Quantifying and Valuing Floodplain Nutrient and Sediment Retention

Krissy Hopkins, Dianna Hogan, Emily Pindilli, Greg Noe, Fabiano Franco, and Stephanie Gordon

A Community on Ecosystem Services

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USGS

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

Interdisciplinary Team

Ecologists

Geographers

Hydrologists

Economists

Research Team Photo

Why Floodplains?

- Floodplains are at the intersection of terrestrial and aquatic ecosystems AND are **biogeochemical hotspots** for nutrient processing
- BUT we have **limited information** on ecosystem service values applicable to local decisions makers

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Difficult Run, VA

Floodplain Ecosystem Services

What is the capacity of floodplain to **retain sediment and nutrients** and provide critical ecosystem services to local and downstream communities?

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Ecosystem Services Flow

Link loads to water quality

Link water quality to final services

Valuing final services

Lower nutrient and sediment loads

Improved water quality

Opportunity to:
- view the environment
- to swim, wade, boat
- catch fish

Willingness to Pay for recreation

Proxy
Replacement costs of wastewater treatment

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Photos courtesy of Chesapeake Bay Program

Floodplain Sediment Balance

Floodplain Sediment Deposition (kg/m/yr) − **Bank Sediment Erosion** (kg/m/yr) = **Net Sediment Retention** (kg/m/yr)

Photo courtesy of Greg Noe

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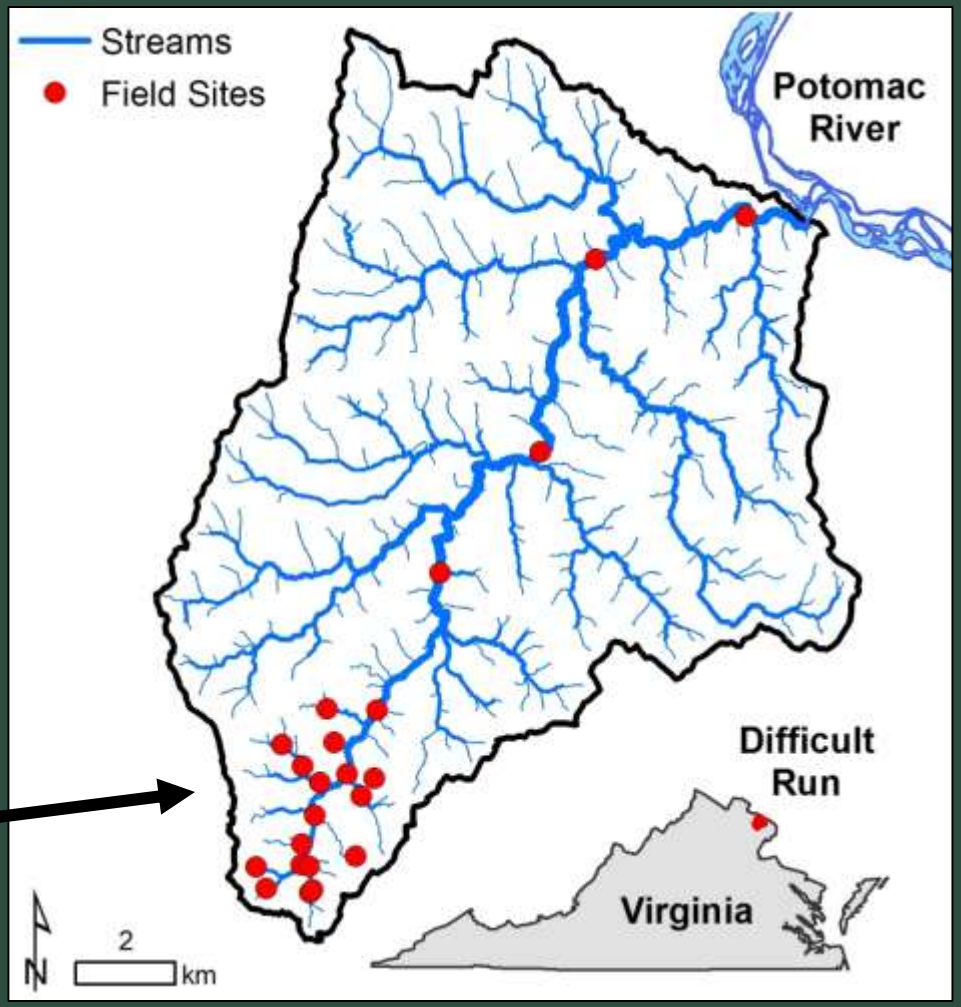
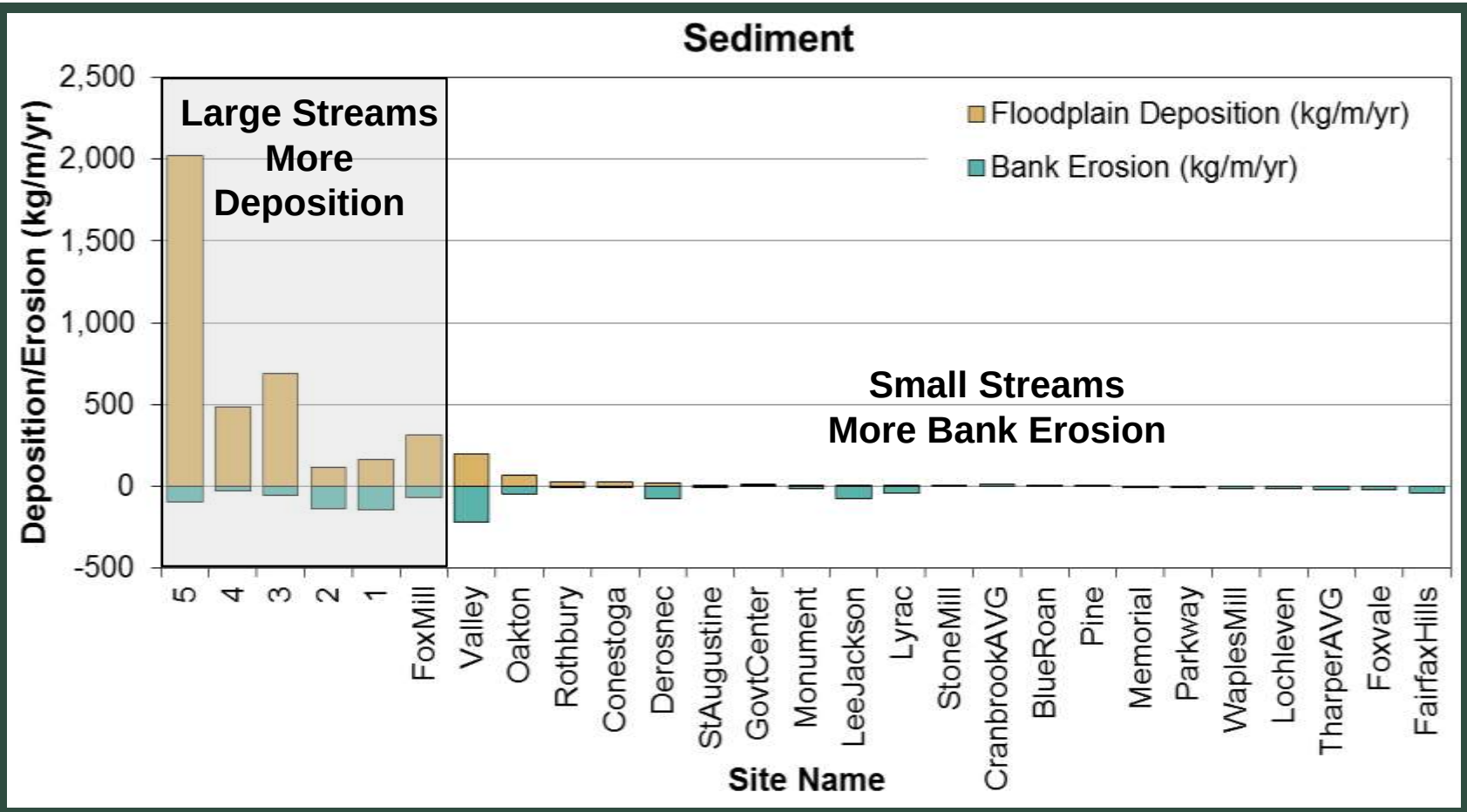
Study Area: Difficult Run, Virginia

- 150 km^2 watershed
- Piedmont of Virginia
- Drains into Potomac River
- 33% forested
- 15% developed



From Hupp et al. 2013

Field Estimates of Sediment Flux



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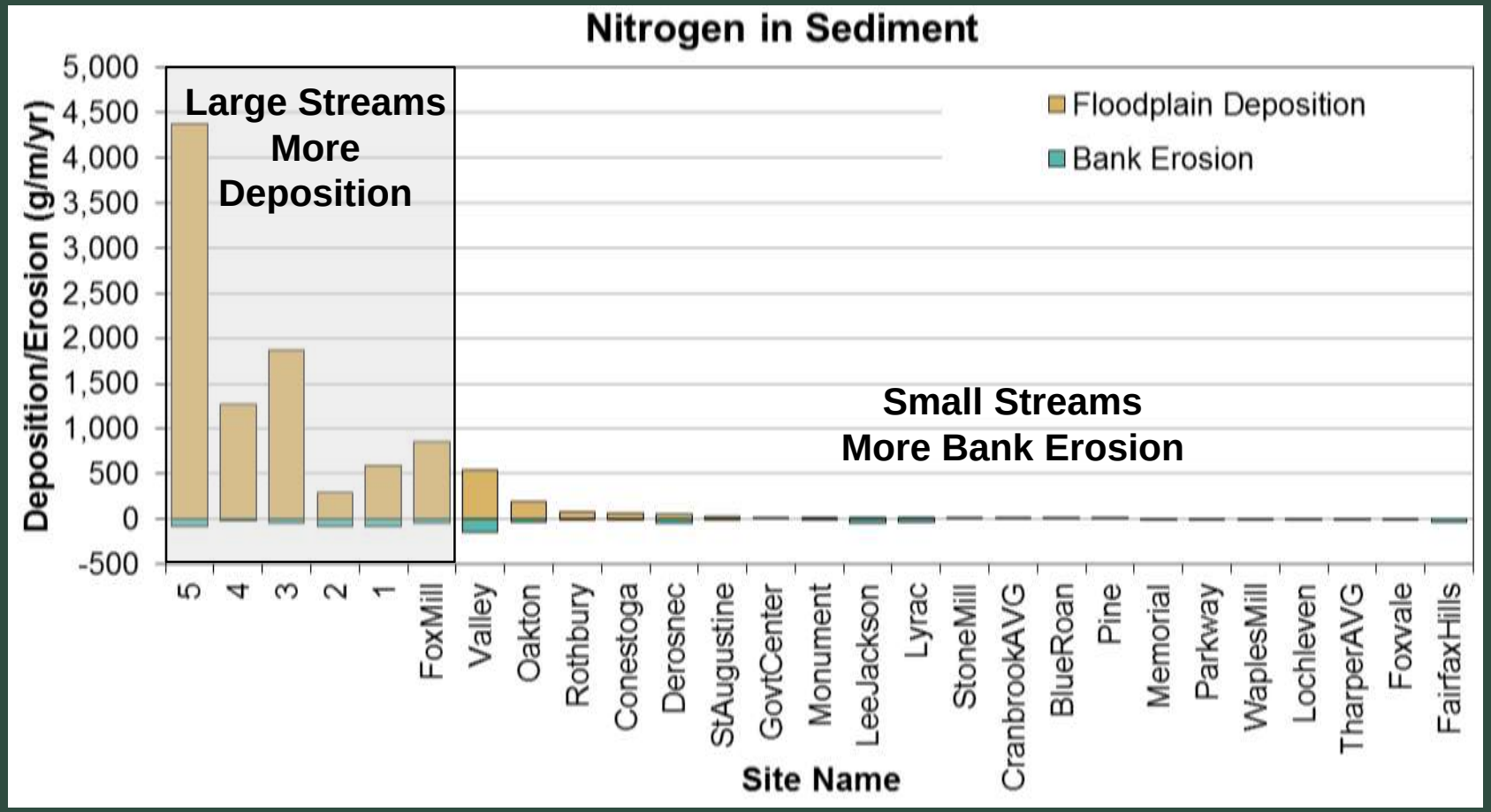
Data Sources: Updated Hupp et al. *Geomorphology* 2013 (5 mainstem)
Gellis et al. *Geomorphology* 2017 (17 headwater)

Field Estimates of Nitrogen Flux



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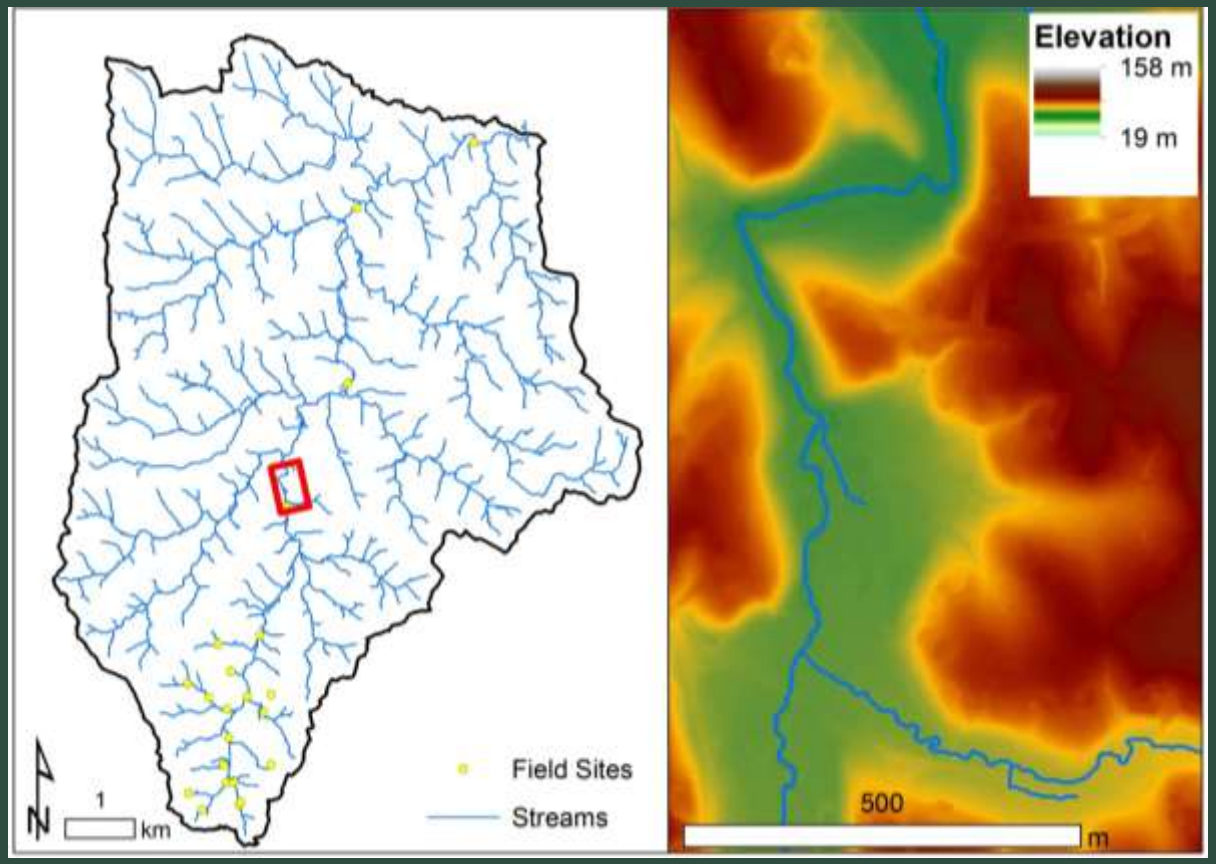
Stream Channel Characteristics

Channel Metrics

- Bank height
- Bank width
- Bankfull area
- Bank angles
- Floodplain width
- Max/min floodplain elevation
- Range/SD of floodplain elevations



USGS Stream Channel and Floodplain Metric Toolbox
Beta version 1.3

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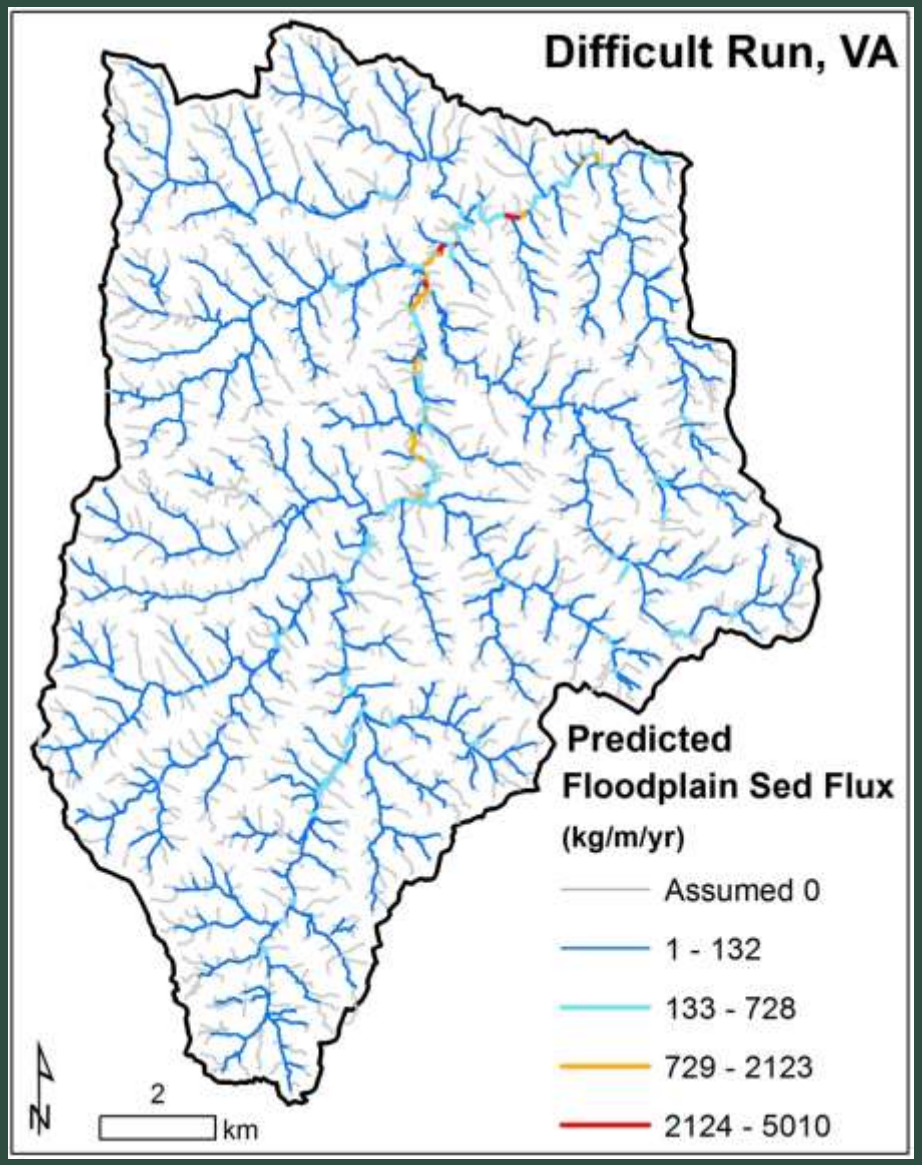
Scaling: Linking Field and Mapping

Regression Models

- **Floodplain Sediment Flux ($R^2 = 0.61$)**
  - Floodplain Net Width
  - Drainage Area
- **Bank Sediment Flux ($R^2 = 0.33$)**
  - Bank Angle
  - Bank Height/Floodplain Net Width

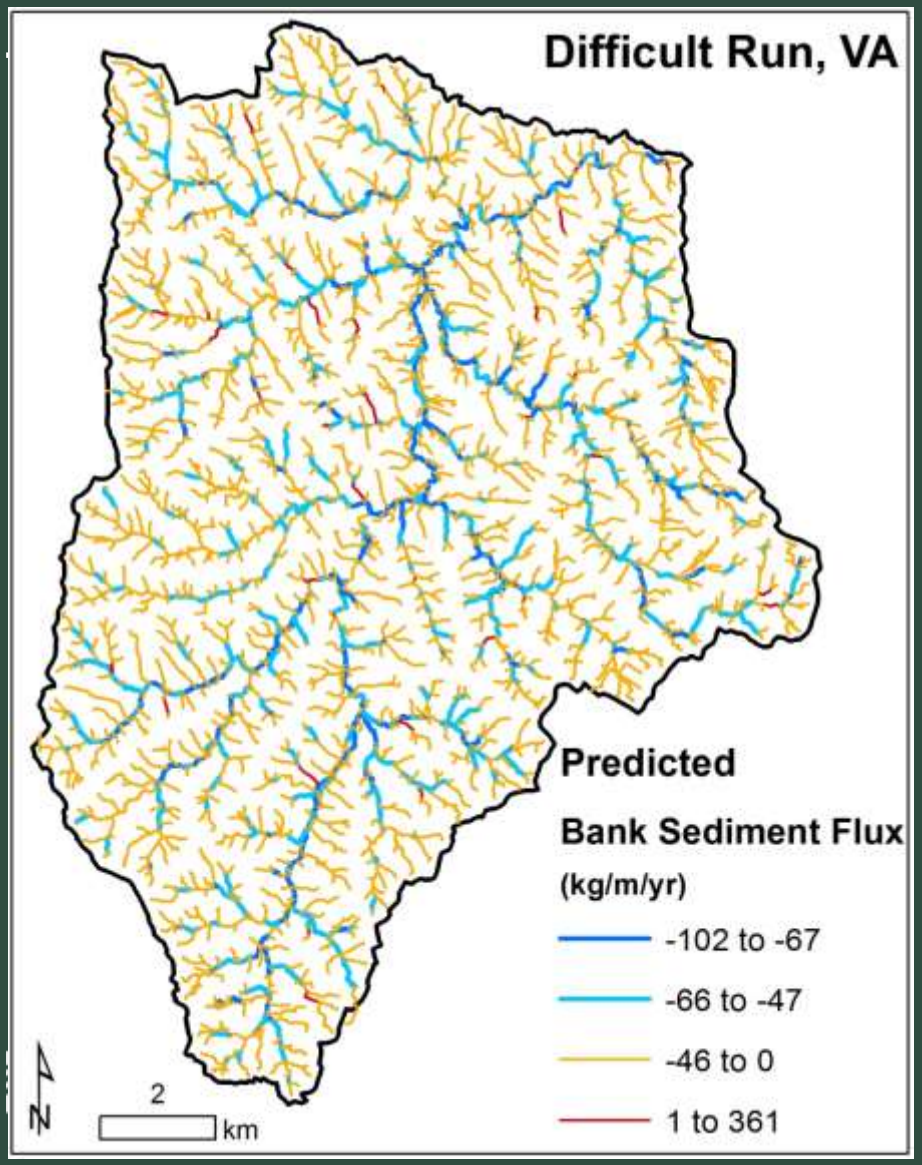
- **Similar models for nitrogen, phosphorus, and carbon**

Spatial Pattern in Floodplain Deposition



Watershed Scale Sediment Deposition

Spatial Pattern in Bank Erosion



Watershed Scale Sediment Erosion

Sediment Balance

Floodplain Sediment Deposition (kg/yr) **−** **Bank Sediment Erosion** (kg/yr) **=** **Net Sediment Flux** (kg/yr)

Net Sediment Flux - 3.3M kg/yr

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Sediment Nitrogen Balance

Floodplain Nitrogen Deposition (kg-N/yr) **−** **Bank Nitrogen Erosion** (kg-N/yr) **=** **Net Nitrogen Retention** (kg-N/yr)

Net Nitrogen Retention + 32,900 kg-N/yr

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Replacement Cost Method

- Proxy using replacement costs of nutrient and sediment retention services provided by floodplains
- $V_e = \sum_i R_i\,(Quantity) * P_i(Marketable\ Cost)$

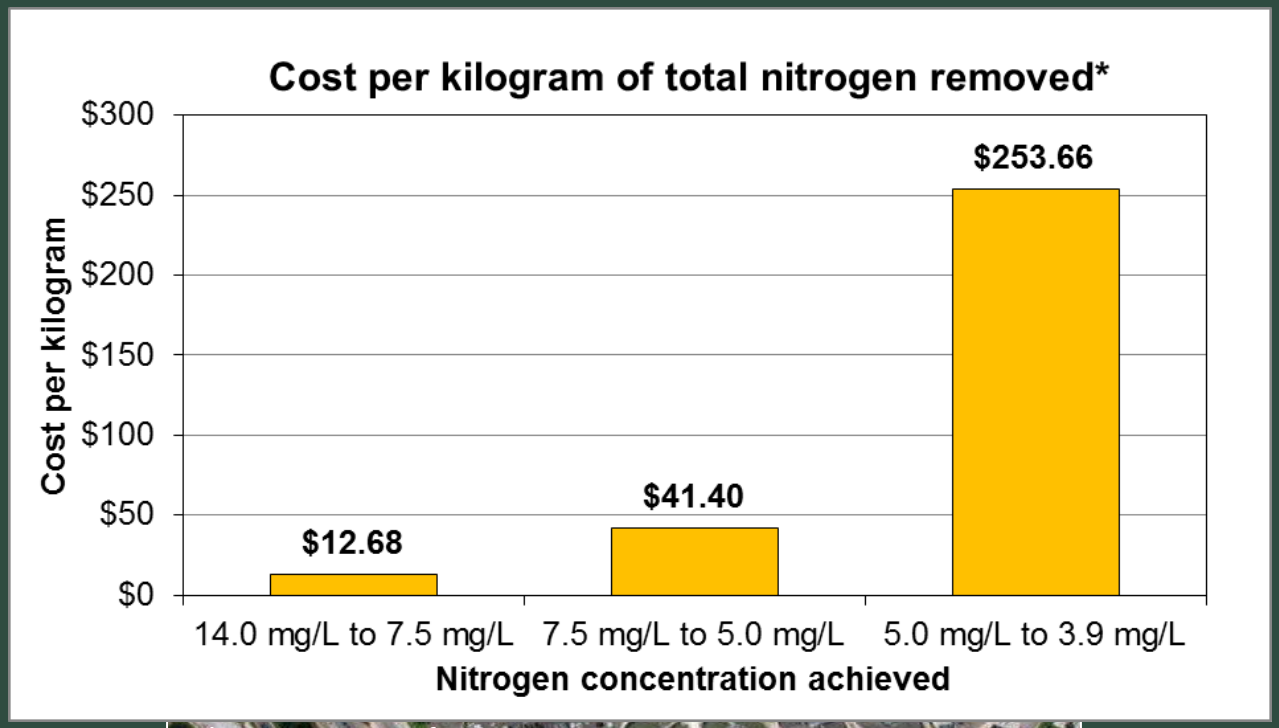


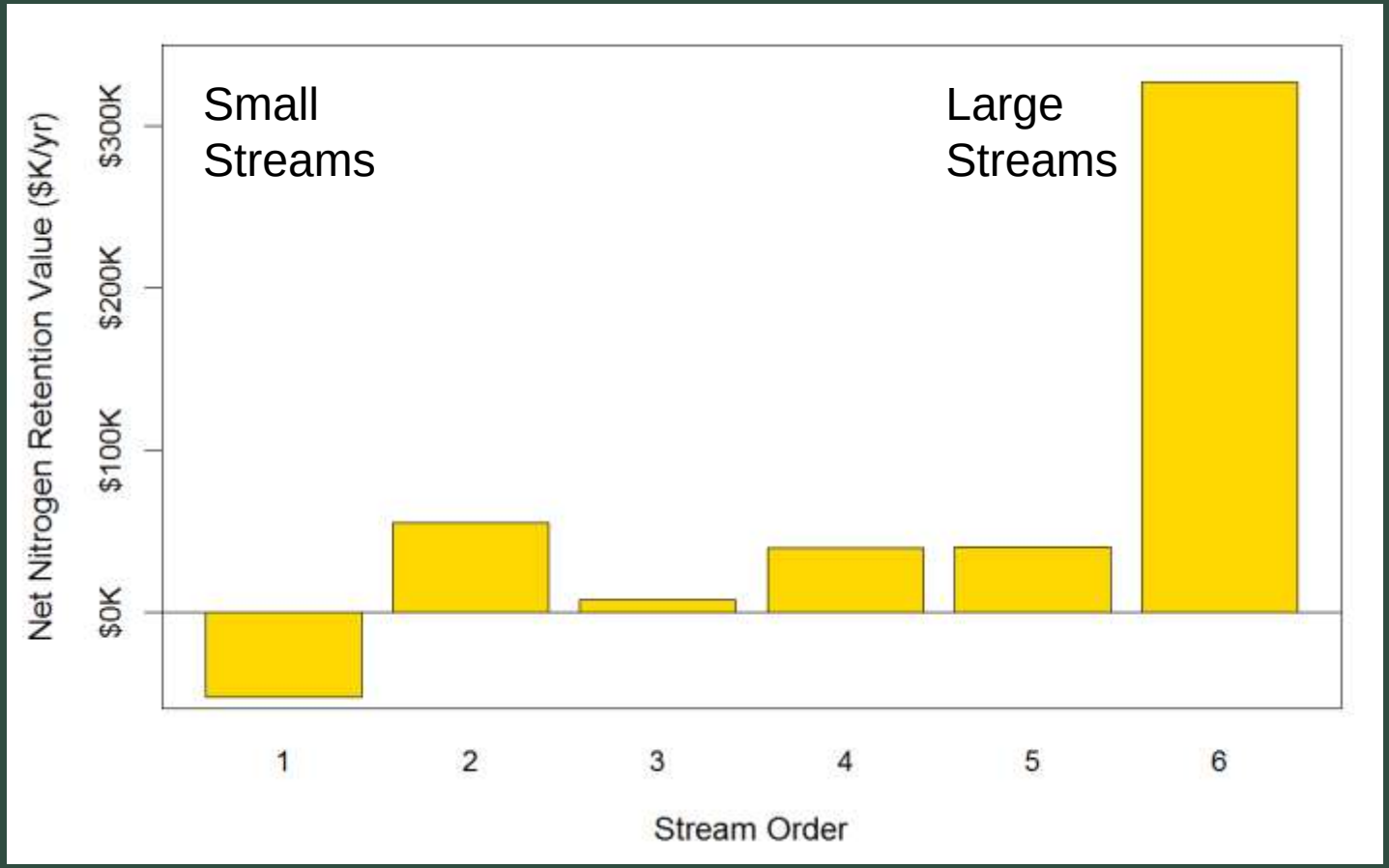
Photo courtesy of DC Water

*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.

Preliminary Indication of Value

Net Nitrogen Retention $416,000 per year

Variable Value with Stream Size



Conclusions

- Floodplain areas and their banks can be a **net source or sink** of sediments and nutrients
- At watershed scale, floodplain trapping provides a **net benefit** for sediments and nutrients
- Preliminary indication of value **+ $590,000/yr deposition and -$174,000/yr erosion**
- Valuation can assist in **targeting** areas for conservation/restoration or development **tradeoffs**

Krissy Hopkins

khopkins@usgs.gov