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science for a changing world

Nutrient and sediment inputs change soil structure and biogeochemistry in floodplain ecosystems: a cross-study synthesis

Greg Noe[1], Cliff Hupp[1], Ed Schenk[2], Ken Krauss[3], Sara McMillan[4], Dan Kroes[5], Scott Ensign[6], Jaimie Gillespie[1], Kristin Wolf[7], and Changwoo Ahn[8]

[1]U.S. Geological Survey, National Research Program, Reston, Virginia

[2]National Park Service, Flagstaff, Arizona

[3]U.S. Geological Survey, Wetland and Aquatic Research Center, Lafayette, Louisiana

[4]Purdue University, West Lafayette, Indiana

[5]U.S. Geological Survey, Baton Rouge, Louisiana

[6]Aquatic Analysis and Consulting LLC, Morehead City, North Carolina

[7]Champlain College, Waterbury, Vermont

[8]George Mason University, Fairfax, Virginia

U.S. Department of the Interior
U.S. Geological Survey

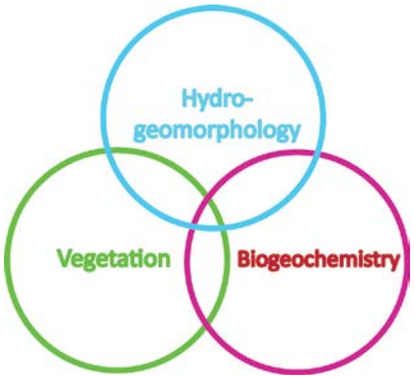
Conceptual models of floodplain ecosystems: ecogeomorphology

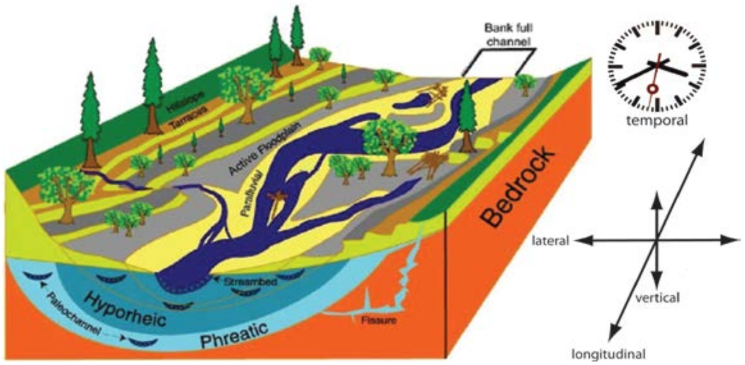
Floodplains are dynamic systems, structured by both channel interactions and internal processes

How does hydrologic connectivity change floodplain sediment and nutrient fluxes and soils?

How do floodplains typically behave, and how does it change across landscapes?

What are geomorphic-biogeochemical interactions and their consequences?





(Noe 2013 *Treatise of Geomorphology*, modified from NRC 2002 Riparian Areas)

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Objectives

Synthesize measurements of inputs and internal cycling of sediment and nutrients made across our multiple studies of floodplains

- Contrast rates among landscape settings and ID watershed controls
- Relate nutrient and sediment inputs to soil characteristics and biogeochemical rates
- Identify typical rates of autochthonous vs. allochthonous C sedimentation rates

→ Insight into consequences of hydrologic connectivity for wetlands

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Common measurement techniques across all studies facilitate synthesis

- Input rates to floodplains

  Sediment: accretion, mass accumulation, C, N, P mass accumulation

  → *short-term artificial marker horizons (tile or feldspar)*

  Dissolved: inorganic N and P

  → *ion-exchange resin bags on soil surface*

- Sediment and soil characteristics

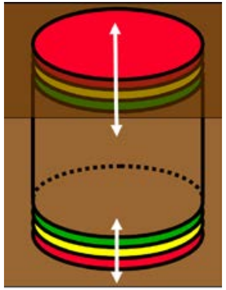
  → *short-term artificial marker horizons (tile or feldspar)*

  → *surficial (0-5 cm) cores*

- Biogeochemical transformation rates

  Net N and P mineralization rates

  → *modified resin cores*



Noe 2011, *SSSAJ.*

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Floodplain sites

<u>Sedimentation</u>:

400 plots

60 river reaches

20 rivers

<u>Soil N&P mineralization</u>:

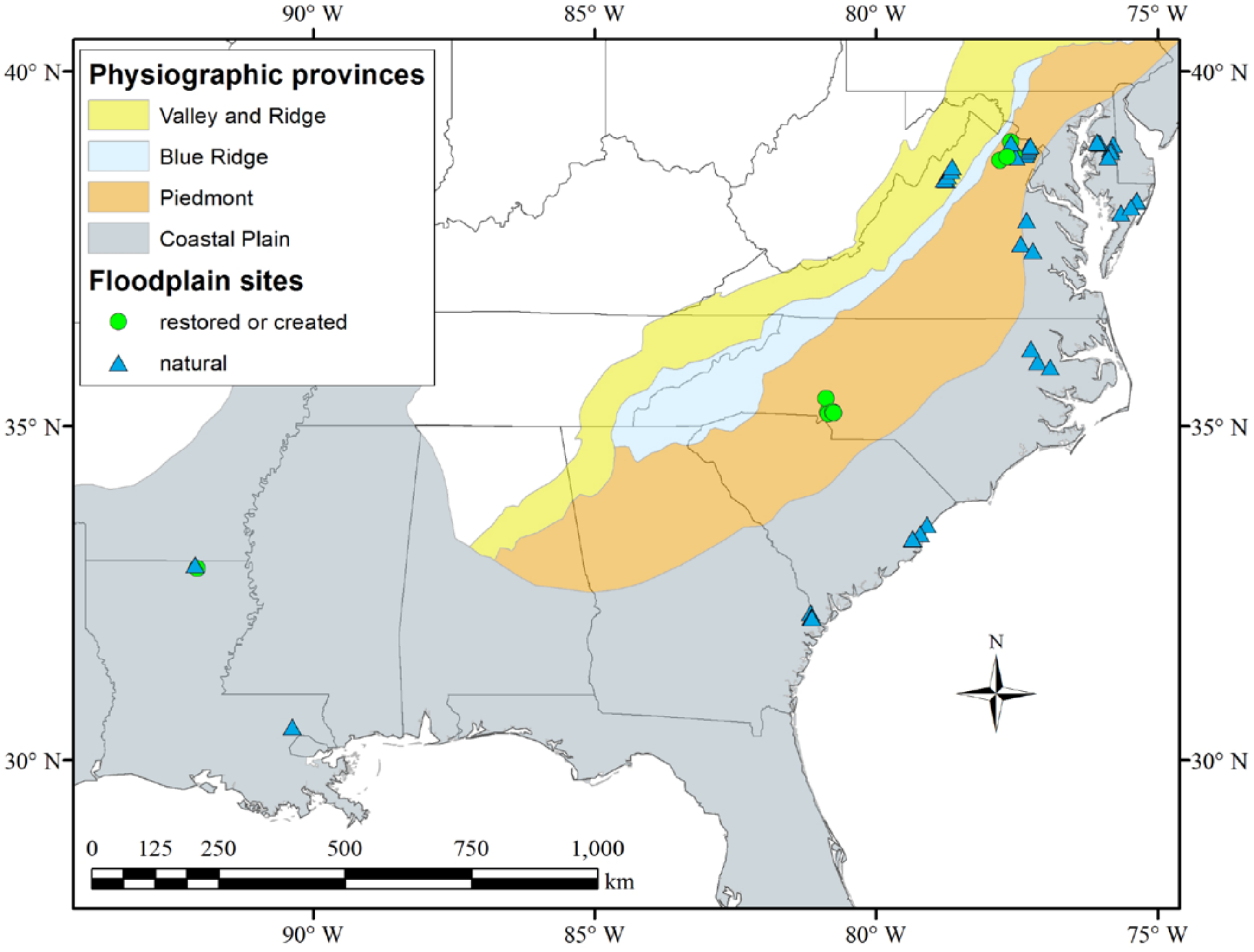
142 plots

29 river reaches

12 rivers

<u>Landscape settings</u>:

Nontidal and tidal rivers



Input rates and sediment characteristics

Average duration = 2.4 yr

Compared to other studies:

Sed fluxes typical

N conc. and fluxes greater

C conc. and fluxes greater

P conc. and fluxes typical

	n	Mean	Median	Coefficient of variation
Sedimentation (g m^{-2} yr^{-1})	400	4629	1449	377%
Sediment deposition (cm yr^{-1})	173	0.70	0.52	95%
Mineral sedimentation (g m^{-2} yr^{-1})	263	5018	1556	406%
Organic sedimentation (g m^{-2} yr^{-1})	263	553	366	158%
C sedimentation (g-C m^{-2} yr^{-1})	398	253	168	132%
N sedimentation (g-N m^{-2} yr^{-1})	398	16.4	10.0	132%
P sedimentation (g-P m^{-2} yr^{-1})	378	3.41	1.47	193%
Organic (%)	259	21.0	15.5	72%
C (%)	389	13.7	9.9	81%
N (%)	389	0.76	0.60	67%
P (mg g^{-1})	369	1.10	1.02	51%
NH_4^+ input (g-N m^{-2} yr^{-1})	144	0.99	0.41	257%
NO_3^- input (g-N m^{-2} yr^{-1})	144	1.73	0.57	216%
SRP input (g-P m^{-2} yr^{-1})	144	0.54	0.38	114%

Mitsch et al. 2005:

median NO_3-N removal = 29 g-N m^{-2} yr^{-1}

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Noe et al., manuscript in prep.

Sedimentation rates

High:

Valley + Ridge

Coastal Plain

Oligohaline

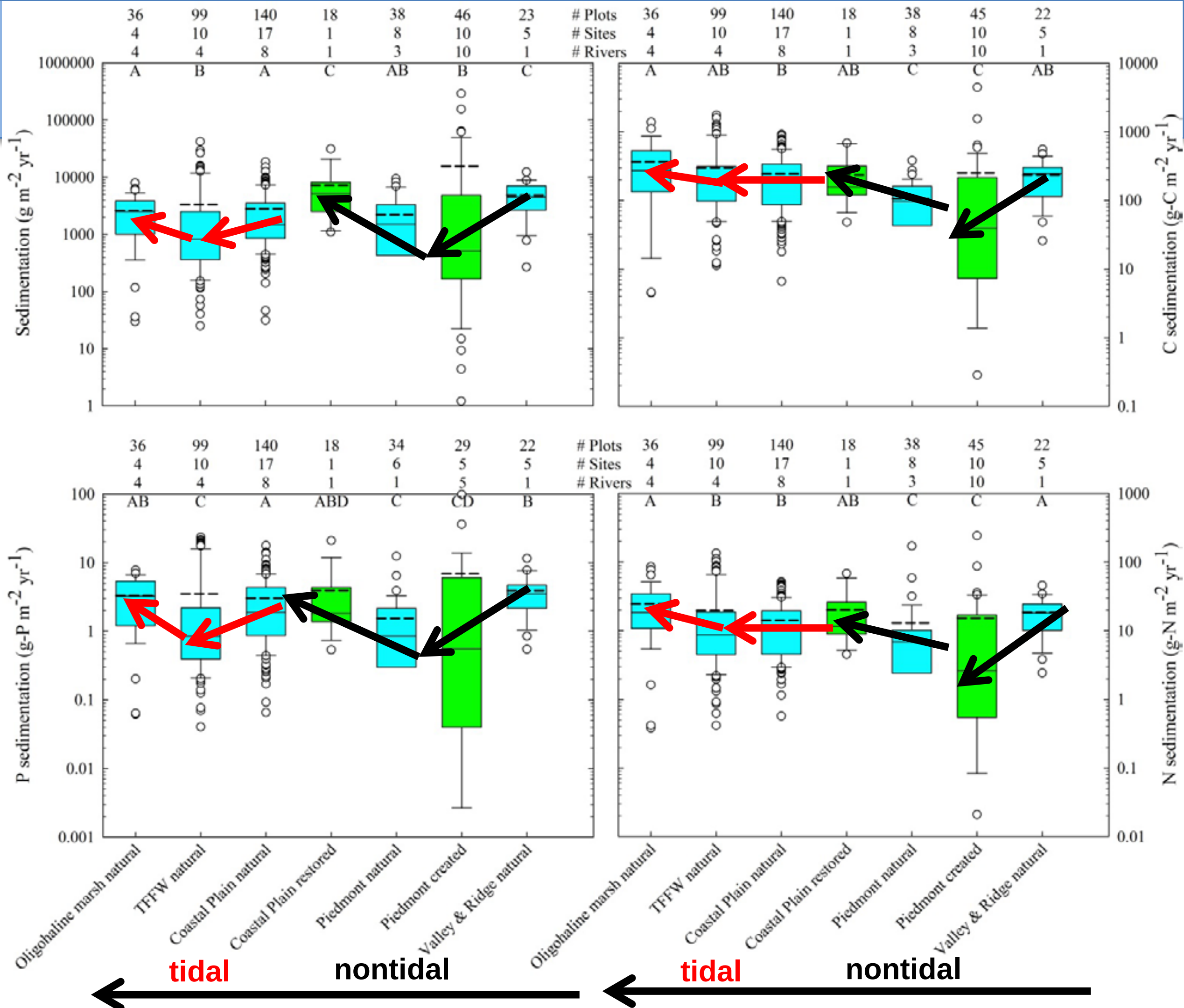
'W'

Low:

Piedmont

TFFW

Restored/created similar to natural in same province



Noe et al. in prep.

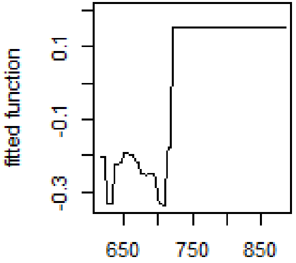
Sedimentation controls (nontidal floodplains only)

Boosted Regression Trees:

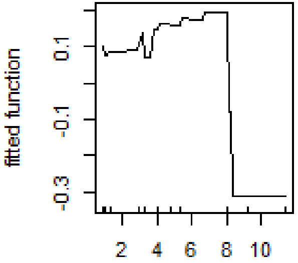
[25 watershed attributes considered]

Explained deviance = 49%

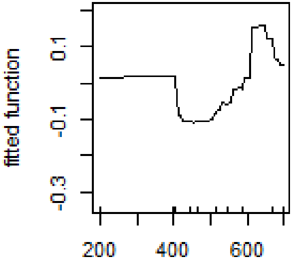
CV correlation = 0.64



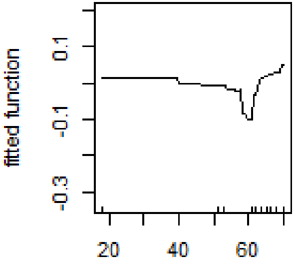
Evapotranspiration (24%)



Infiltration-excess overland flow % (23%)

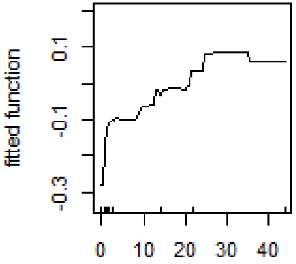


Natural soil P (13%)

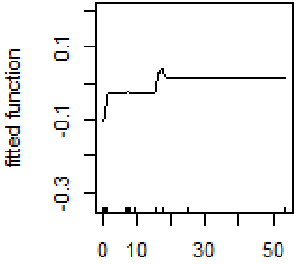


Geologic SiO_2 (12%)

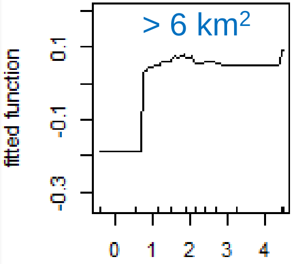
N and P sedimentation:
Pasture, Developed land use also important



Impervious % (11%)



Pasture % (9%)



Log Basin area (9%)

Organic sedimentation

y-intercept = 212 g-OM m^{-2} yr^{-1} (95% CI: 171 to 253)

NAPP – decomposition = 133-200 g-OM m^{-2} yr^{-1}

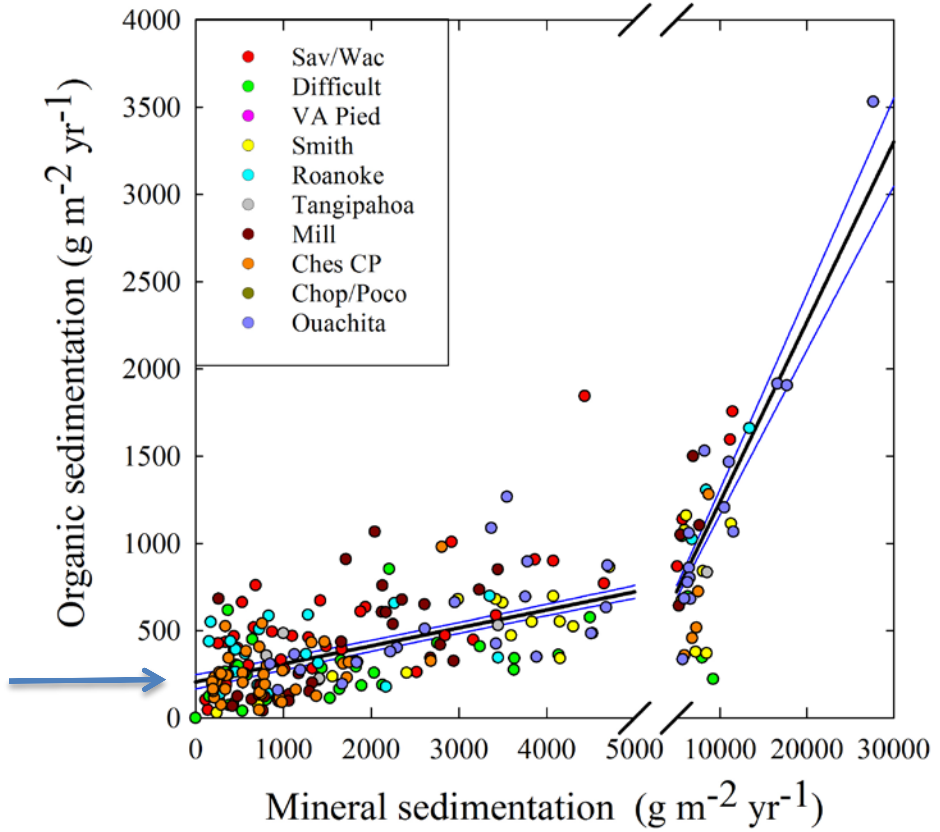
(Conner and Cherry 2013) , (Lockaby and Walbridge 1998)

Disconnected floodplain deposition = 165 g-OM m^{-2} yr^{-1}

(Noe and Hupp 2005)

autochthonous ~ 180 g-OM m^{-2} yr^{-1}, 70 g-C m^{-2} yr^{-1}

allochthonous ~ 370 g-OM m^{-2} yr^{-1}, 150 g-C m^{-2} yr^{-1}



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P mineralization controls

Boosted Regression Trees:

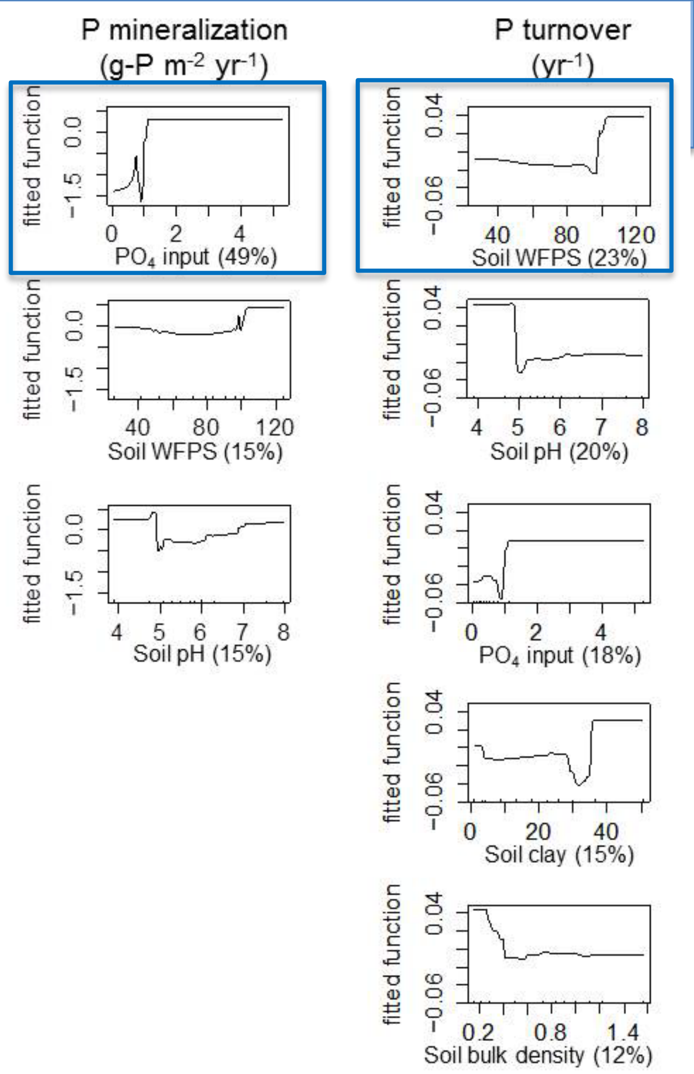
Deviance explained = 93% P min., 89% P turnover

CV correlation = 0.81 P min., 0.80 P turnover

P min.: 60% control by material inputs, 40% by soil character.

P turn.: 26% …   , 74% …

PO_4 inputs, WFPS, and pH most important



N mineralization controls

Boosted Regression Trees:

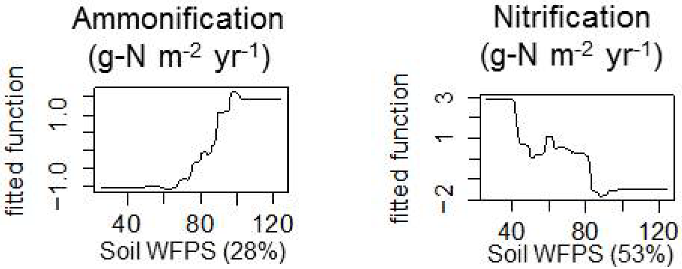
Deviance explained = 49% P min., 63% P turnover

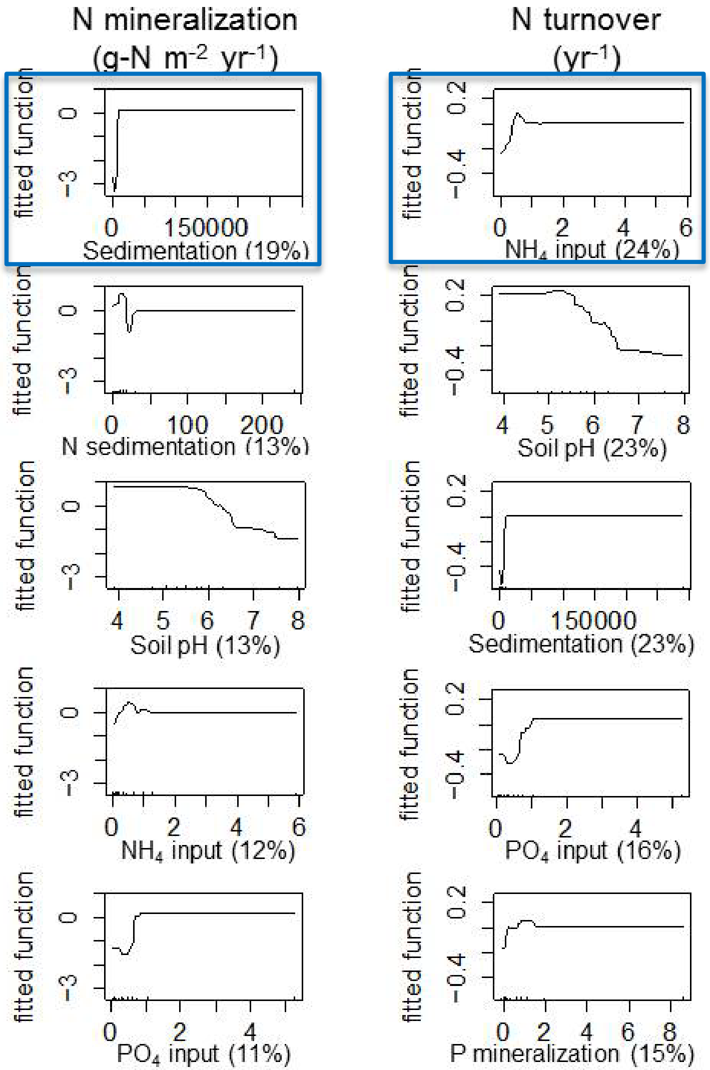
CV correlation = 0.30 N min., 0.50 N turnover

N min.: 65% control by material inputs, 35% by soil character.

N turn.: 62% … , 38% …

Sedimentation, NH_4 inputs, and pH most important





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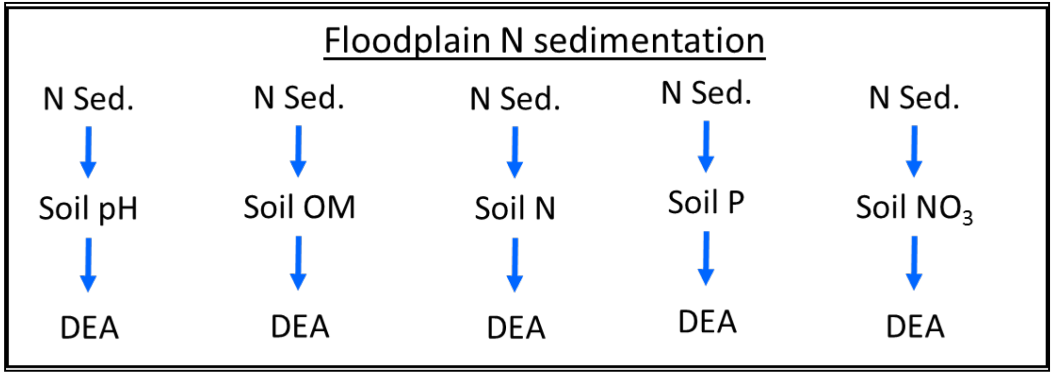
Sediment inputs stimulate denitrification

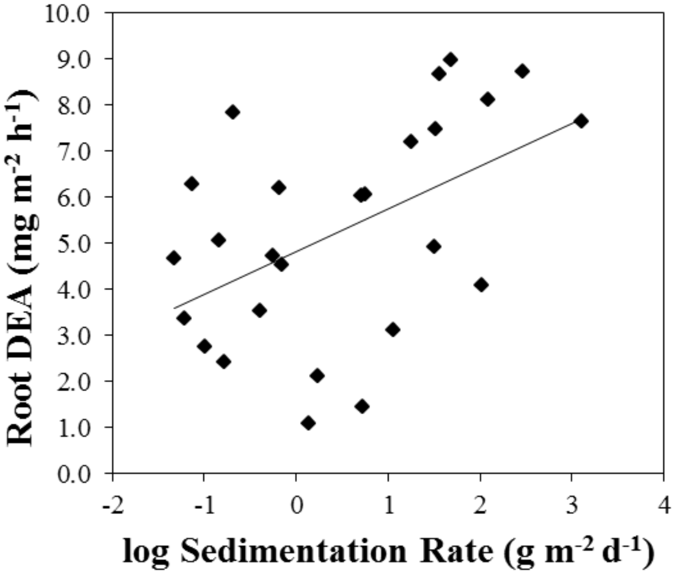
Individual studies…

Chesapeake floodplains



Korol et al. in review

Urban restored streams, Charlotte NC



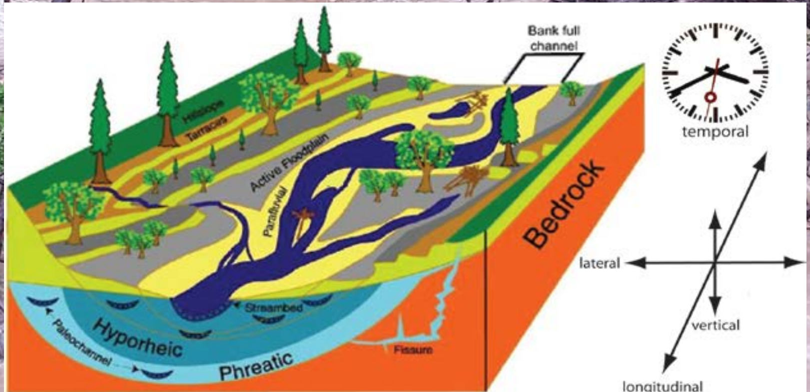
McMillan and Noe 2018

Conclusions

This multi-study synthesis, comparing common measurements across a wide range of floodplains, provides comprehensive flux <u>#</u>'s and highlights the importance of ecogeomorphology:

- Landscape/watershed (and reach geomorphology) controls on variation in sedimentation and N and P input fluxes can provide predictability

- Hydrologic connectivity → C, N and P inputs → mineralization and denitrification

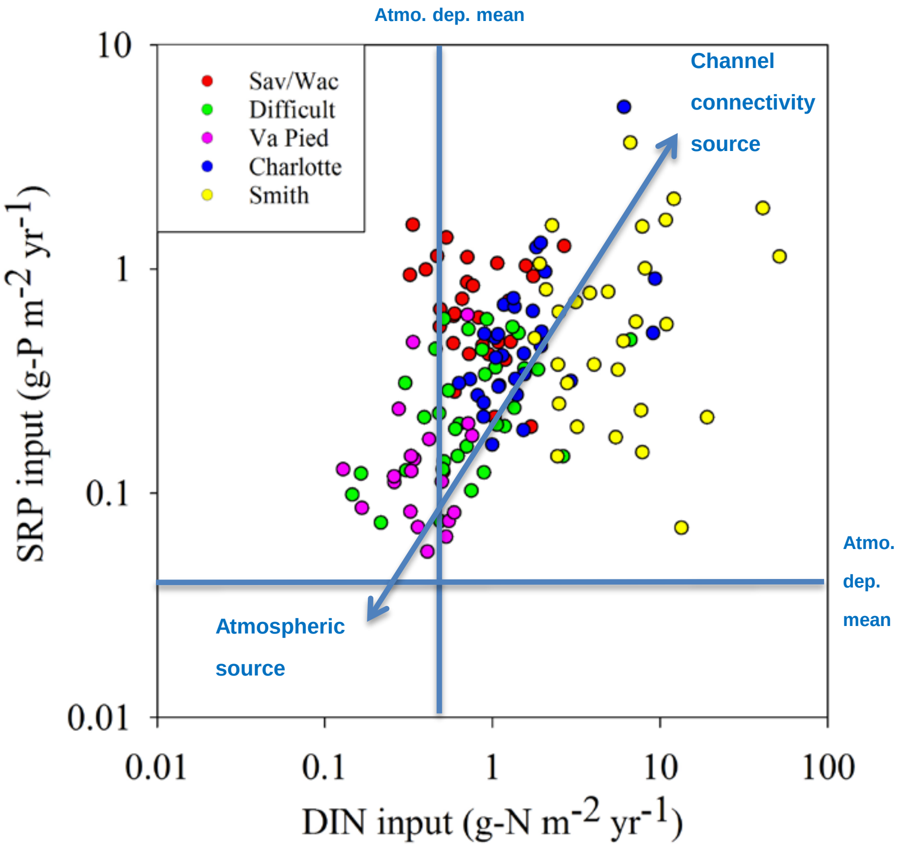


Dissolved inorganic nutrient inputs

Increase with watershed agriculture and development

Greater than atmospheric deposition to most wetlands

Particulate NP >>	Dissolved NP inputs
3.6 g-P m^{-2} yr^{-1}	0.6 g-P m^{-2} yr^{-1}
13.6 g-N m^{-2} yr^{-1}	2.1 g-N m^{-2} yr^{-1}



(Johnston 1991)

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Soil N and P mineralization

P min. more variable than N min.

N turnover more variable than N min.

P turnover = P min.

Created = or > Natural