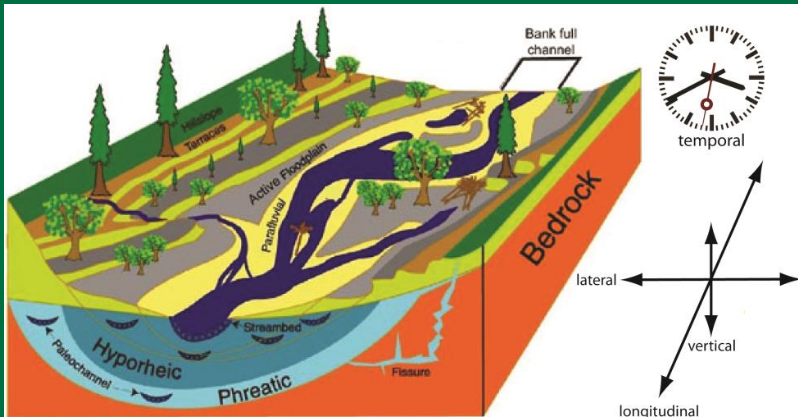
Sediment and nutrient transport and storage along the urban stream corridor

Greg Noe, Cliff Hupp, Ed Schenk, Jackie Batson, Nancy Rybicki, Allen Gellis

What is the role of floodplains everywhere?



Noe 2013, *Treatise of Geomorphology*

Table 1. Average annual sediment yields by physiographic province for 65 stations draining the Chesapeake Bay Watershed, 1952–2001.

[$Mg/km^2/yr$, megagram per square kilometer per year]

Physiographic province	Sediment yield ($Mg/km^2/yr$)	Number of stations used in the analysis
Appalachian Plateau	58.8	19
Blue Ridge	56.8	2
Valley and Ridge	66.3	19
Piedmont	103.7	21
Coastal Plain	11.9	4

USGS SIR 2008-5186

USGS

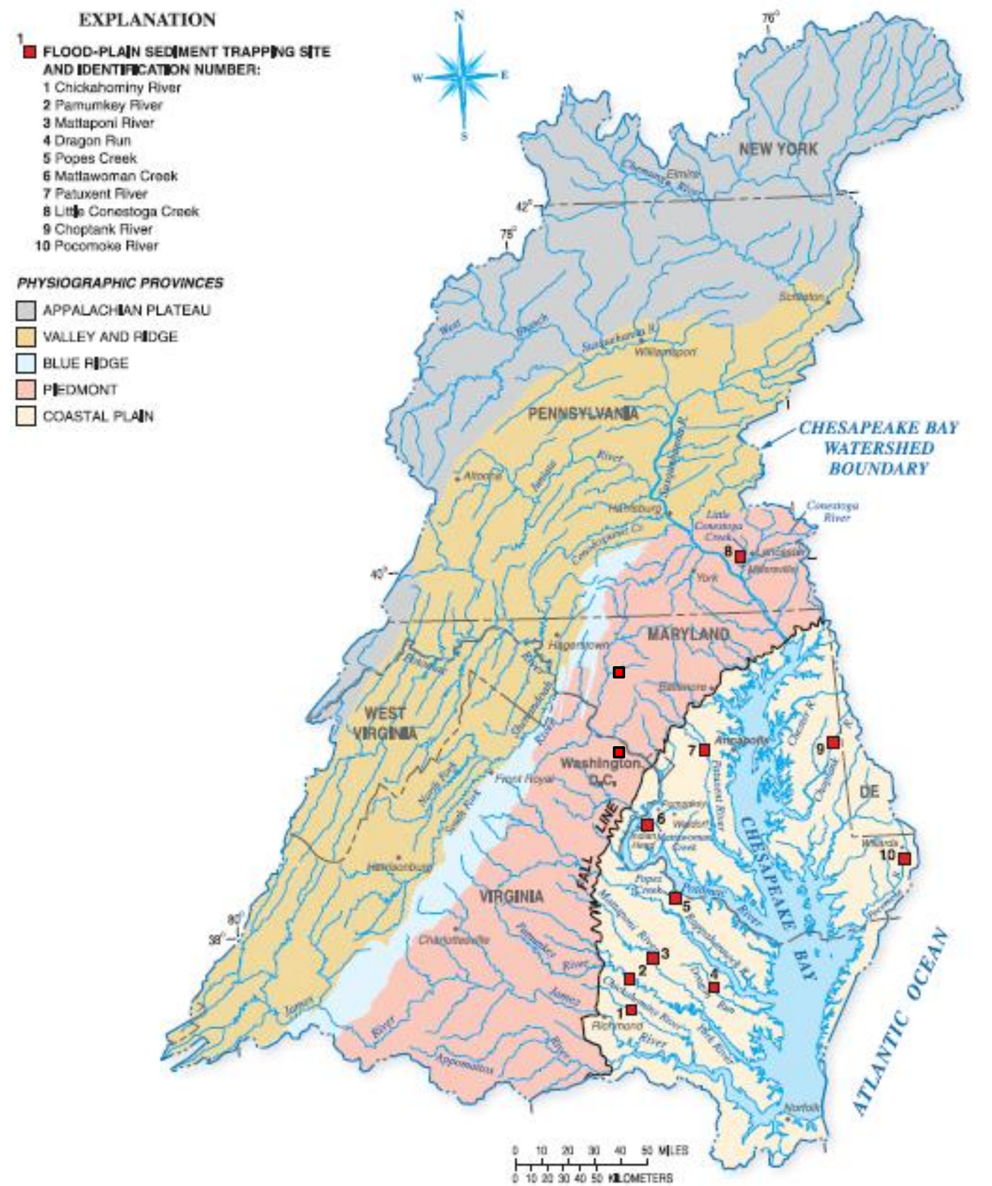


Figure 2. Location of flood-plain sediment trapping sites in the Chesapeake Bay Watershed. [Dates of measurements range from 1996 through 2006 (modified from Bachman and others, 1998).]

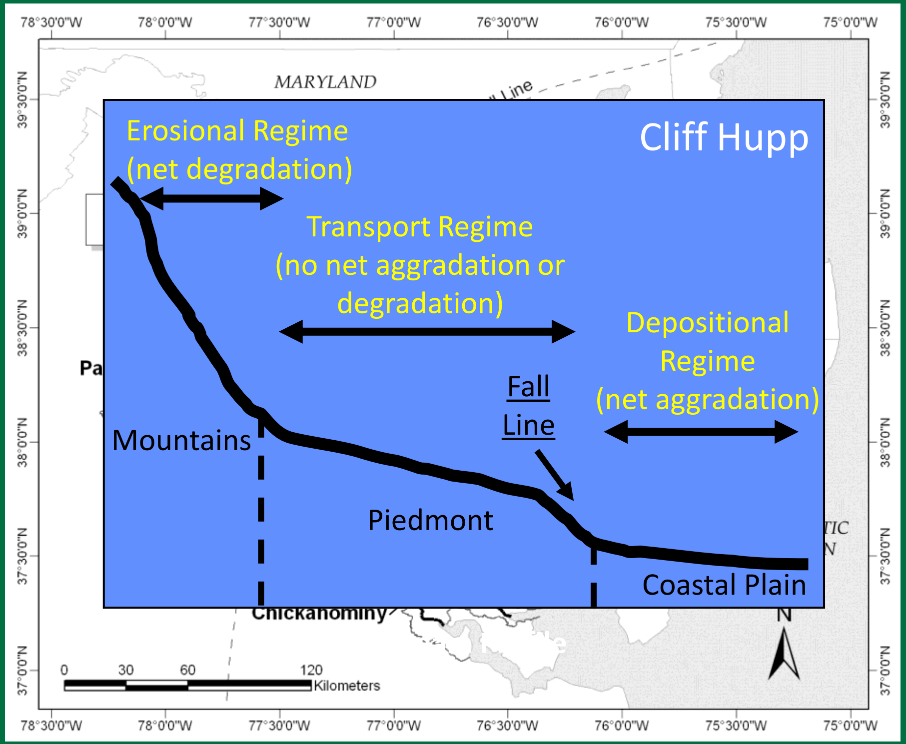
Coastal Plain floodplains trap large nutrient loads

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%)

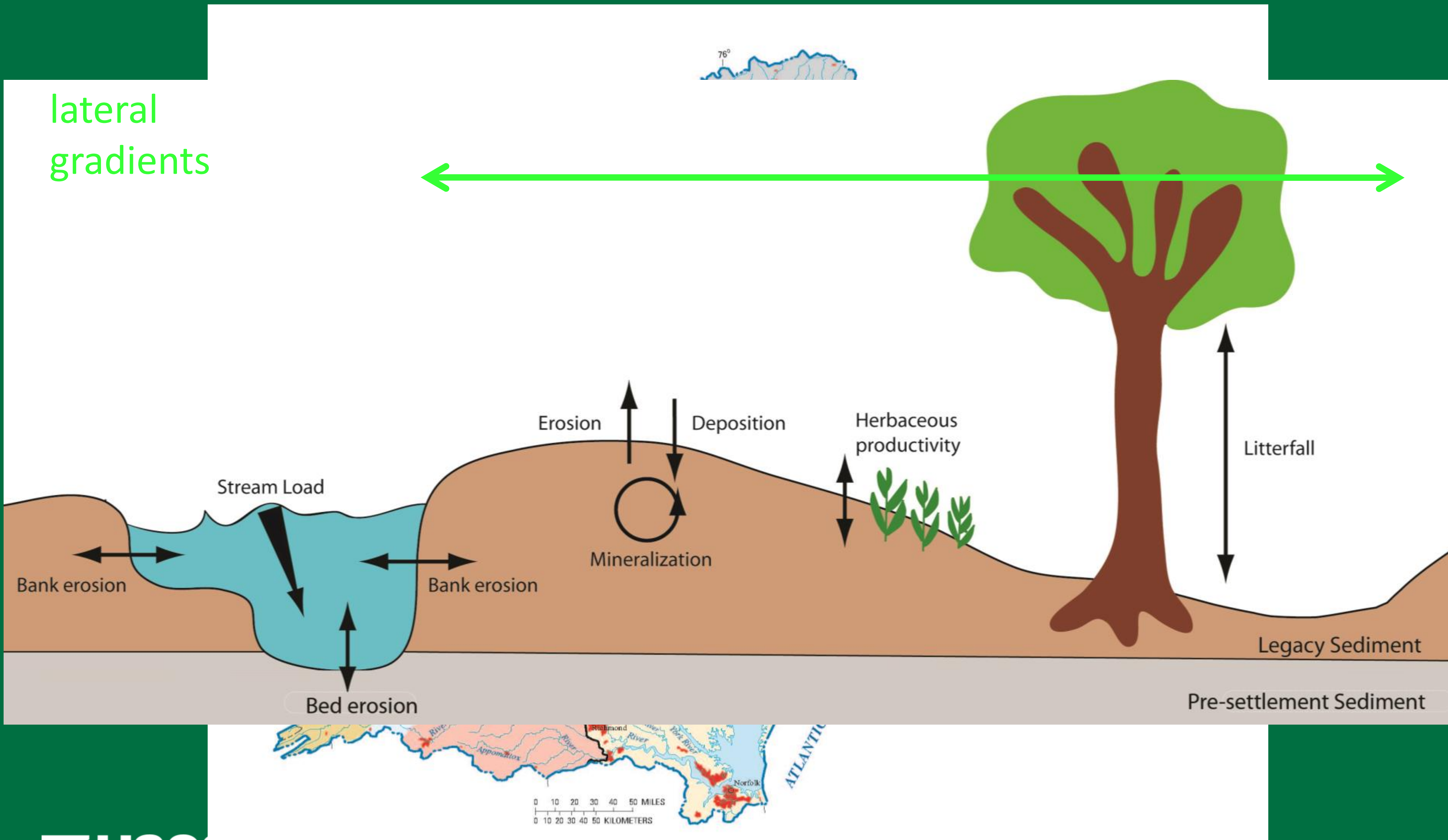


Noe and Hupp 2009, *Ecosystems*

USGS

Difficult Run Floodplain Study

measuring sediment and nutrient retention along lateral and longitudinal stream-floodplain gradients in an urban, Piedmont watershed



Difficult Run watershed has changed dramatically

Long history of agricultural soil erosion

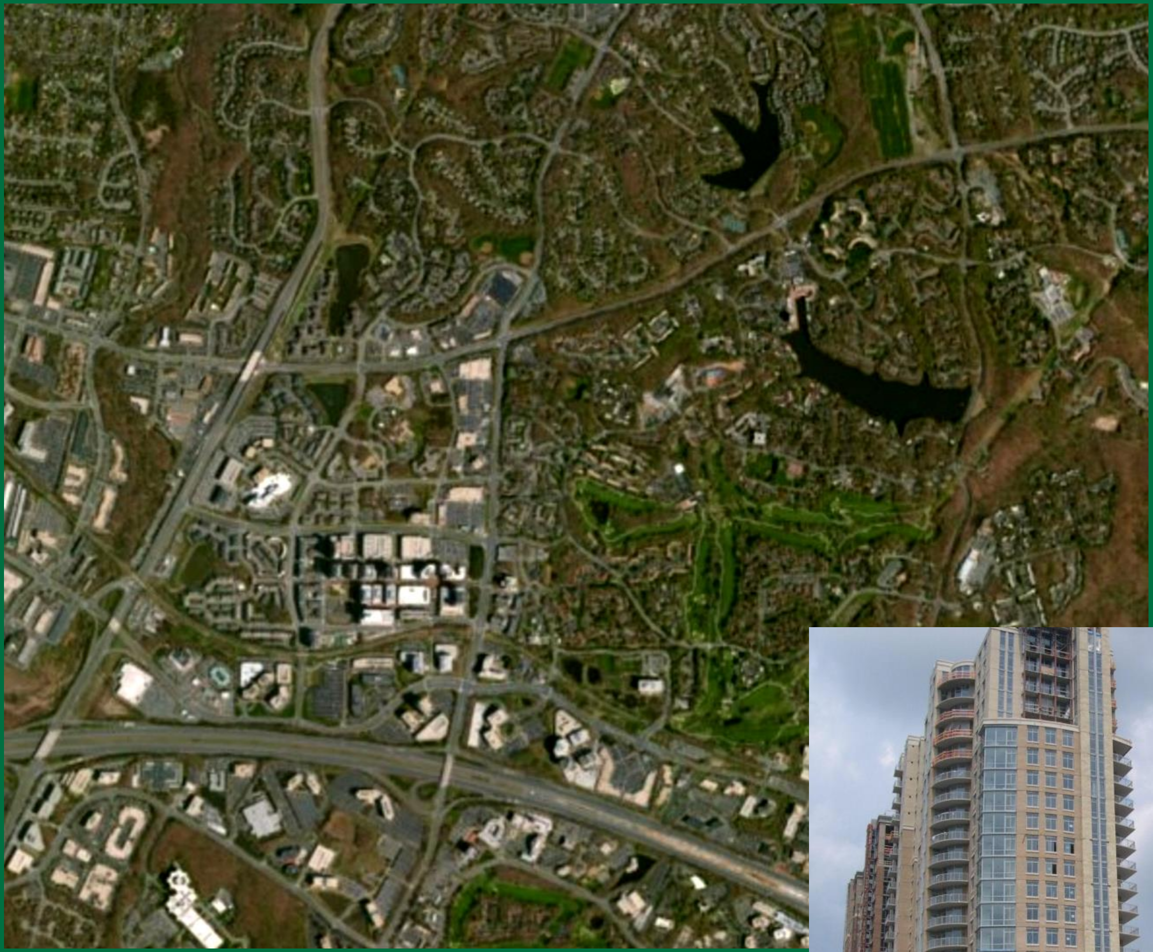
1949

From appalachianhistory.net

Difficult Run watershed has changed dramatically

1949

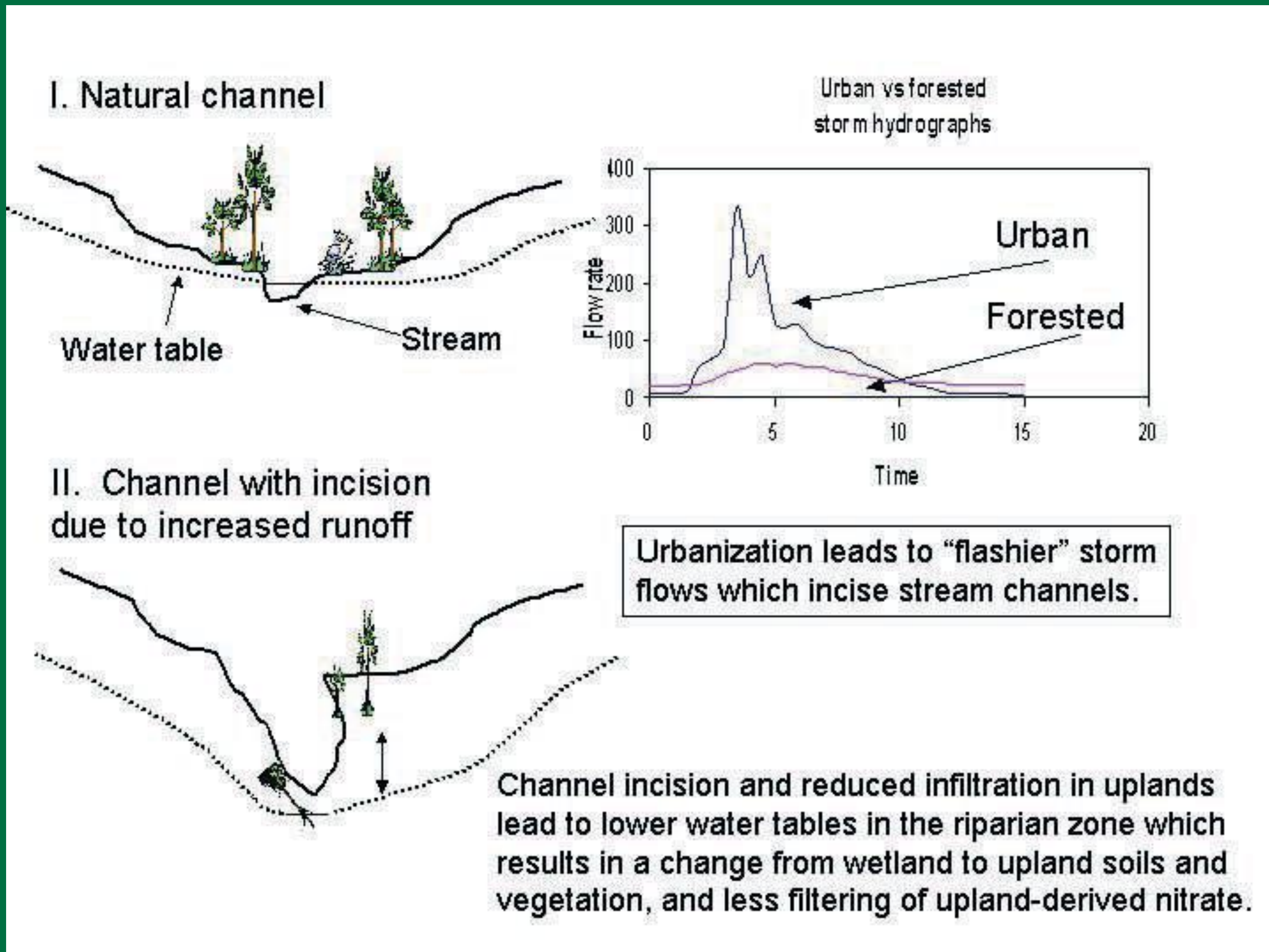
Difficult Run watershed has changed dramatically



2013

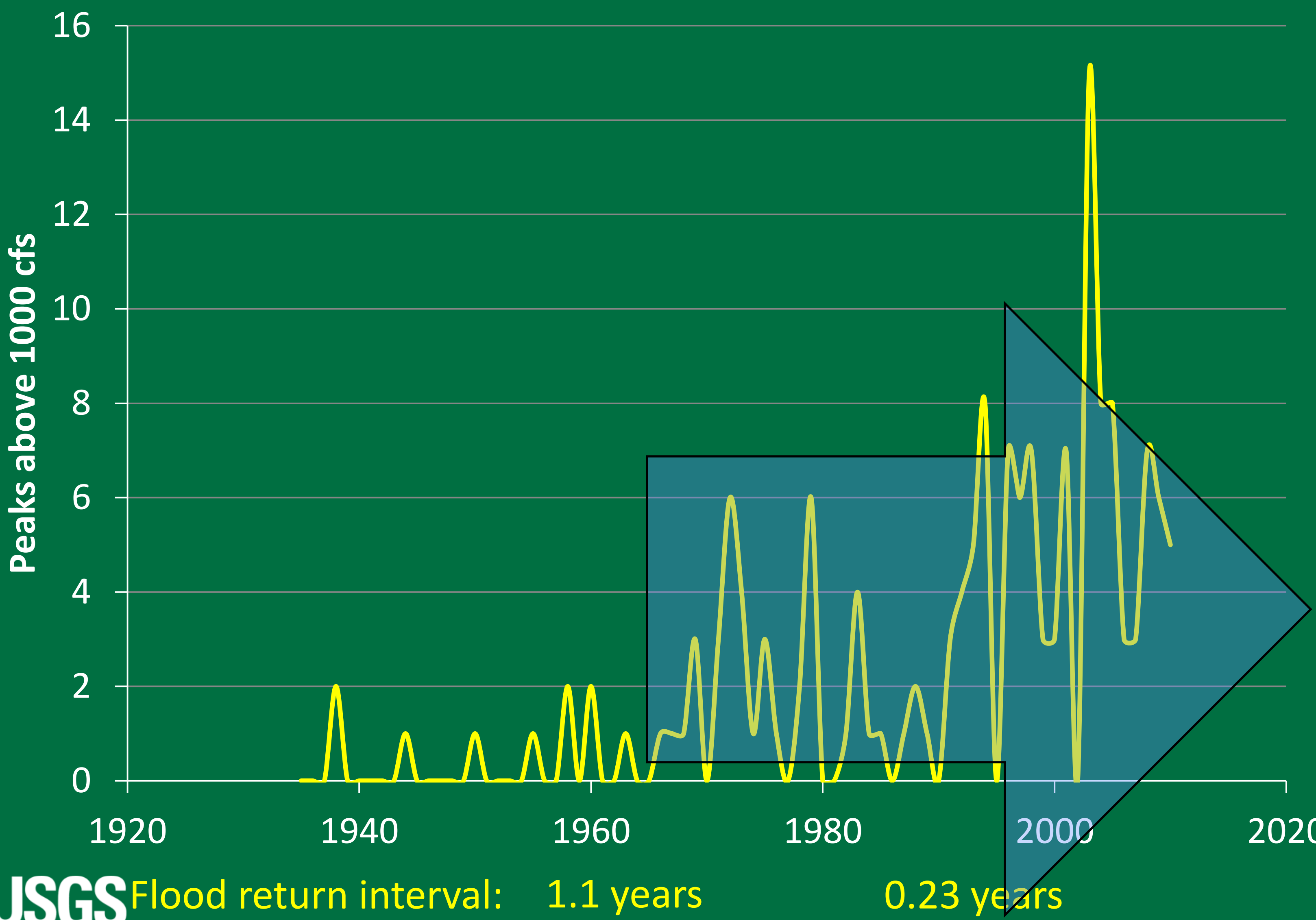
USGS

Urban river floodplains



Groffman et al. 2003

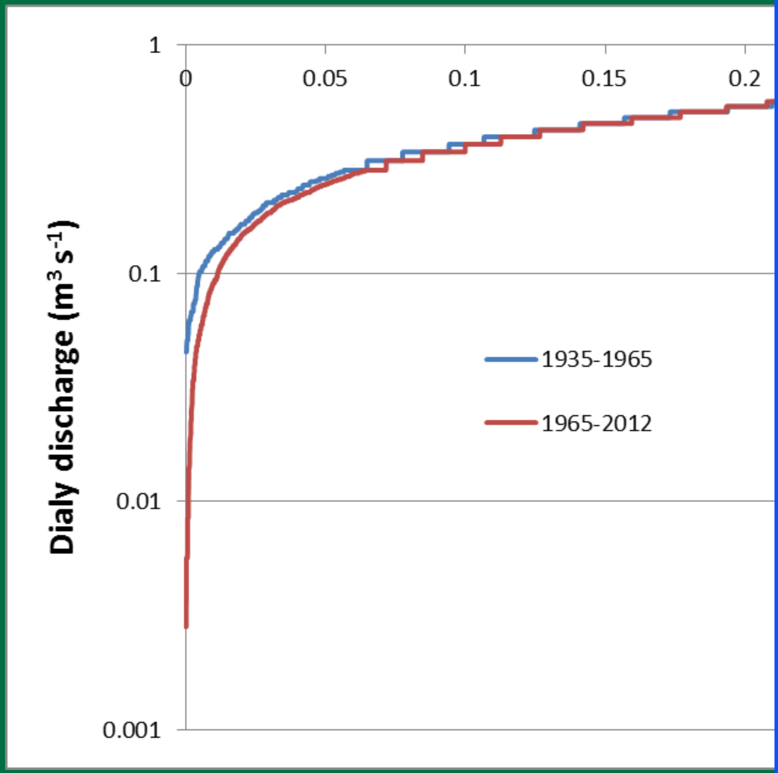
Hydrologic changes due to urbanization

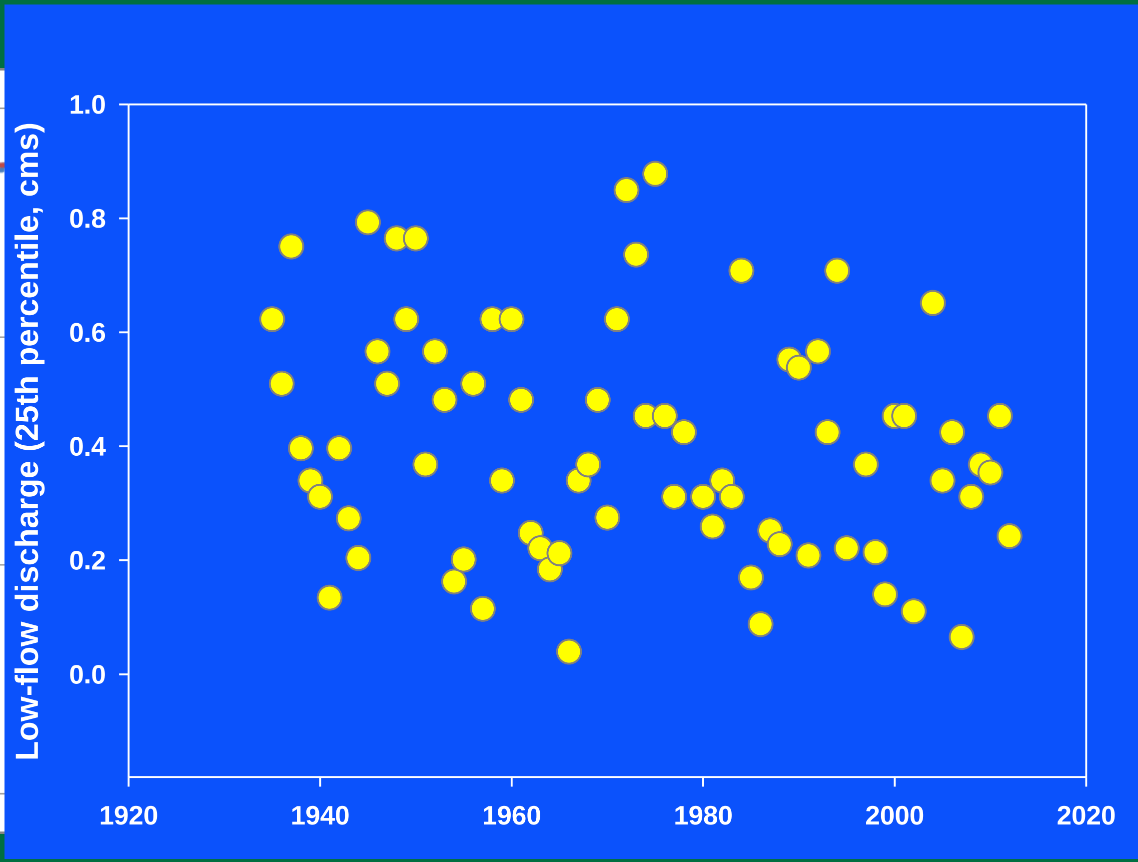


Flood return interval: 1.1 years 0.23 years

Hupp et al. 2013, *Geomorphology*

Hydrologic changes due to urbanization



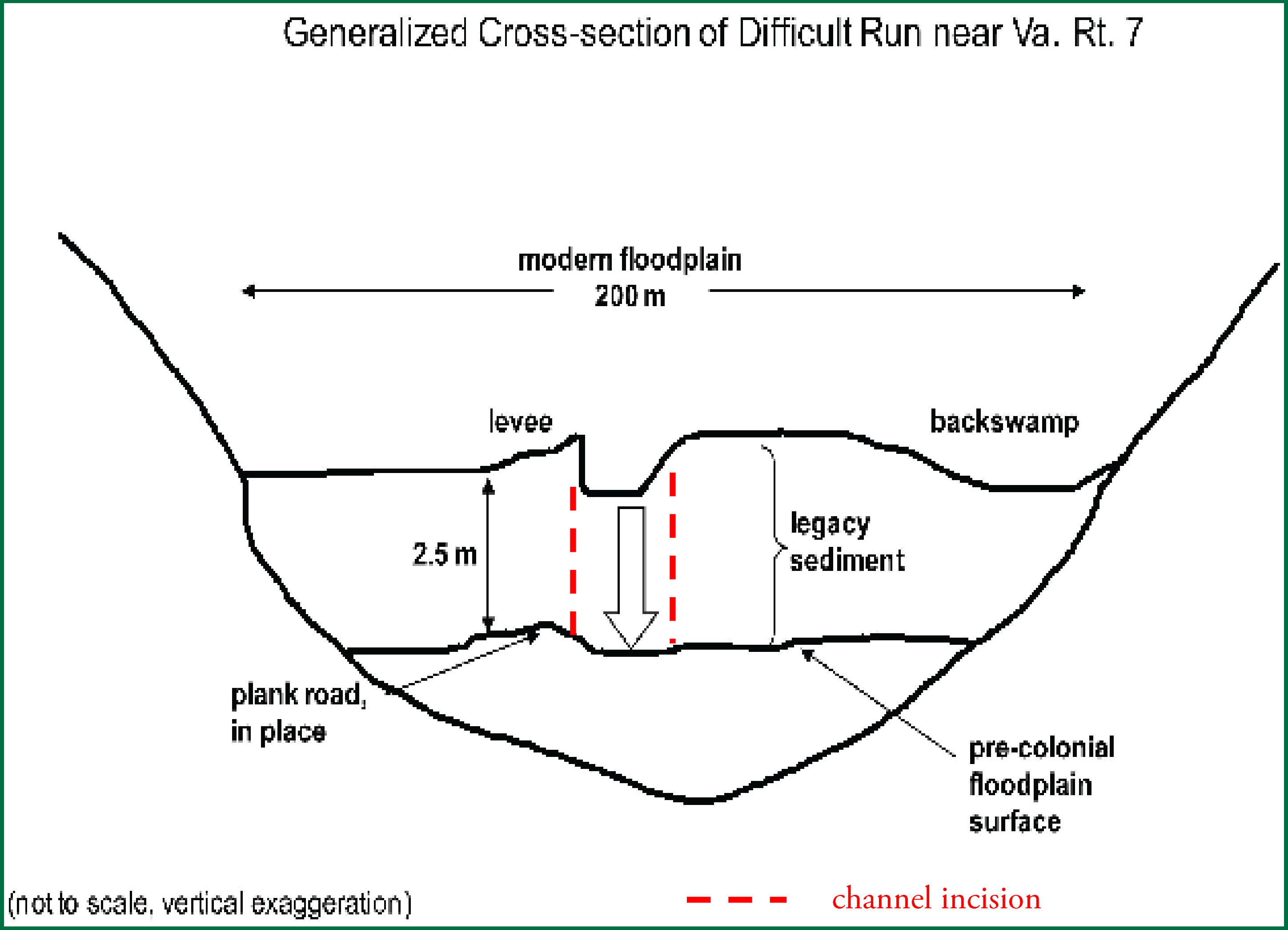


Baseflow decrease over time, stormflow increase over time

USGS

Batson et al. in prep.

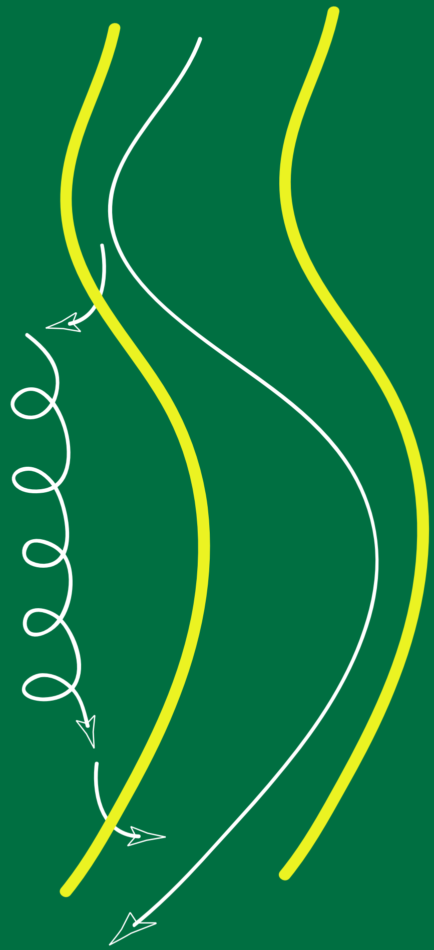
One-Two punch of historic and current impacts



USGS

Hupp et al. 2013, *Geomorphology*

The driest of times, the wetter of times



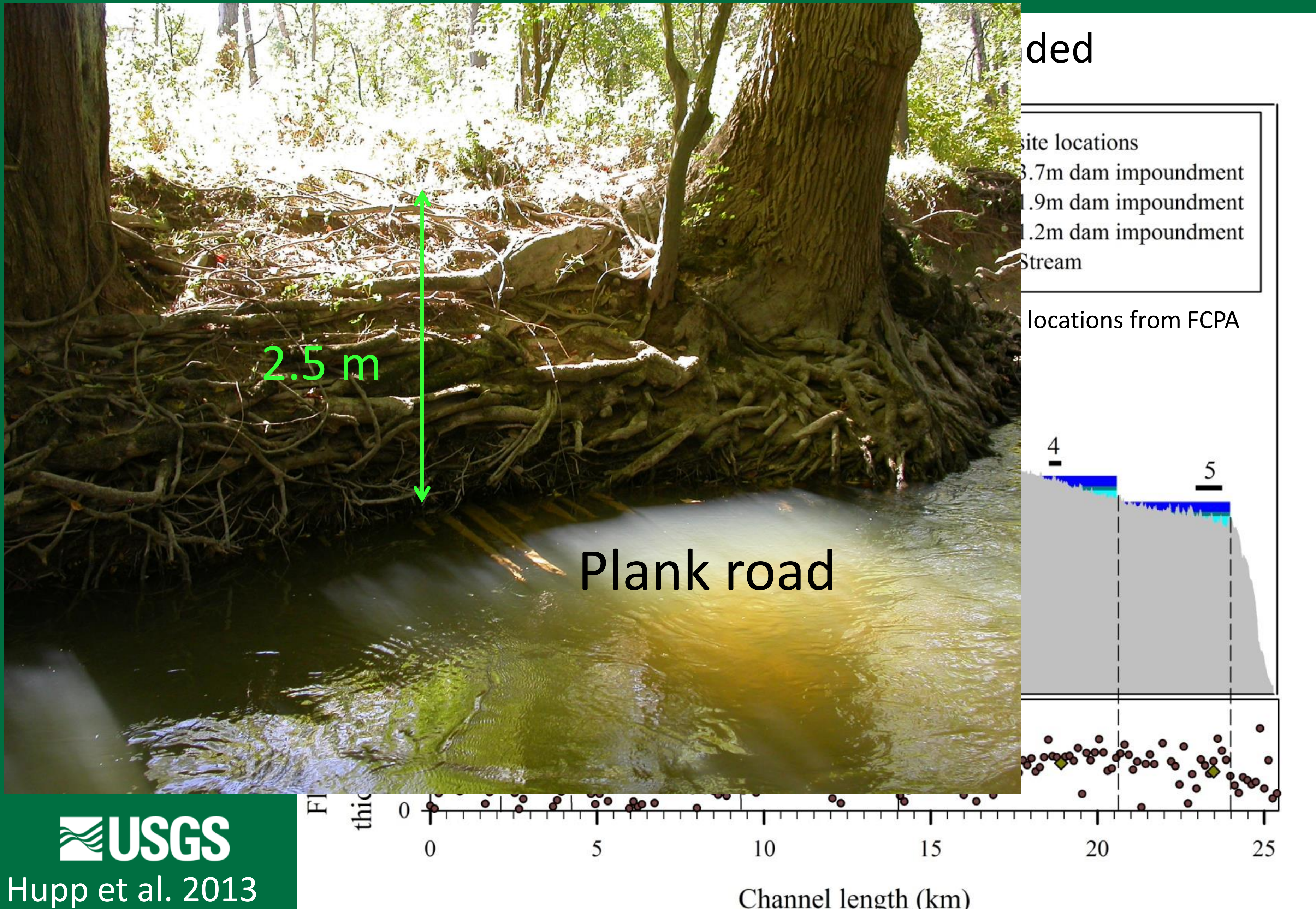
Extreme bank erosion (Site 2, upper Difficult Run)

25 Au

2011

USGS

Difficult Run: Historic mill dams and legacy sediment



USGS

Hupp et al. 2013

Floodplains do flood!

Mean frequency of inundation (%)

Site	Levee	Backswamp	Toe-slope
1	0.00	9.98	0.00
2	0.00	0.20	
3	0.03	4.25	0.11
4	0.12	30.79	
5	7.43	23.68	7.72

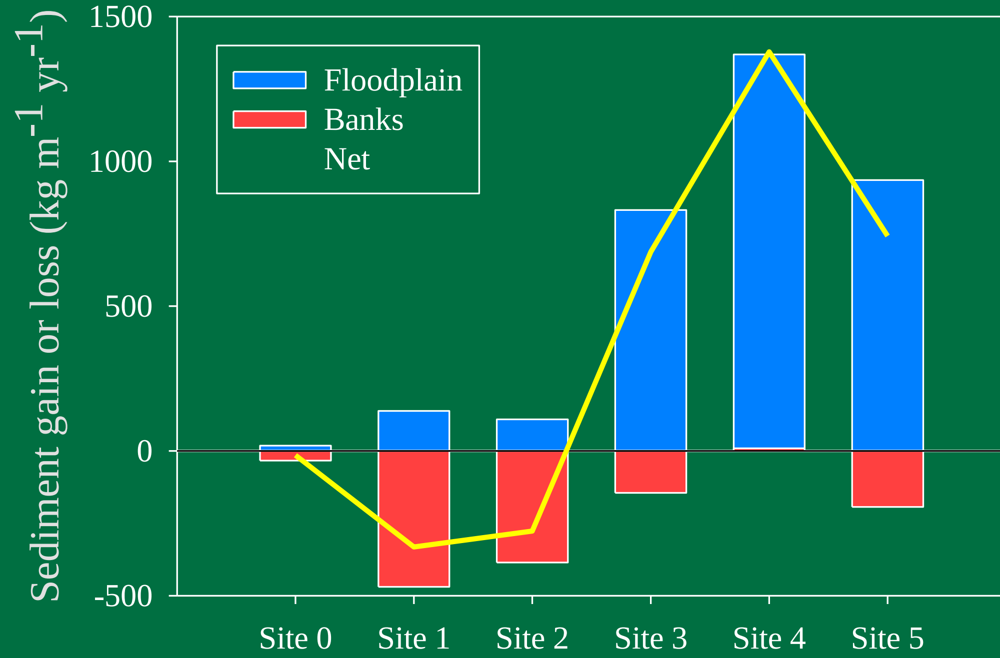
Average is 3% of time
Most floodplain inundation events < 12 hr

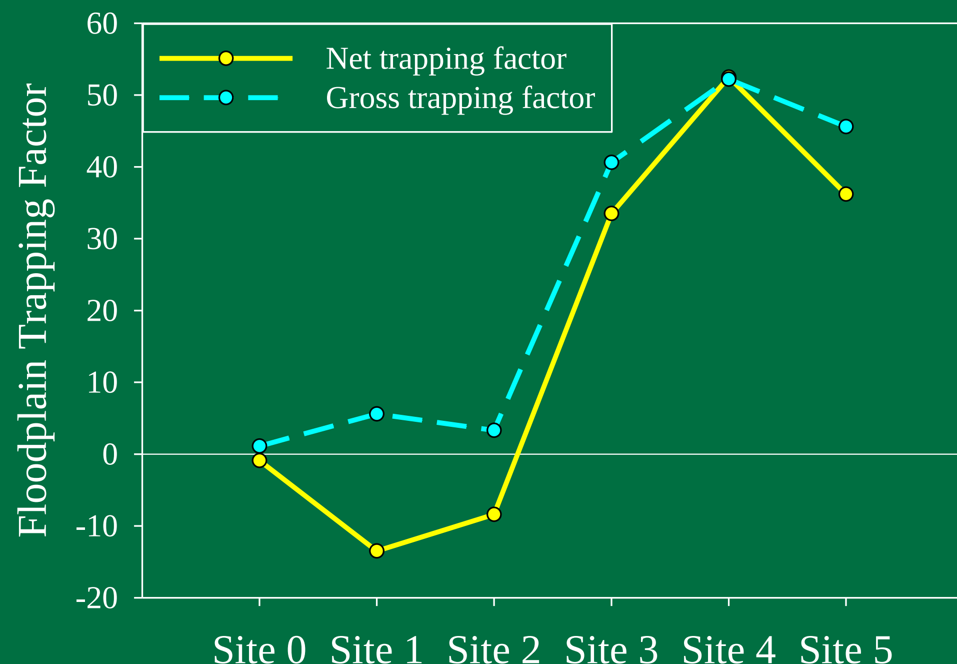
USGS

Hupp et al. 2013, *Geomorphology*

Erosion upstream, deposition downstream

USGS





Floodplain soils hold on tightly to N and P

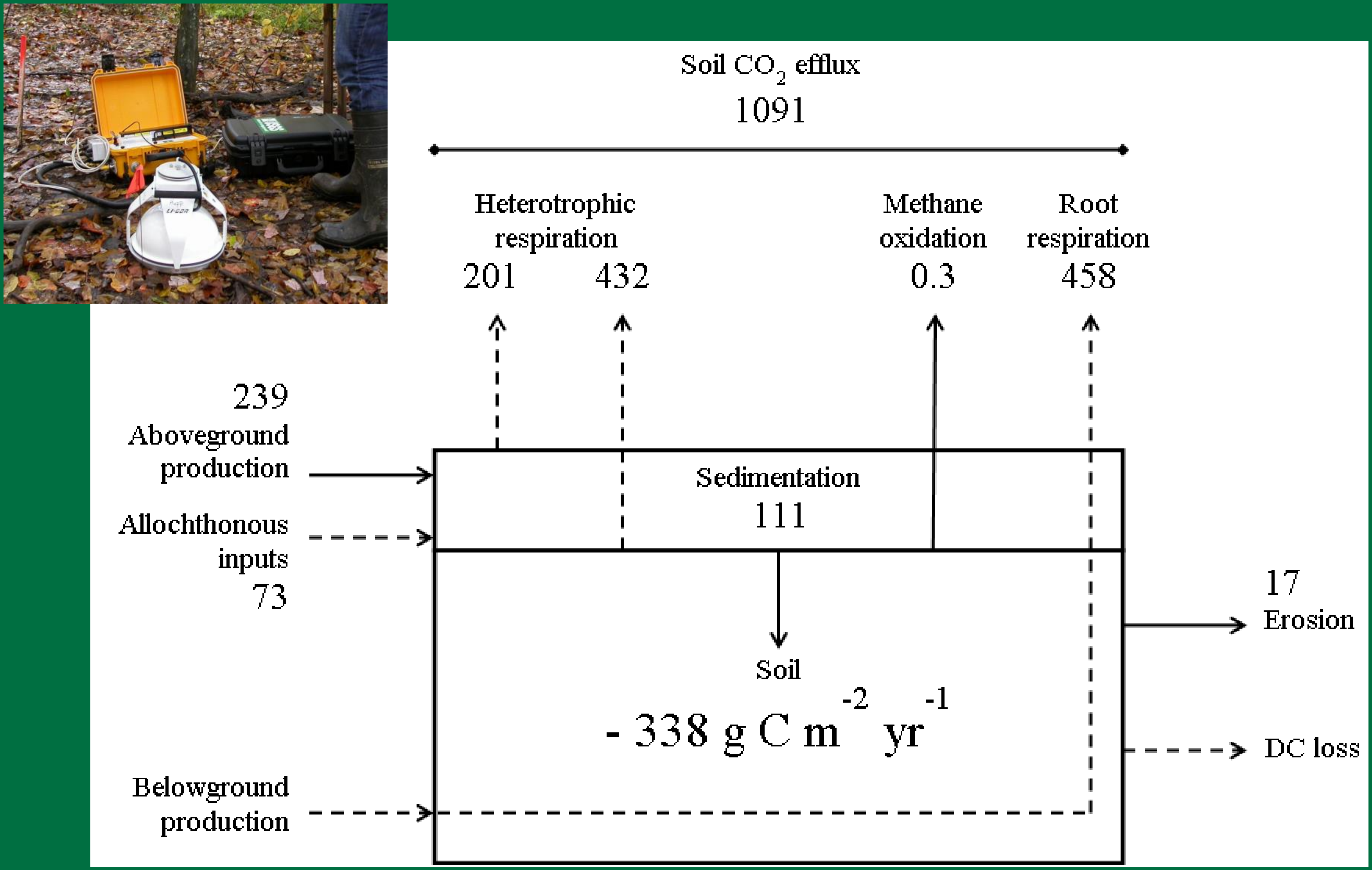
Rate	Areal mineralization (mmol m^{-2} yr^{-1})	Turnover rate (mol mol^{-1} yr^{-1})	Turnover time (yr)
P mineralization	3.60	0.0026	383
N mineralization	319	0.044	23

% nitrification	66%

USGS

Noe et al. 2013, *Ecosystems*

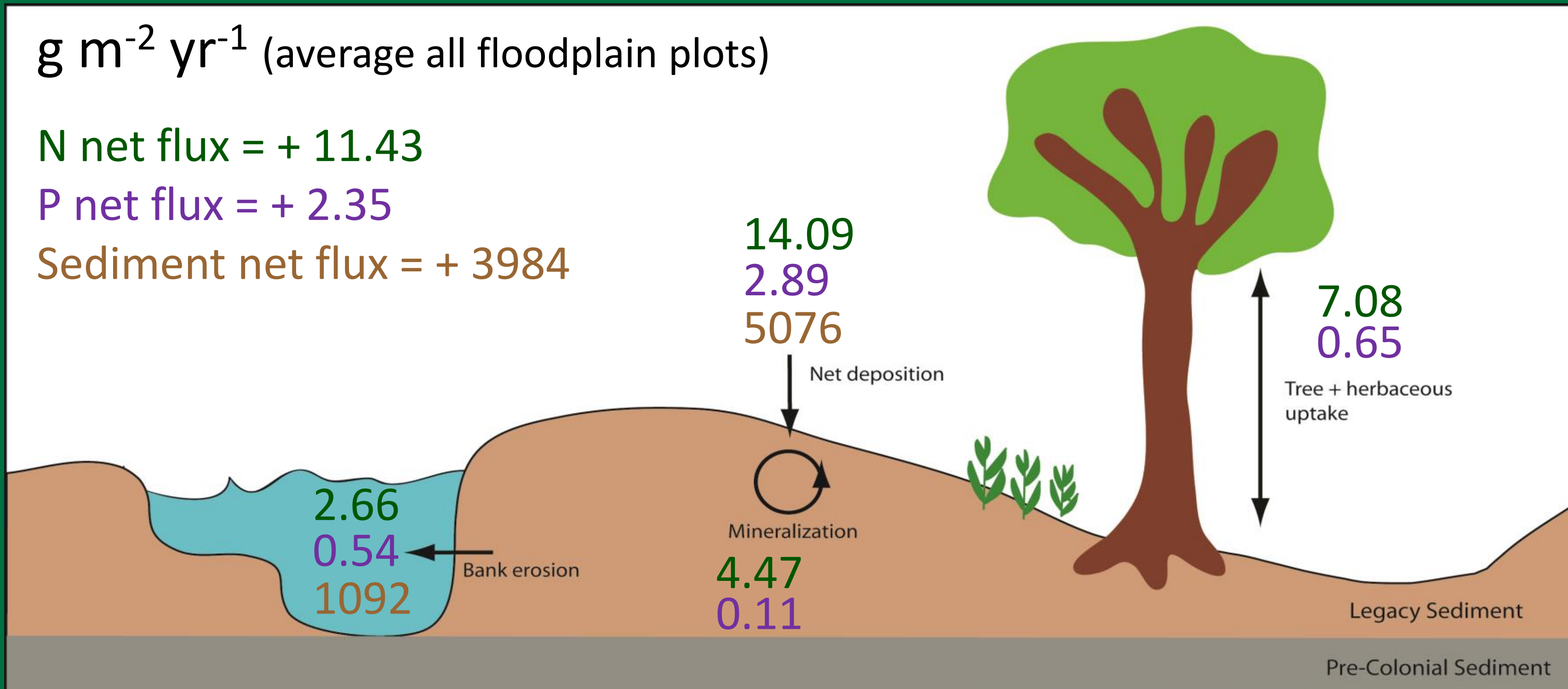
Urbanization is bad for C sequestration!



USGS

Batson et al., in prep.

Budgeting: mainstem floodplains are great traps



Noe et al. 2013, *USGS Science Summary*

Hupp et al. 2013, *Geomorphology*

Noe et al. 2013, *Ecosystems*

Rybicki et al. in prep.

Noe et al. in prep.

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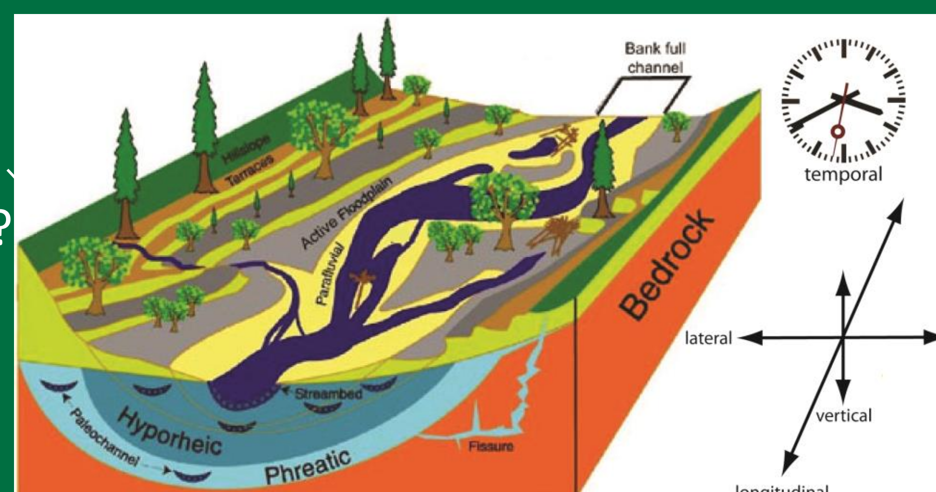
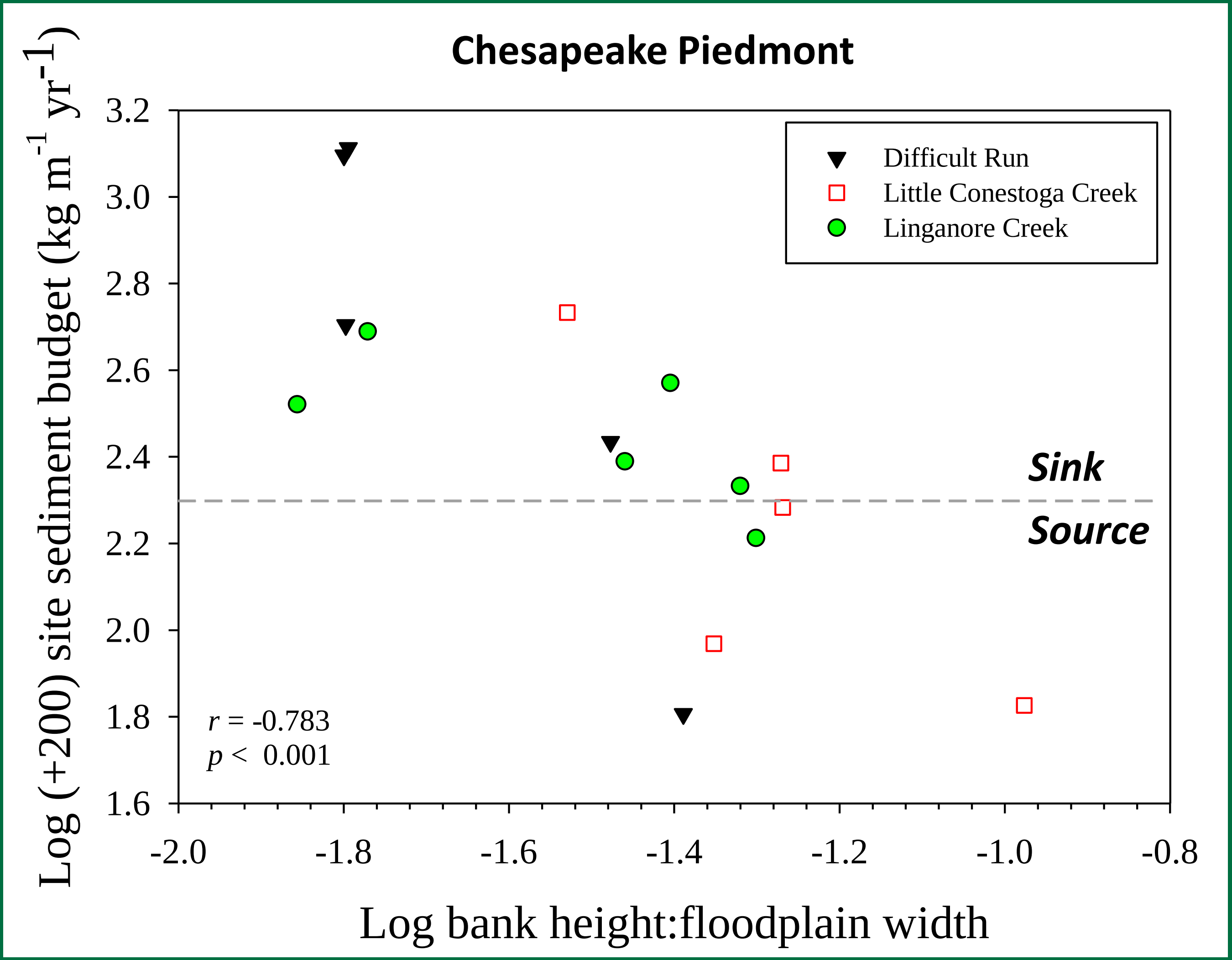


Predicting floodplain WQ functions



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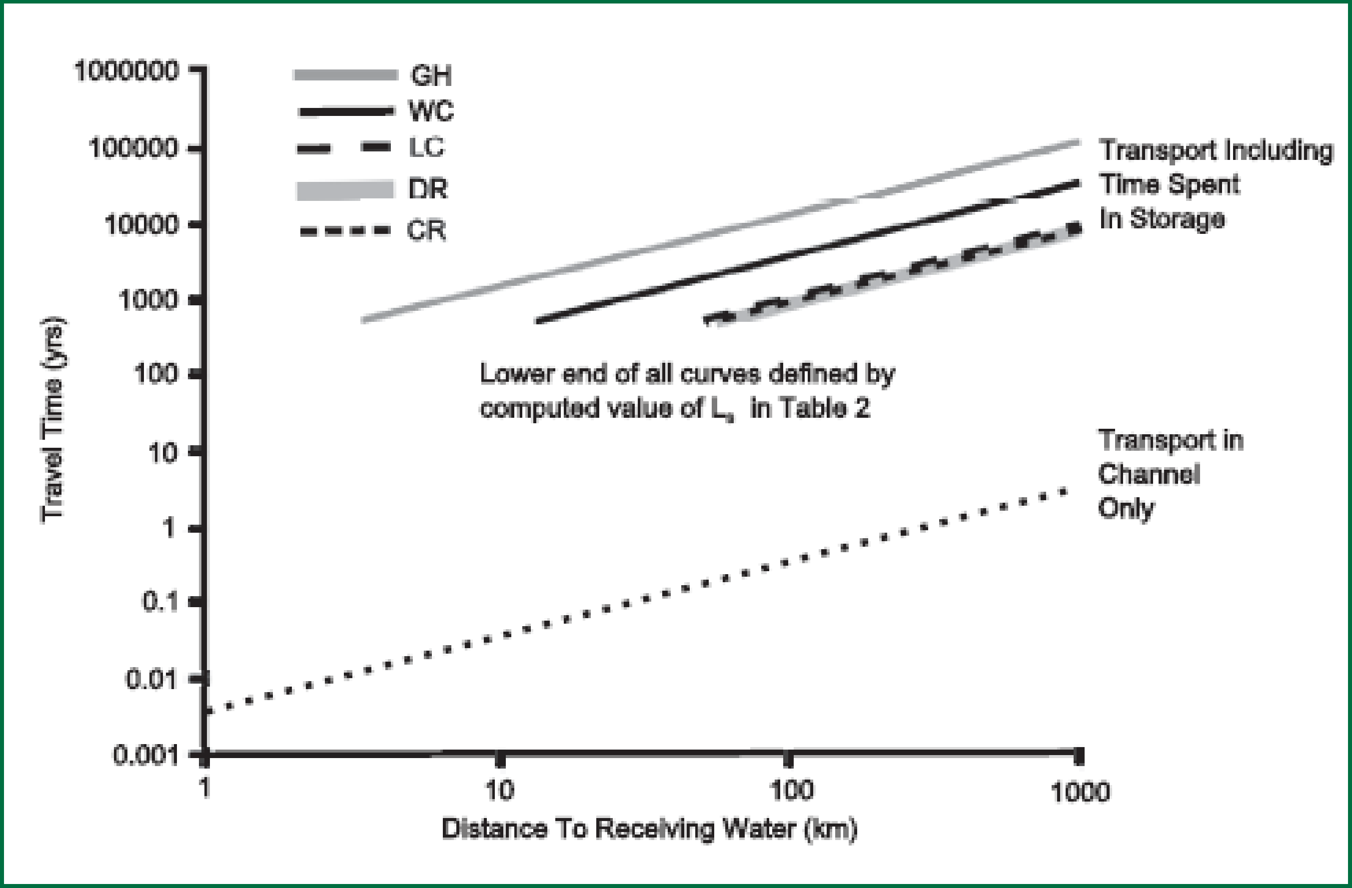
Schenk et al. 2013, *ESP&L*

Influence of floodplains on sediment transport lag times

Pizzuto et al. 2014. Characteristic length scales and time-averaged transport velocities of suspended sediment in the Mid-Atlantic Region, U.S.A. *Water Resources Research*.



Average fine sediment velocity: ~ 0.1 km/yr

Average particle travel time out of medium sized watersheds:
~ 100-1000 yr

USGS

The Chesapeake Floodplain Network

Measure and predict the sediment/N/P balance (sink or source of floodplain/banks) in entire Chesapeake watershed

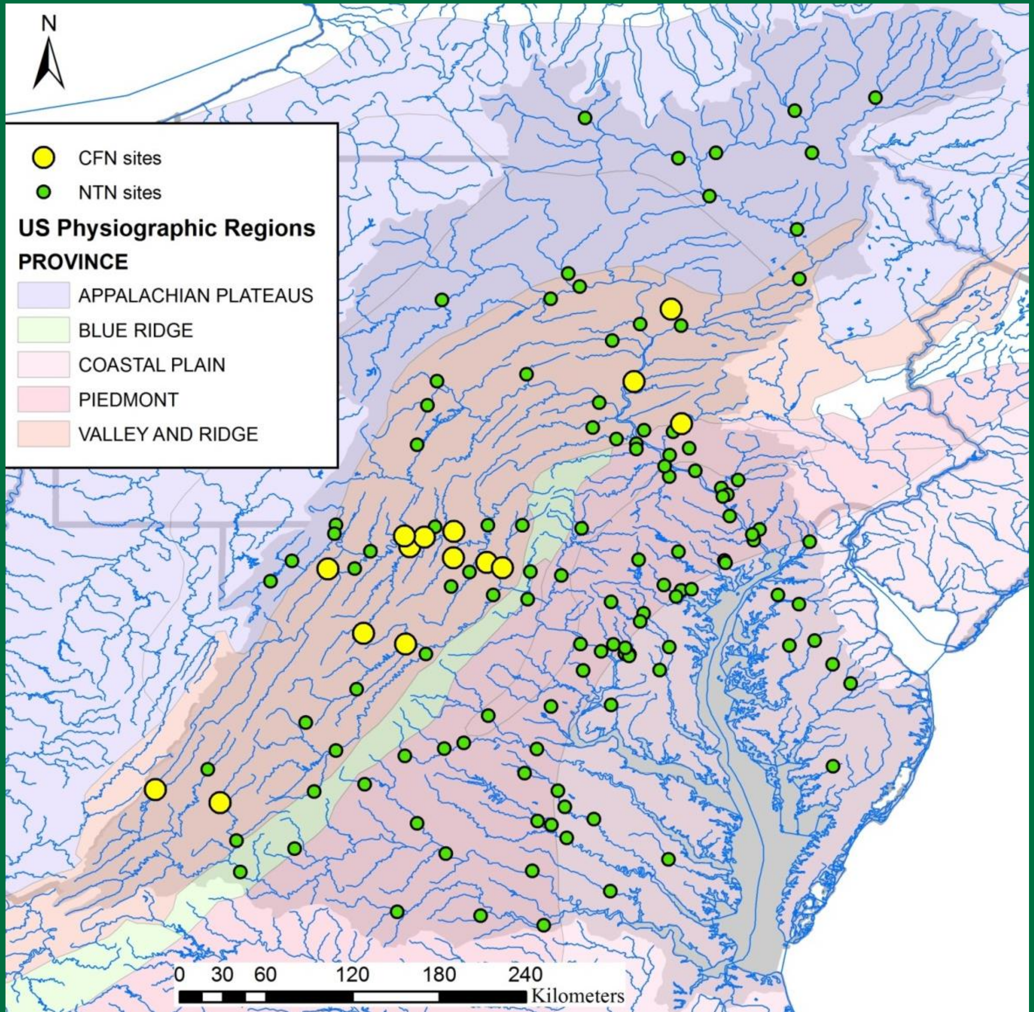
Measurements:
- Reach scale sediment net flux (and associated TN & TP)
- Soil mineralization, DEA, P sorption, CO2 efflux, Veg NP limitation

Install:

FY13: Ridge & Valley (n=15)
FY14: Piedmont (n=15)
FY15: Coastal Plain (n=15)

Scaling:

Statistical regression and
GIS spatial prediction
(need floodplain maps!)



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SPARROW modeling of wetland influence on N and P loads

Attenuate aquatic phase transport of N and P:

Atlantic Coastal Plain Blackwater Stream Floodplain Forest
Southern Piedmont Small Floodplain and Riparian Forest

Enhanced delivery to stream for N:

East Gulf Coastal Plain Small Stream and River Floodplain Forest
East Gulf Coastal Plain Near-Coast Pine Flatwoods
Southern Coastal Plain Nonriverine Basin Swamp (including Okefenokee)
Southern Coastal Plain Blackwater River Floodplain Forest

Reduced delivery to stream for N:

Atlantic Coastal Plain Peatland Pocosin

Enhanced delivery to stream for P:

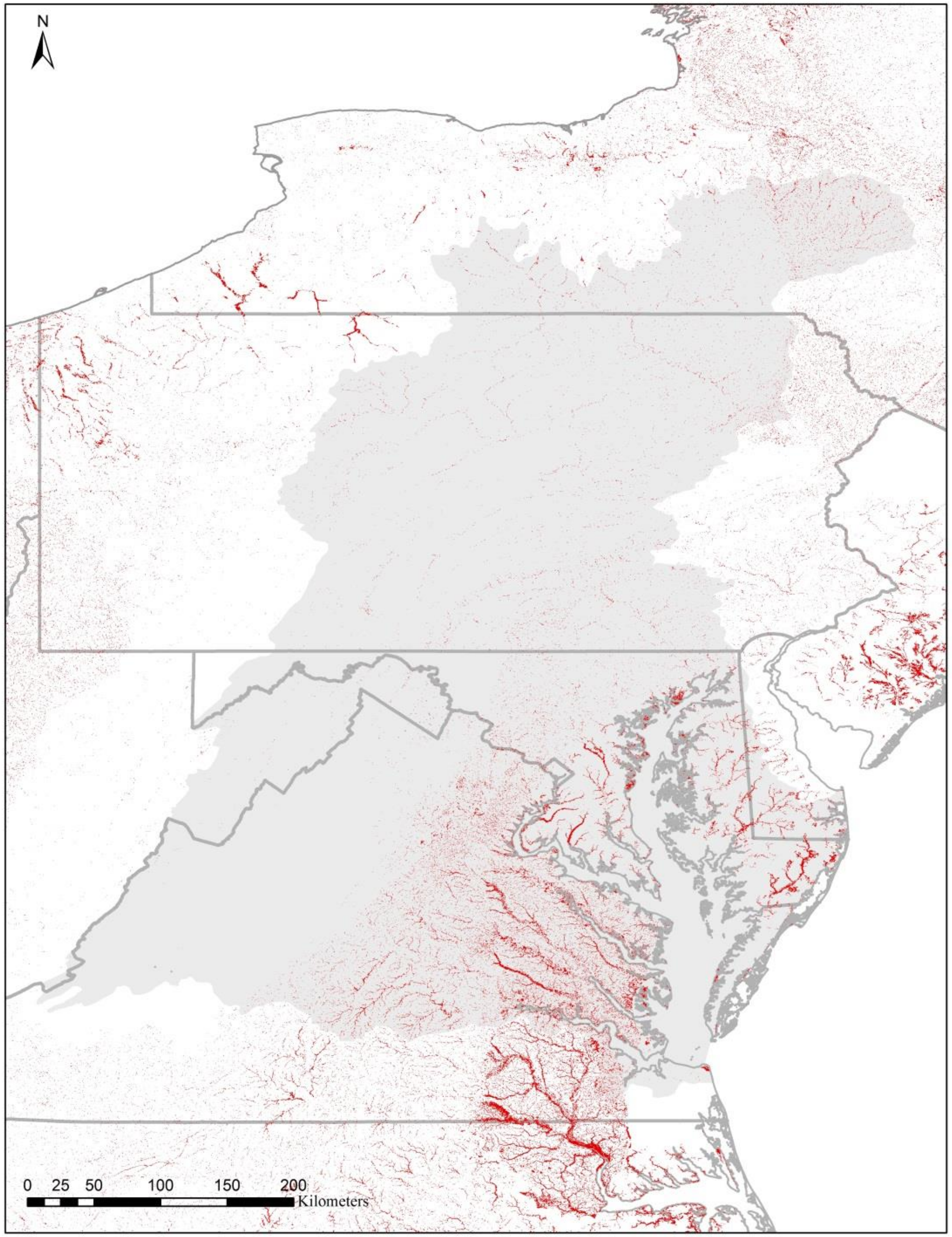
Central Interior and Appalachian Riparian Systems
Laurentian-Acadian Floodplain Systems
Atlantic Coastal Plain Small Blackwater River Floodplain Forest

Reduced delivery to stream for P:

Atlantic Coastal Plain Peatland Pocosin
Southern Coastal Plain Nonriverine Cypress Dome
Southern Coastal Plain Nonriverine Basin Swamp (including Okefenokee)
Southern Piedmont Small Floodplain and Riparian Forest

USGS

Hoos et al. 2013, *USGS SIR*



Conclusions for resource management

- *There is likely a long lag time between the implementation of management actions and stable long-term decreases in downstream pollutant loading to streams, rivers, and the Chesapeake Bay.*

- *Efforts to reduce bank erosion would be most effective near the headwaters*.

- *Floodplains should be managed to be as natural as possible, with minimal infrastructure, to allow flooding. Floodplains hold onto what they trap.*

- *Vegetation management could favor trees over meadow plants in riparian restoration efforts in order to maximize the ability of floodplains to hold onto nitrogen.*


THANK YOU