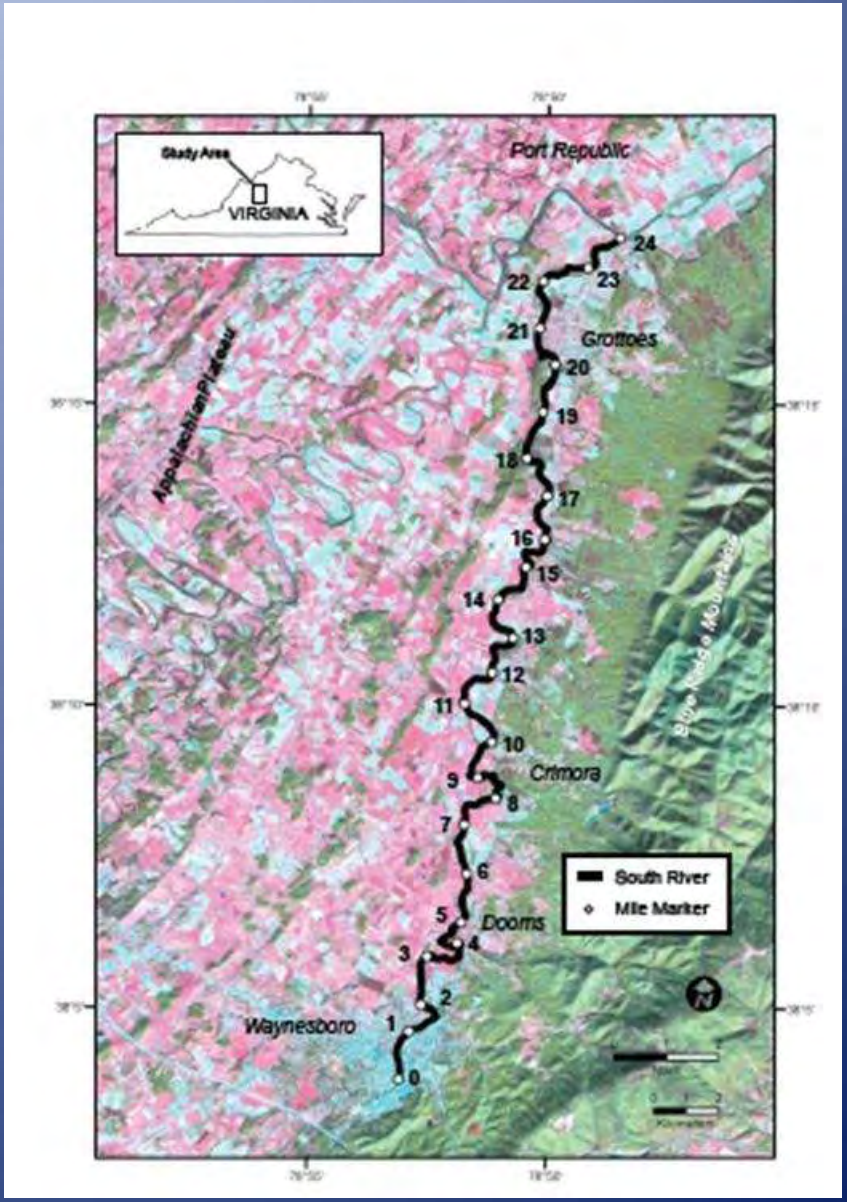
- Particles are not simply transported downstream
- They can be STORED along river corridors
  - Floodplains
  - Behind downed trees and other debris
    - "fine-grained channel margin deposits"
  - Within the gravel stream bed
    - Hyporheic zone

Particle Pathways In A River Reach

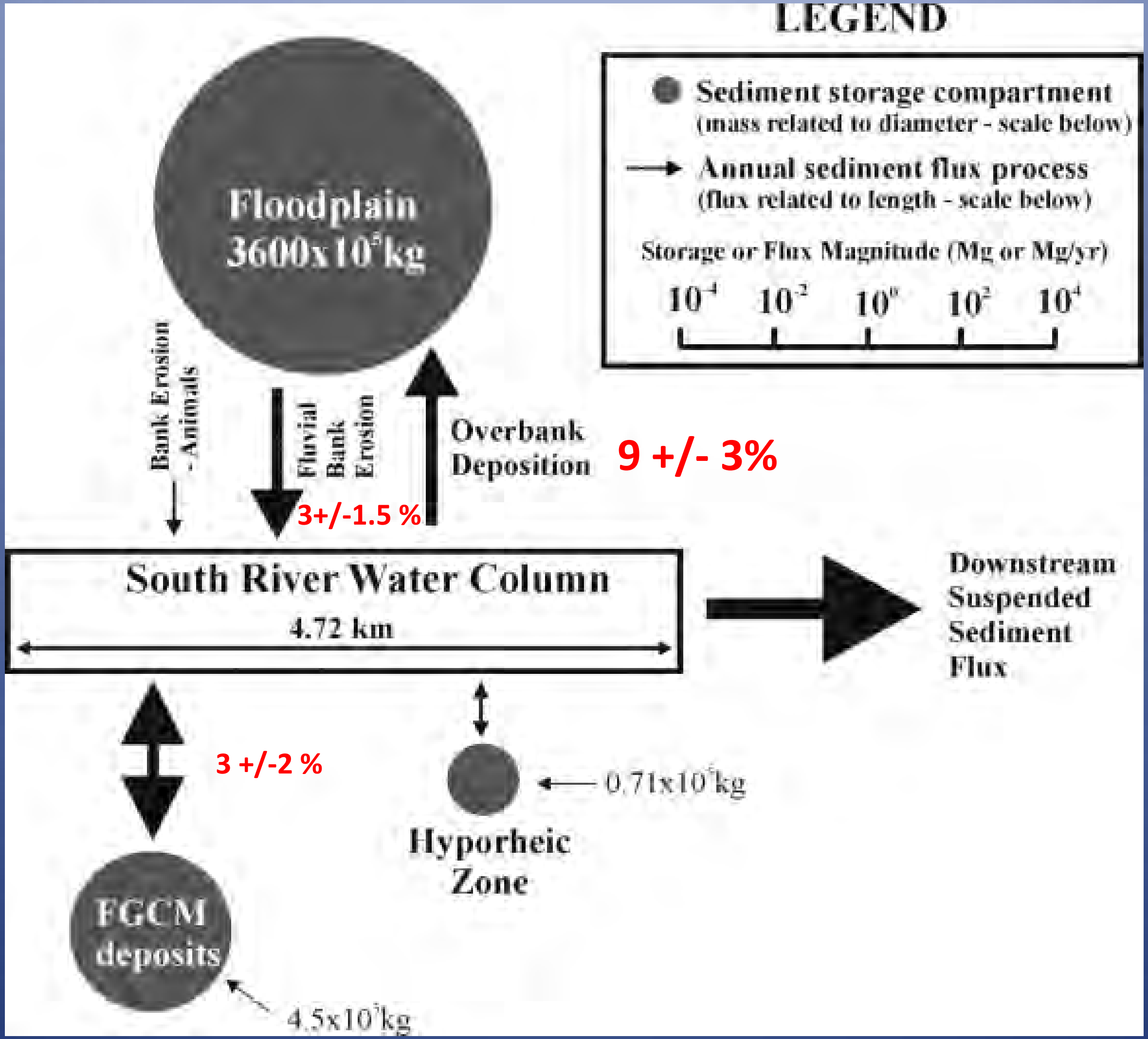


These need to be QUANTIFIED!!

Evidence From the South River, VA



By % of Annual Suspended Sediment Load…



The Exchange Rate of Suspended Sediment

- Fraction of suspended sediment load exchanged with sediment in storage = *0.022 +/- 0.10 per km*

Distance Required To Exchange 100% of the Load with Stored Sediment

- Fraction of suspended sediment load exchanged with sediment in storage = *0.022 +/- 0.10 per km*
- *This is the inverse of the exchange rate = (1/0.022) = 46+/- 22 km*

Average Time Spent In Storage

- Average “storage time” = stored volume/exchange rate ….*4800+/- 2600 yrs*

Time and Spatially Averaged Transport Velocity

- = Exchange Length/Storage Time = 46 km/4800 yrs =

Time and Spatially Averaged Transport Velocity

- = Exchange Length/Storage Time = 46 km/4800 yrs =

9 +/- 7 m/yr

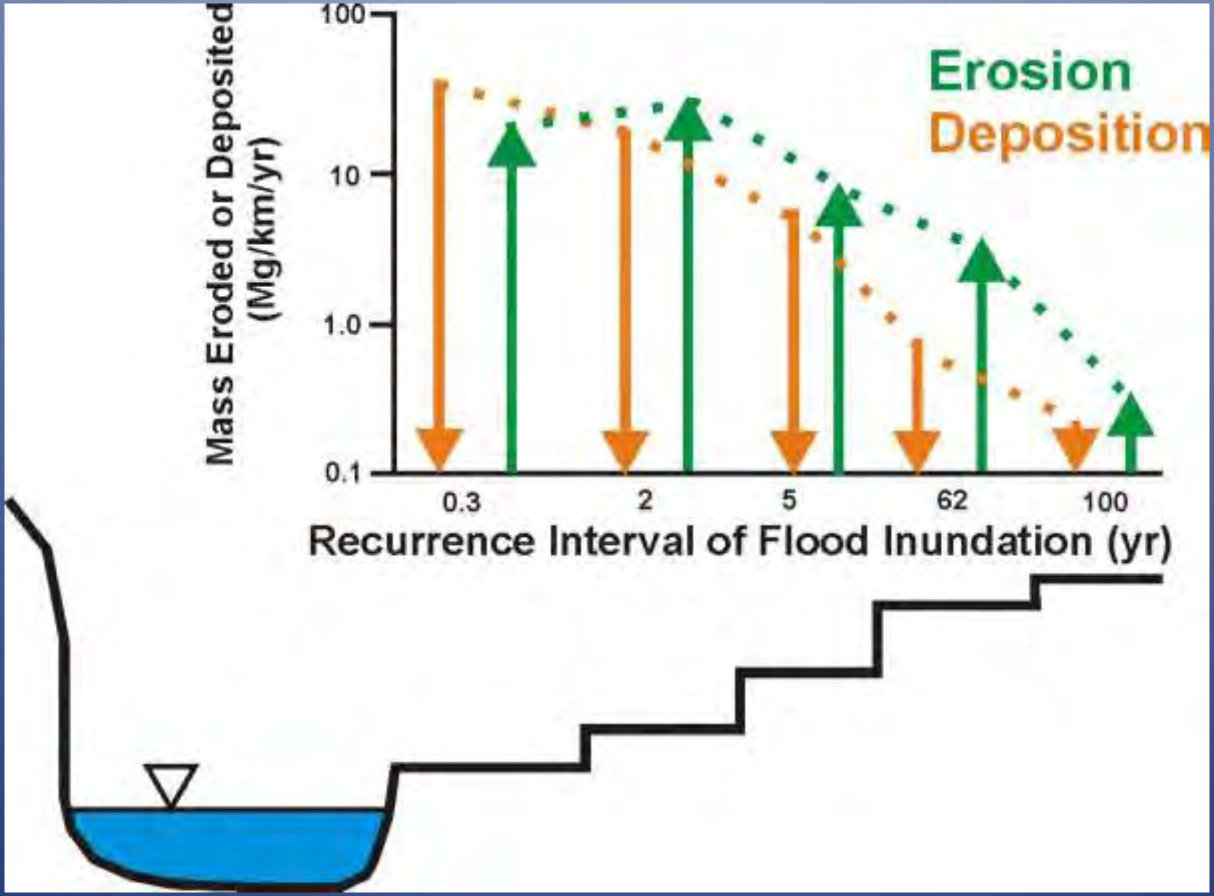
Ongoing Studies In The White Clay Creek Watershed

- ***Modeling particle trajectories through floodplains (probability approach)***
  - ***Toby Ackerman, PhD candidate***
- Time-averaged particle velocities by grain size near Stroud Center from sediment budgeting
  - Elyse Williamson, MS candidate
- Influence of Colonial mill dams on river sedimentation
  - Adam Pearson, PhD candidate
- Paleoenvironmental history of he Christina River estuary
  - Meg Christie, PhD candidate

Particles are Preferentially Deposited and Reworked From Low Lying Areas of Floodplains

- A result from modeling
  - Ackerman, 2012

Erosion and Deposition are Localized in Low-Lying, Frequently Inundated Areas of the South River's Floodplain



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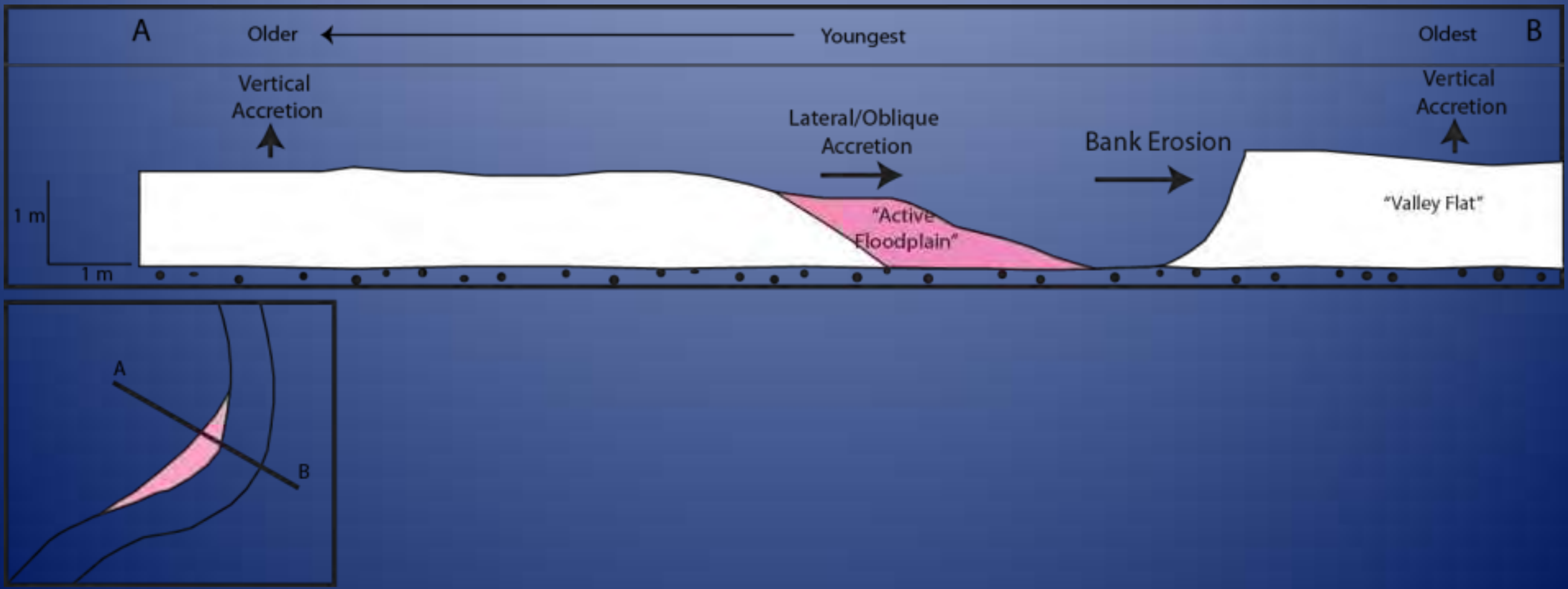
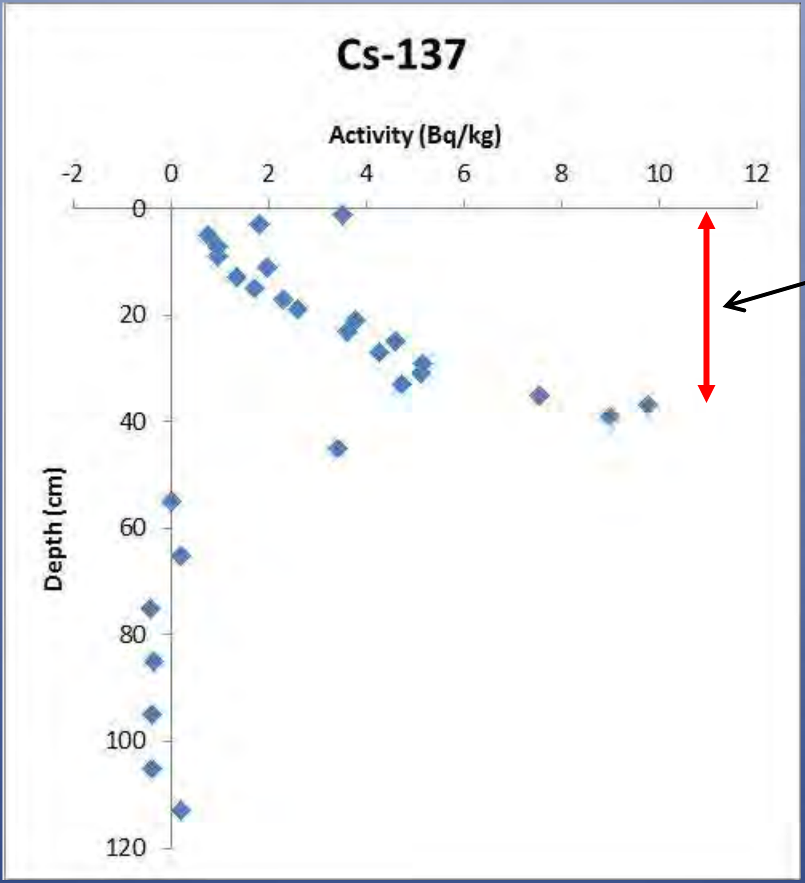
Objective 1: geomorphic model

- To identify important sediment sources and sinks.



Floodplain Accretion From Radioisotopes

Mostly provided by Dr. Rolf Aalto, Univesity of Exeter

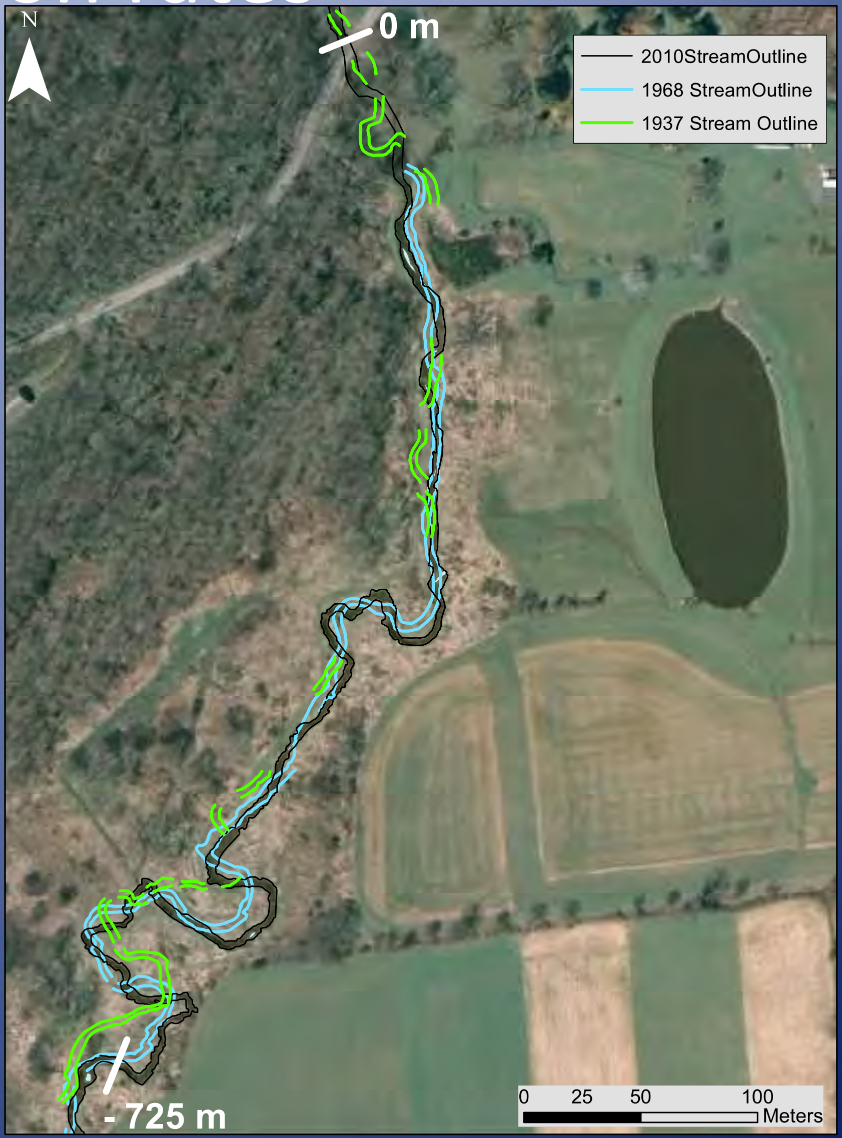


39 cm deposited since 1963

Data from Pearson, 2011

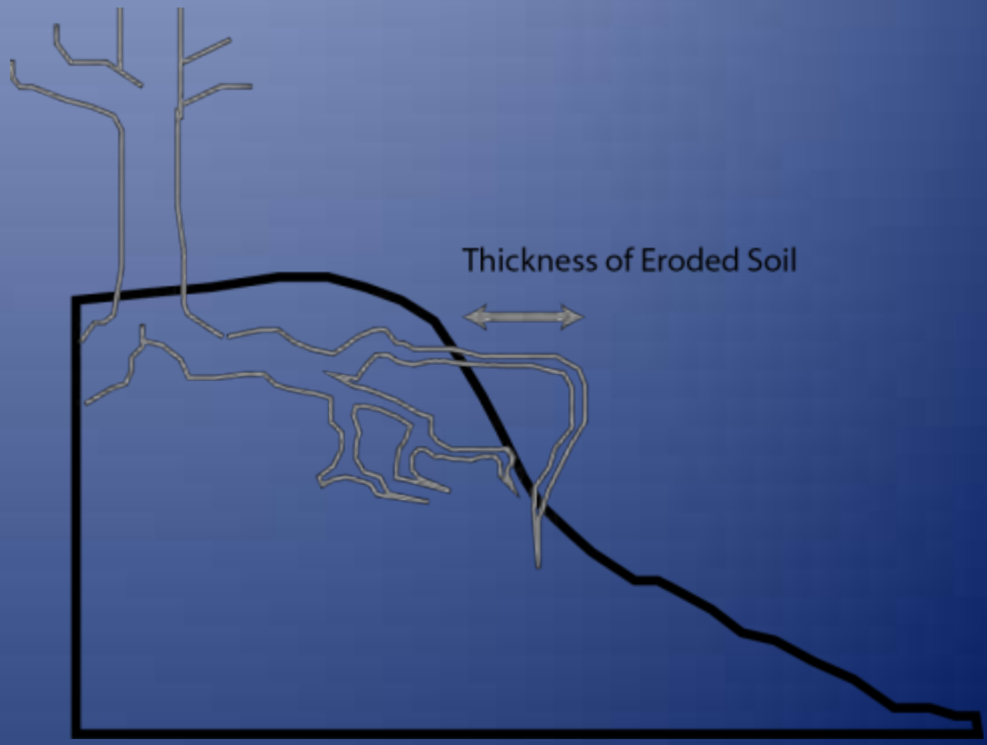
Objective 2: Sediment budget

Bank erosion rates



Bank erosion rates from tree roots

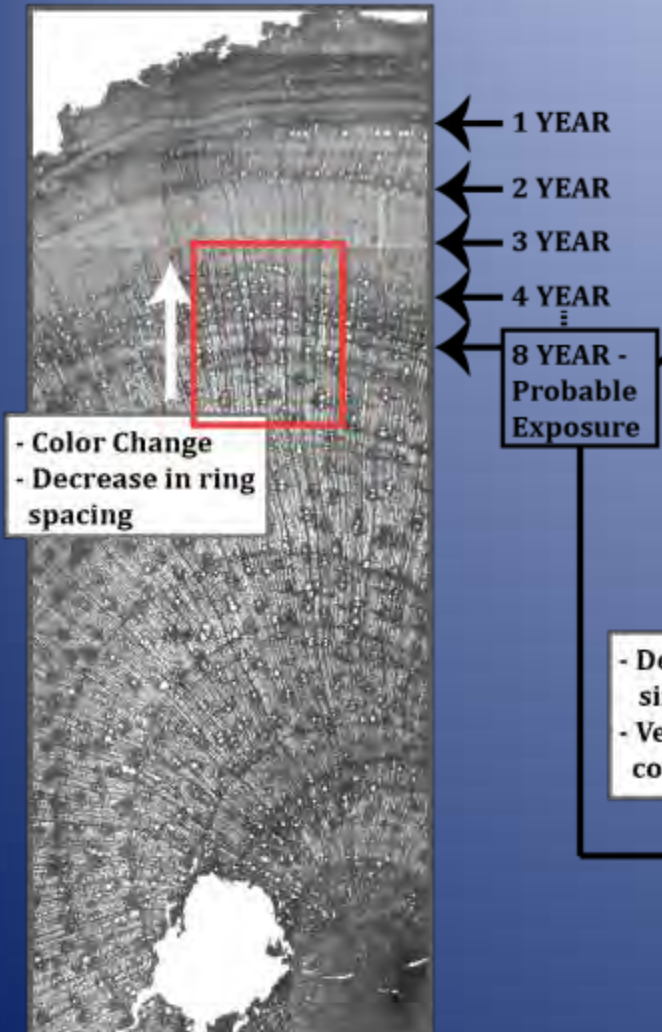
- Sampled 11 small, live, exposed roots
- Determine time of root exposure by identifying anatomical changes (Gartner *et al*., 2001)

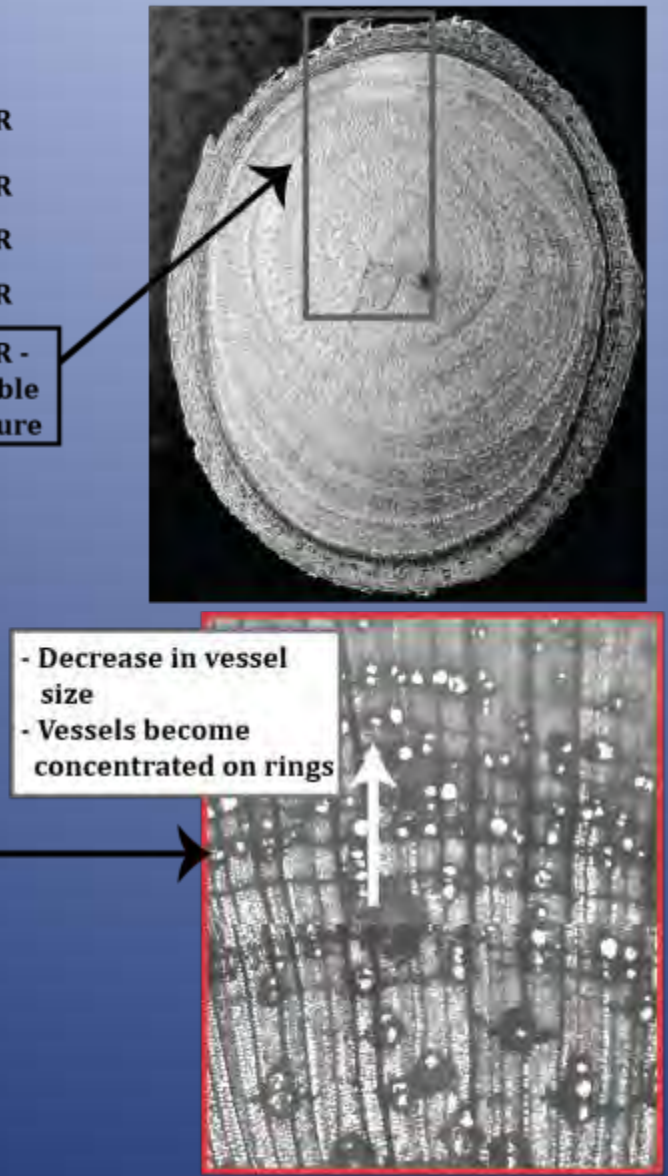


ASH

Thickness of Eroded Soil: 30 cm

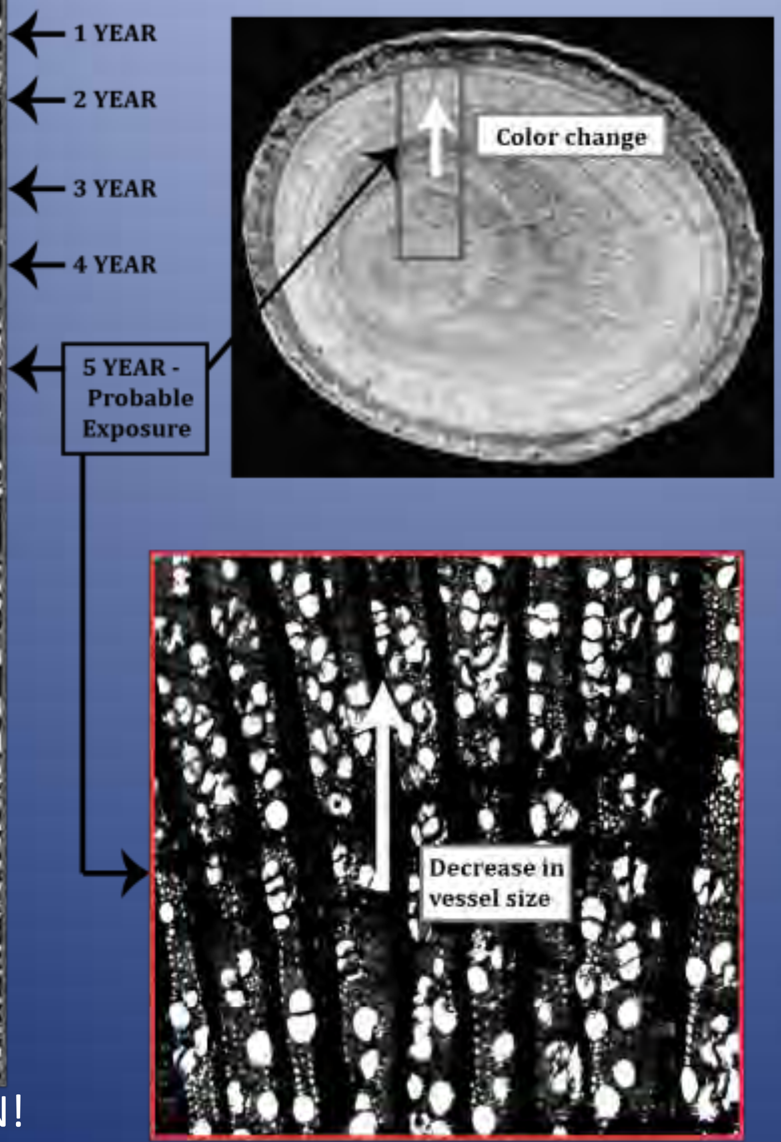
Erosion Rate: 3.8 cm/yr





THANK YOU SEAN!

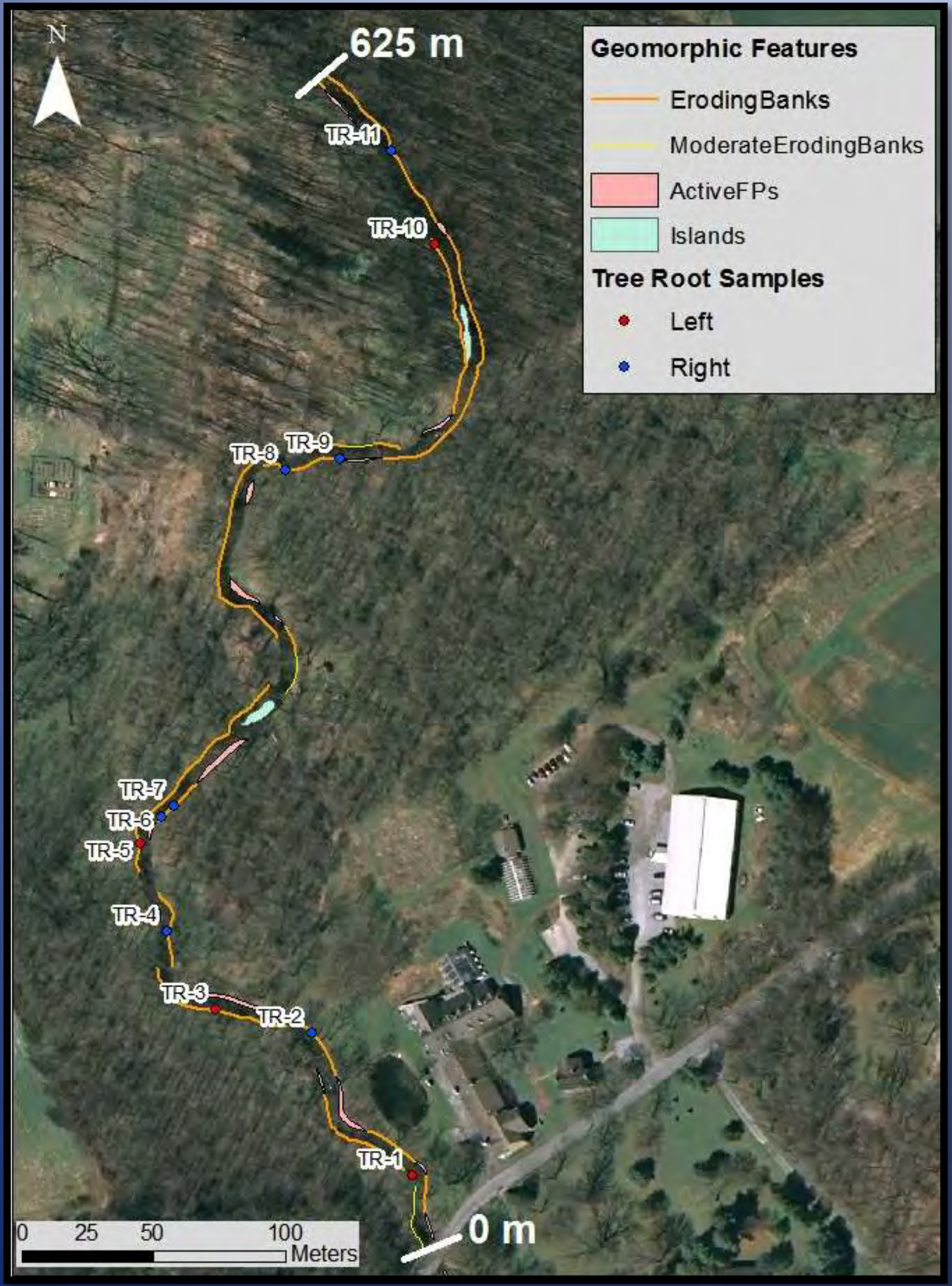
TULIP POPLAR



Thickness of
Eroded Soil: 22.9 cm

Erosion Rate: 4.6 cm/year

THANK YOU SEAN!



- Extrapolate erosion rates to non-sampled eroding banks
- Correlate erosion rate and curvature

Storm Sampling

- Difference in grain size between suspended sediment and stored sediment?
- Fraction of sediment minimally held in storage?

- Sediment Traps
  - Collect samples during storm event
- Compare to suspended sediment samples

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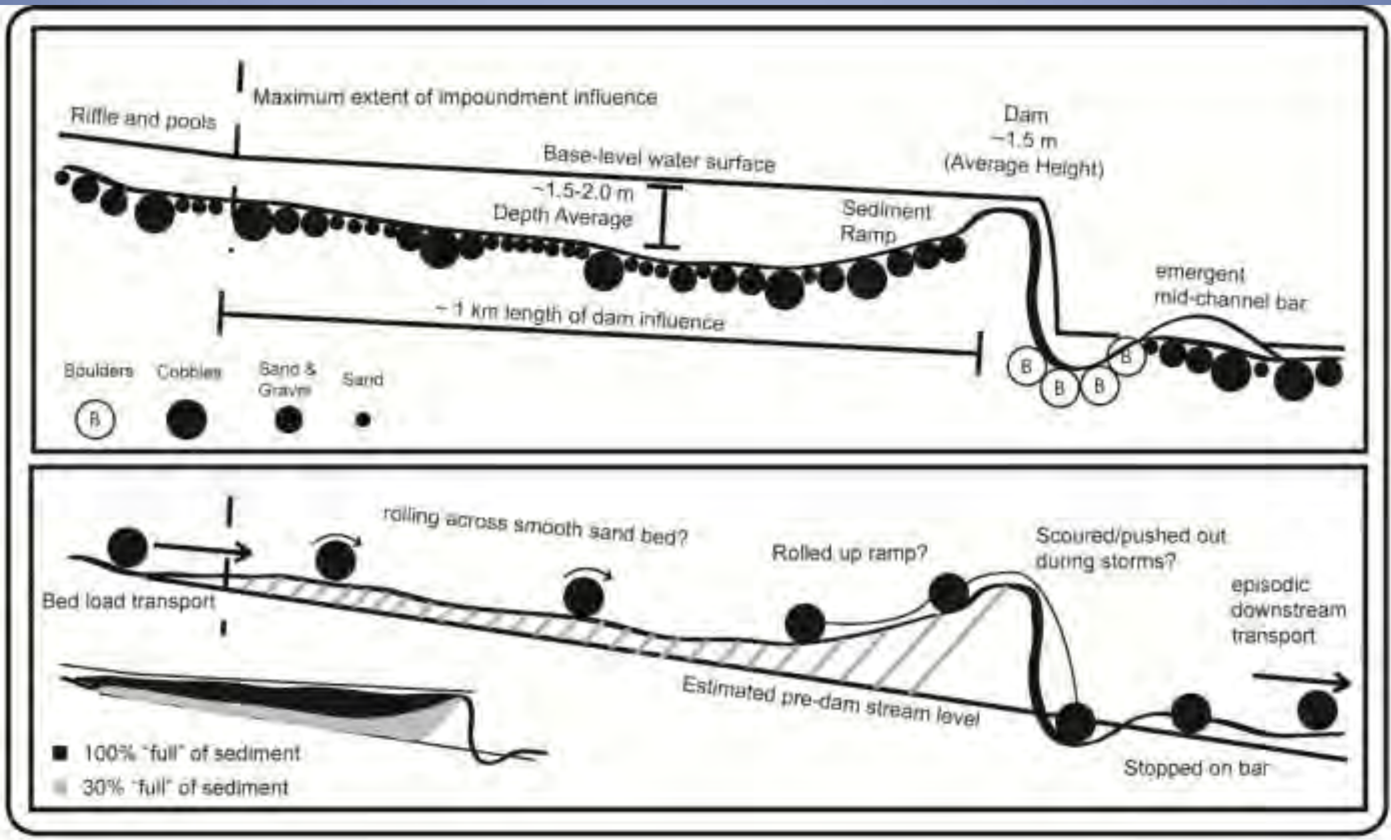
Effects of Mill Dams

- Existing impoundments do not trap much sediment
  - Only ~30% "full"
  - bars downstream composed of sand and gravel suggest that even large grains can be transported through impoundments
- Hypothesis:
  - Impoundments fill until sediment can be transported through during storm flows

Summary of Field Observations and a Conceptual Model for Impoundment Geomorphology



Pearson, et al. 2011

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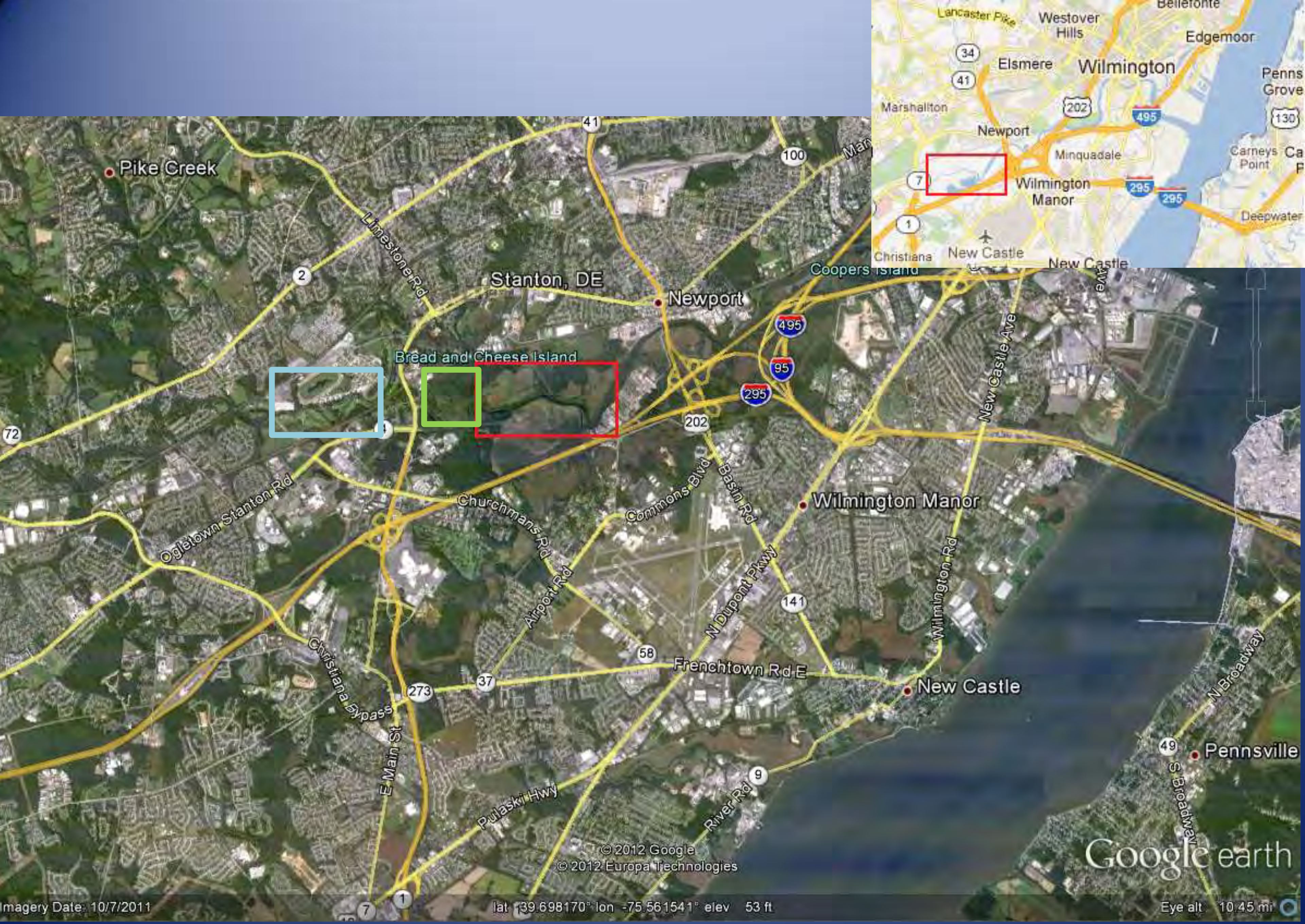
- Influence of Colonial mill dams on river sedimentation
  - Adam Pearson, PhD candidate
- ***Paleoenvironmental history of the Christina River estuary***
  - ***Document natural vs anthropogenic factors controlling its evolution***
  - ***Meg Christie, PhD candidate***


Pike Creek
Limestone Rd
Stanton, DE
Newport
Bread and Cheese Island
Coopers Island
Ogletown Stanton Rd
Churchmans Rd
Commons Blvd
Basin Rd
Wilmington Manor
New Castle Ave
Airport Rd
N Dupont Pkwy
Wilmington Rd
Frenchtown Rd E
New Castle
Christiana Bypass
E Main St
Pulaski Hwy
River Rd
N Broadway
S Broadway
Pennsville
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Imagery Date: 10/7/2011
lat 39.698170° lon -75.561541° elev 53 ft
Eye alt 10.45 mi
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Lancaster Pike
Westover Hills
Bellefonte
Edgemoor
Elsmere
Wilmington
Penns Grove
Marshallton
Newport
Minquadale
Carneys Point
Wilmington Manor
Deepwater
Christiana
New Castle


First State Blvd
Bread and Cheese Island
Core 2
Core 1
Core 4
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lat 39.701104° lon -75.627633° elev 9 ft
Eye alt 6956 ft

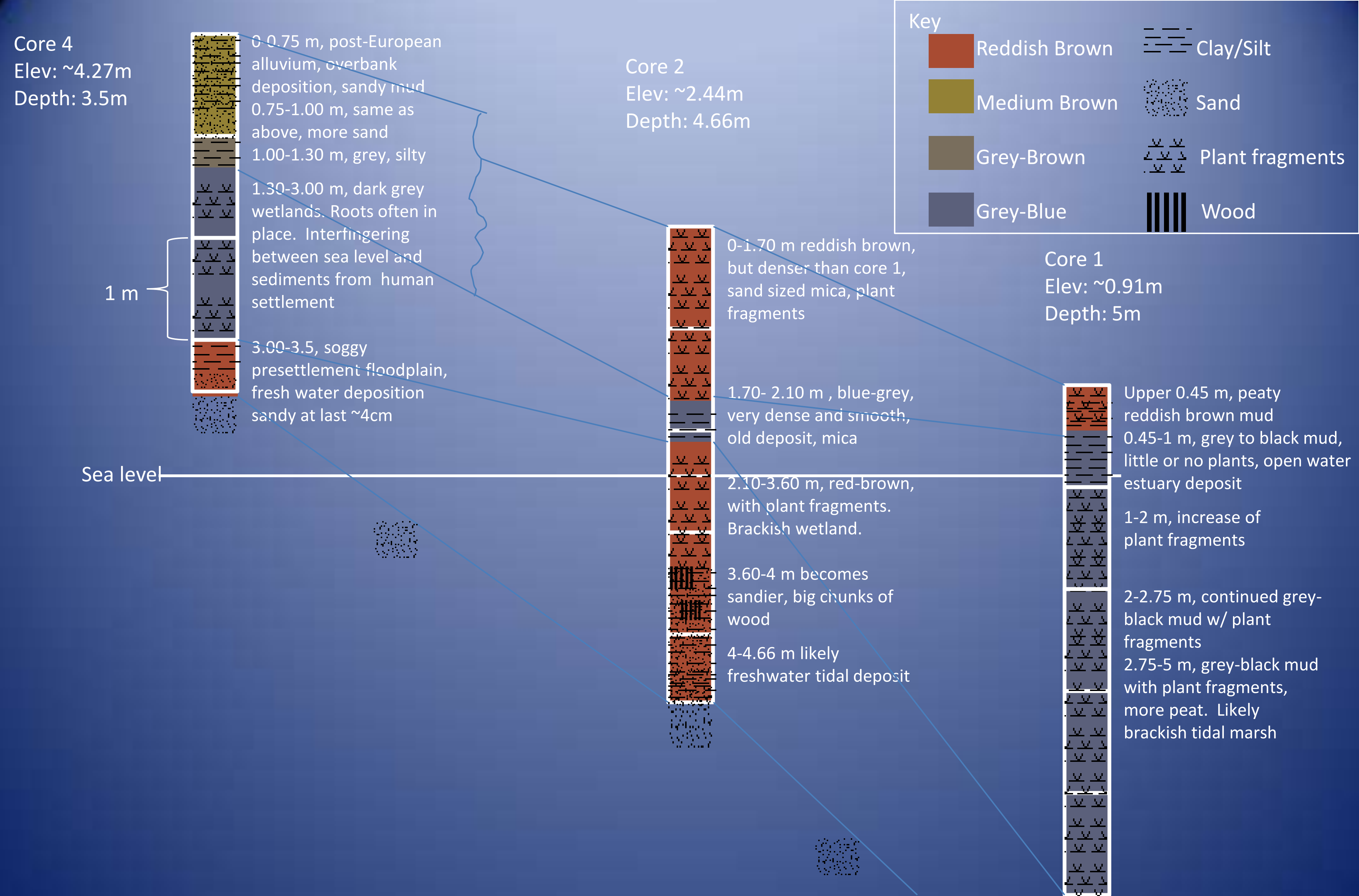

Figure 1: Diagram of exploratory core samples. These cores indicate an interfingering between sediments related to sea level changes and sediments related to settlement. Additionally, they indicate that prior to settlement, the area was comprised of brackish to fresh wetlands, with the brackish wetlands being tidal, and the fresh water wetlands being likely tidal, but possible non-tidal. Elevations from Google Earth.

Any Questions?