Evaluating Stream Restoration Tradeoffs in Water Quality across Watershed Scales

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Challenges in Detecting Effects of Restoration and Conservation – Why?

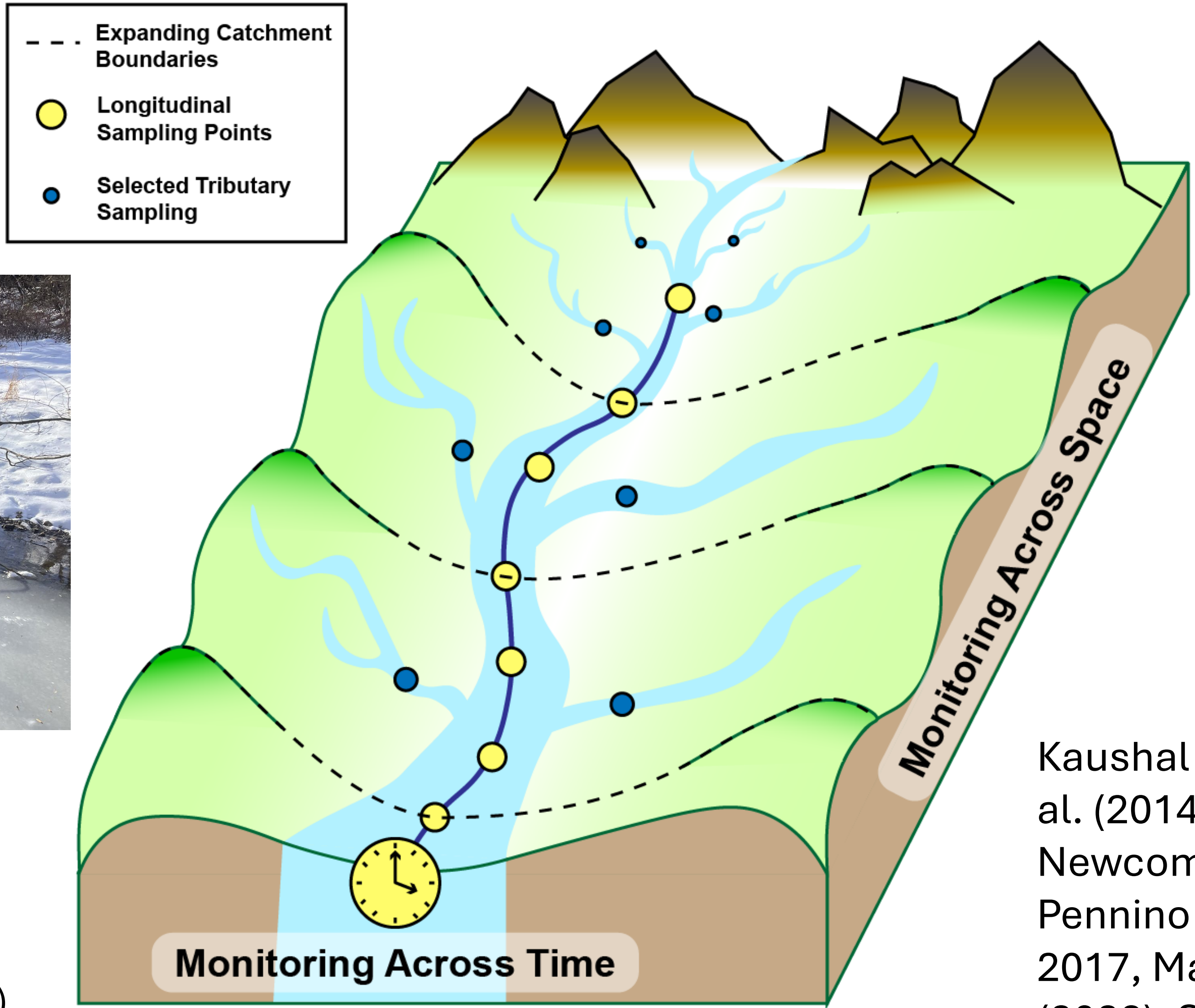
-Most monitoring efforts occur over time – what about space?

-We focus on one or a few metrics – a more holistic approach?

-What about connections along flowpaths to receiving waters?

The Watershed Continuum Approach

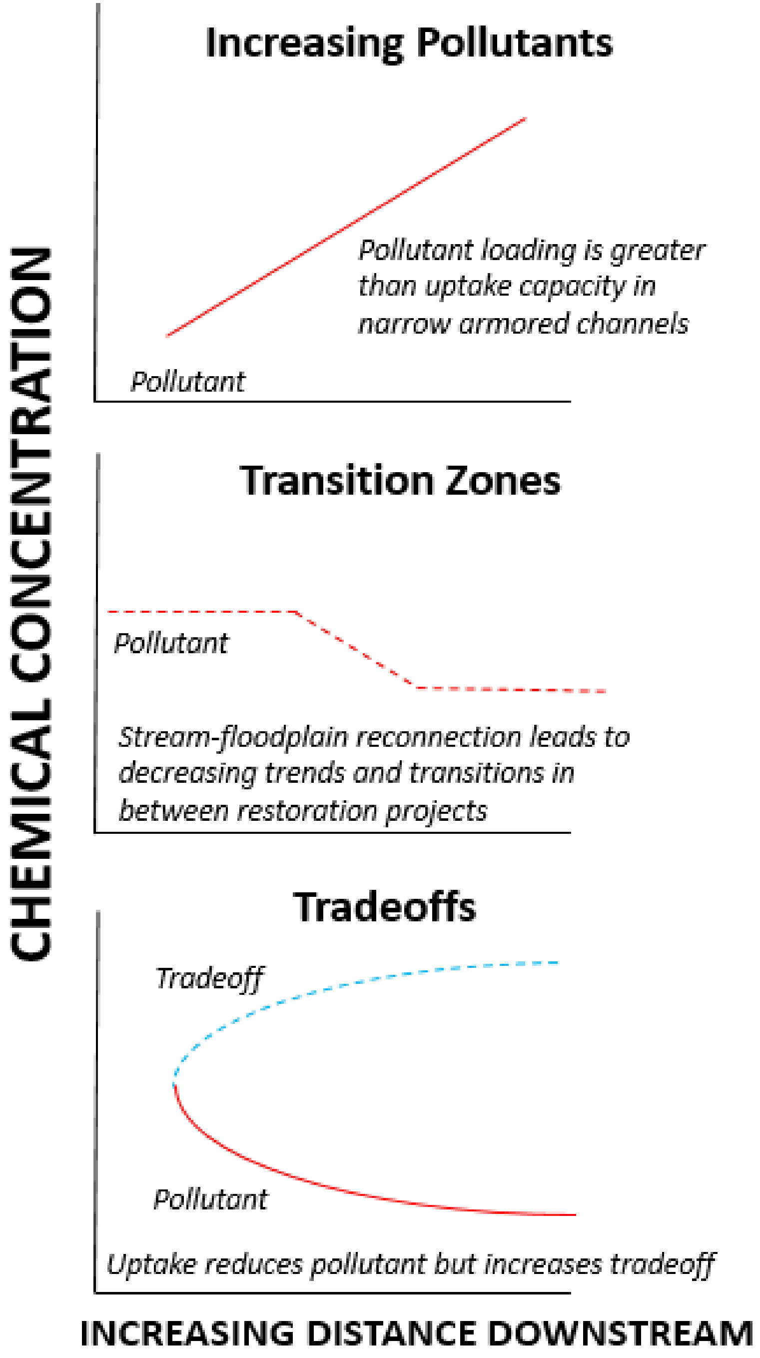
Wes Saughter



Kaushal et al. (In Prep)

Kaushal and Belt (2012), Kaushal et al. (2014, 2023), Sivirchi et al. 2011, Newcomer-Johnson et al. (2014), Pennino et al. (2016), Smith et al. 2017, Maas et al. (2023), Malin et al. (2023), Shelton et al. (2023)

Hypotheses



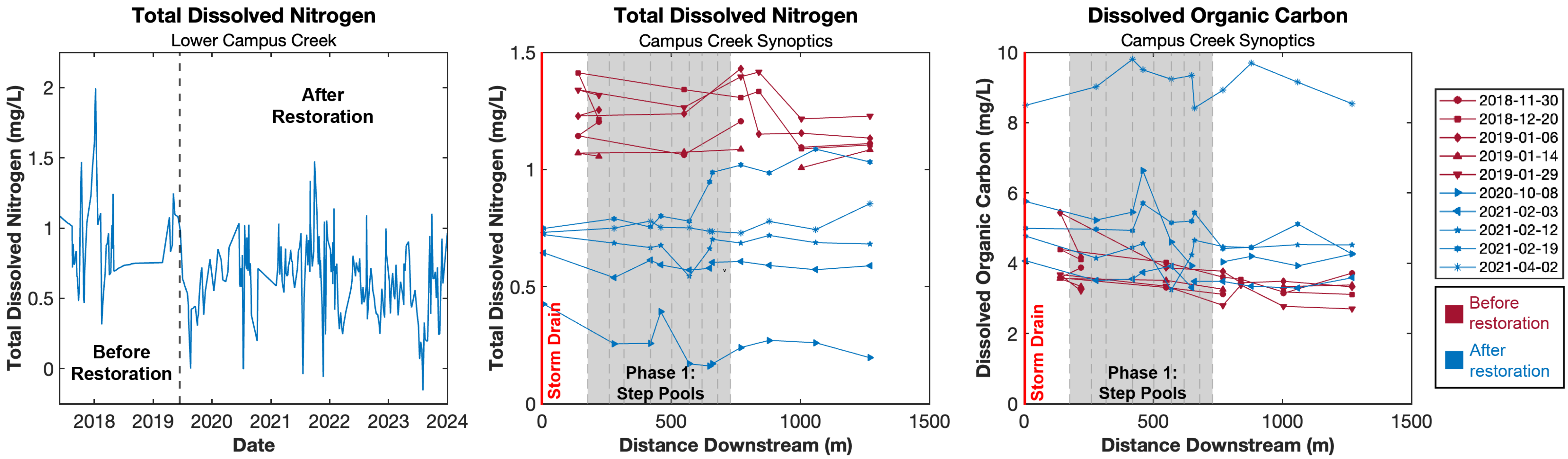
Adapted from Kaushal et al. (2023)

-There will be decreasing trends in pollutants and increasing trends in water quality tradeoffs along restored stream flowpaths based on different types of stream-floodplain reconnection.

-Decreasing trends in pollutants along stream flowpaths will be related to increasing riparian buffer widths across watershed scales.

***There will be longitudinal trends in co-benefits of restoration and conservation!**

Stream Restoration Can Reduce Nitrogen across Space-Time

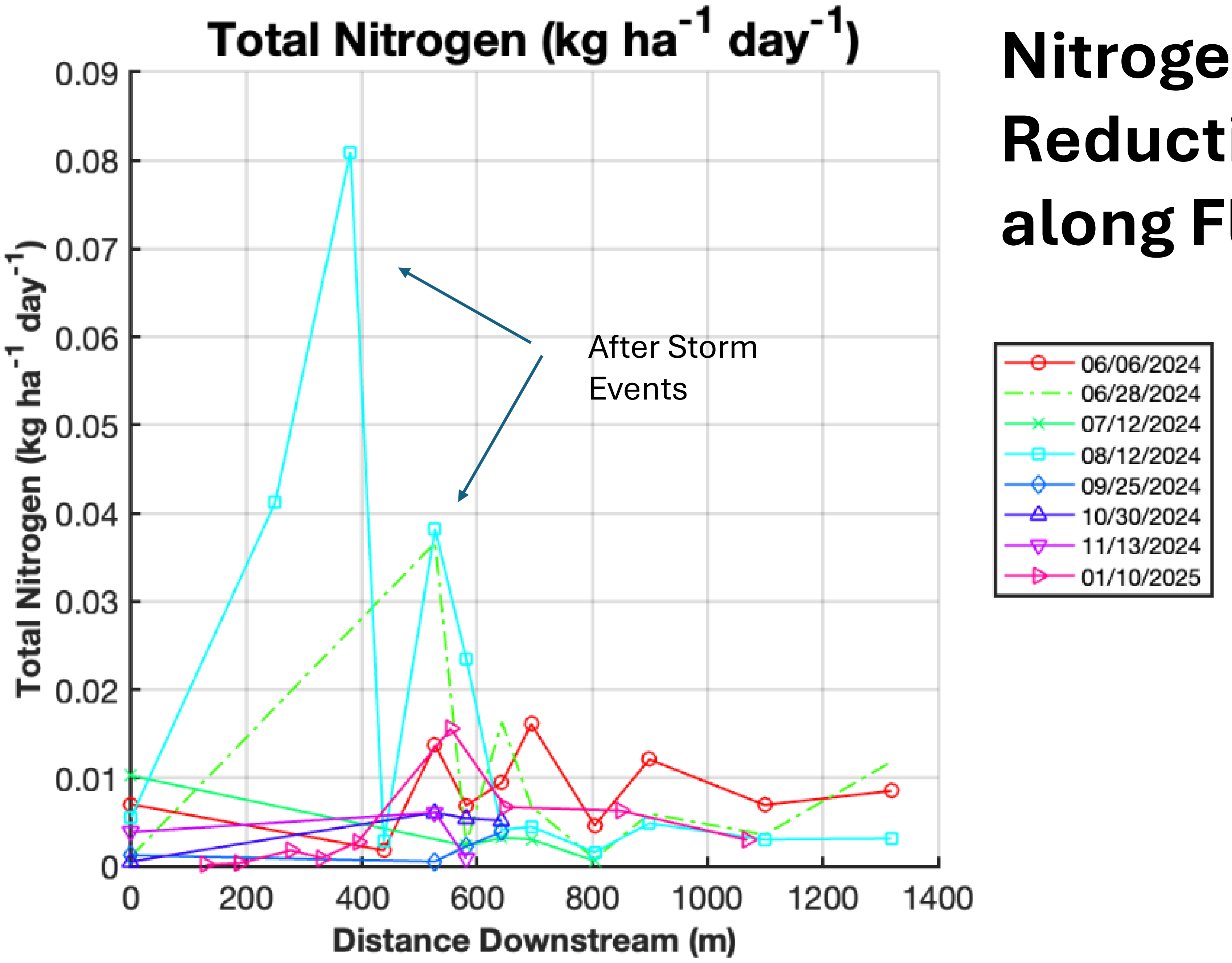


Kaushal et al. (In Prep)

Stream Restoration Can Increase Organic Carbon

Tradeoff or Benefit?

Nitrogen Export Reductions along Flowpath



What Are Tradeoffs?

Potential Water Quality Benefits	Potential Water Quality Costs
Decreased nutrients and sediments due to greater retention in floodplains and pools →	Increased hypoxic and anoxic periods of low dissolved O_2 (DO)
Decreased N and P along stream flowpaths due to greater biological uptake →	Increased production of algae and bacteria and biochemical oxygen demand (BOD)
Decreased concentrations of Na^+ and Cl^- from road salts through soil ion exchange →	Increased mobilization of N, P, and metals from soil ion exchange sites and Na dispersion of soils
Decreased sediment due to retention of particulates in RSC pools and floodplains →	Increased mobilization of dissolved P from soils due to desorption at low DO and high pH

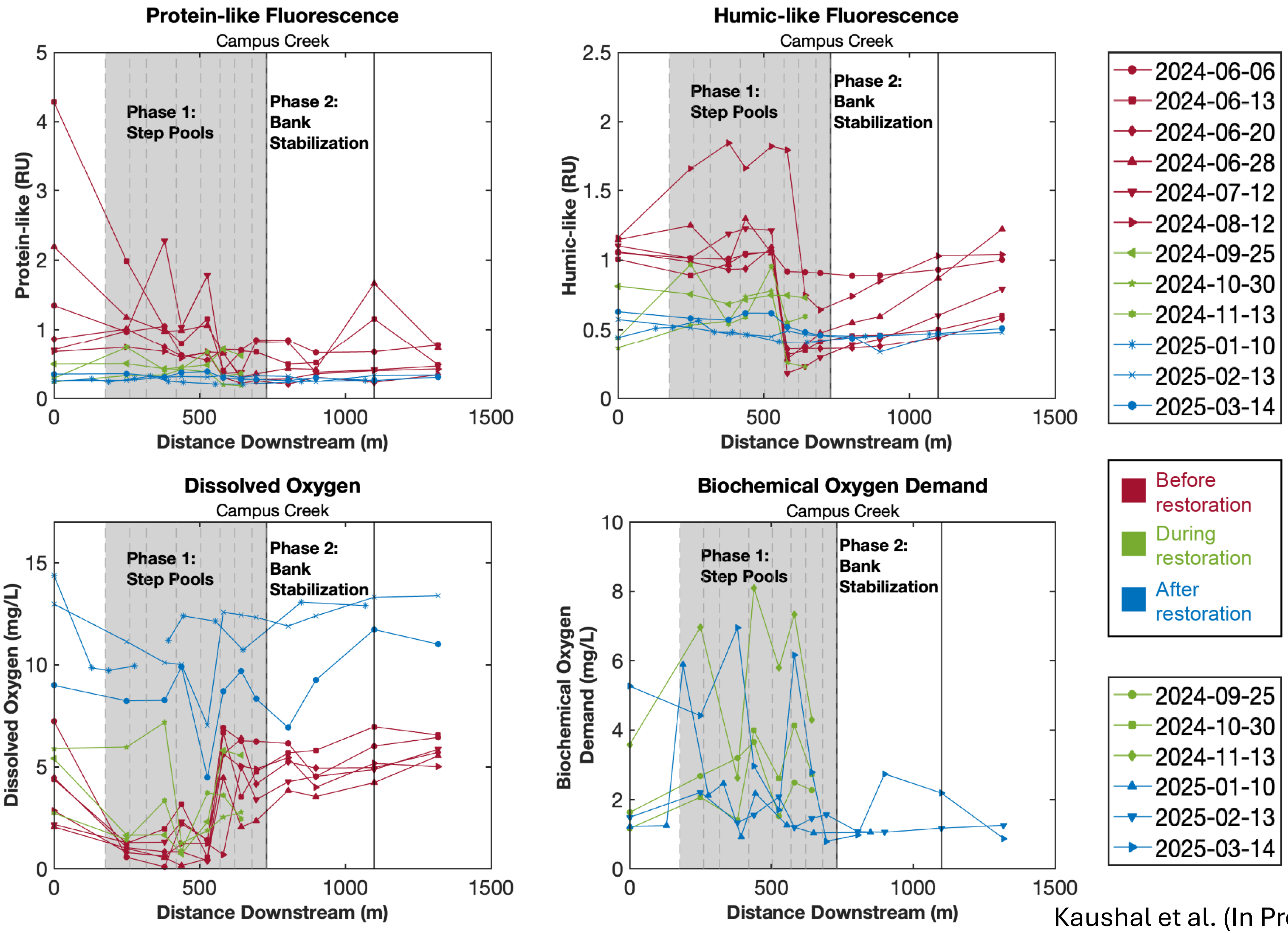
Kaushal et al. (In Prep)

***What Are Co-Benefits?** Attenuation of nutrients, salts, metals, and increases in hydrologic connectivity (Kaushal et al. 2023, Shelton et al. 2024, Malin et al. 2024)

Trading Nitrogen for Carbo

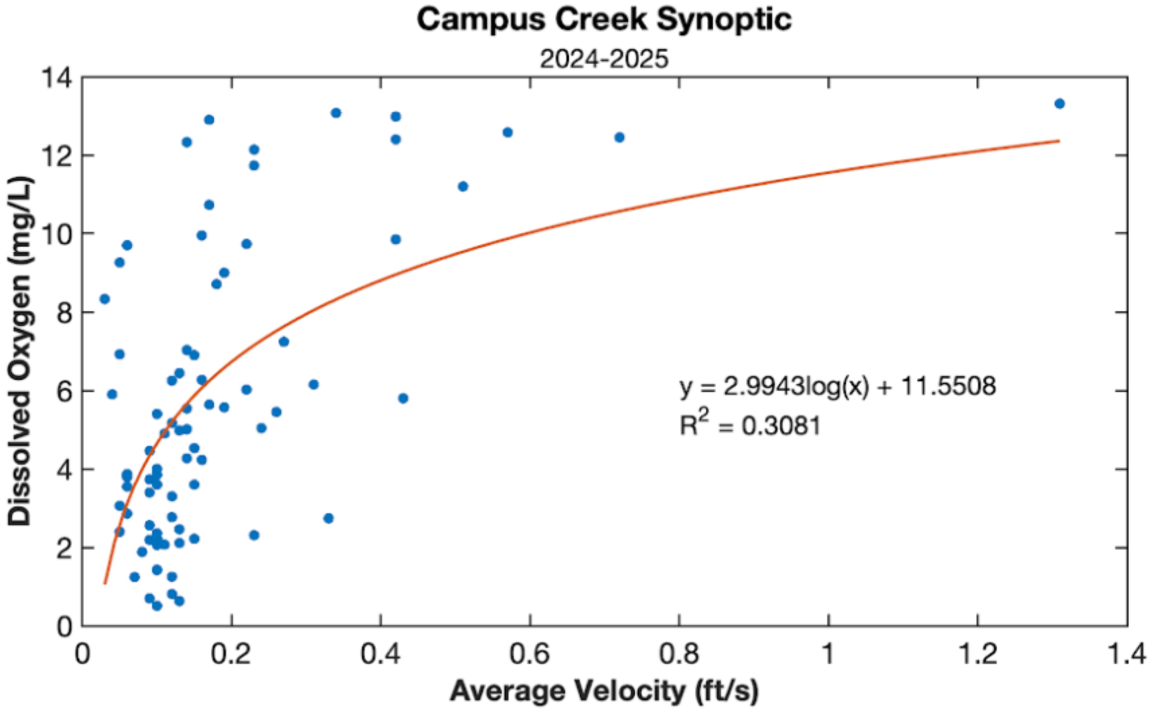
Nitrogen is reduced but reactive carbon is increased.

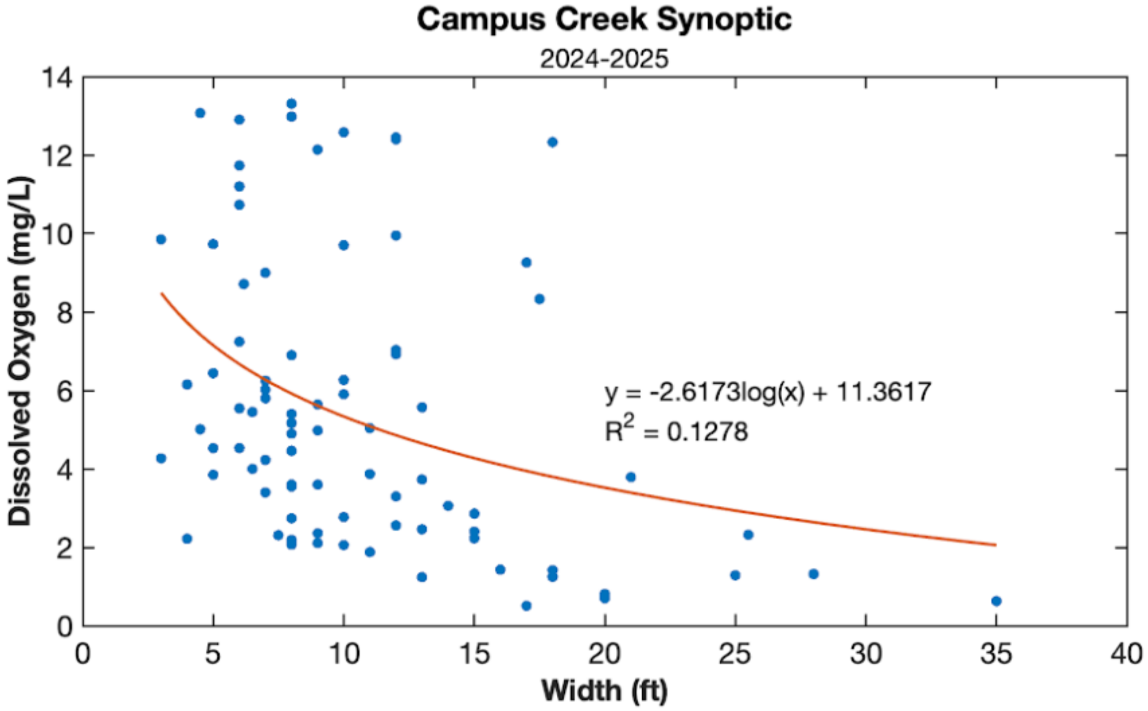
Tradeoff or Benefit?



Kaushal et al. (In Prep)

Dissolved Oxygen Is Related to Stream Width and Stream Velocity along Watershed Flowpaths





Kaushal et al. (In Prep)

Tradeoff: Trading Decreased Stream Velocity for Lower Oxygen?

Tradeoff or Benefit?

Restoration Realities: Comparing Hydrologic Connectivity

-*Channel Stabilization* (In-stream structures and water In the channel)

-*Floodplain Reconnection* (Designed to spill water out of the channel)

-*Step Pool* Conveyance (Designed to slow flow and pool water)

Photo Courtesy: Kelsey Wood

Hickey Run: Can Water Quality Improve?

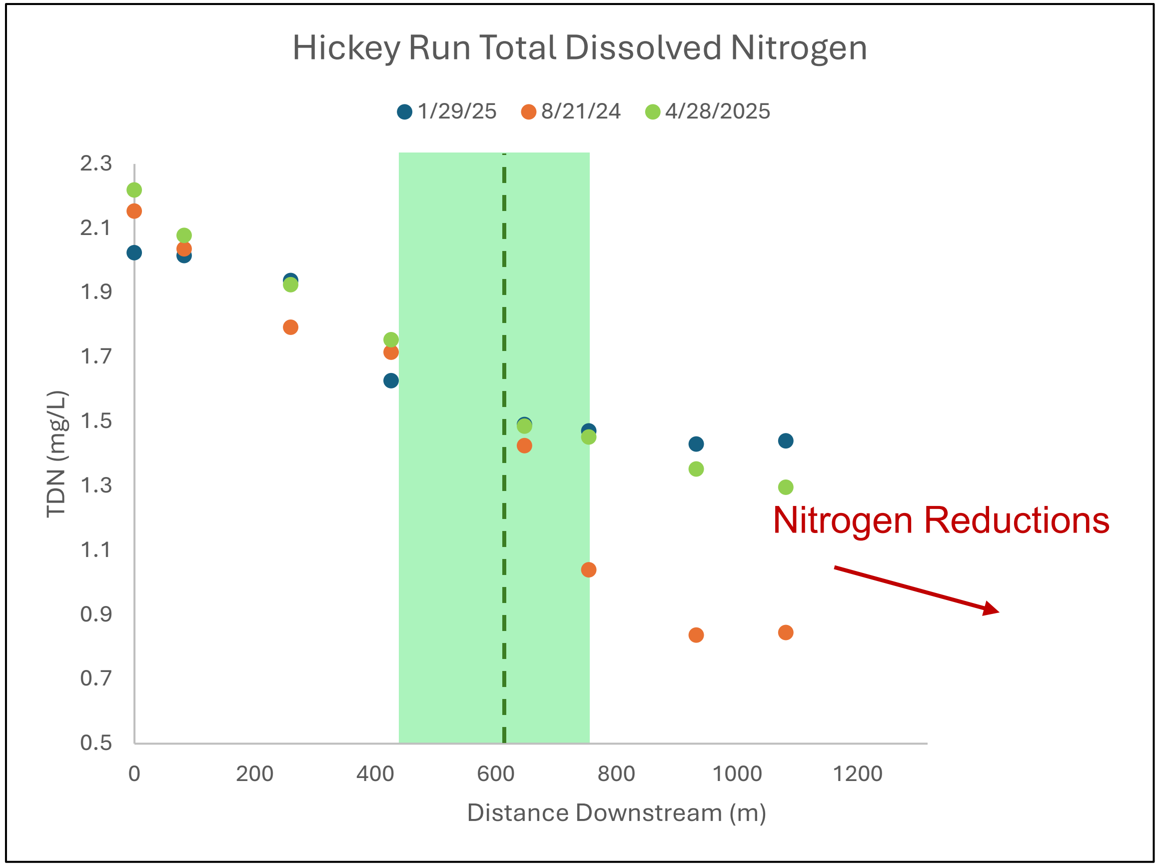
Hickey Run (storm drain) before it flows through restoration

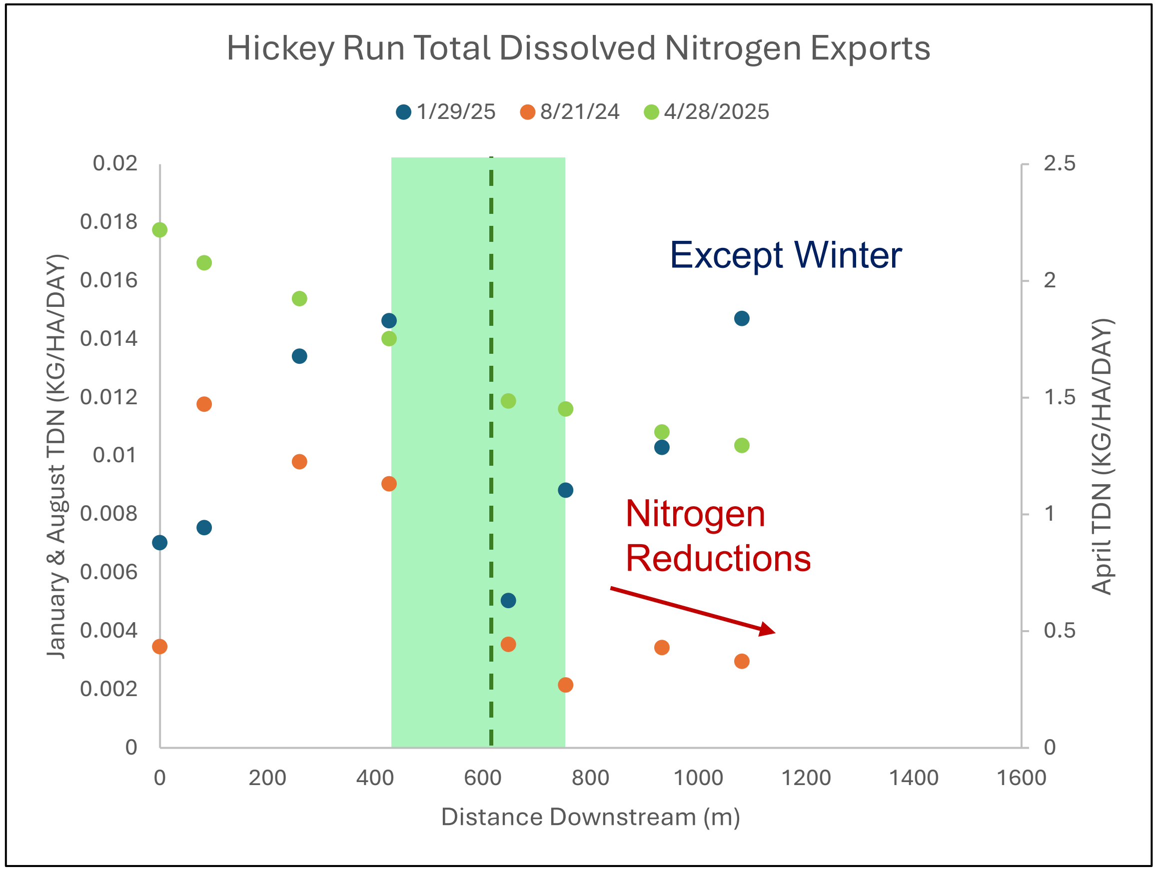
Springhouse Run (tributary of Hickey Run)

Water quality improves as urban Hickey Run flows from storm drain, through and downstream of stream restoration projects, and through National Arboretum

Thanks to Ashley Dann

Hickey Run

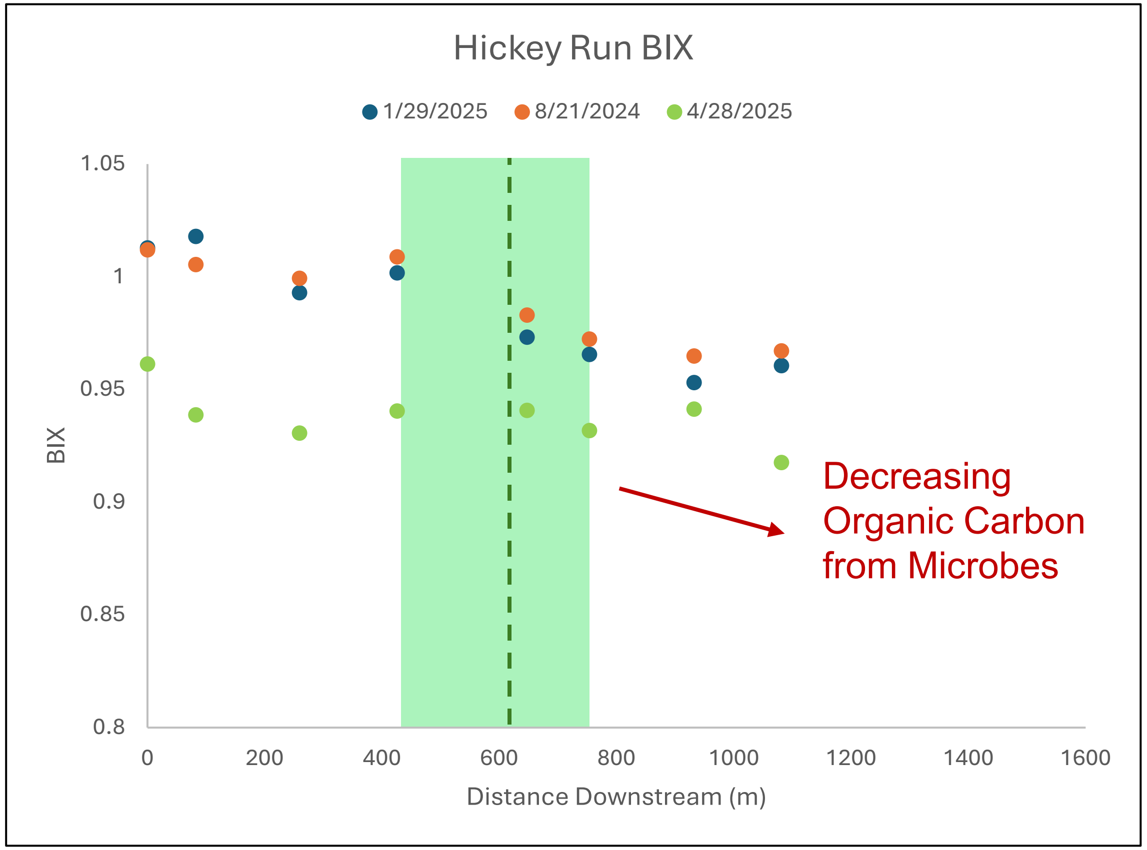


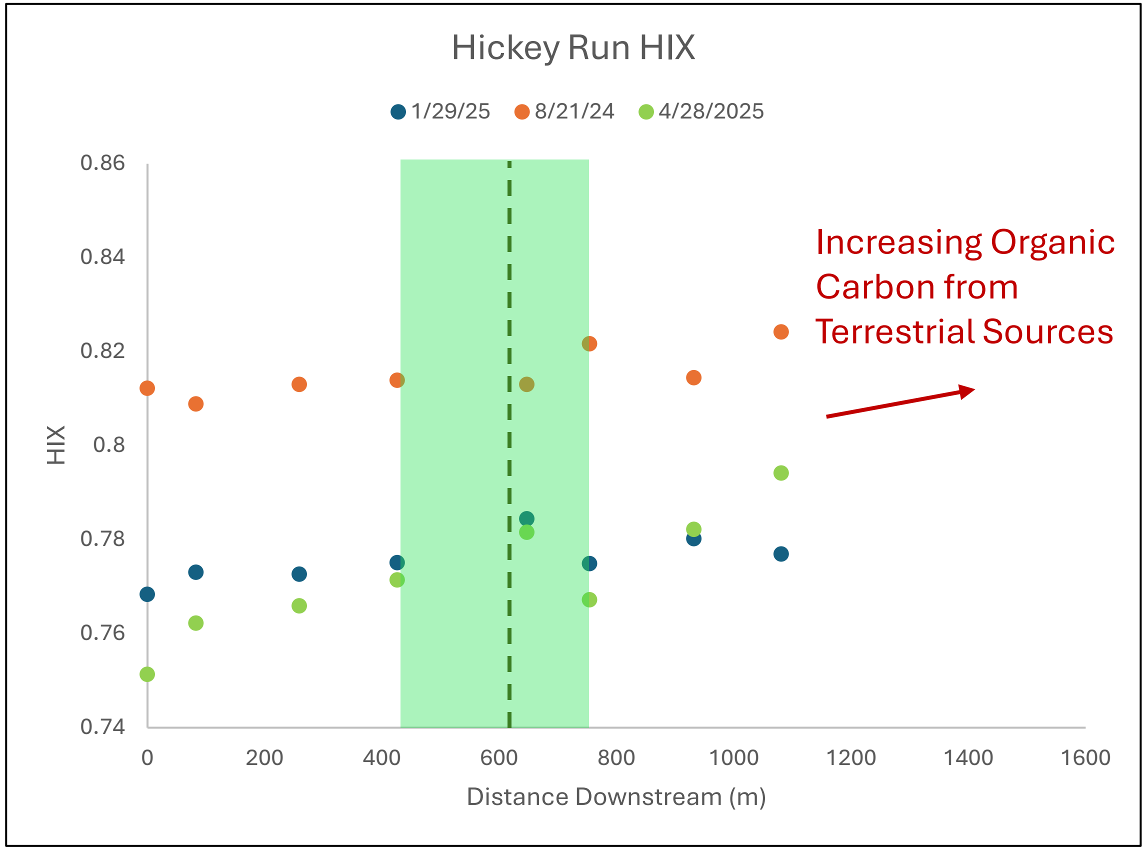


Longitudinal decline in N concentrations and watershed N exports as Hickey Run flows from storm drain through stream restoration project and National Arboretum

Thanks to Ashley Dann

Hickey Run

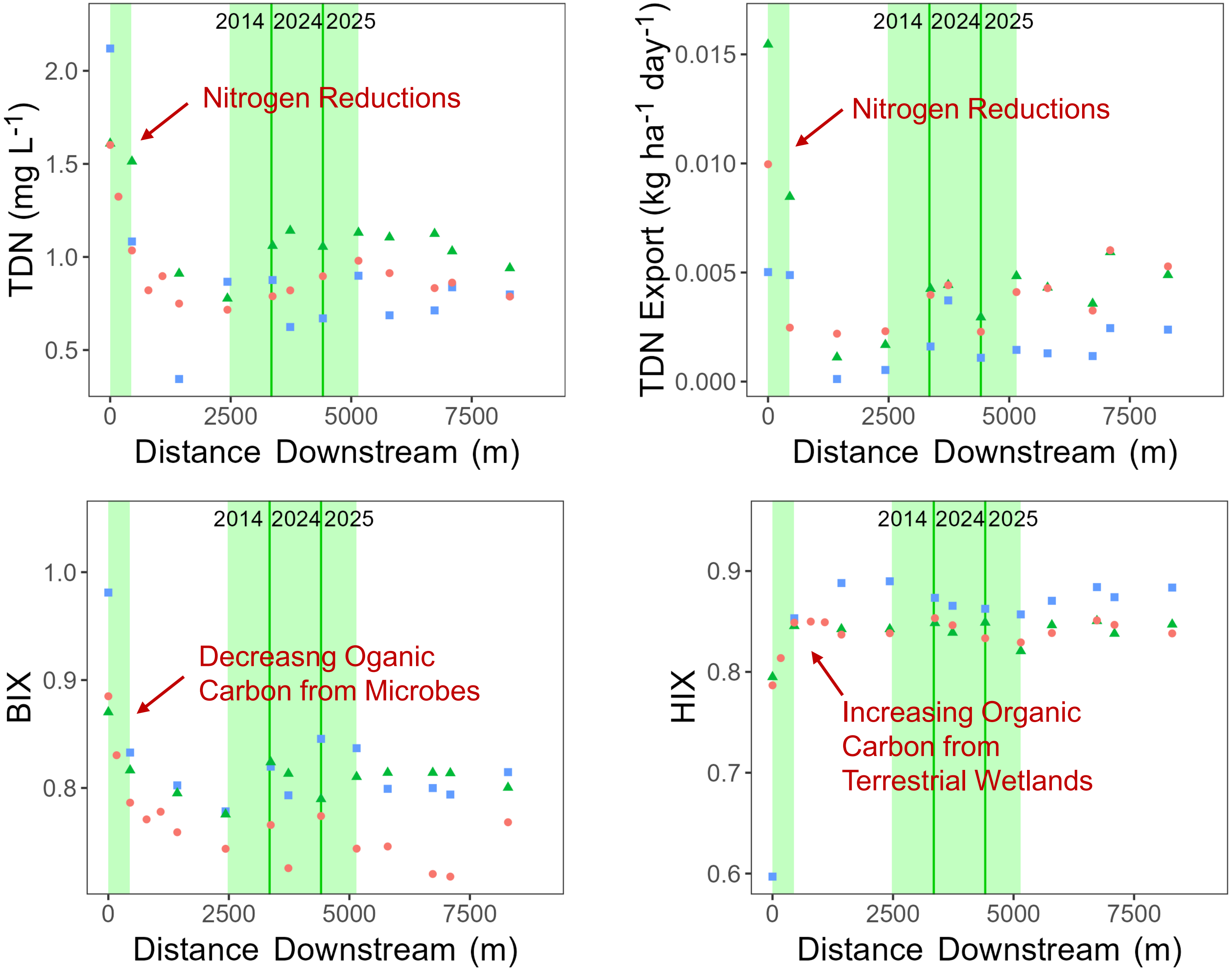




Longitudinal change in organic matter sources as Hickey Run flows from storm drain through stream restoration project and National Arboretum

Thanks to Ashley Dann

Scotts Level Branch: Nitrogen Reductions



Restored

- 03/12/2025 Construction
- 01/15/2025 Construction
- 08/15/2024

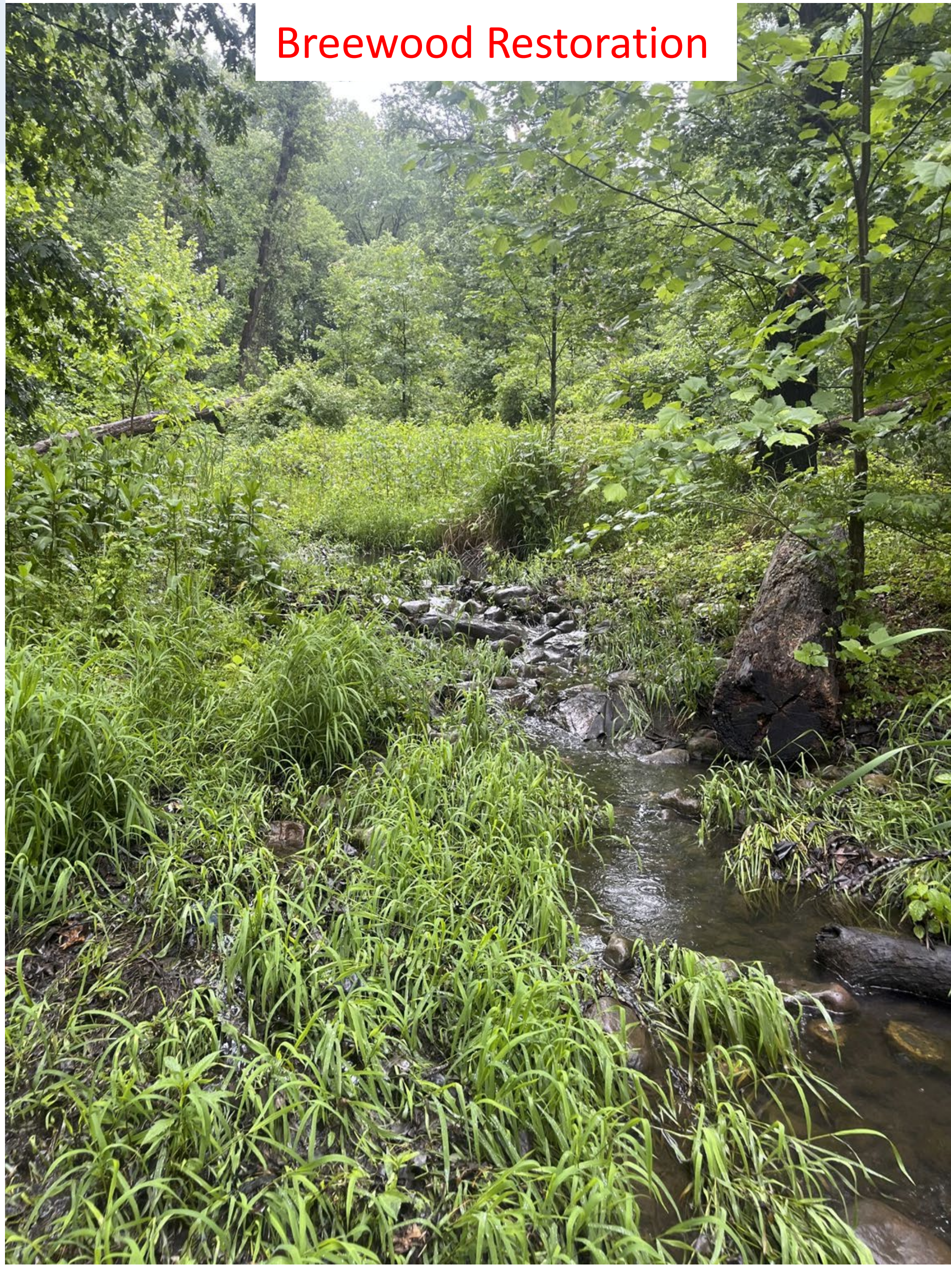
Thanks to Sydney Shelton

Section 319
NONPOINT SOURCE PROGRAM SUCCESS STORY
Maryland
Stream Restoration Reduces Peak Storm Flow and Improves Aquatic Life in Sligo Creek

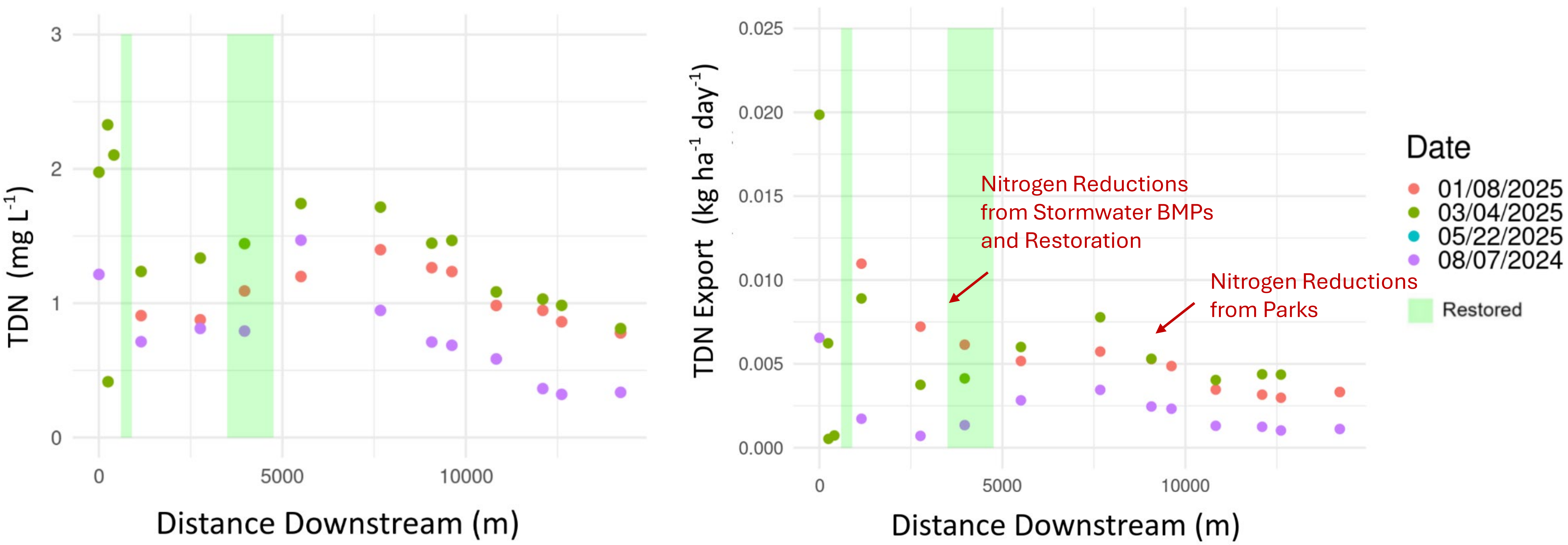
Retention Pond along Stream Synoptic

Thanks to Wes Slaughter

Breewood Restoration

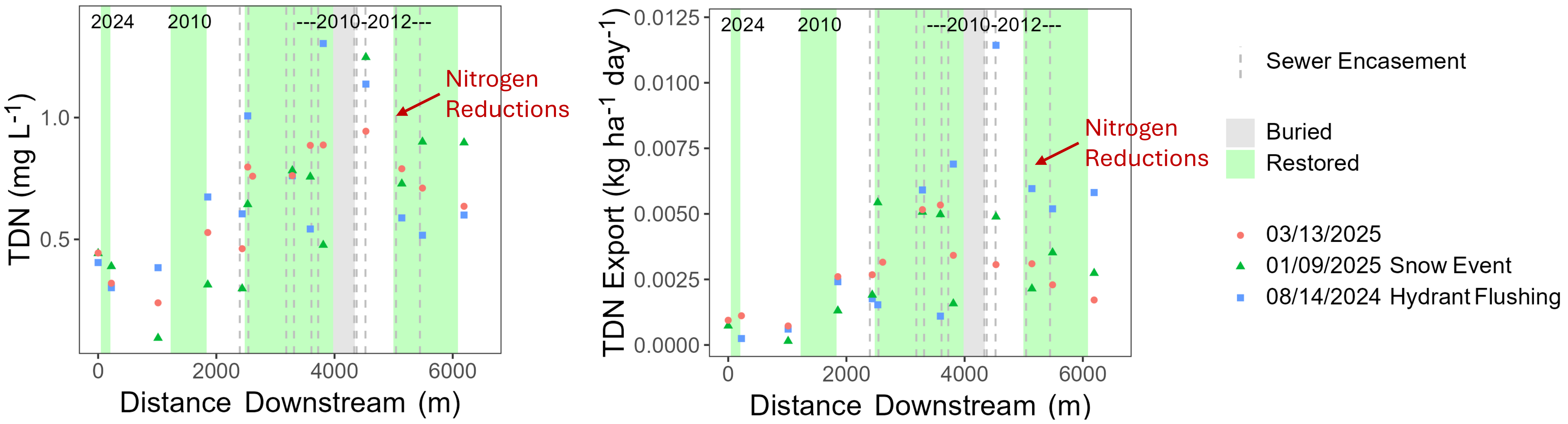


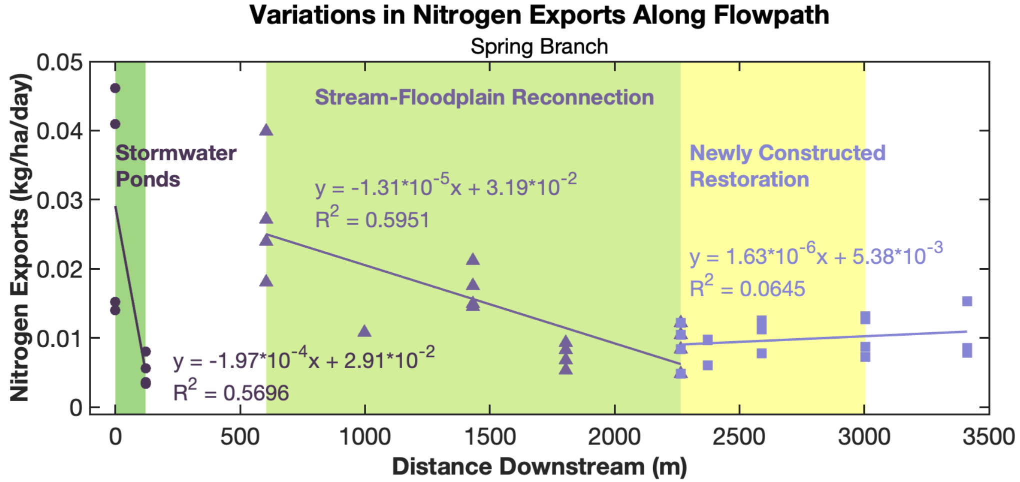
Nitrogen Reductions along Sligo Creek

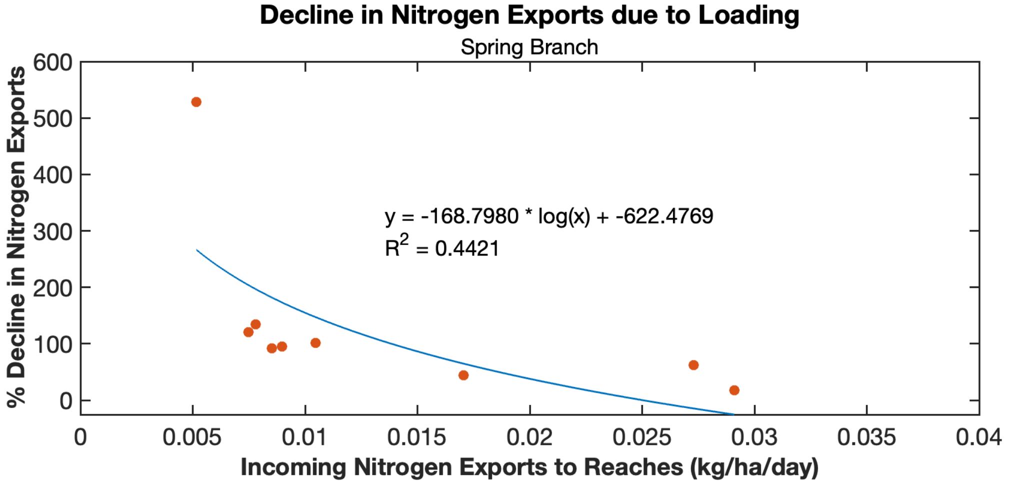


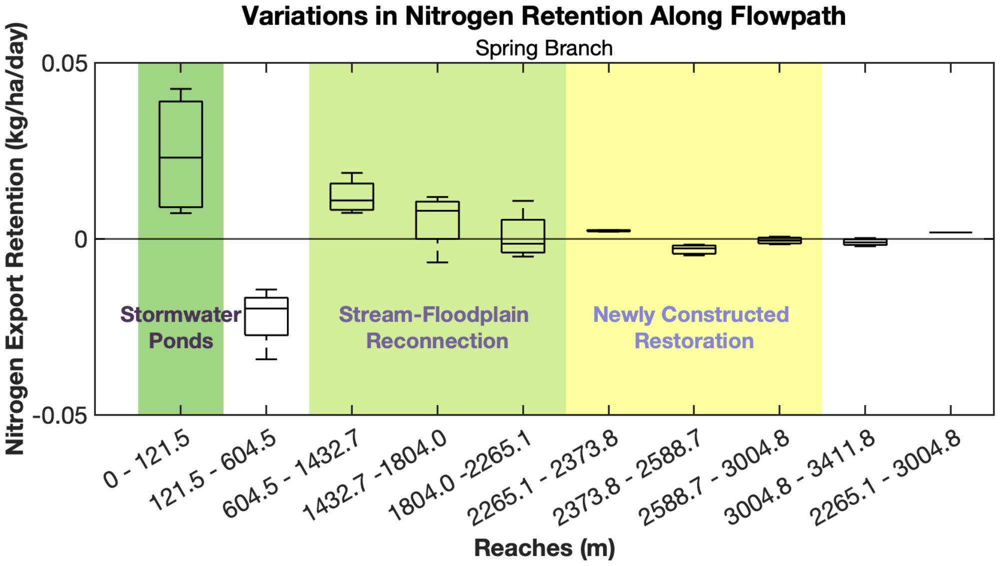
Thanks to Wes Slaughter

Watts Branch: Variations in Nitrogen Reductions





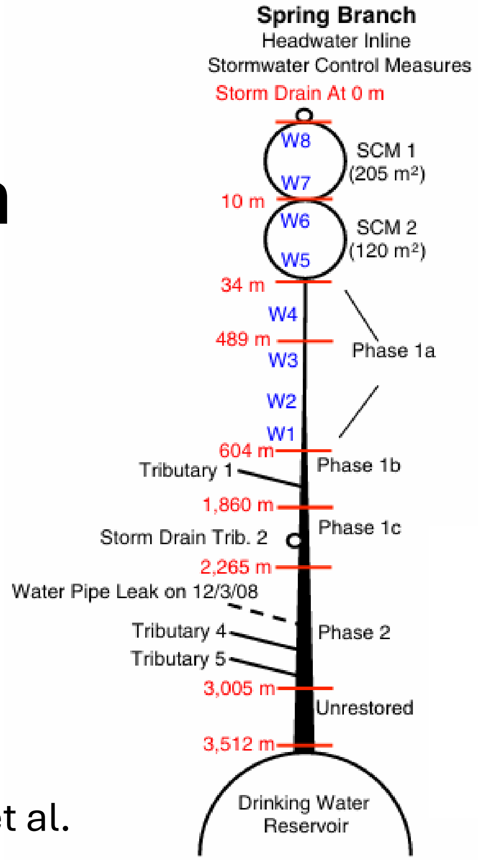




Kaushal et al. (In Prep) and
many thanks to Ashley Mon!

Variations in Nitrogen Retention Can Be Quantified Among Reaches

Sivirichi et al. (2011)



Newcomer Johnson et al.
(2014)

Conclusions for Year 1

-Stream-floodplain restoration can reduce nitrogen transport at watershed scales.

-There can be tradeoffs between nitrogen retention, carbon, and dissolved oxygen.

-Water quality hot spots and transition zones can be identified and guide restoration.

-The downstream distance that water quality can be restored can be quantified.

Acknowledgments

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- Thank you to Ari Engelberg for translating research.
- Thank you to Dennis Genito and Joe Berg for sharing insights and knowledge.
- Thank you to Chris Ruck, Shannon McKenrick, and Carol Cain for suggestions.
- Thank you to all CBT partners.

Translation Slides

What are the take home points?
What does this mean for me?

Translation Slides by Ari Engelberg

What does this mean for me?

- These streams exhibited very dynamic patterns in nutrient levels as water flowed through the restorations. This likely reflects a combination of the effects of the restoration and local watershed conditions.
- Increasing levels of terrestrial carbon in some stream restorations was correlated to decreasing N levels as you moved from upstream-downstream (Scotts Level and Hickey Run).
- Potential trade offs between nutrient reduction and dissolved oxygen reduction in restorations that slowed stream flow (Campus Creek)
- Some potentially identifiable effects of stormwater management at the watershed scale resulted in decreased N loads (Sligo Creek) . Will need more work to tease apart what's causing this pattern.

What does this mean for me?

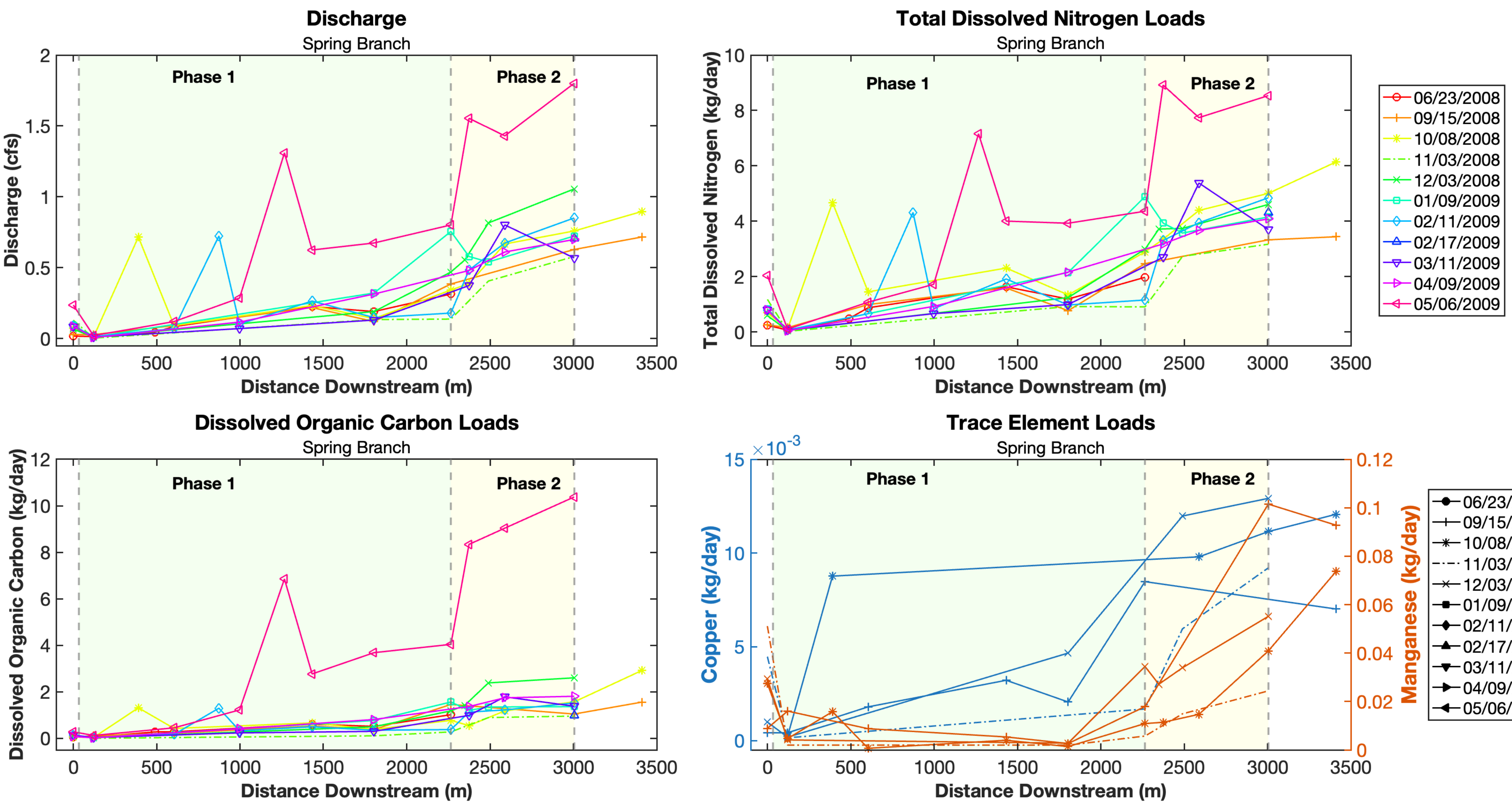
What do I take from this if I am a practitioner:

- Keep in mind potential trade offs from slowing down streamflow.
- Minimize limit of disturbances during construction and protect riparian buffers; mature forest provides a critical carbon source for the stream that may promote denitrification and nutrient cycling.

What do I take from this if I am a regulator:

- Keep in mind the above when siting and reviewing stream restorations.
- Consider increasing post-restoration longitudinal sampling of funded or permitted projects. This may supplement traditional before/after sampling to reveal useful information on restoration performance.

Pollution "Hot Spots" Can Be Identified along Watersheds



Kaushal et al. (Submitted)

Future and Ongoing Work

-Continue longitudinal monitoring and analyze incoming results

-Statistical relationships between land use/land cover and pollutant concentrations and loads (*e.g.*, Kaushal et al. 2023, Maas et al. 2023)

-Analysis of statistical breakpoints to detect restoration and conservation signals and how far they persist downstream (*e.g.*, Shelton et al. 2024)

-Comparison of changes in concentrations and loads before and after stream restoration over time and space (*e.g.*, Mayer et al. 2022, Kaushal et al. 2023)

-Comparisons using 3 paired and nested watersheds (Scotts Level/trib, Hickey Run/Springhouse trib, Paint Branch/Campus Creek trib) .