Implications of Discharge Frequency and Magnitude on Water, Carbon, and Nitrogen Flux Through Tidal Freshwater Rivers

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USGS science for a changing world

United States Environmental Protection Agency

WRRI Water Resources Research Institute of The University of North Carolina

UNC The Graduate School

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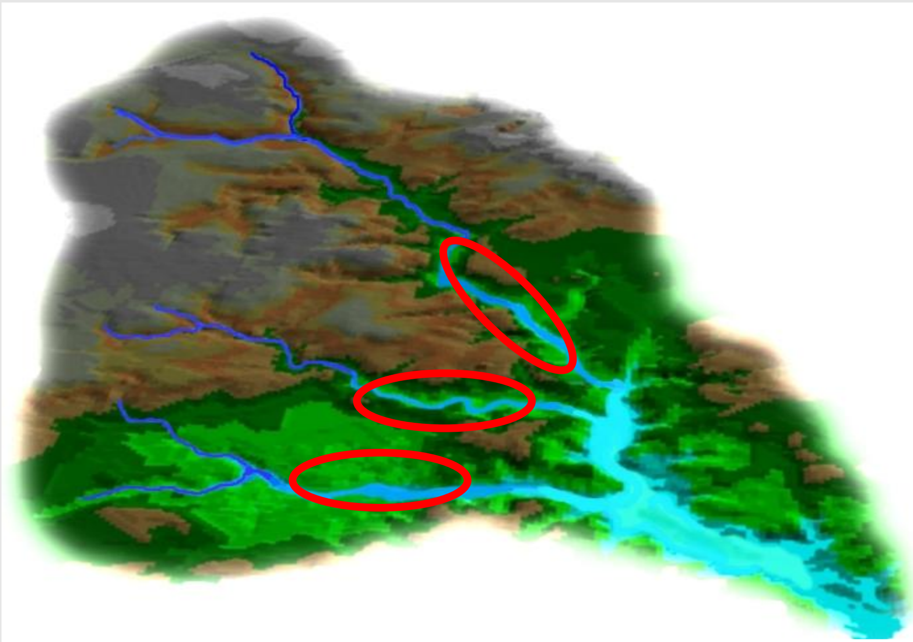
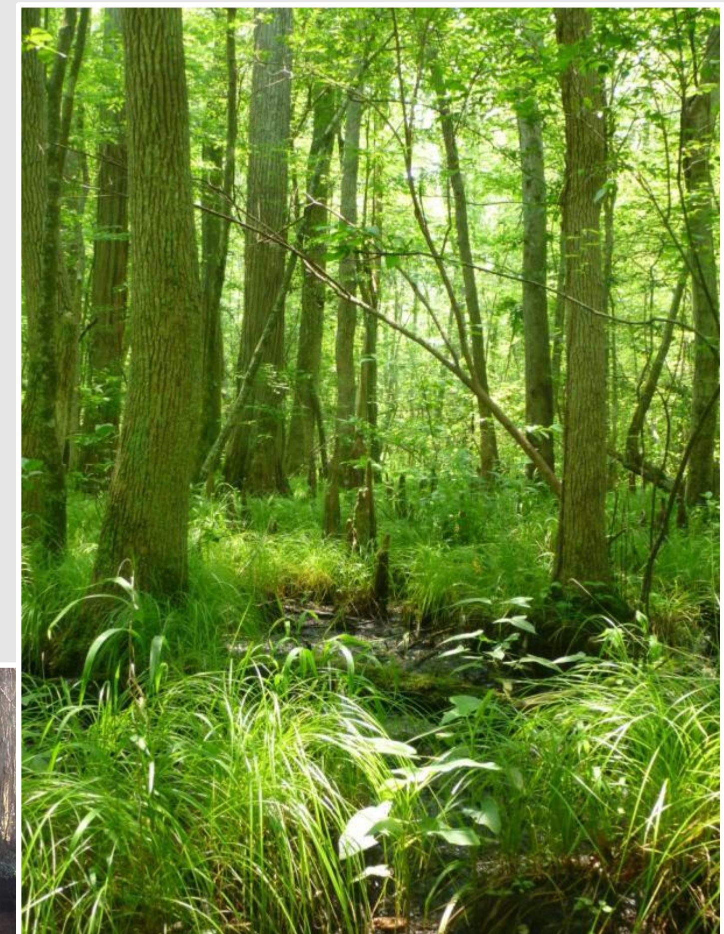
Plumbing watersheds to estuaries often involves treating the river-estuary transition zone as a black box (or no box).





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How do we incorporate the dynamics of riparian inundation and river discharge into empirical models of material flux?

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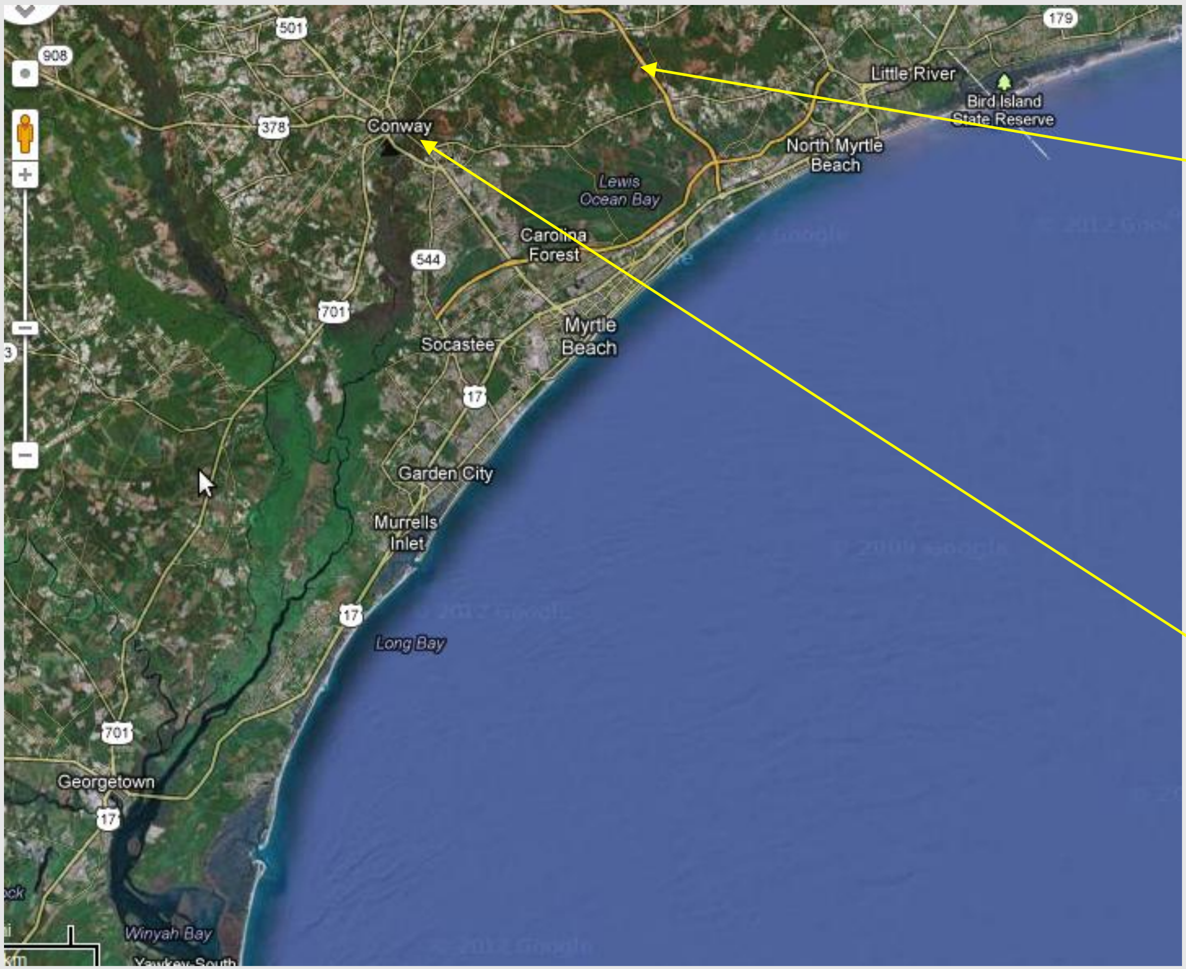
Comparison of non-tidal with tidal freshwater discharge and level highlights differences in frequency-magnitude caused by tides.



www.flickr.com/photos/mountaineerpics/4682836438/

activerain.com/blogsview/279491/pottery-landing-conway-south-carolina

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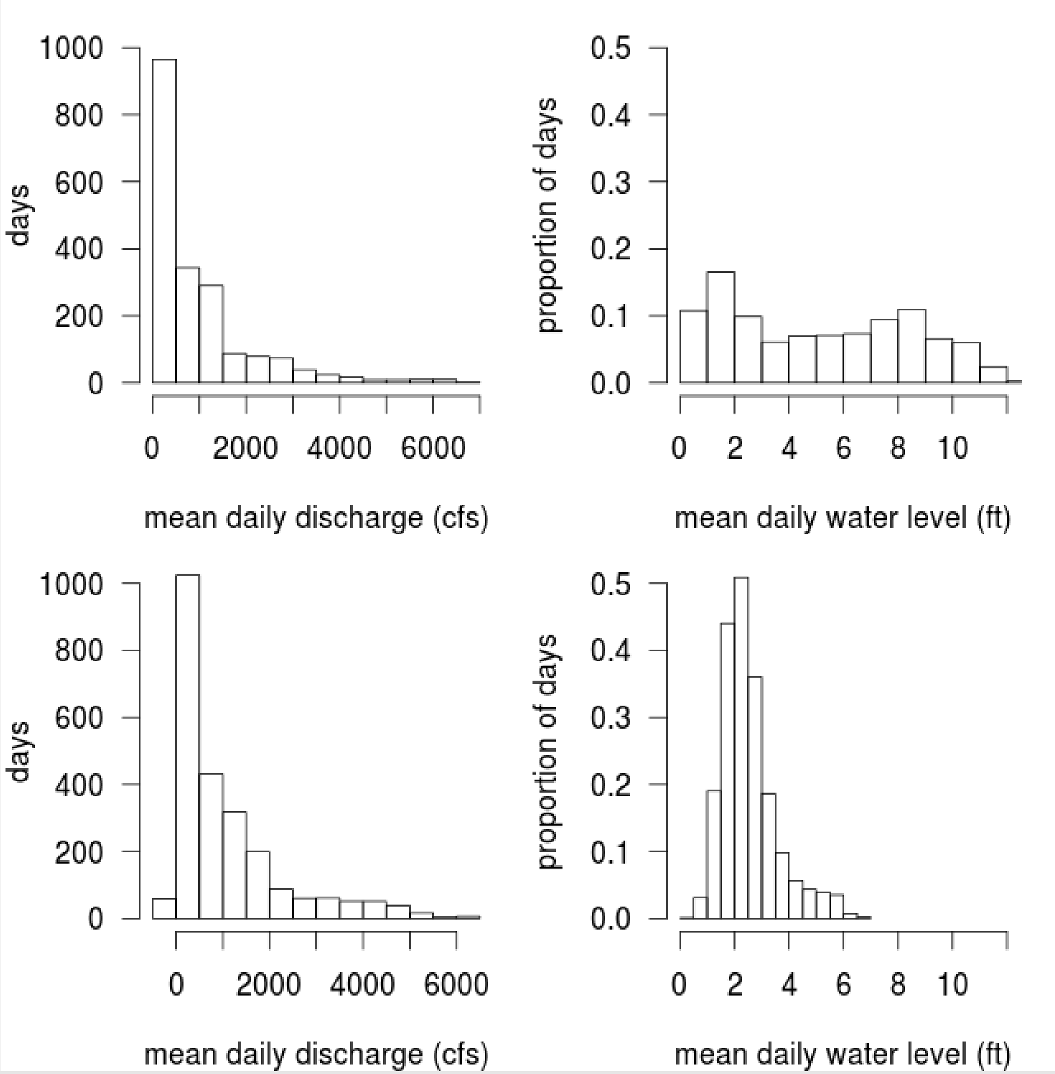
The frequency-magnitude of daily mean (net) discharge is similar, but water level is strongly affected by tide.

non-tidal gage near Longs, SC

tidal freshwater gage at Conway, SC



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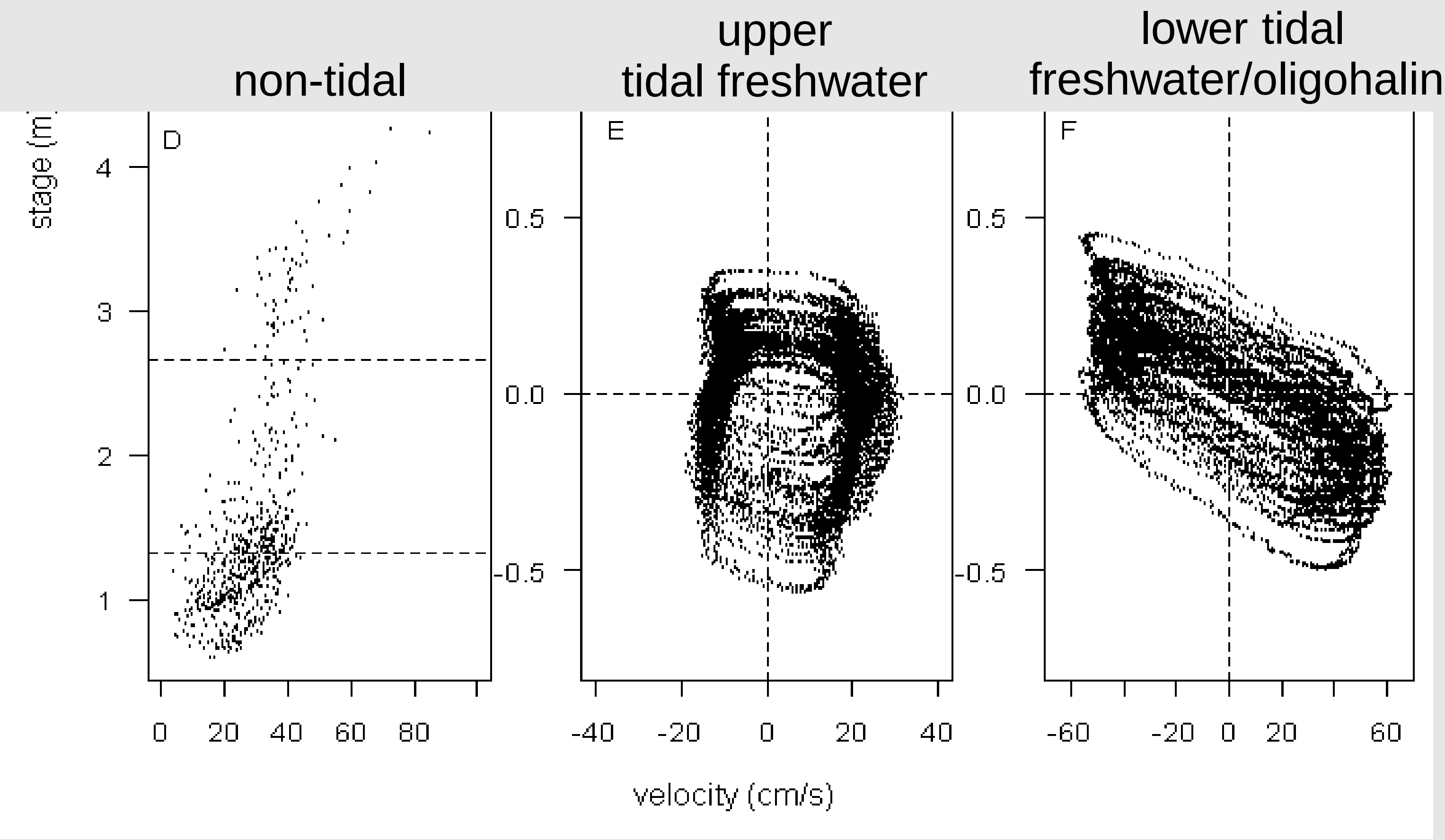
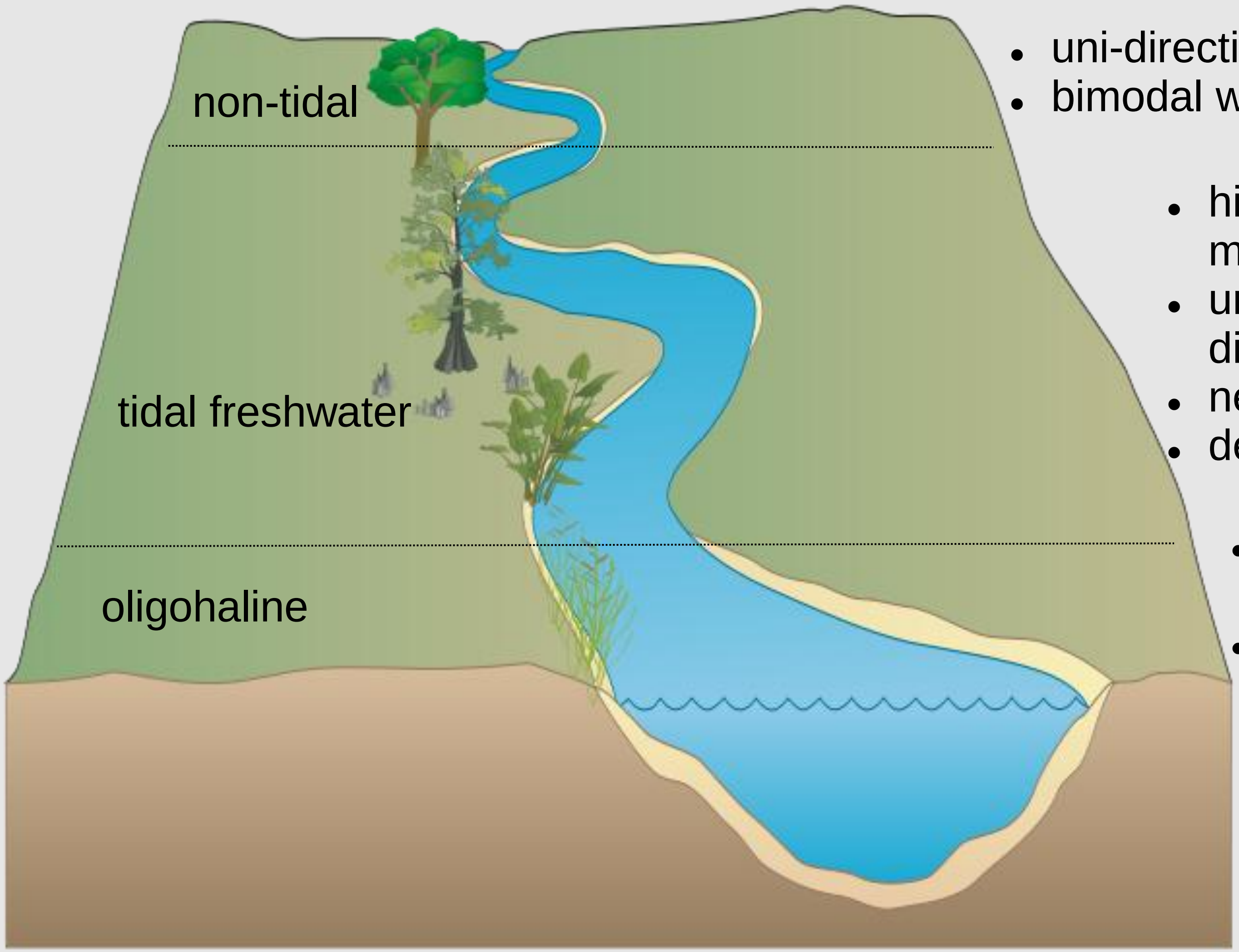
High velocity flow events occur daily in the lower tidal freshwater zone.



Ensign, Noe, and Hupp. in review, *JGR Earth Surface*

Gradients in hydrology along the tidal freshwater zone:



- uni-directional flow and discharge
- bimodal water level distribution

- high frequency, low magnitude velocity
- unimodal water level distribution
- net upstream water flux (?)
- decreased energy (?)

- high frequency, high magnitude velocity
- increased energy (?)

Flow magnitude and frequency affect inundation of the riparian zone and carbon storage.

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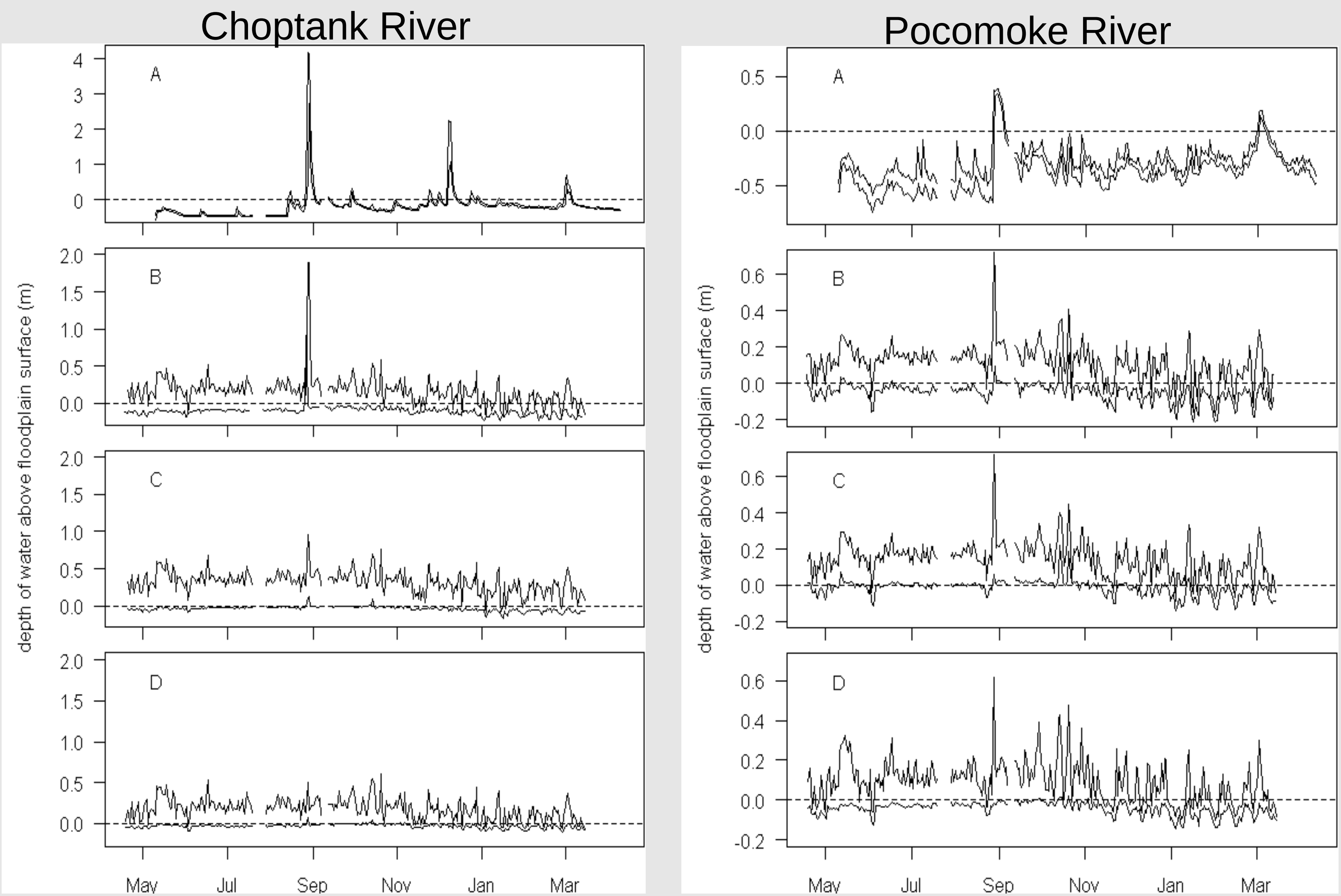
The flood of record occurred on the non-tidal Choptank River following Hurricane Lee; the tidal freshwater zone was less affected.

non-tidal

tidal freshwater forest

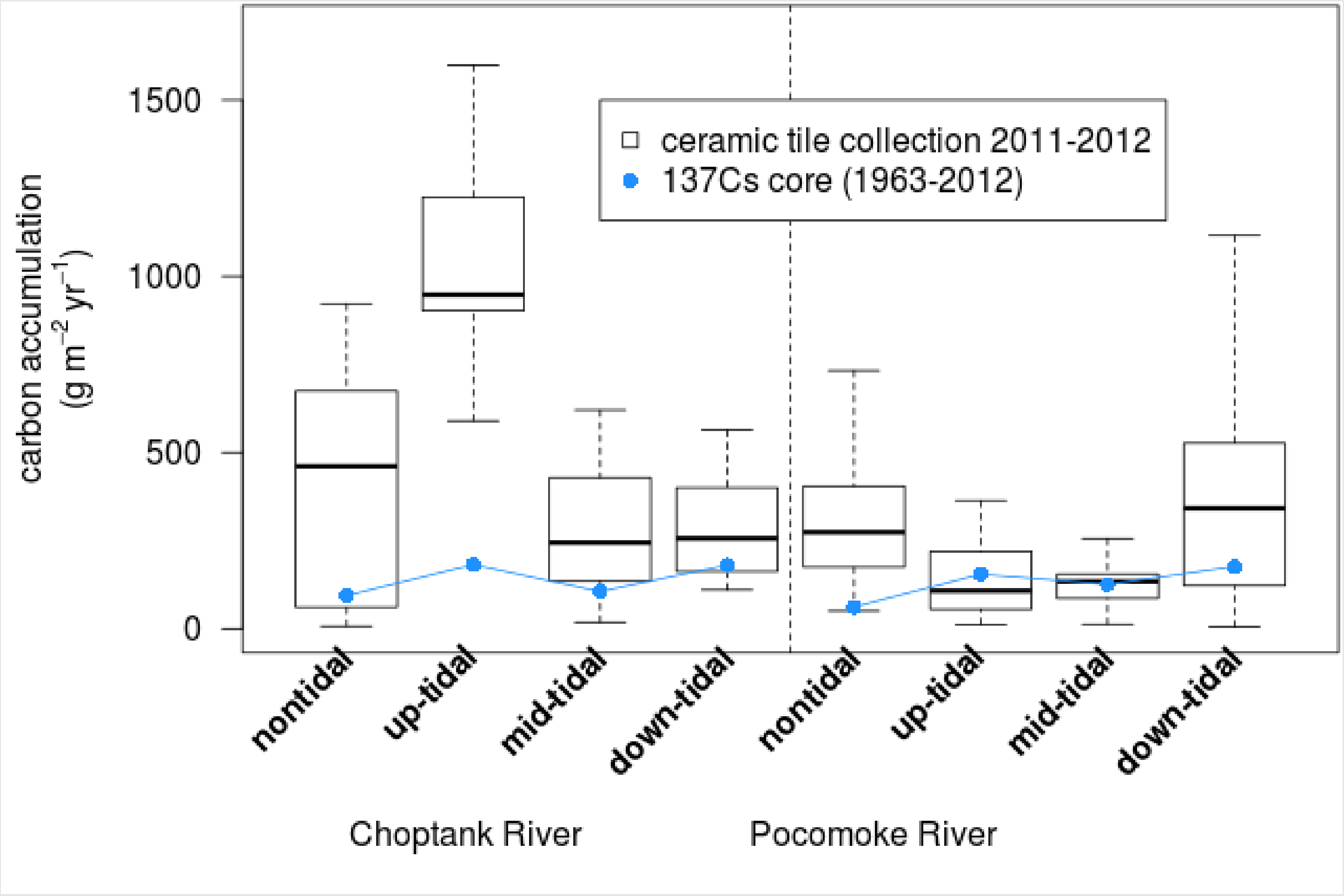
tidal freshwater forest

oligohaline marsh



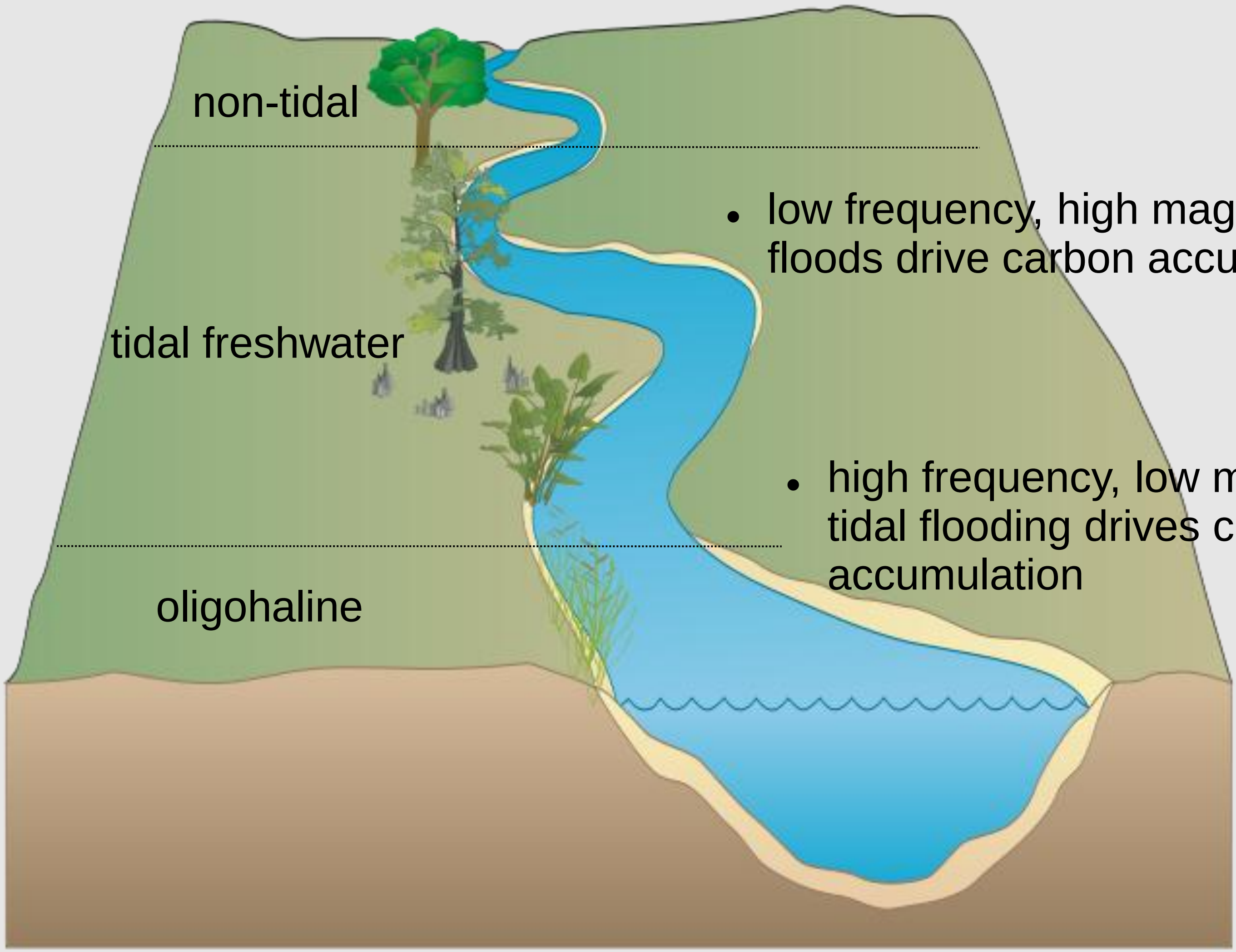
Ensign, Noe, and Hupp. in review, *JGR Earth Surface*

Carbon accumulation in wetlands is driven by contrasting frequency-magnitude regimes at opposite ends of the tidal freshwater gradient.



Ensign, Noe, and Hupp, in prep.

Patterns in carbon accumulation in tidal river floodplains:



- low frequency, high magnitude river floods drive carbon accumulation
- high frequency, low magnitude tidal flooding drives carbon accumulation

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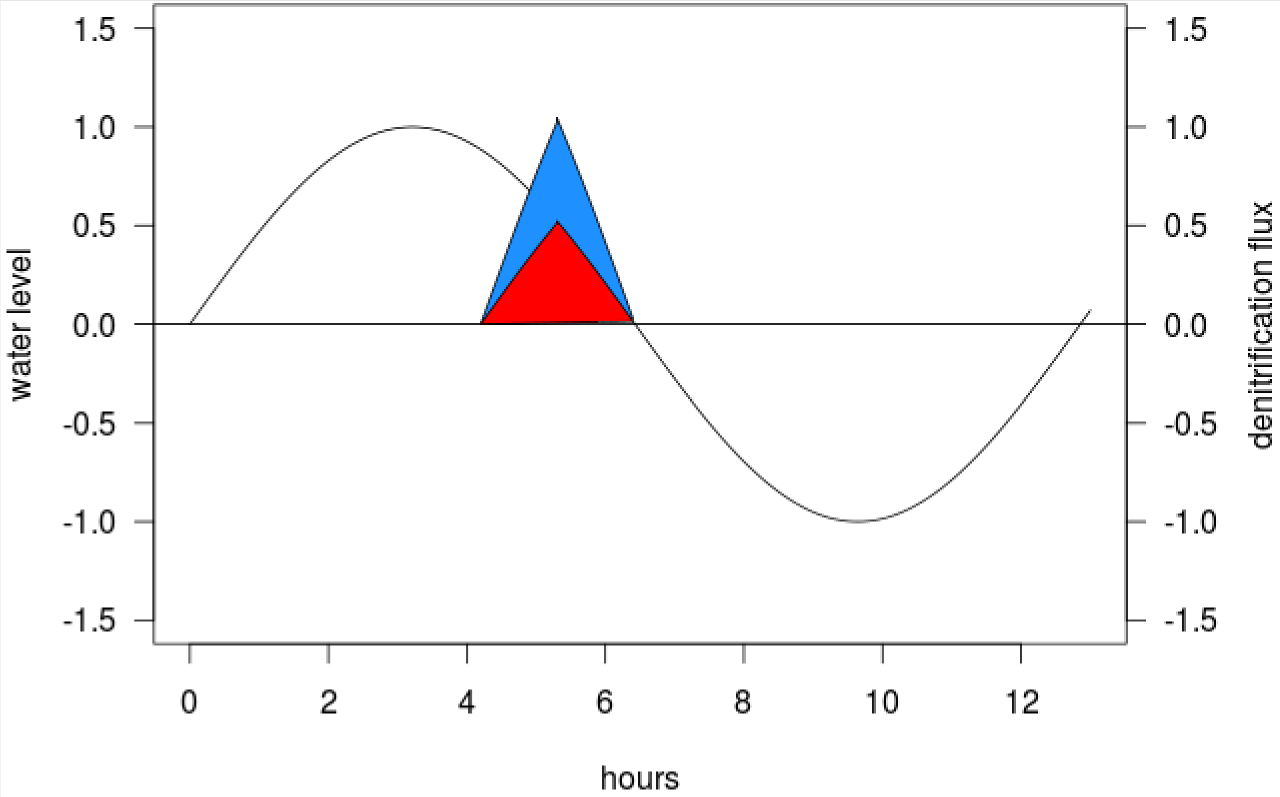
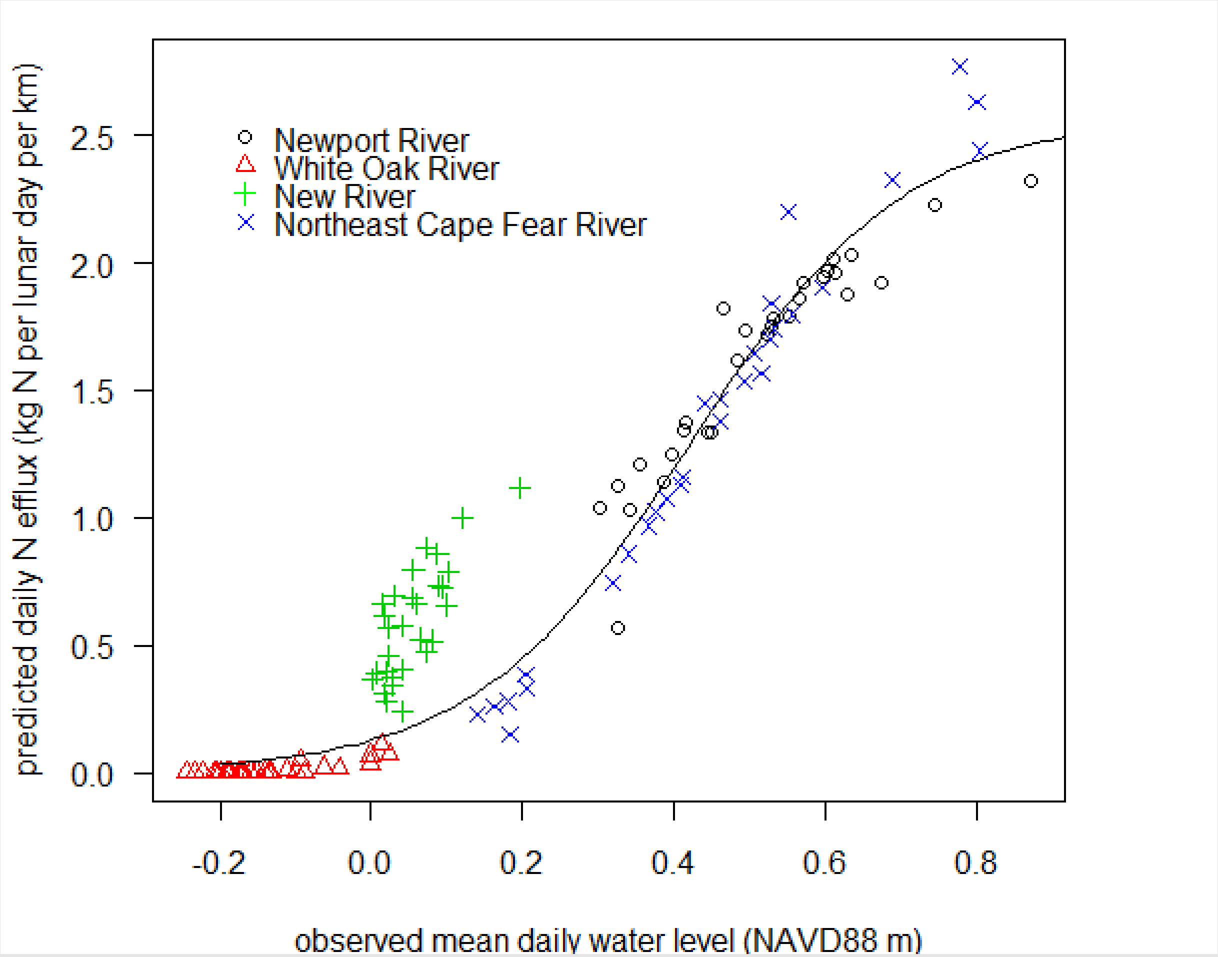
Riparian denitrification flux can be modeled as a function of denitrification rate and the surface area of floodplain inundated.

$$\mathrm{N_2efflux} = \int_{t_1}^{t_2} A_{t,s} \times R + \int_{t_3}^{t_4} A_{t,s} \times R$$



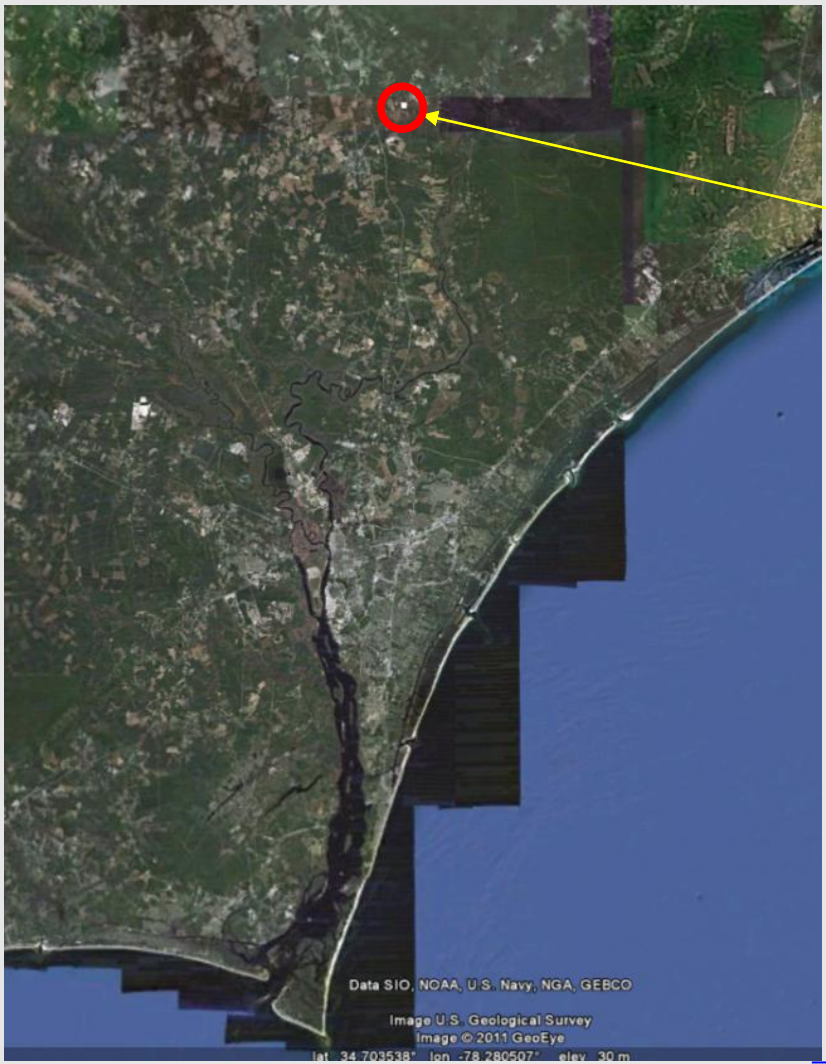
Ensign, Piehler, and Doyle. 2008. *Biogeochemistry*

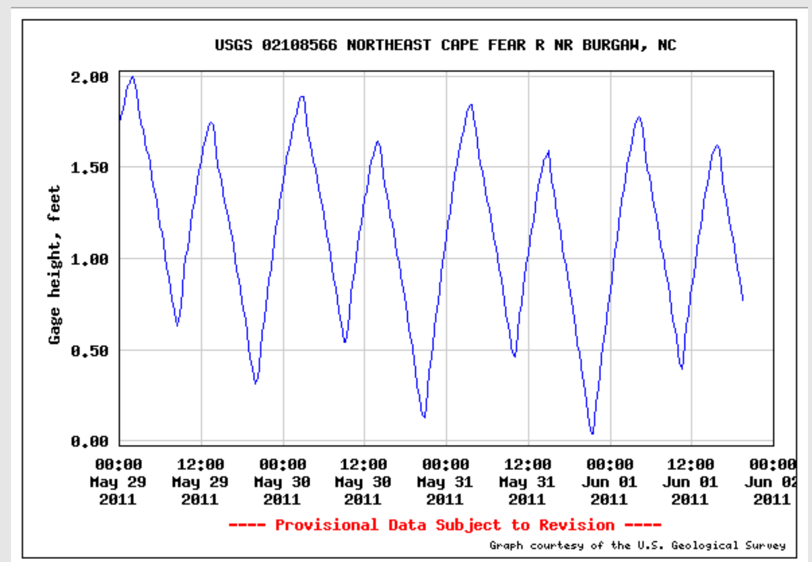
Denitrification flux from tidal freshwater riparian zones over a month period closely corresponded with mean daily water level.



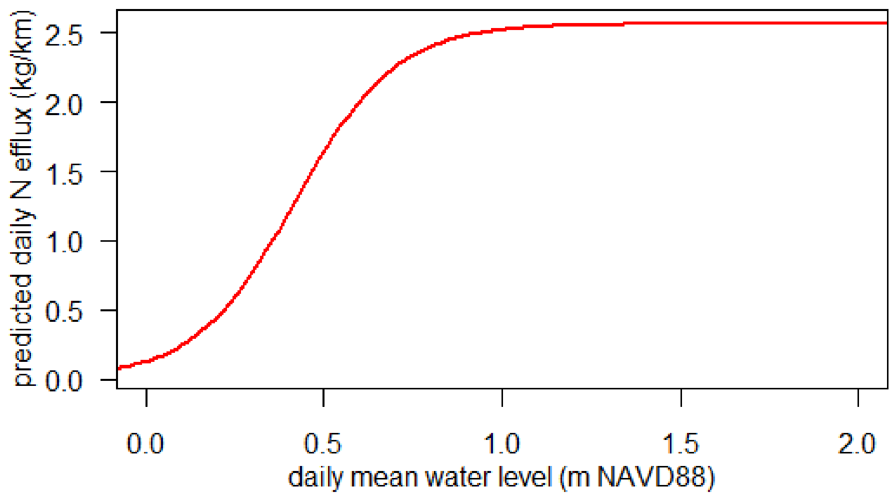
Ensign, Piehler, and Doyle. 2012. *Estuaries and Coasts*

The Northeast Cape Fear River near Burgaw provides long term data for a frequency-magnitude analysis of N_2 flux and level.





A frequency-magnitude analysis reveals that high frequency, low magnitude flooding is the predominant driver of denitrification.



Ensign, et al. 2012. *Estuaries and Coasts*

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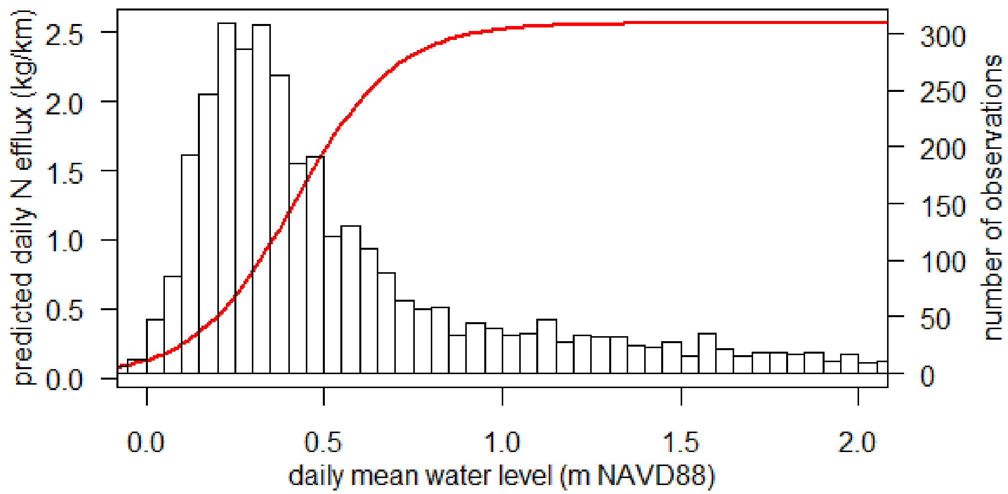

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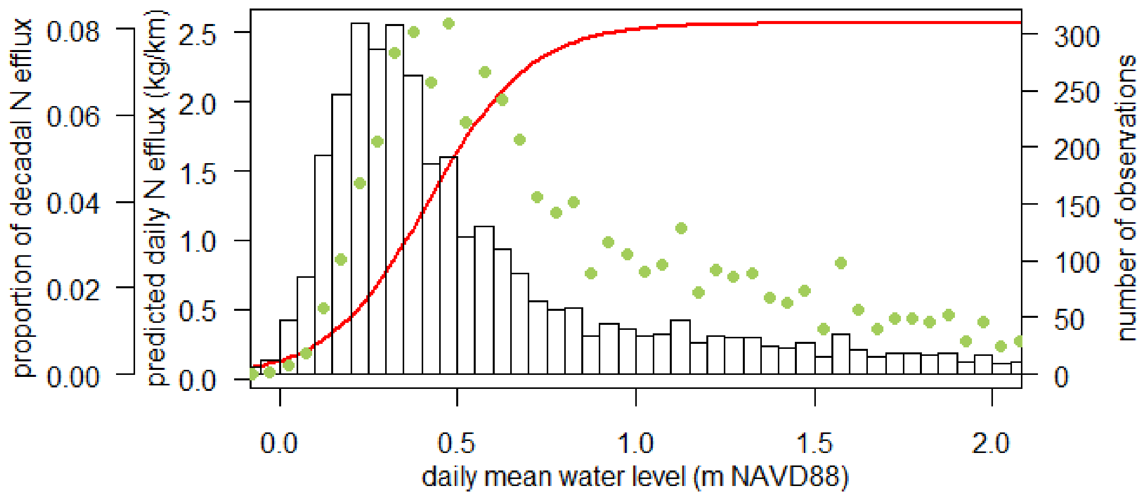

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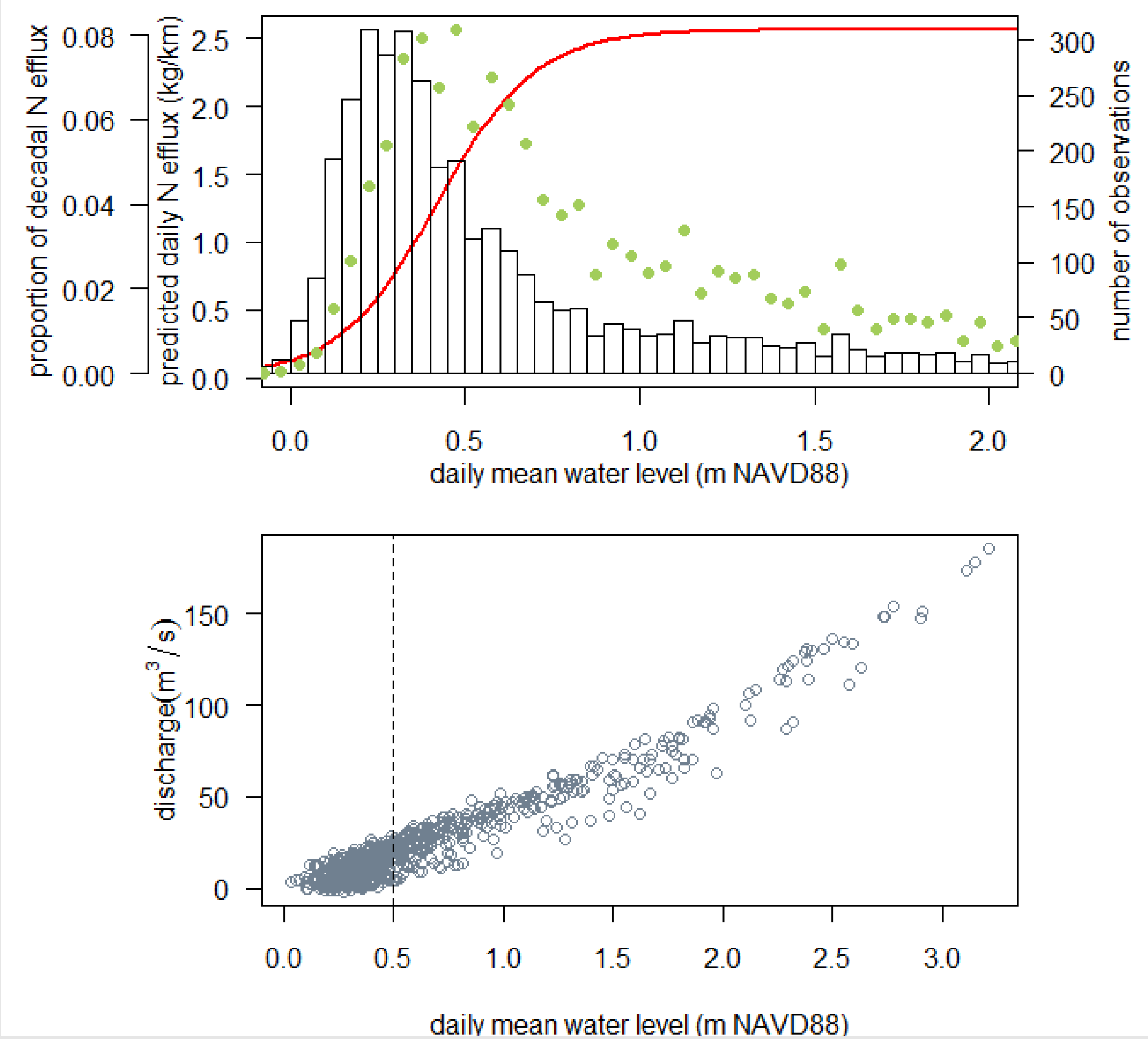
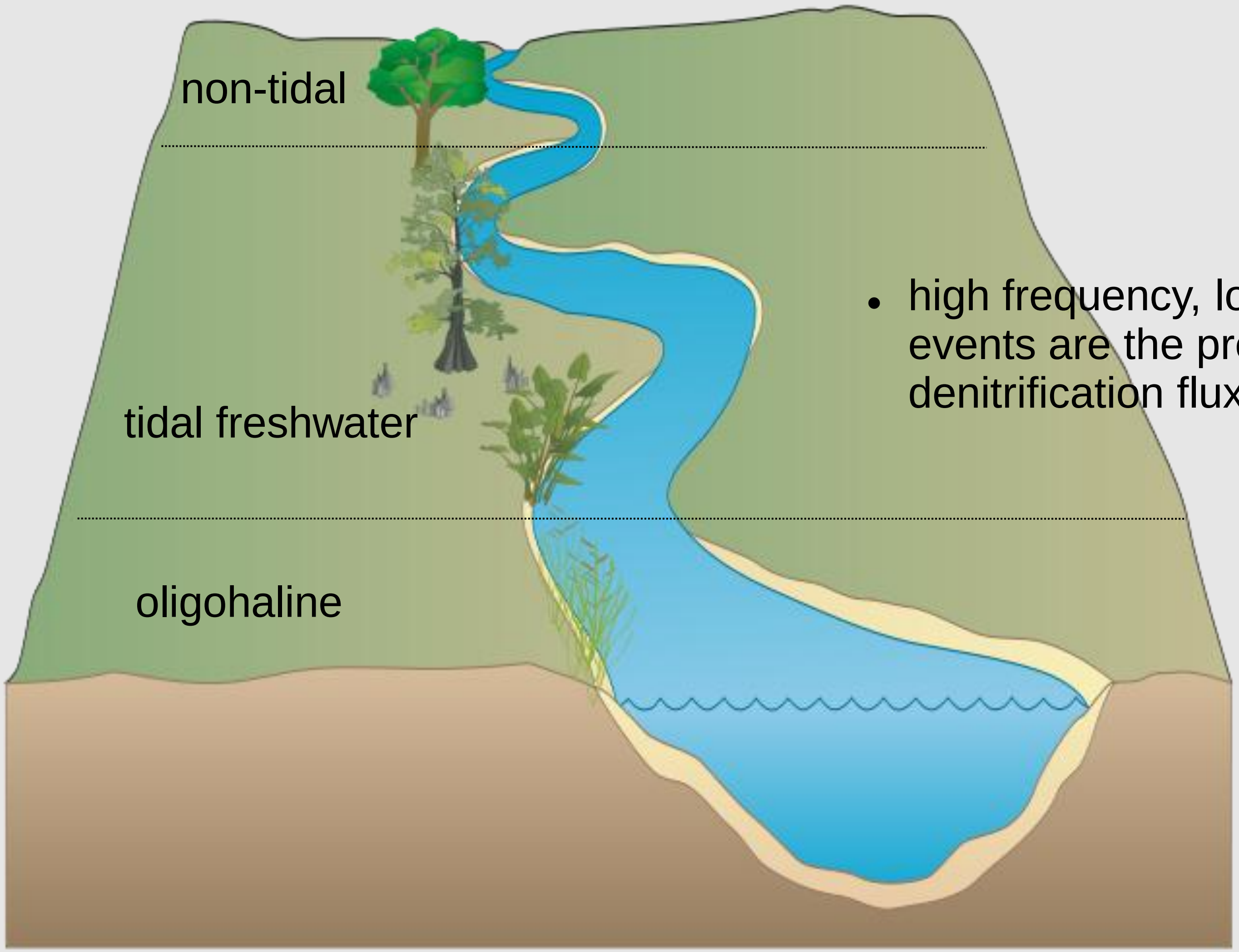


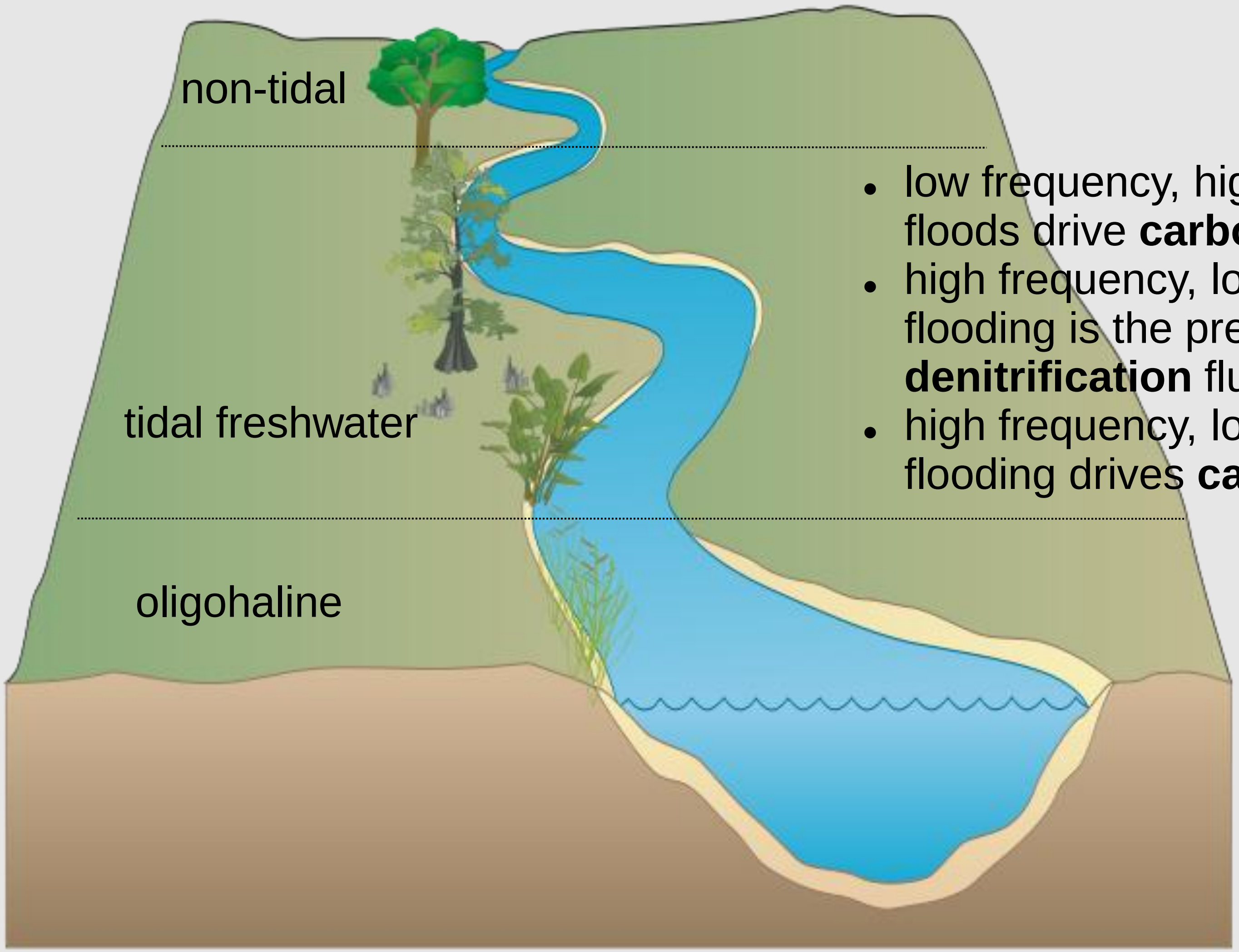
Ensign, et al. 2012. *Estuaries and Coasts*

Denitrification flux from tidal freshwater river riparian zones:



- high frequency, low magnitude flood events are the predominant control on denitrification flux

Patterns in carbon and nitrogen biogeochemistry in the tidal freshwater zone differ based on their particulate and dissolved form:



- low frequency, high magnitude river floods drive **carbon** accumulation
- high frequency, low magnitude tidal flooding is the predominant control on **denitrification** flux
- high frequency, low magnitude tidal flooding drives **carbon** accumulation