Modeling the impacts of floodplain vegetation flow resistance on river corridor hydrologic connectivity

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Floodplain vegetation

- Strong biological driver of physical processes
- Mechanical stabilization of banks
- Planform dynamics
- Complex hydrodynamic conditions during floods

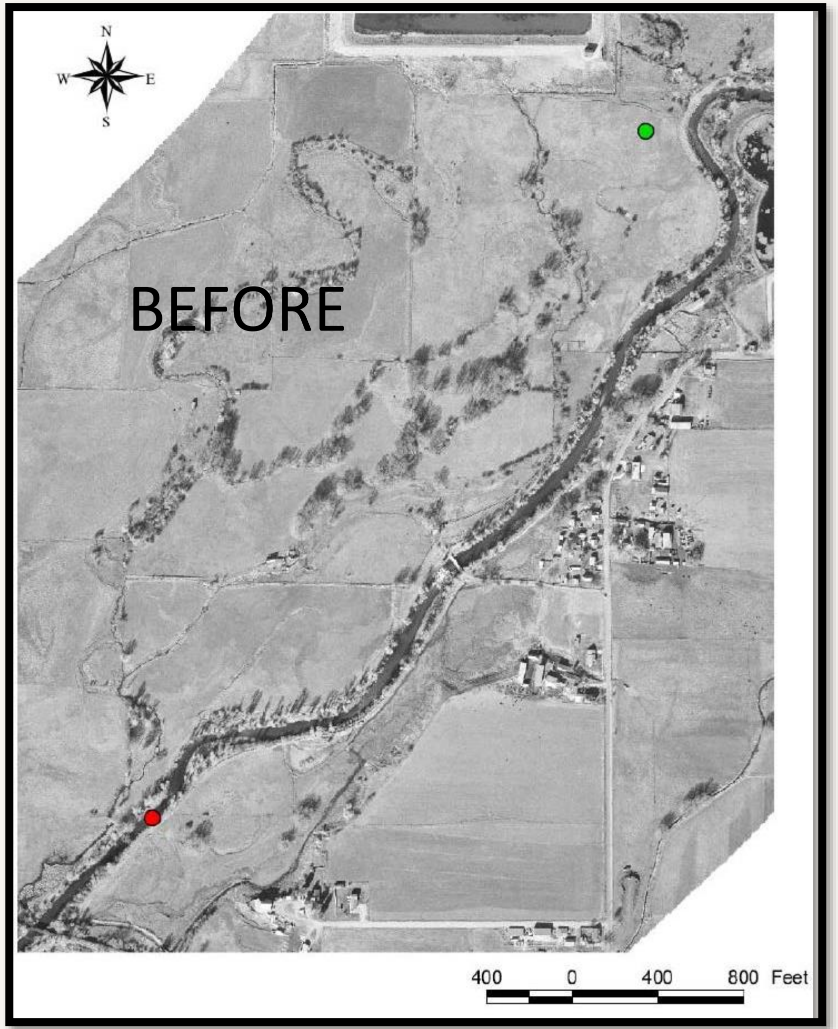
Ecosystem Services

- Flood wave attenuation
- Nutrient cycling

Credit: Aneta Goska

Historical and contemporary management of river corridors

Simplified channel
Sparse floodplain vegetation



Morphologically complex
High density floodplain vegetation

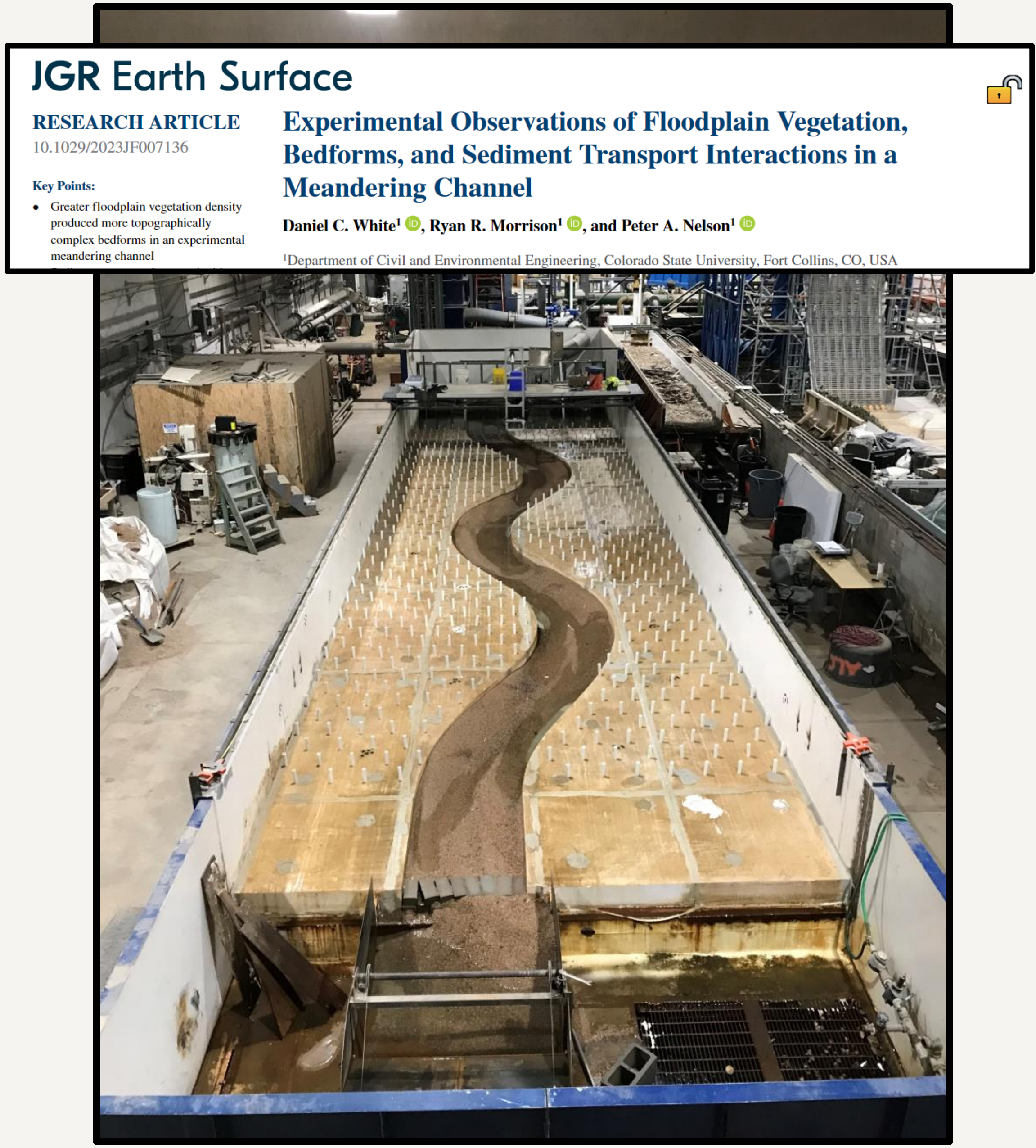
Provo River Restoration Project (Erwin et al. 2016).

How does rigid emergent vegetation influence flow dynamics?

Can we quantify hydraulic roughness?

Experimental flume observations:

- 3 Flow depths
- 3 vegetation cover scenarios
- Rigid emergent cylindrical vegetation elements



JGR Earth Surface

RESEARCH ARTICLE

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Key Points:

- Greater floodplain vegetation density produced more topographically complex bedforms in an experimental meandering channel

Experimental Observations of Floodplain Vegetation, Bedforms, and Sediment Transport Interactions in a Meandering Channel

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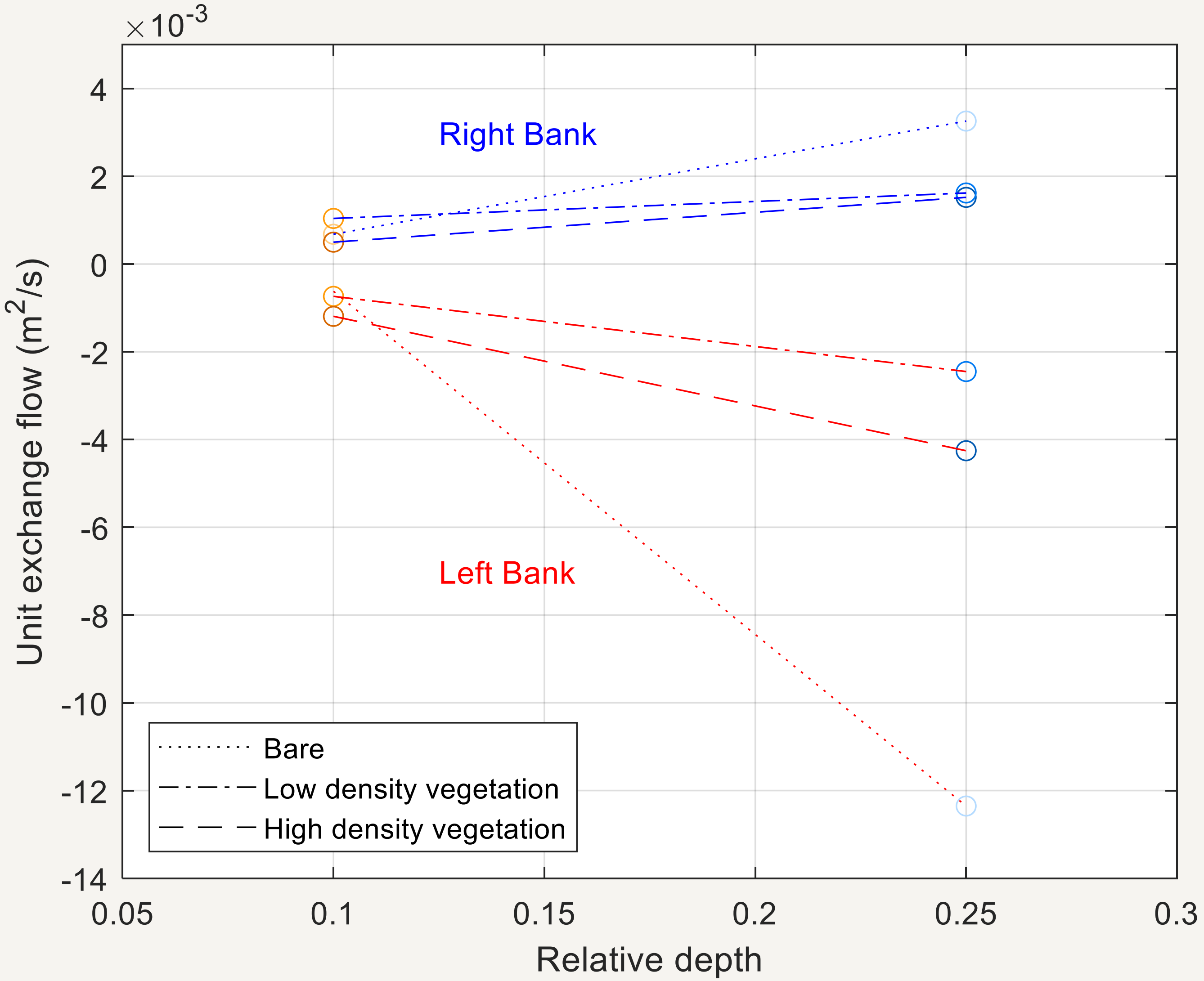
Channel-floodplain exchange flow



Flume Takeaways

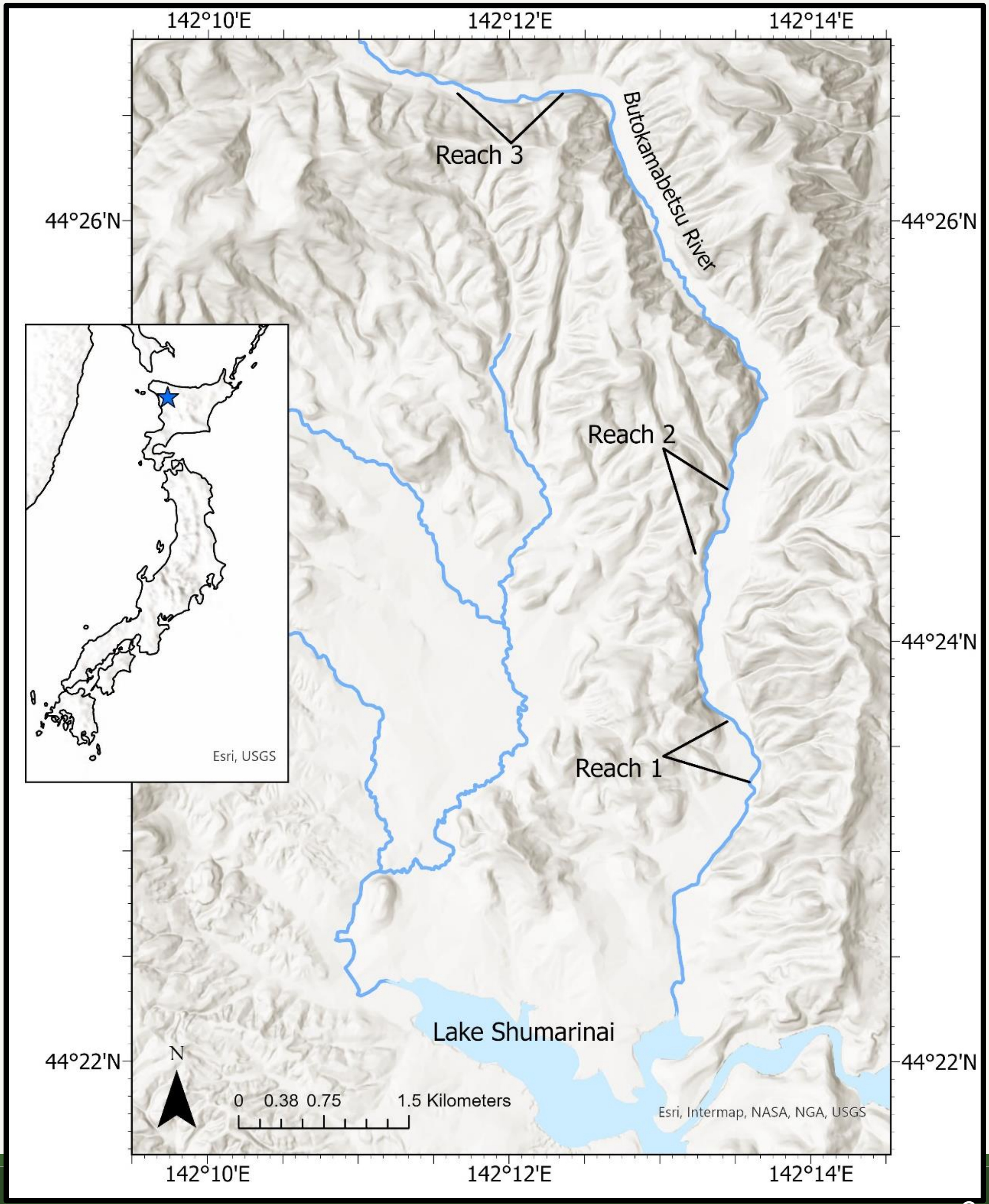
- Increased vegetation density enhanced helical flow structure through the meander bend.

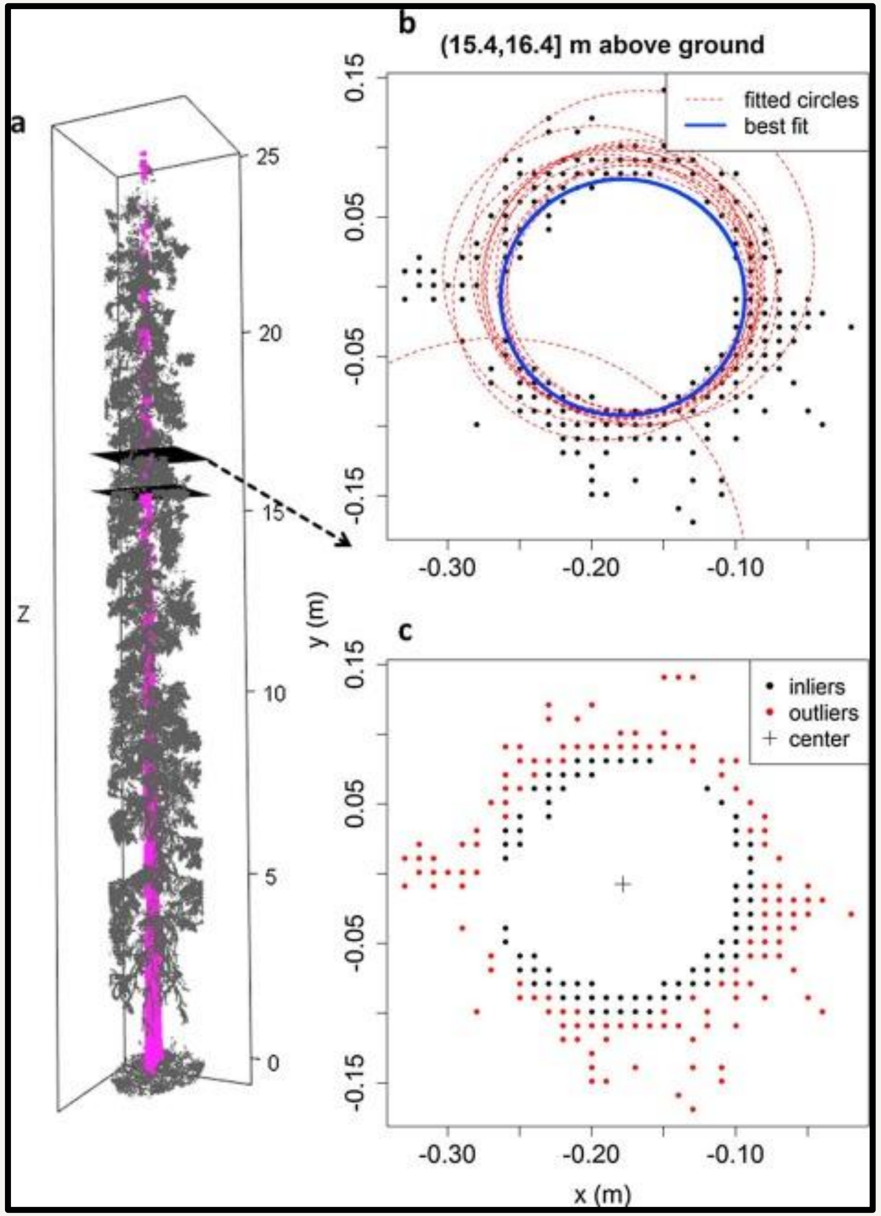
- High-density floodplain vegetation attenuates channel-floodplain exchange flow as a result of 3D flow dynamics.

Do 2D numerical models capture similar flow dynamics resulting from varied floodplain vegetation density?

Numerically modeling the influence of floodplain vegetation on 2D flow

- Butokamaetsu River, Hokkaido, Japan
- Vegetation classification
- HEC-RAS 2D
- Three reaches with varied slopes and sinuosity
- Simulate four vegetation densities



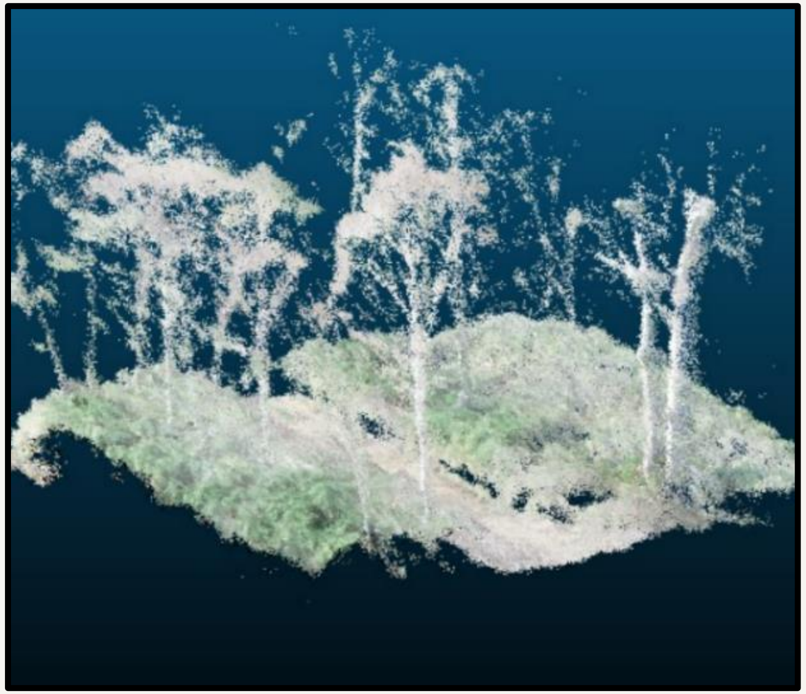


Stem classification - TreeLS

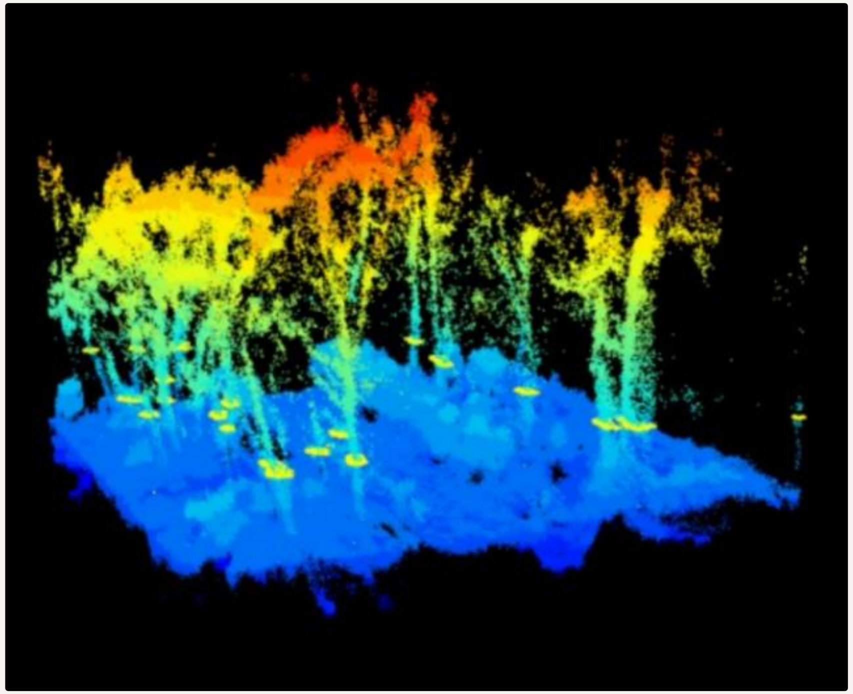
From de Conto et al. (2017) In this method, a random sampling consensus (RANSAC) algorithm computes the probability that a sample of points contains no outliers and identifies a best fit circle to approximate the stem diameter and height.

Effectiveness of the tool depends on vegetation density, morphology, and point cloud quality.

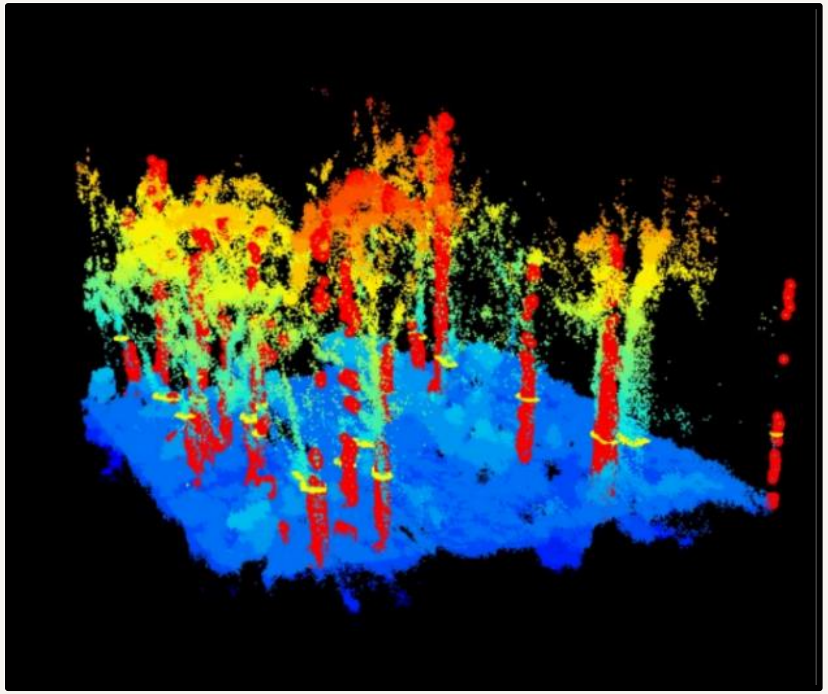
TreeLS vegetation segmentation and classification



Raw LiDAR Tile



Stems Detected at BH



Stem height detected

Parameterization of model roughness

Using TreeLS vegetation classification, parameterize floodplain roughness coefficients. (Baptist, 2007)

$$C = \sqrt{\frac{1}{\left(\frac{1}{C_b^2}\right) + \left(\frac{C_d m D_S h}{2g}\right)}}$$

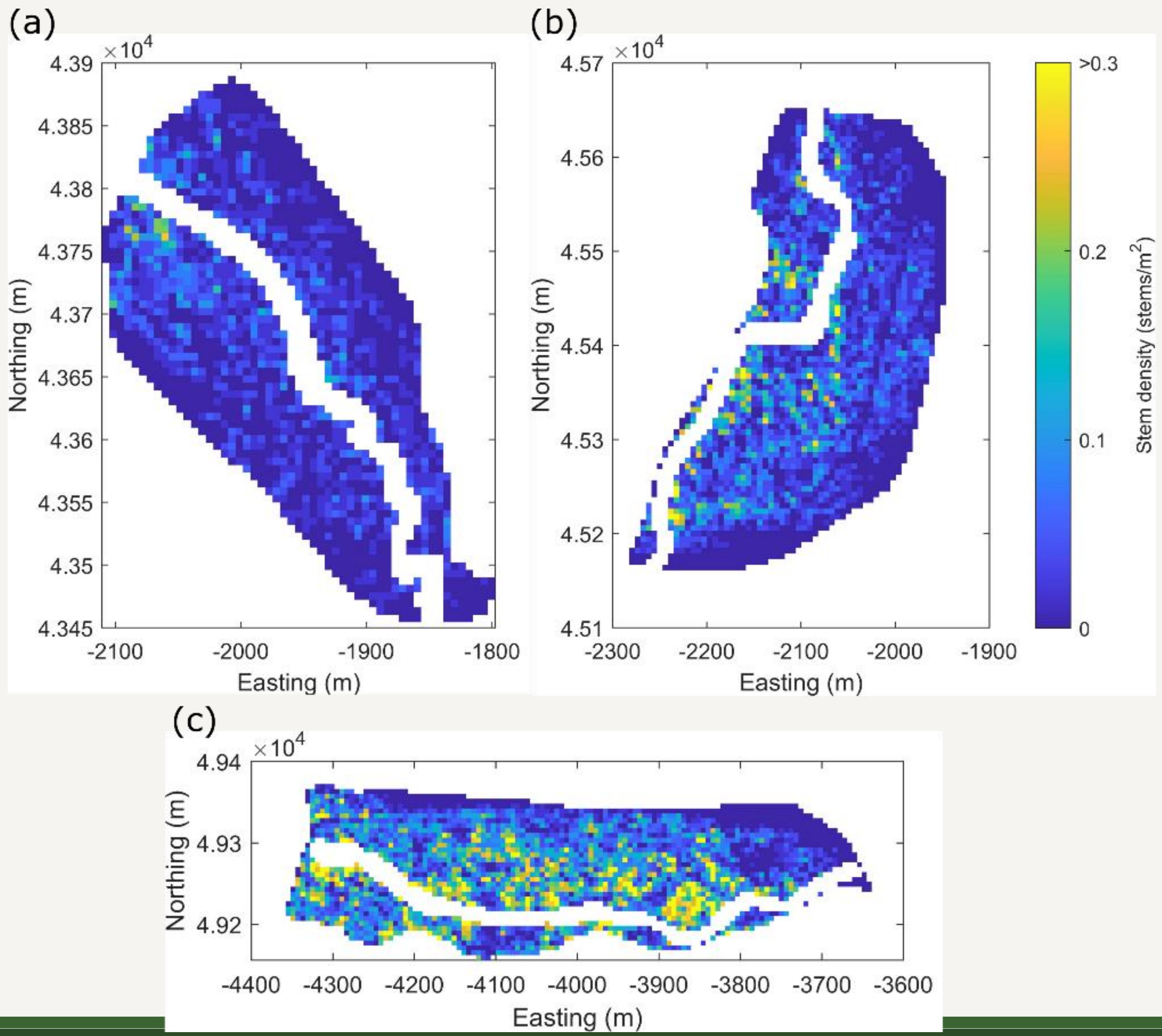
$$m = vegetation\ stem\ density\ \left(\frac{stems}{m^2}\right)$$

$$D_s = \text{stem diameter (m)}$$

Convert to Manning's n and develop spatially distributed roughness maps for modeling in HEC-RAS 2D

$$n = \frac{1}{C} h^{1/6}$$

Stem density



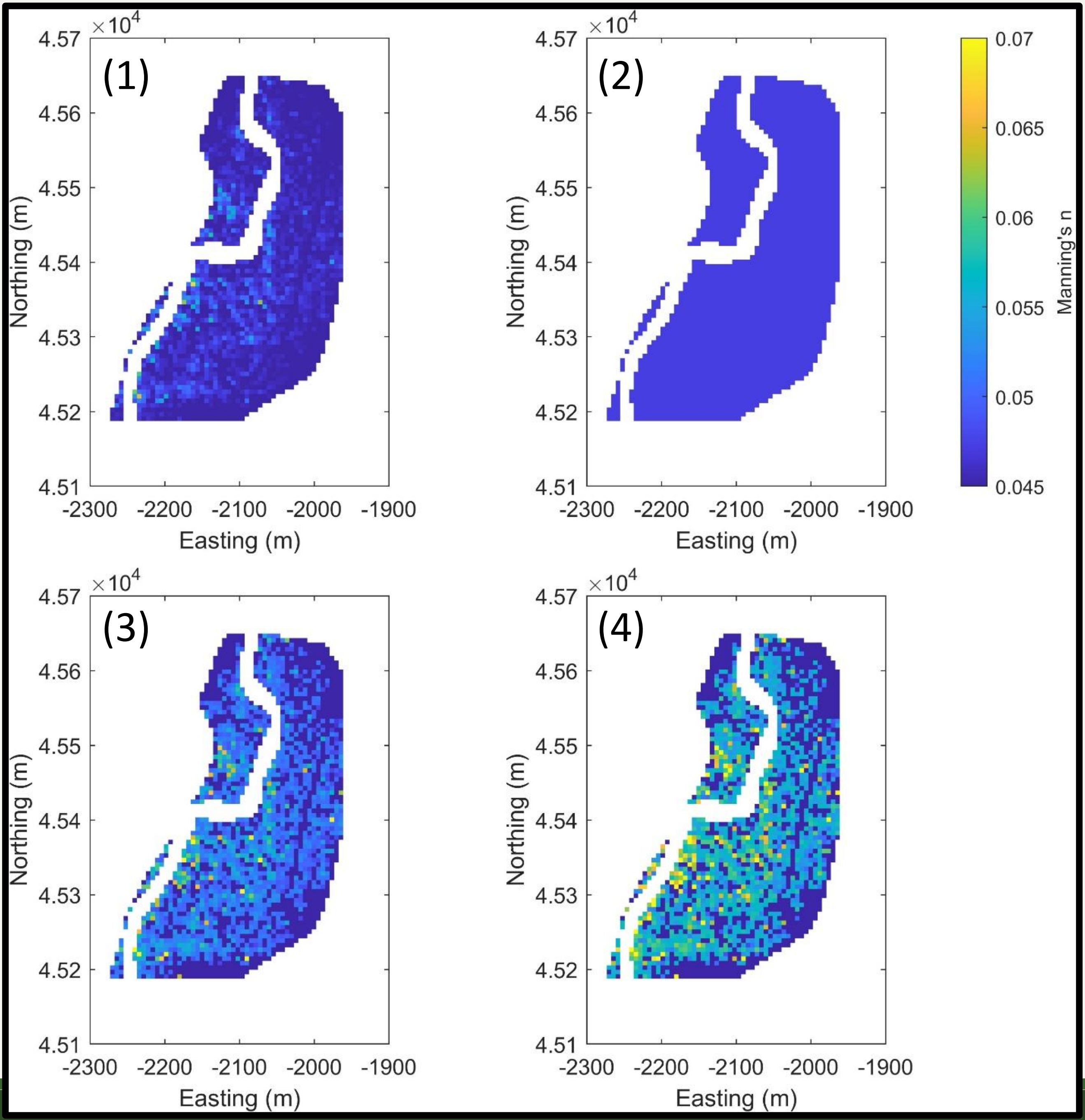
Parameterize Manning's coefficient using:

(1) Measured vegetation characteristics

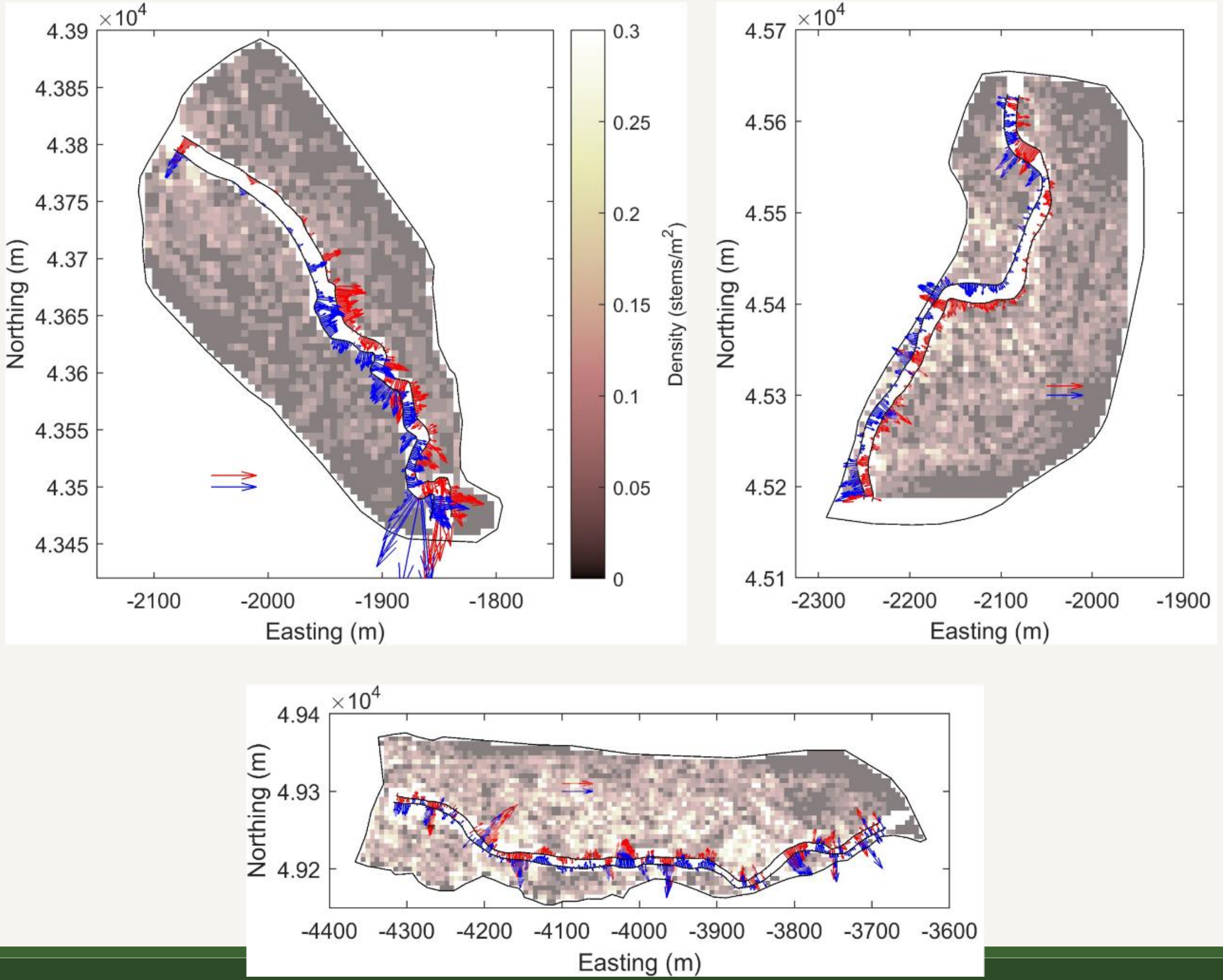
(2)Reach-averaged roughness

(3) Medium-density vegetation

(4) High-density vegetation

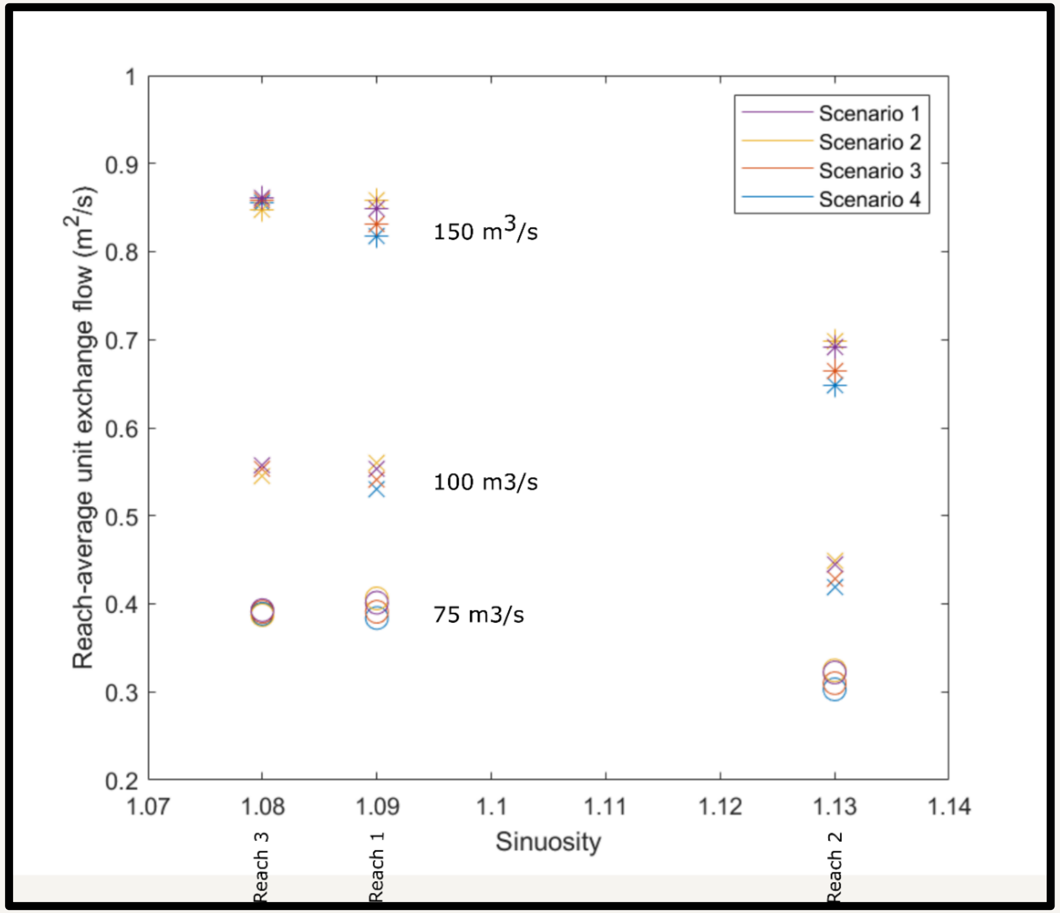


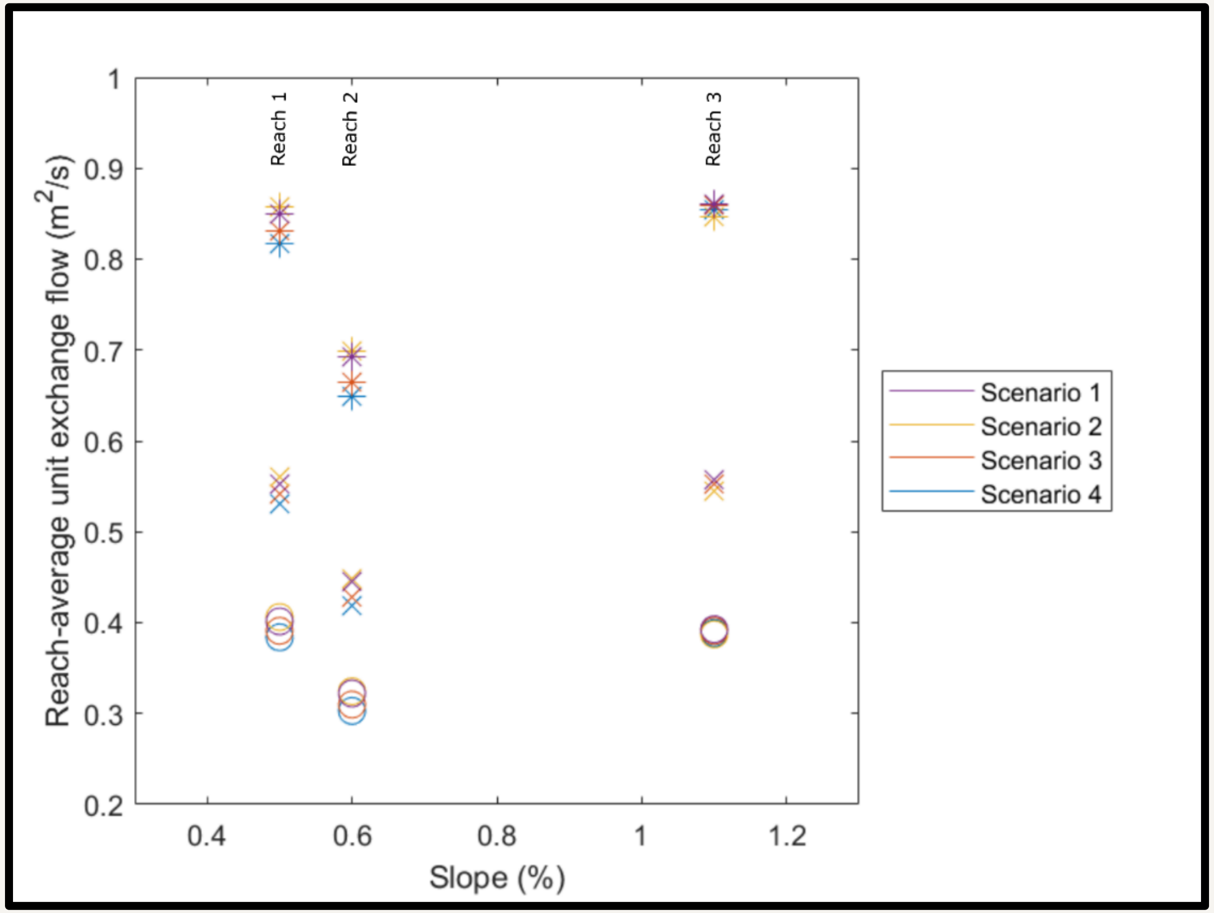
Channel-floodplain exchange flow



Reach-averaged exchange flow

Reach 3 (high slope, low sinuosity) was not significantly influenced by increased floodplain vegetation density



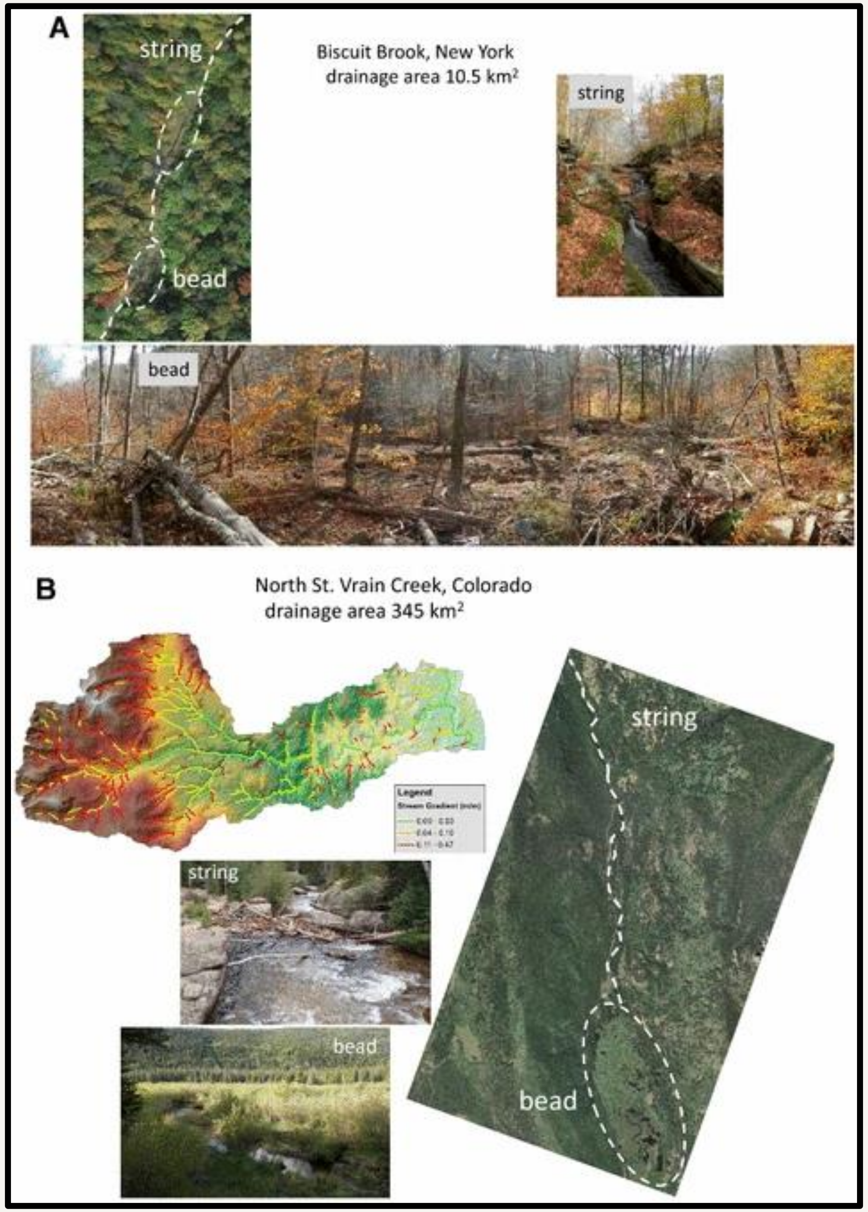


River Strings

- High slope
- High energy
- Low sinuosity

River Beads

- Low slope
- High sinuosity
- High attenuation of fluxes



(Wohl et al. 2018)

Key takeaways

Channel-floodplain exchange flow is more heavily influenced by variation in floodplain vegetation density in low-gradient, high-sinuosity reaches.

Prioritization of river restoration through vegetation planning and management in river beads may result in increased attenuation of fluxes at the channel-floodplain interface.

THANK YOU!

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