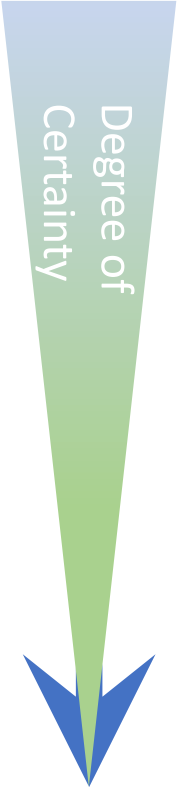
Freshwater-Tidal Gradients: Eco-geomorphology Linkages to Watershed-Estuarine Dynamics

Kathy Boomer (The Nature Conservancy)

Scott Ensign (Stroud Research)

Greg Noe (USGS)

Concluding Speculations:
It's all about micro-topography/bathymetry!



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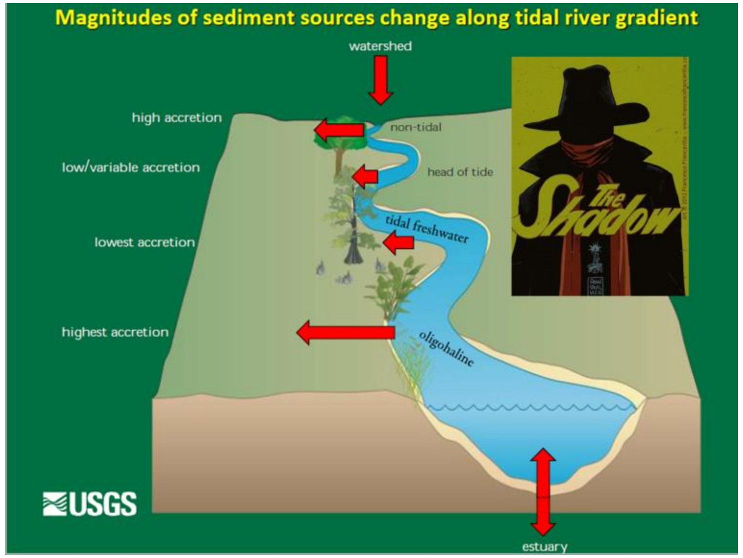
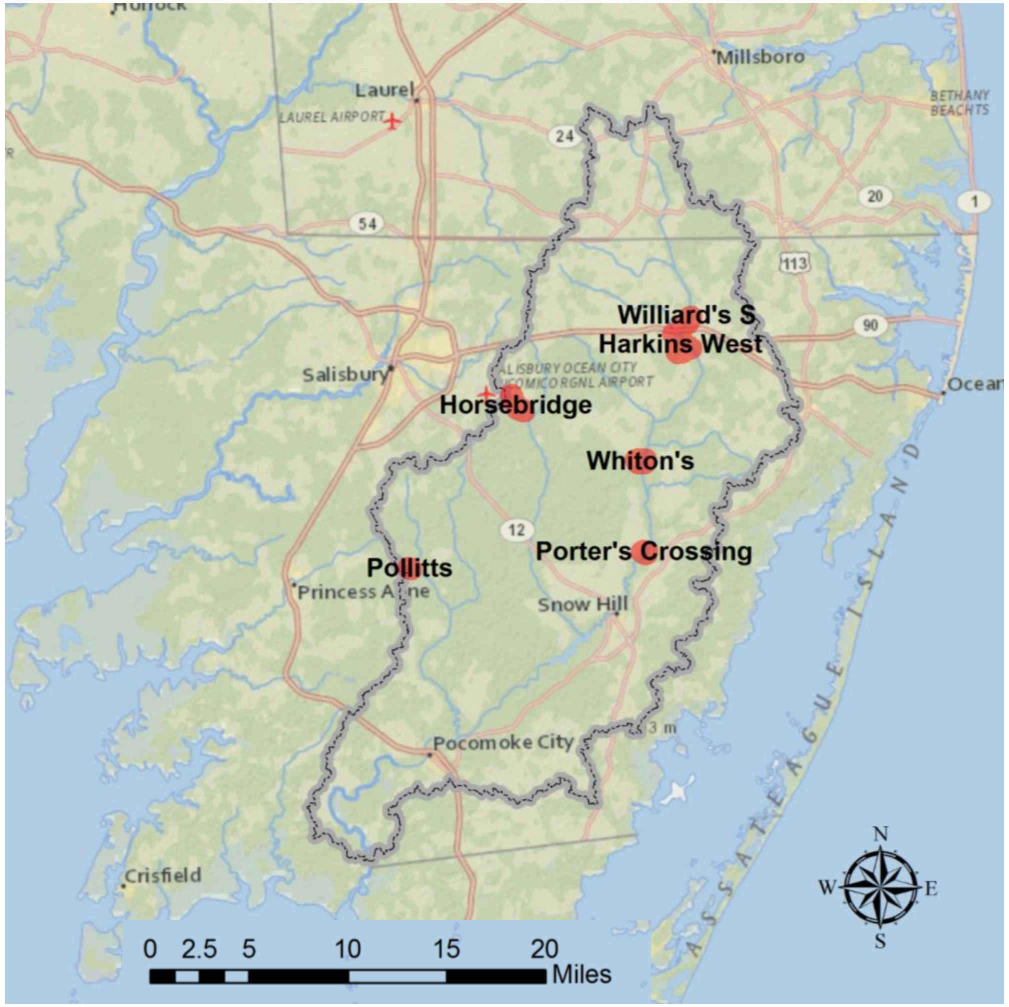
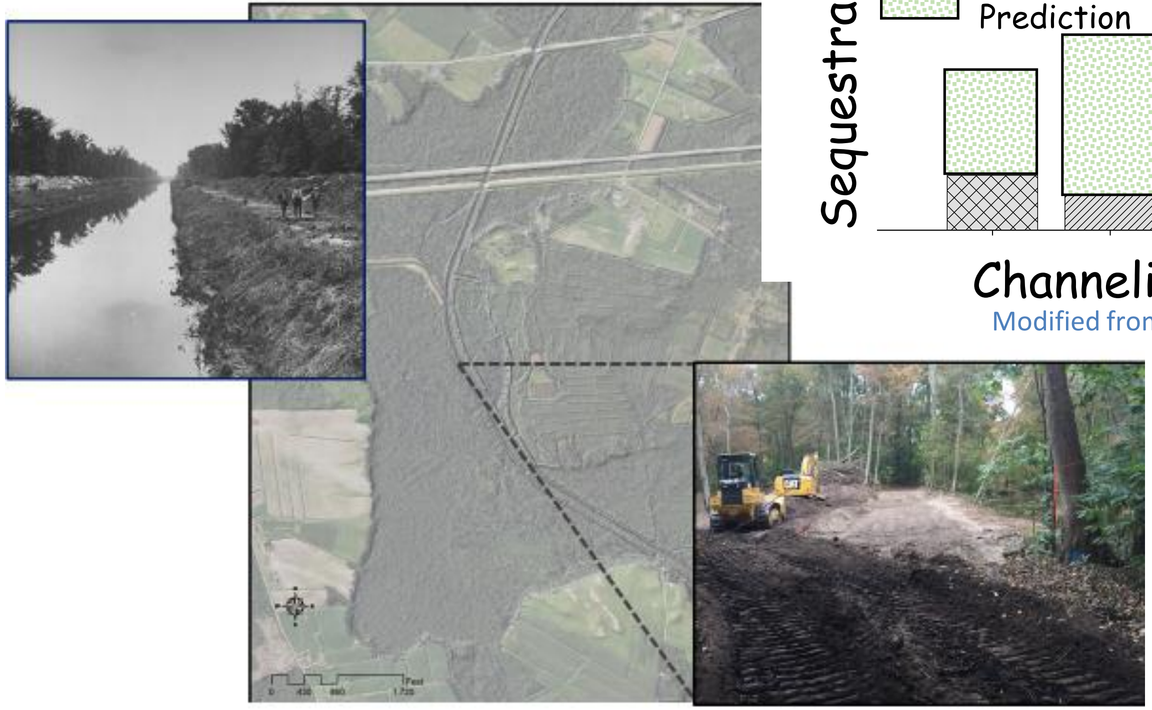
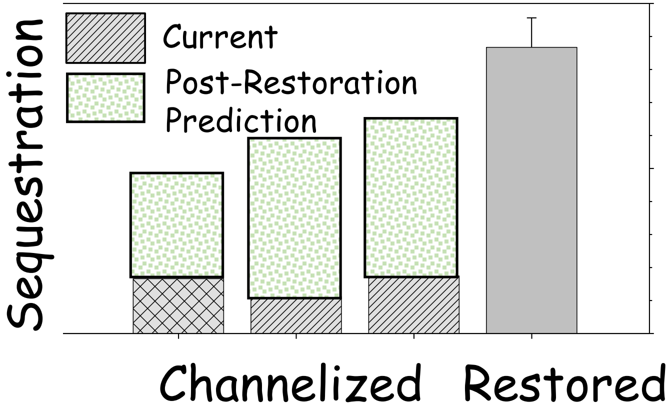


Background: Floodplain Function along the Pocomoke







Modified from Noe and Hupp (2005)

Site (Location)	Floodplain Area (km^2)	Watershed Area / Local Contributing Area (km^2)
Channelized headwater	0.02	5.5/0.7
Channelized mainstem	0.2	152 / 1
Restored headwater	0.2	7 / 0.6
Restored mainstem	1.5	145/6.7
Restored mainstem	0.9	213 / 4.3
Natural mainstem	0.1	505 / 0.2

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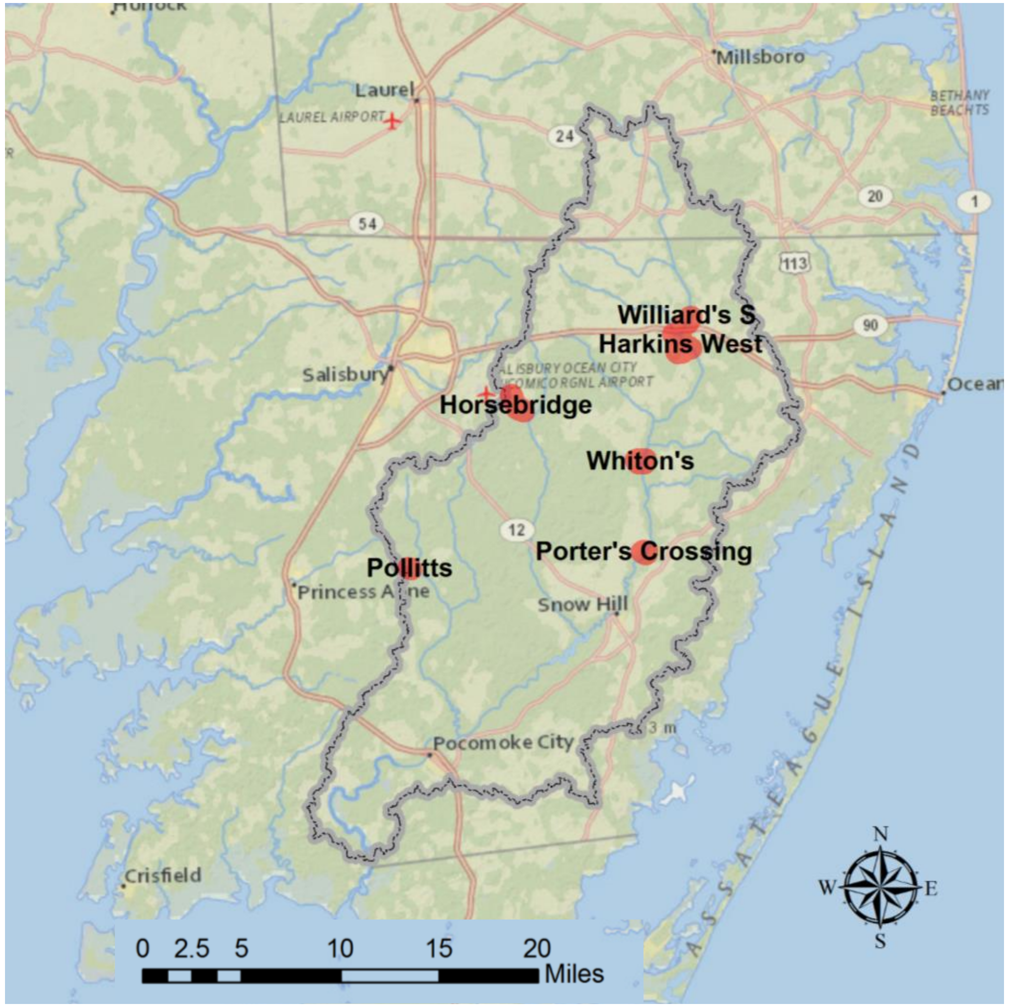

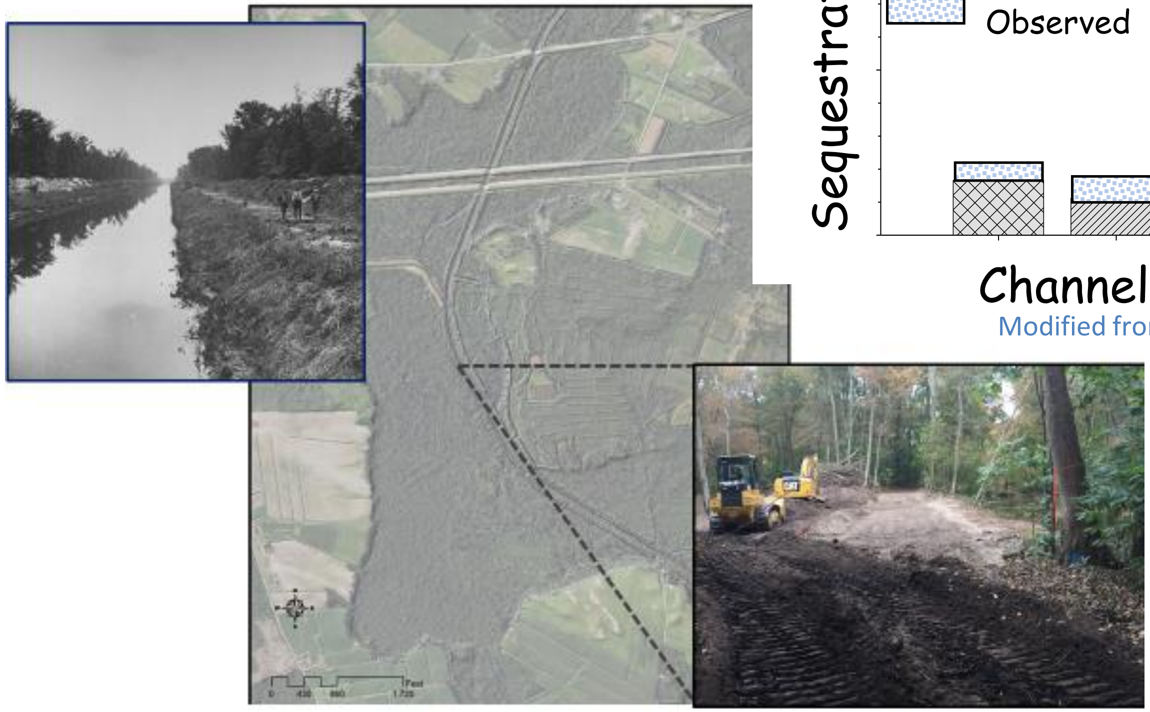

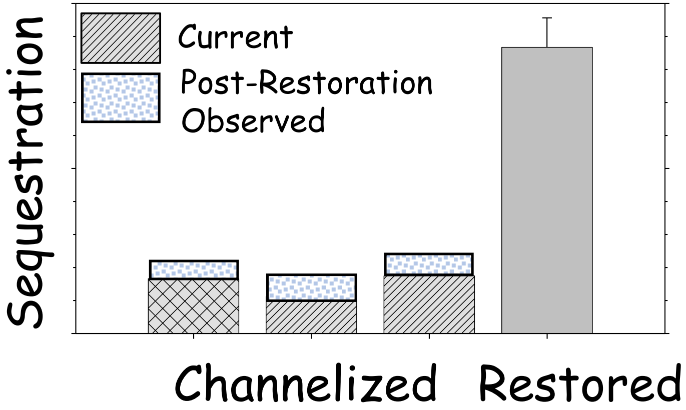

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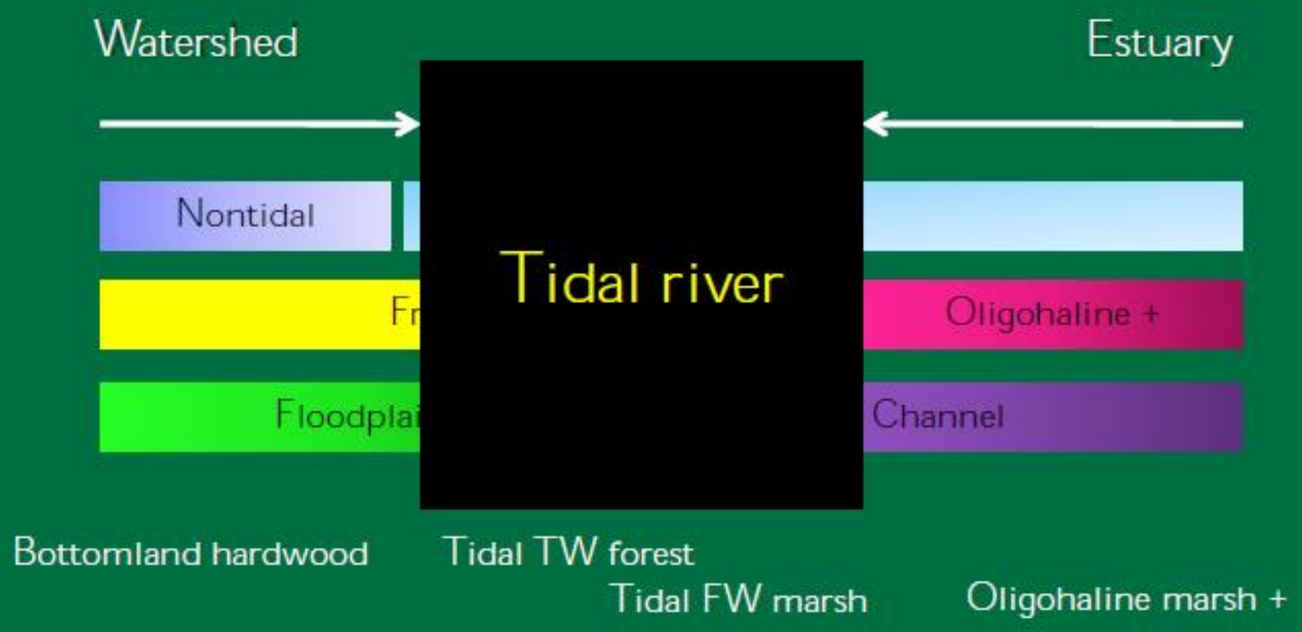
How do watersheds and estuaries control eco-geomorphic responses to sea-level rise?

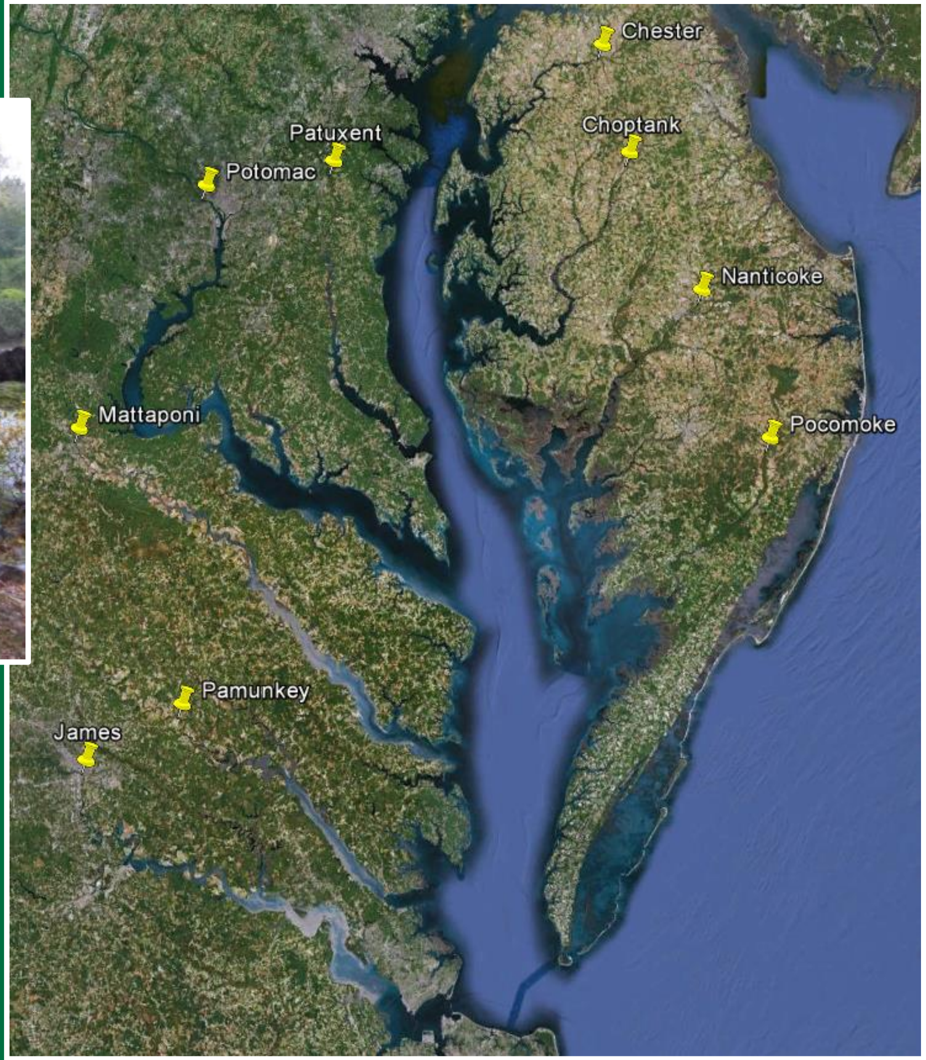


Sediment delivery from the watershed to the Chesapeake Bay: the *Sediment Shadow* in tidal freshwater rivers

Gregory B. Noe[1], Jaimie Gillespie[1], Cliff R. Hupp[1], Ken Krauss[2], Scott Ensign[3]

USGS science for a changing world

The tidal freshwater rivers and wetlands extend far upstream from the saline portion of the estuaries.



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METHODS Sediment accretion was measured along the tidal freshwater through oligohaline estuary on four rivers.

Piedmont versus Coastal Plain River

progressive versus standing waves

USGS

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progressive versus standing waves

USGS

Review of methodologies:

	Savannah	Waccamaw	Choptank	Pocomoke
water level	not presented	not presented	surface flooding	surface flooding
sediment accretion	marker pad (~2 yr)	marker pad (~ 2 yr)	marker pad (~1 yr) ^{137}Cs(48 yr)	marker pad (~1 yr) ^{137}Cs (48 yr)
C and N accumulation	not presented	not presented	tile (~1 yr) ^{137}Cs (48 yr)	tile (~1 yr) ^{137}Cs (48 yr)
vegetation production	leaf fall emergent plants	tree litter fall emergent plants	not measured	not measured
velocity	not measured	not measured	ADCP	ADCP
suspended sediment	not measured	not measured	filtration ADCP backscatter	filtration ADCP backscatter

Backscatter signal strength from ADCPs was used to predict suspended sediment concentration.

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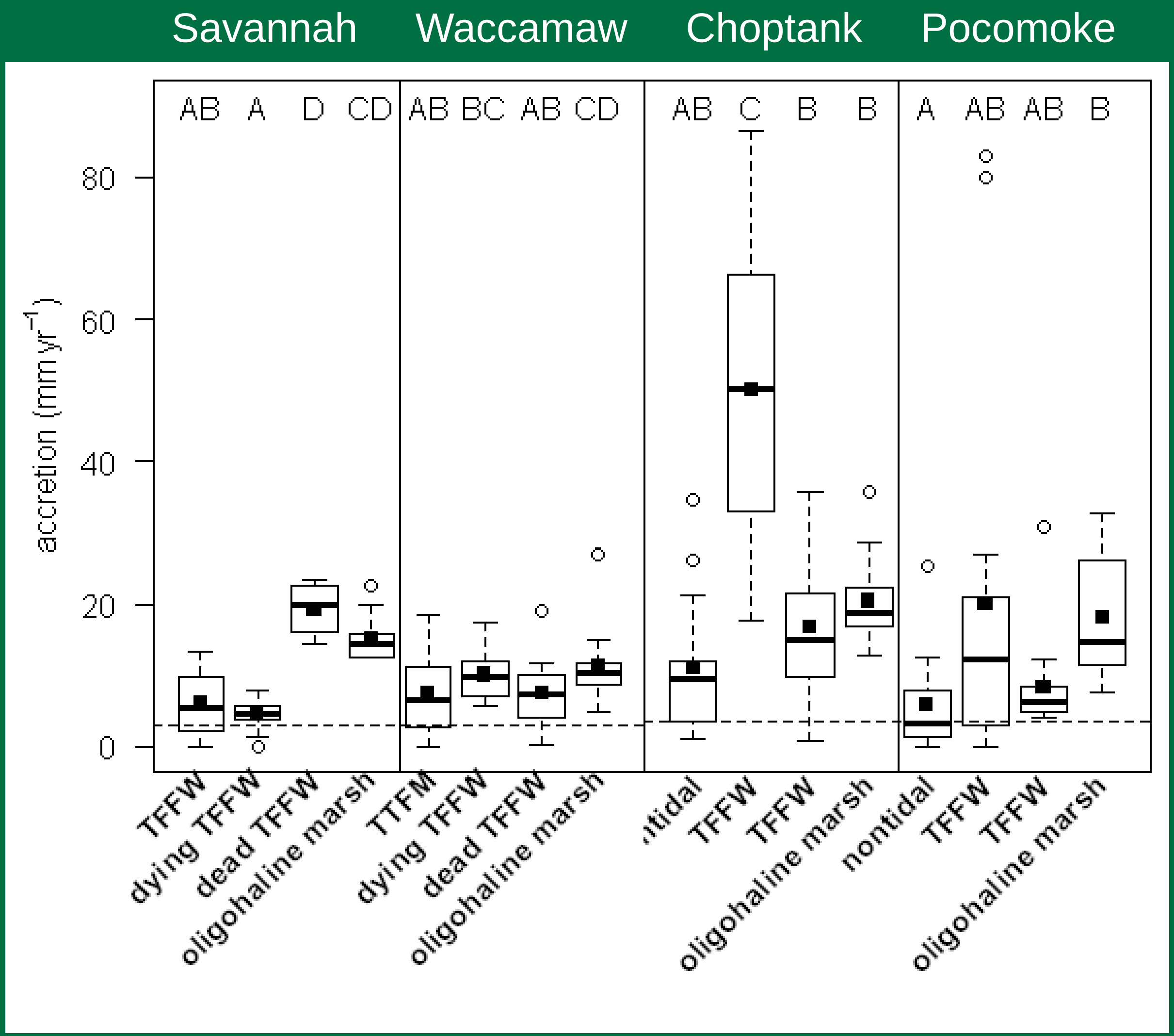
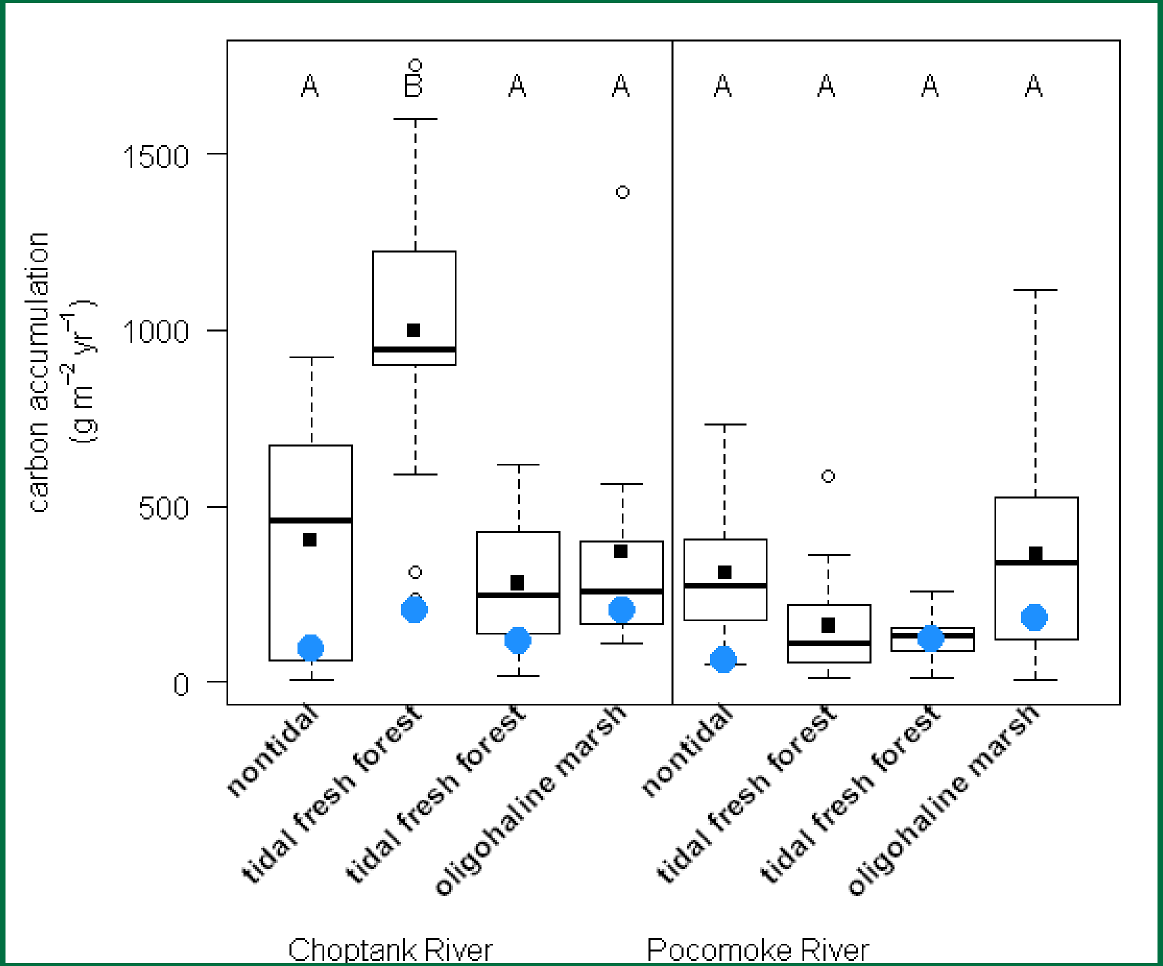
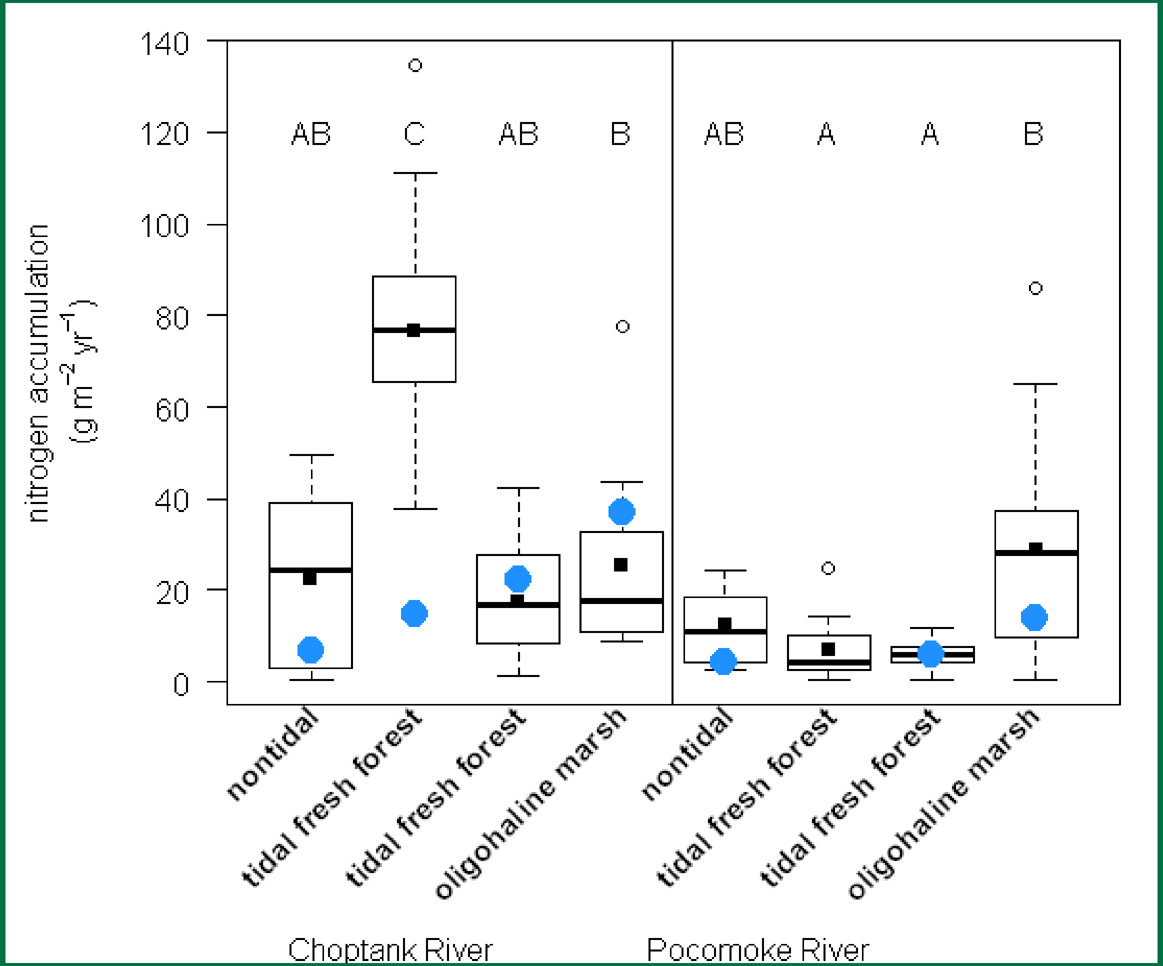
Sediment accretion was highest at the upper extent of tidal influence and in the oligohaline marshes.



Carbon accumulation was greatest at the head-of-tide and oligohaline marsh.



Nitrogen accumulation was greatest at the head-of-tide and in oligohaline marshes.



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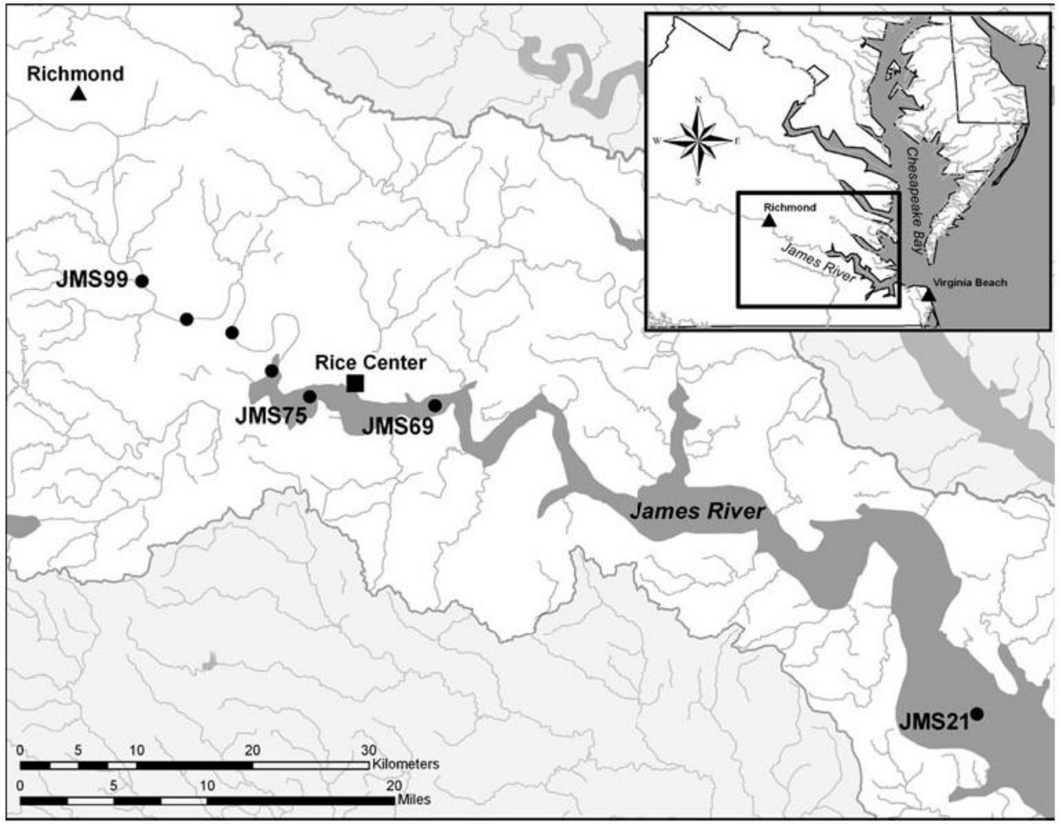
1. Tidal freshwater river corridors provide critical river-estuarine linkage.



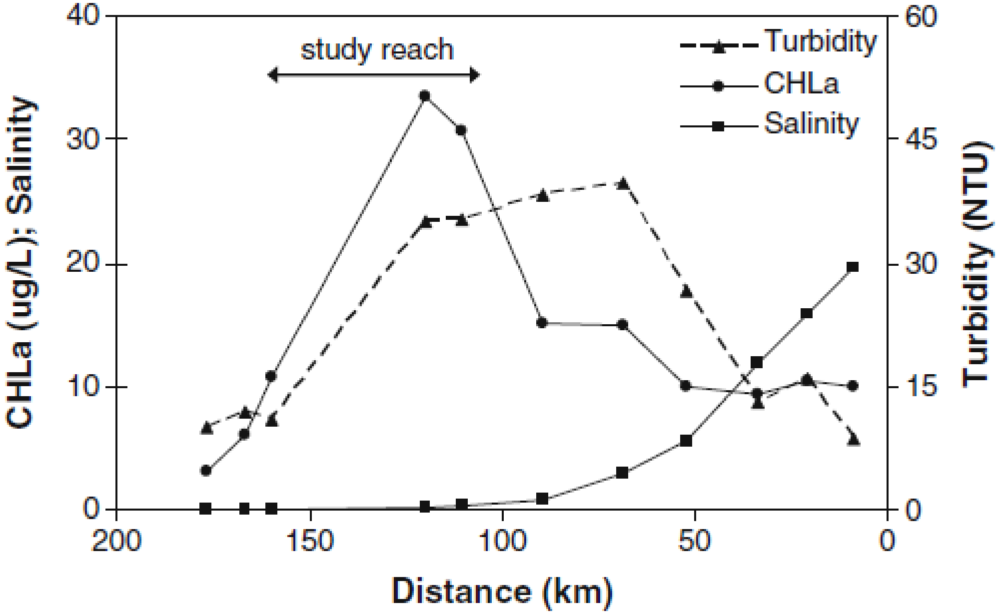
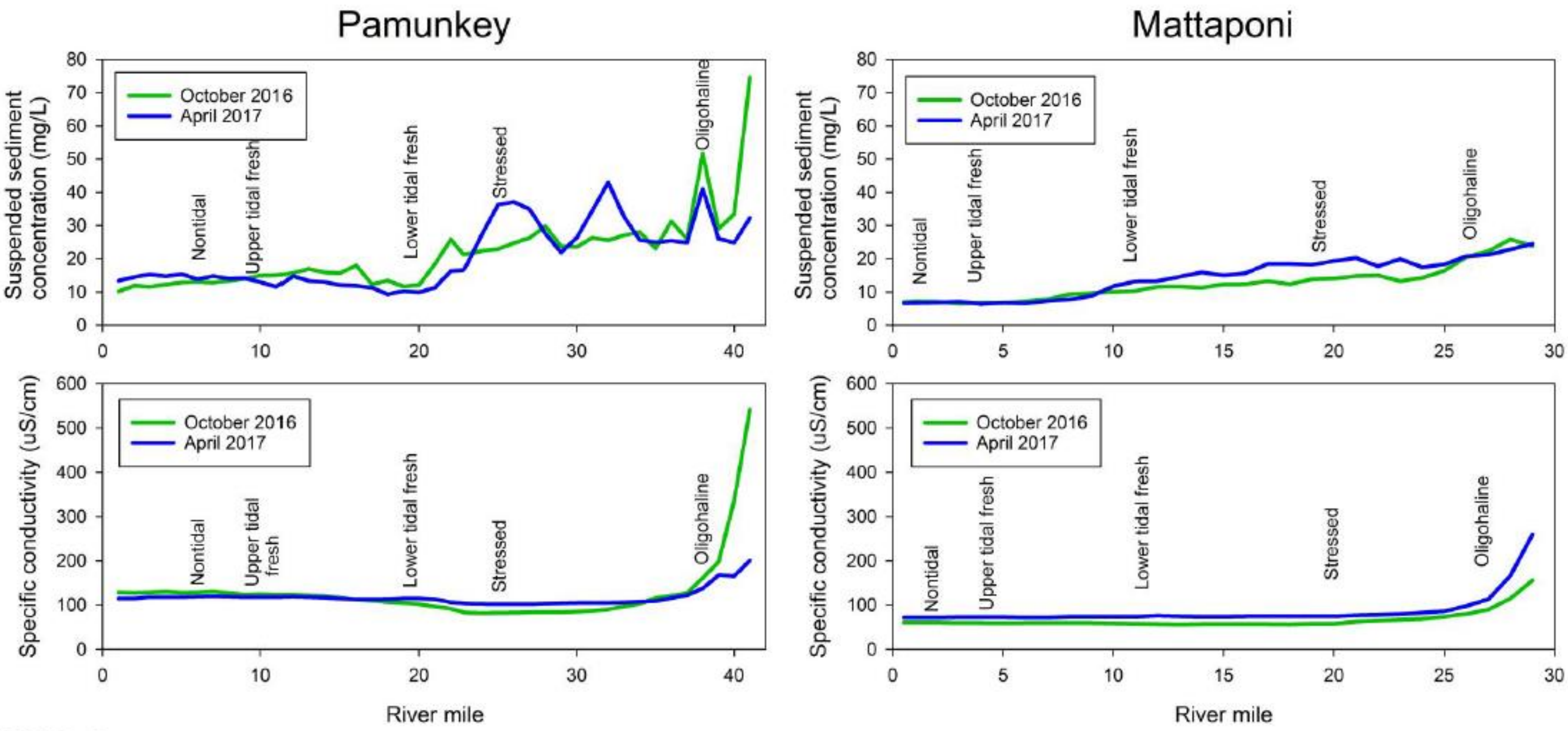


Fig. 1 Longitudinal patterns in turbidity, salinity and CHL*a* in the James River Estuary (distance is from the confluence with Chesapeake Bay). Data are average values for 1999–2004 based on monthly sampling for the Chesapeake Bay Program by the Virginia Department of Environmental Quality (http://www.deq.state.va.us/bay/cbpmon.html)

Bukaveckas, P.A., L.E. Barry, M.J. Beckwith, V. David, and B. Lederer, 2011. Factors Determining the Location of the Chlorophyll Maximum and the Fate of Algal Production within the Tidal Freshwater James River. Estuaries and Coasts 34:569–582.

Higher Suspended Sediments near Estuarine Mouths Indicate Open Water Source



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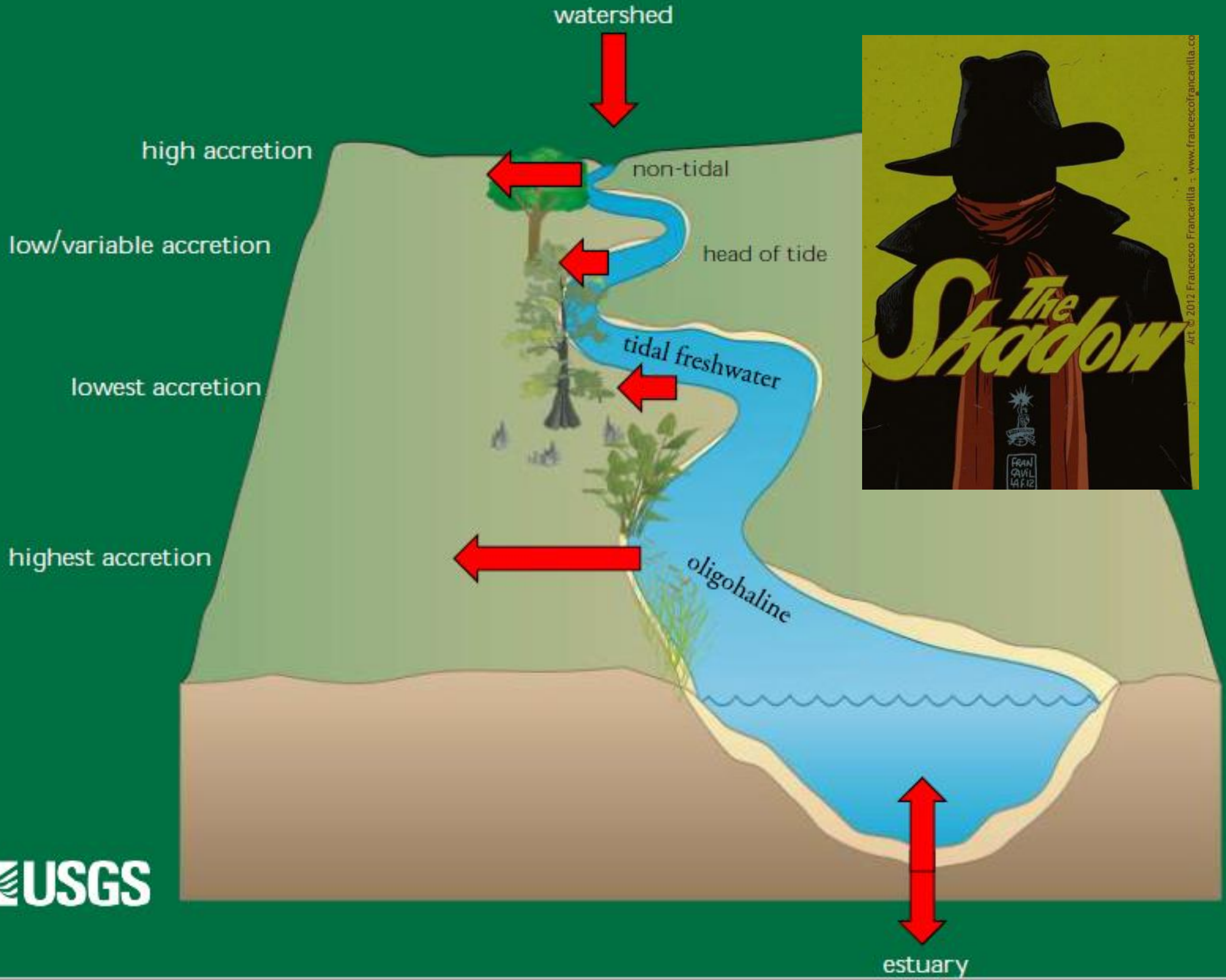
These data are preliminary and are subject to revision. They are being provided to meet the need for timely 'best science' information. The assessment is provided on the condition that neither the U.S. Geological Survey nor the United States Government may be held liable for any damages resulting from the authorized or unauthorized use of the assessment.

Magnitudes of sediment sources change along tidal river gradient



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Triblet Channel Shapes Indicates Predominant Hydrologic Drivers affecting Sediment Deposition and Wetland Accretion.

SCHEMATIC DIAGRAM OF ESTUARINE MEANDERS

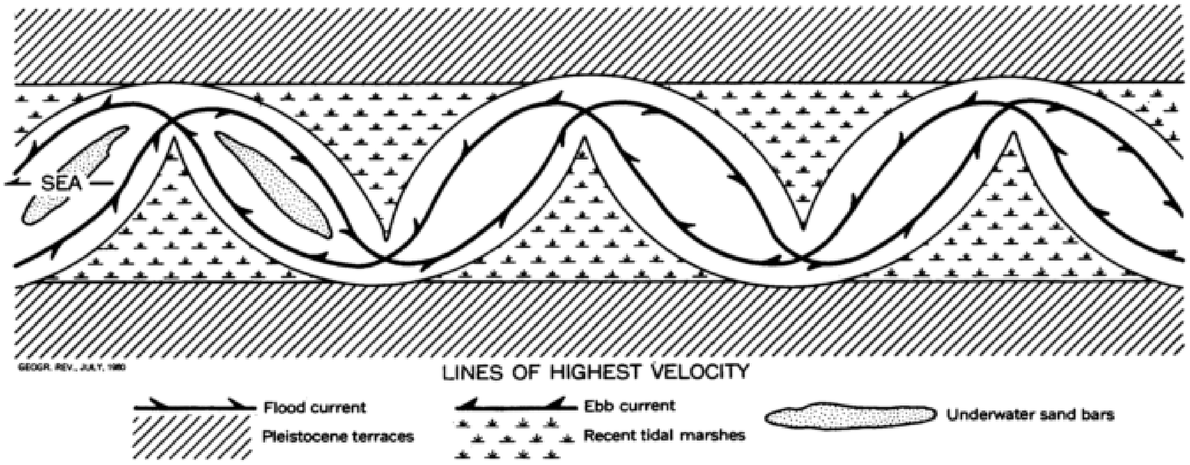


FIG. 3

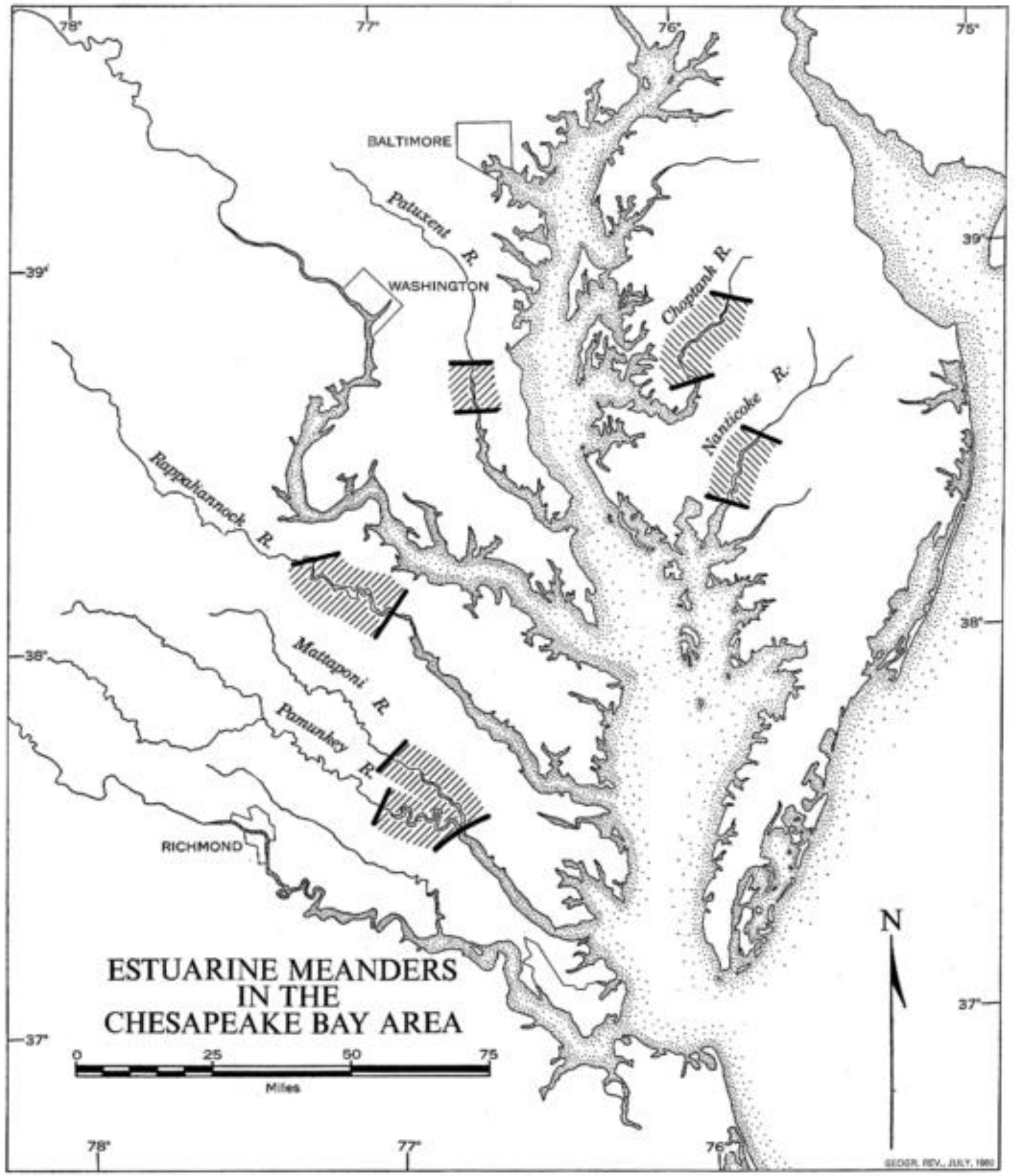
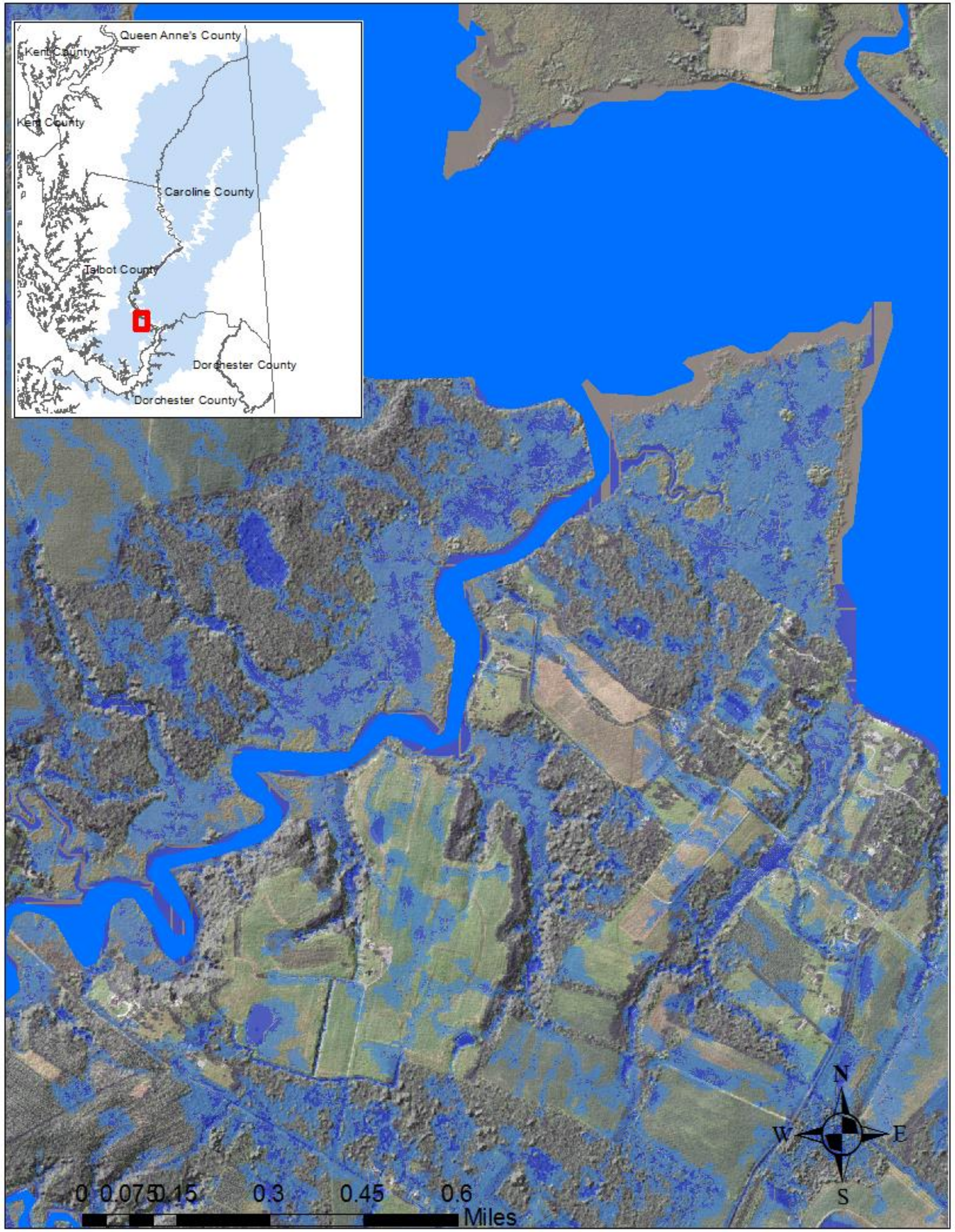


FIG. 4—Shaded sections indicate location of estuarine meanders.

Ahnert, F. 1960. Estuarine Meanders in the Chesapeake Bay. American Geographical Society 50(3):390-401.

2. Shape of tidal freshwater reaches may indicate primary hydrodynamic controls.

- Meander Shape ⇨ Balance of fluvial and tidal flow dynamics (affected by geology, tide variation)
- Funnel Shape ⇨ More fluvially influenced.



3a. Channelization and other hydrologic alterations likely compacted freshwater tidal gradients downstream… and can exasperate impacts from sea level rise upstream, if not restored.

- "Hardened" landscapes and hydrologic alterations have altered watershed hydrologic regimes.
- Salinity gradients shifted and concentrated downstream.
  - ⇨Tidally influenced meander patterns occur upstream head-of-tides.

Restoration along lower river corridors likely to facilitate coastal wetland migration, especially with sea level rise.

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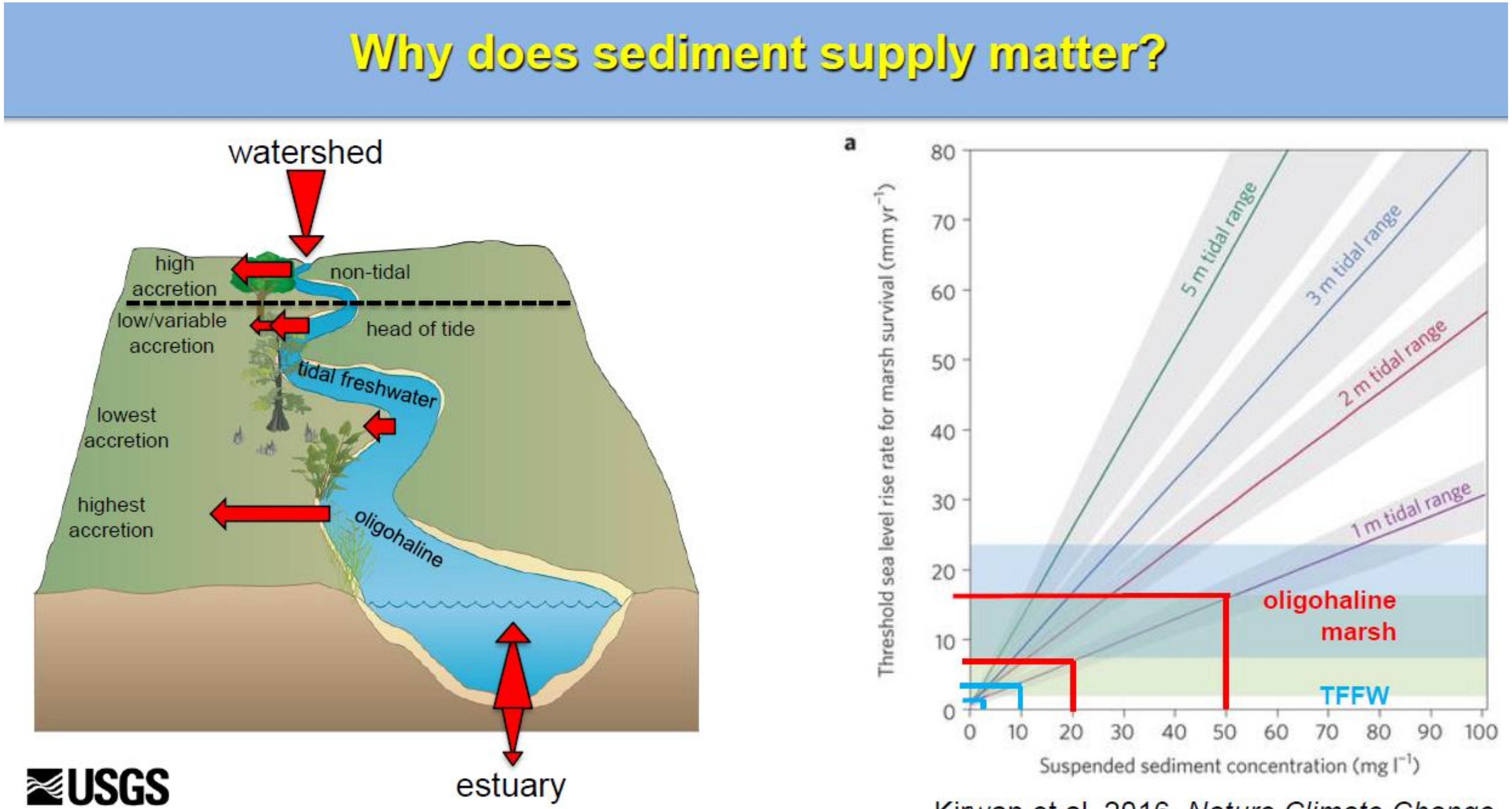

Kirwan et al. 2016, *Nature Climate Change.*

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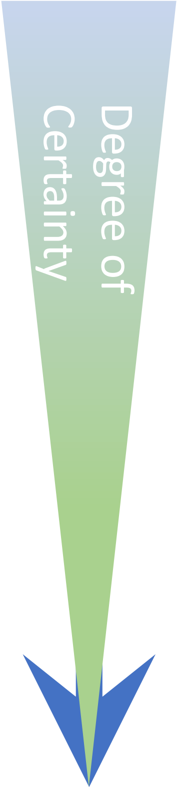

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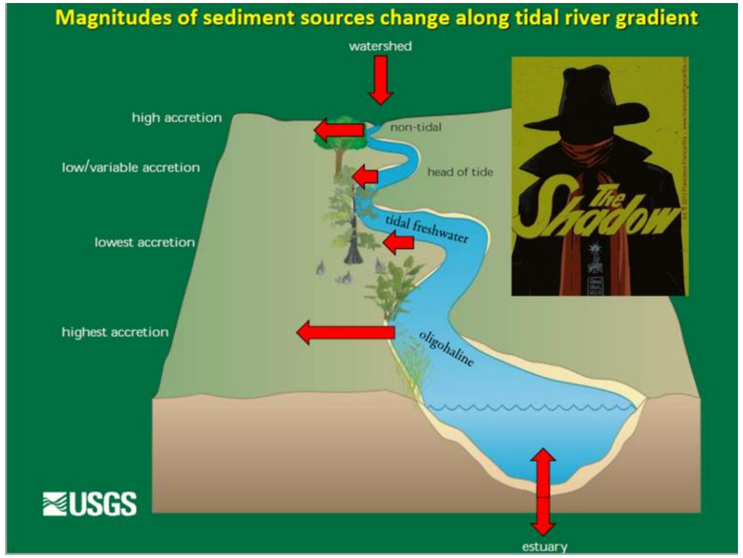


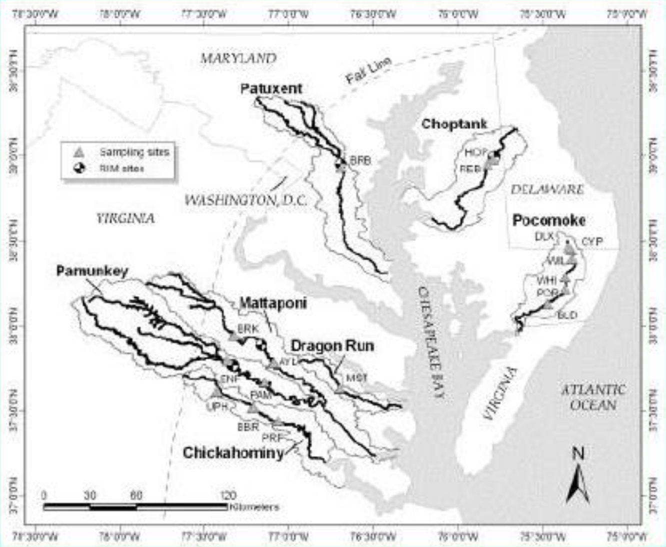
Coastal Plain non-tidal floodplains trap large loads

1) Measured sedimentation fluxes in plots
2) Scaled to entire CP extent of floodplain
3) Compared to river load

$$\frac{g\ m^{-2}\ yr^{-1} \times m^{2}}{g\ yr^{-1}}$$

Percent retention for 7 rivers:

	Median	Range
Nitrogen	22%	(5 to 150%)
Phosphorus	59%	(14 to 587%)
Sediment	119%	(53 to 690%)



Noe and Hupp 2009, *Ecosystems*

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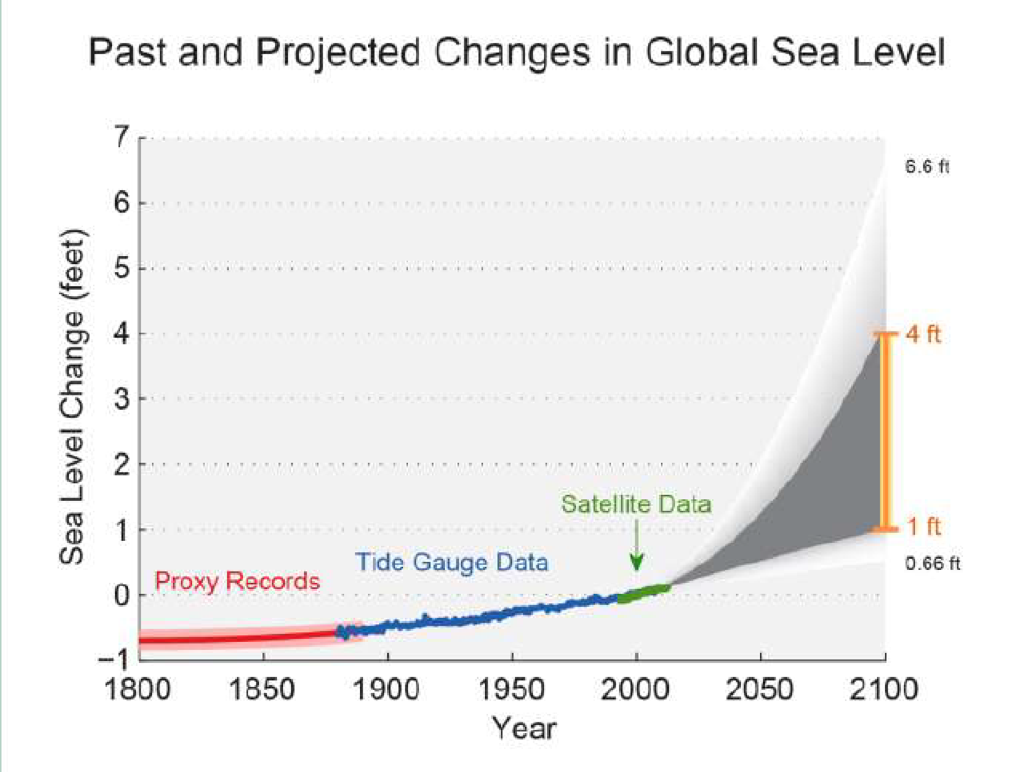
What are potential sea-level rise impacts?

Estuarine control



Climate Change Impacts in the United States: The Third National Climate Assessment. 2014.

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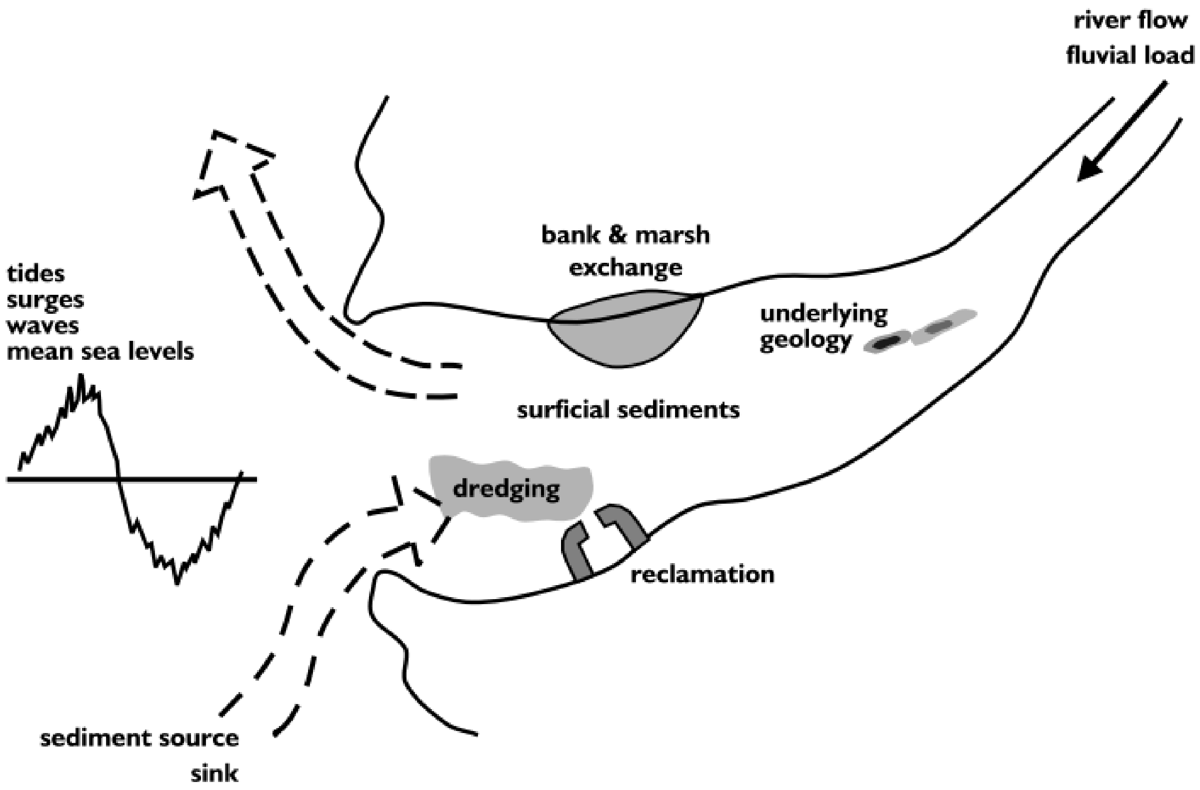

Fig. 1. Schematic of factors influencing estuarine bathymetry.

- Water depth
- Lateral and longitudinal flow velocities
- Friction coefficient
- Roughness coefficient
- Salinity

F(tide amplitude, estuary morphometry, sediment supply)

Triblet function revealed by tidal freshwater wetland studies

- Known estuarine-freshwater gradients, less often considered freshwater tidal gradients
  - Tidal flow patterns
    - Outer vs Inner Coastal Plain
    - Strength of tidal influence
    - Stage of estuary evolution (given trends in sea level)
  - Effects on bathymetry
  - Flow effects on nutrient and sediment dynamics
  - Temperature patterns?
- Relevance to management?

How much of the watershed sediment load reaches the Chesapeake Bay?

Watershed controls