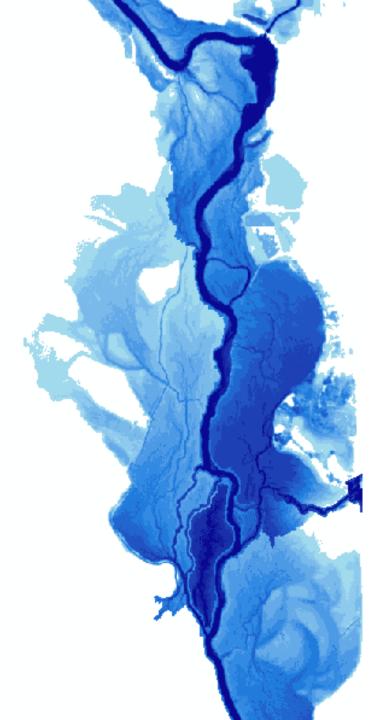# Estimating Floodplain Benefits in the Chesapeake

Krissy Hopkins, Ph.D.
U.S. Geological Survey

Scientific, Technical Assessment and Reporting
(STAR) Meeting
May 23, 2024

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

Study Objective

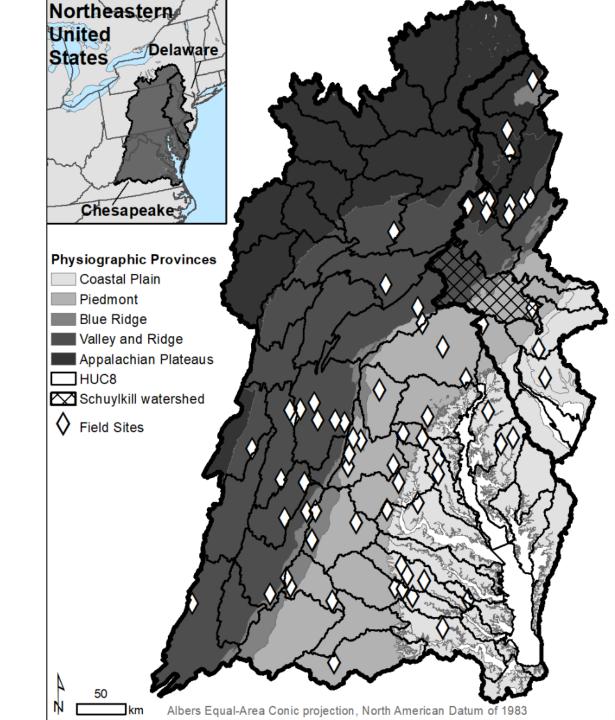What is the capacity of floodplains to **retain sediment, nutrients,** and flood waters?

Study Area

Floodplain Sediment and Nutrient Retention

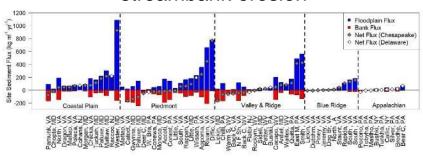Non-tidal wadable streams in the Chesapeake and Delaware River watersheds.
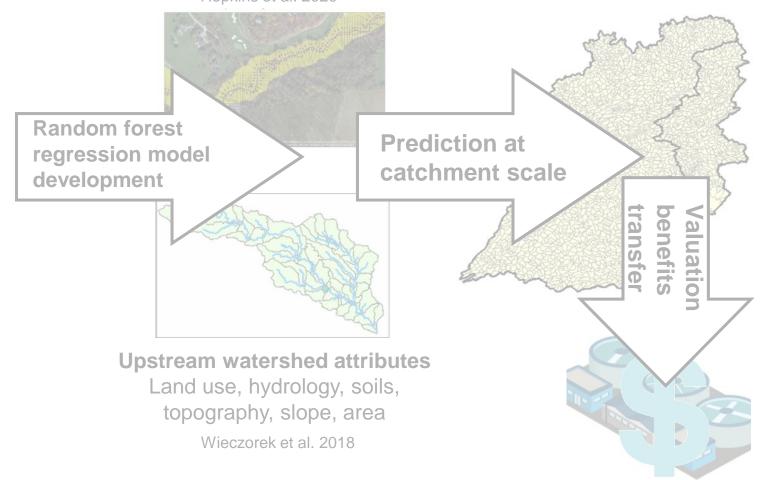
Methods Workflow

Field Geomorphic Measurements

Floodplain deposition and streambank erosion

Watershed + Reach Predictors

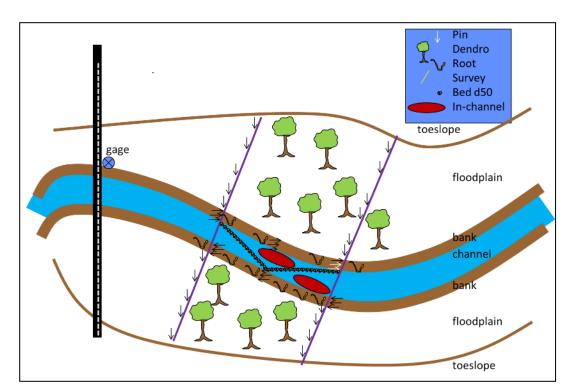**Reach fluvial geomorphometry**

Floodplain width, bank height, channel width

Hopkins et al. 2020

Random forest regression model development

Prediction at catchment scale

Valuation benefits transfer

Upstream watershed attributes

Land use, hydrology, soils, topography, slope, area

Wieczorek et al. 2018

≋USGS

Floodplain Deposition Measurements

Site Layout: 100 m reach

Field survey metrics

Active floodplain width
Bank height
Channel width
Lateral and vertical change (cm/yr)
% eroding bank
Adjusted lateral erosion (cm/yr)

Floodplain deposition

562 floodplain tree cores with mean tree age of 48 years.

Streambank Erosion Measurements

Site Layout: 100 m reach

Field survey metrics

Active floodplain width
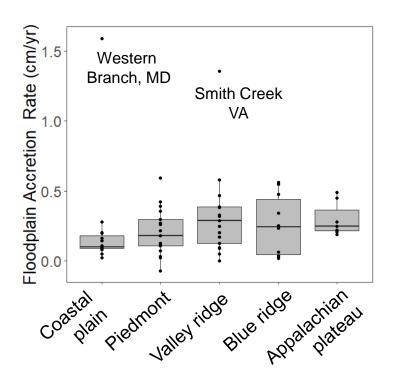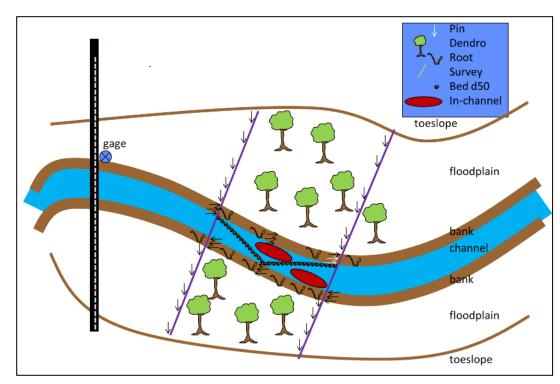Bank height
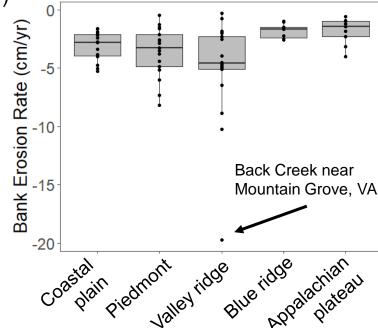Channel width
Lateral and vertical change (cm/yr)
% eroding bank
Adjusted lateral erosion (cm/yr)

Streambank Erosion
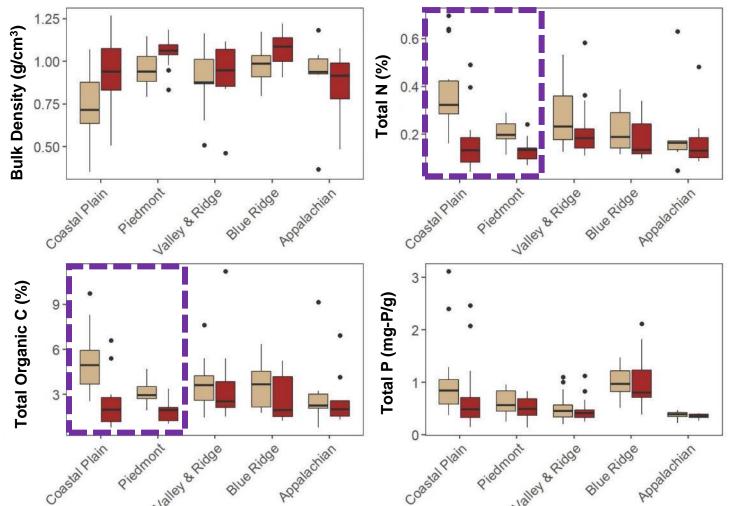

492 root cookies with mean exposure age 17 years.

Back Creek near Mountain Grove, VA

Sediment Characteristics at 68 Sites

296 Floodplain samples

461 Stream bank samples

Sampled Top 5 cm
Bulk density (g/cm^3)
Bulk density <2 mm (g/cm^3)
Bulk density <1 mm (g/cm^3)
% organic
% mineral
% carbonate
Total OC (%)
Total N (%)
Total P (mg/g)
Total Ca (mg/g)
Total Na (mg/g)
Total Mg (mg/g)
Total K (mg/g)
Total Al (mg/g)
Total Fe (mg/g)
Total Ti (mg/g)
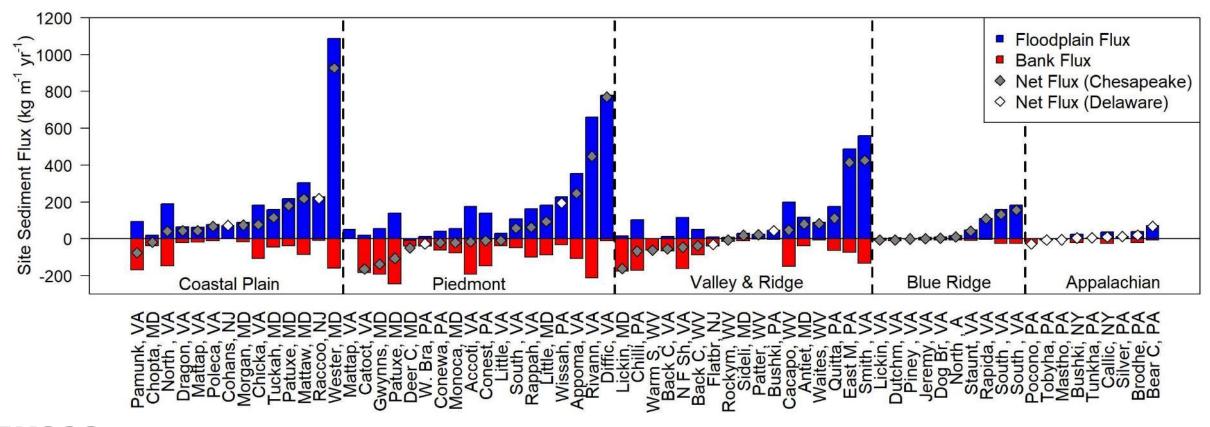Particle size: mean (um)
Particle size: d50 (um)
Particle size: %<63 um

Sediment Flux

Floodplain Flux = vertical accretion rate (m/yr) x floodplain width (m) x sediment bulk density (kg/m^3) = kg/m/yr

Bank Flux = lateral erosion rate x bank height x 2 banks x sediment bulk density
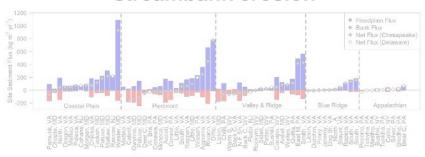
Methods Workflow
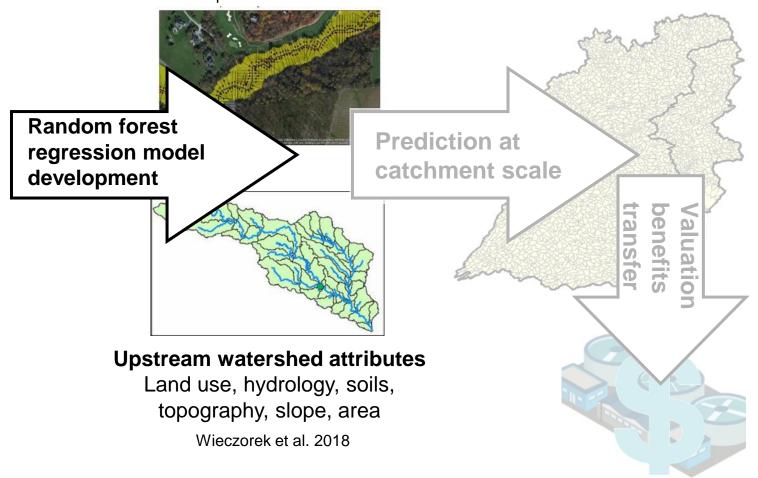
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Reach fluvial geomorphometry
Floodplain width, bank height,
channel width
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topography, slope, area
Wieczorek et al. 2018

Floodplain and Chanel Evaluation Tool (FACET)
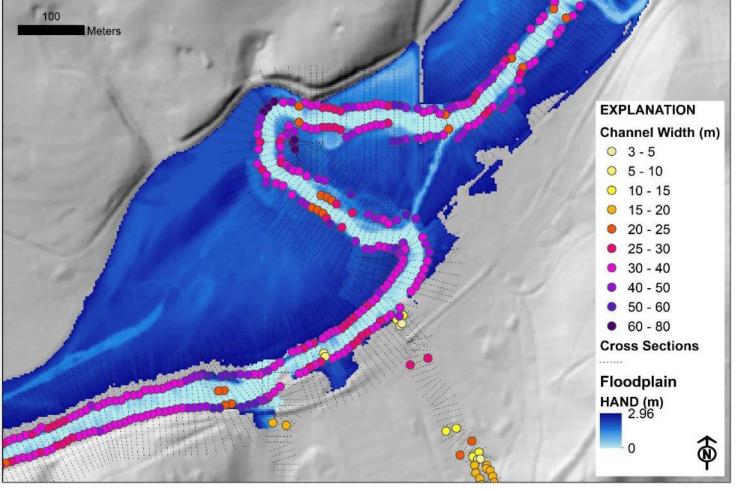
Automated fine-scale fluvial geomorphometry applied to large scales.

Functionality

- DEM pre-processing
- Stream network delineation
- Stream bank detection
- Mapping floodplain extent
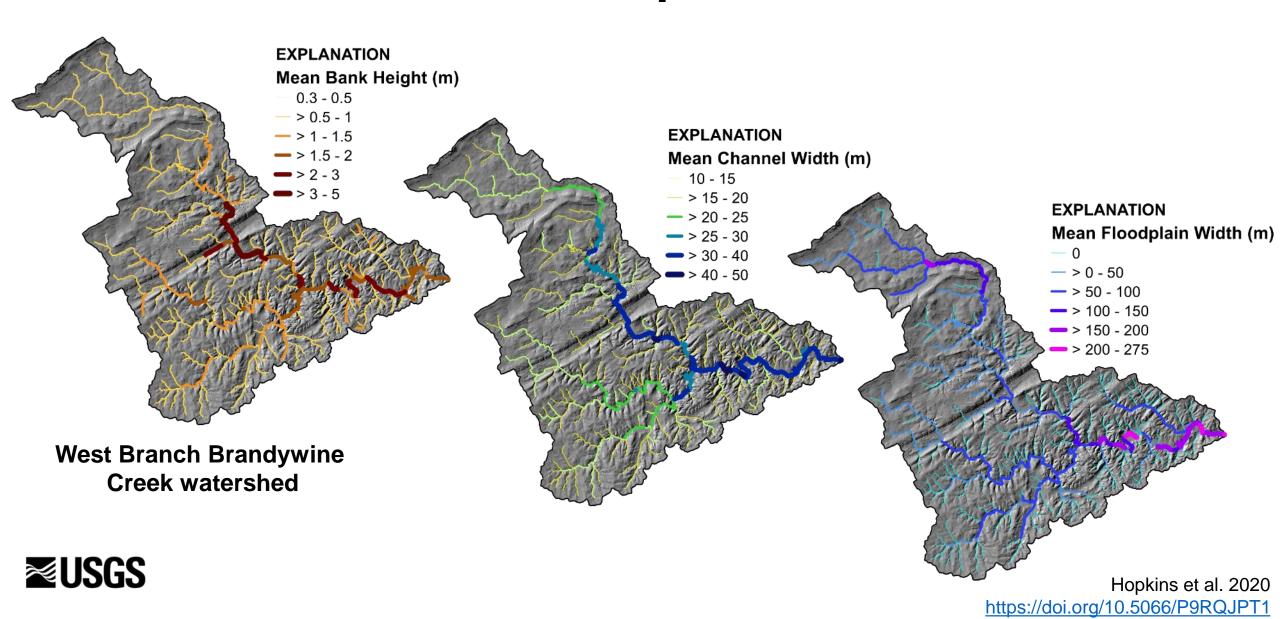- Calculate channel and floodplain metrics

Metrics

- Bank height
- Channel width
- Channel area
- Floodplain width

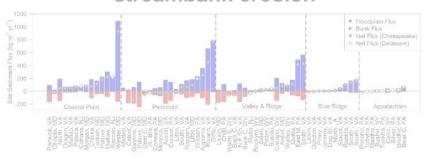Example FACET output.

FACET Channel and Floodplain Dimensions
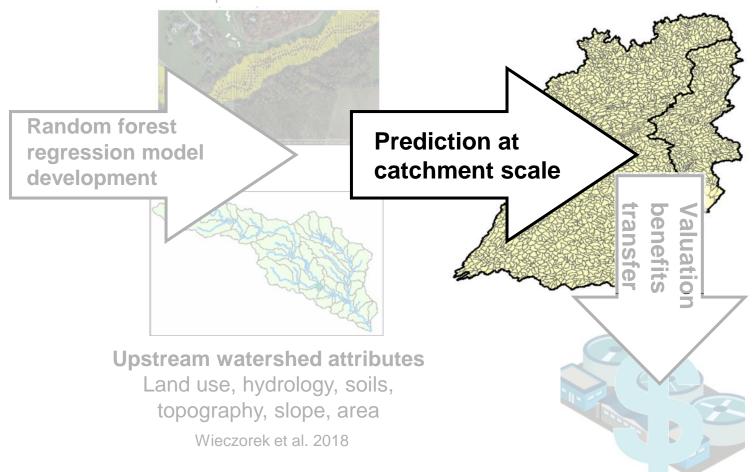
West Branch Brandywine
Creek watershed

Hopkins et al. 2020
https://doi.org/10.5066/P9RQJPT1

Methods Workflow

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Floodplain deposition and streambank erosion

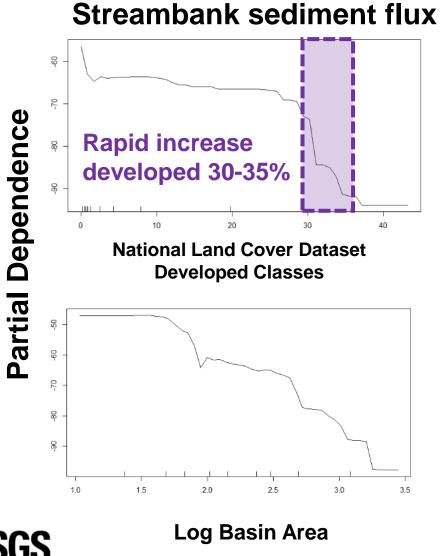**Random forest regression model development**

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≋ USGS

Random Forest Models

Streambank sediment flux

Rapid increase developed 30-35%

National Land Cover Dataset Developed Classes

Log Basin Area

(log) Floodplain sediment flux

Saturation developed > 20%
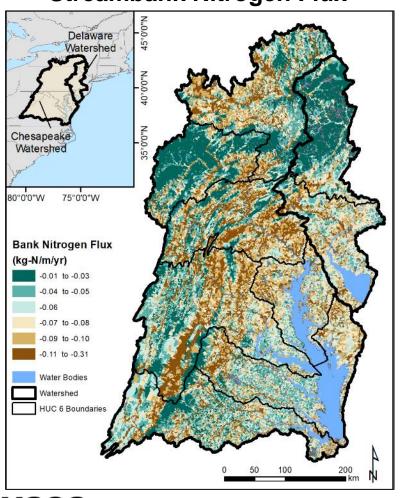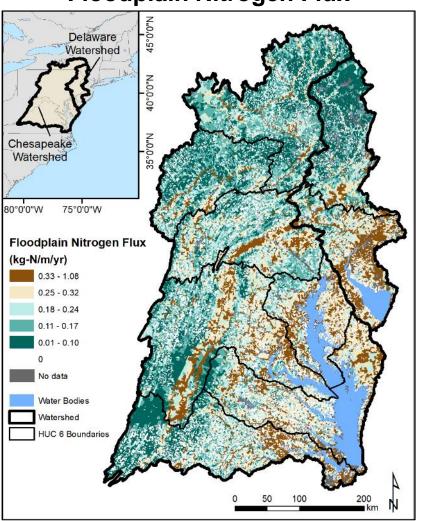
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Log Basin Area
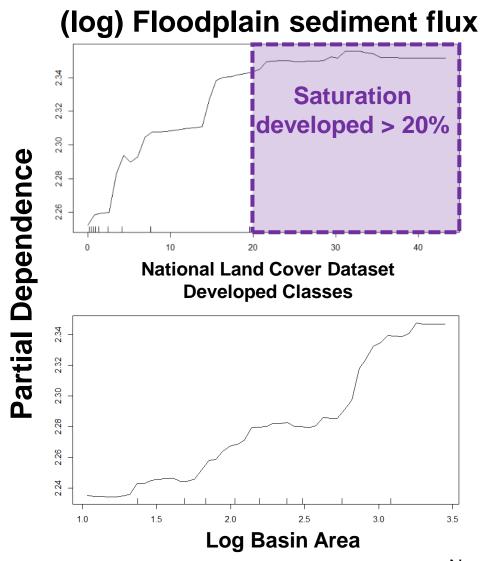
Floodplain Deposition and Streambank Erosion Predictions

Streambank Nitrogen Flux

Floodplain Nitrogen Flux

Summarize conditions at **river basin** and **catchment** scales.

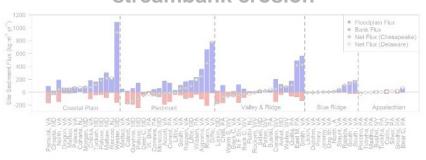Identify areas more **prone** to **erosion** or **deposition.**

Useful in **targeting** areas for **restoration** or high-value areas for **conservation.**
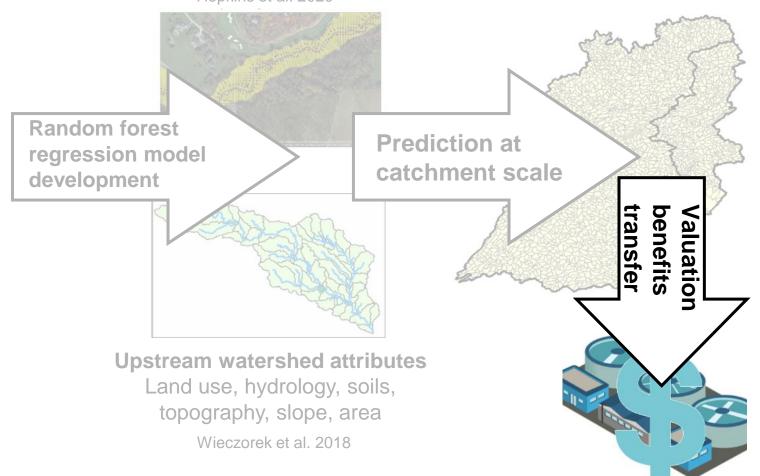
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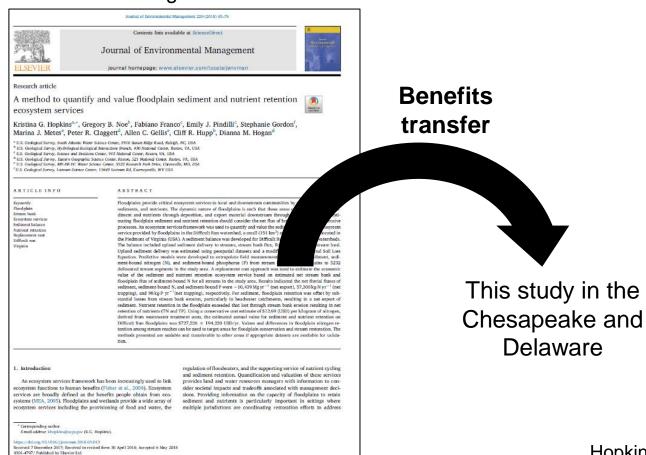Hopkins et al. 2020

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Wieczorek et al. 2018

Valuation benefits transfer

≋ USGS

Benefits Transfer Approach for Valuation

Treatment costs to reduce nitrogen from 4.0 to 7.5 mg/L **$16.12 USD per kg-N.**

Study within the Chesapeake Bay watershed in Virginia.

Benefits transfer

This study in the Chesapeake and Delaware

Blue plains wastewater treatment plant.

Hopkins et al. 2018
https://doi.org/10.1016/j.jenvman.2018.05.013
Hopkins et al. 2023
https://doi.org/10.1016/j.jenvman.2023.118747

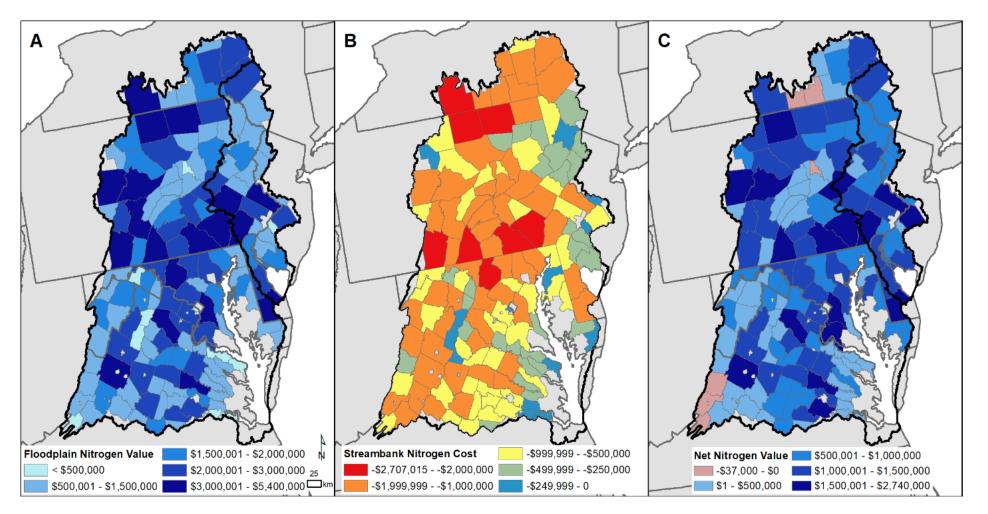# Floodplains Provide Substantial Benefits by Trapping Sediments and Nutrients

Floodplain Trapping Benefit

Chesapeake
$223 million USD/yr

Delaware
$38 million USD/yr

Streambank Erosion Cost

Chesapeake
$123 million USD/yr

Delaware
$14 million USD/yr

Net Nitrogen Retention $100 million USD per year

Chesapeake Bay watershed

USGS

Spatial Variability in the Value of Floodplain Sediment and Nutrient Retention

Hopkins et al. 2023
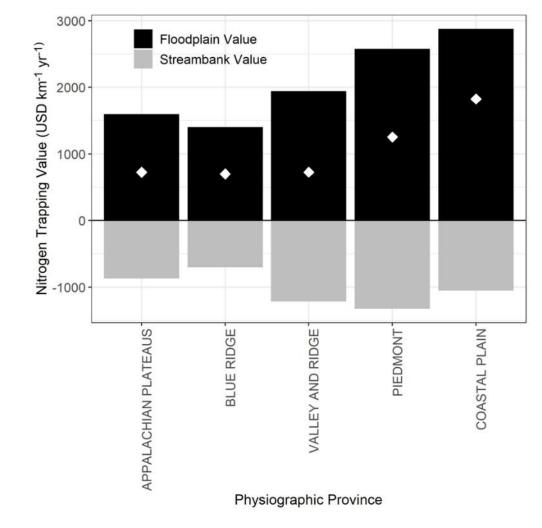https://doi.org/10.1016/j.jenvman.2023.118747

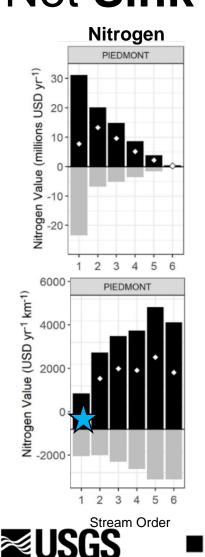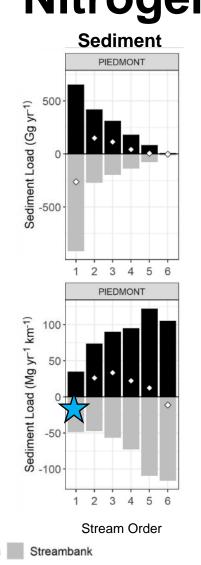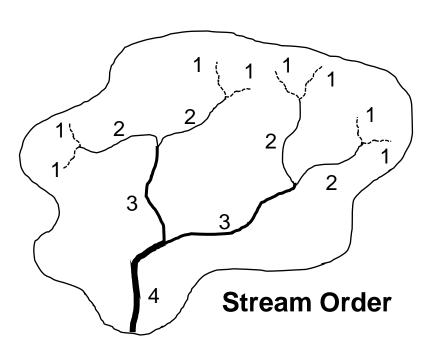# Coastal Plain Floodplains Provided the Highest Nutrient Trapping Benefits

Headwater Streams Net **Source of Sediment**, but a Net **Sink for Nitrogen**
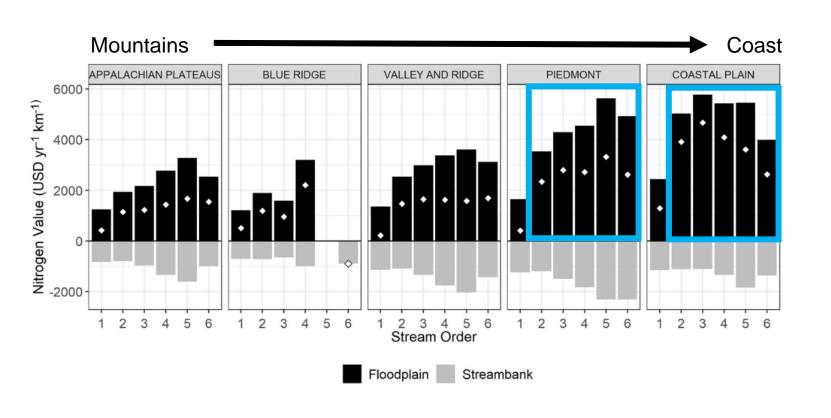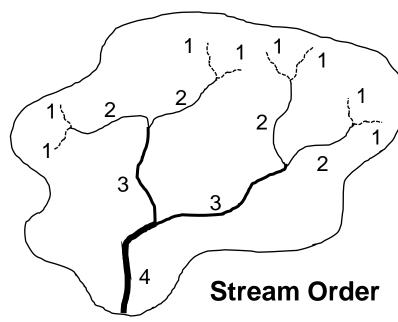

More nitrogen is deposited in headwater floodplains.

More sediment is eroded from streambanks than deposited on the floodplain.

Higher Order Streams Provide the Most Nitrogen Trapping per Length of Stream

Floodplain Ecosystem Services Mapper

Floodplain Ecosystem Services Mapper
https://apps.usgs.gov/sawsc/floodplains/

Summary

Floodplains provide substantial benefits by trapping nutrients and sediment, upwards of $220 million per year in the Chesapeake Bay watershed.

Landscape position and land use control the services and benefits that floodplains provide to people

Appalachian Plateau · Valley and Ridge · Blue Ridge · Piedmont · Coastal Plain

Streambank erosion hotspot

Floodplain trapping hotspot

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