TASCC: Using nutrient spiraling as a restoration tool

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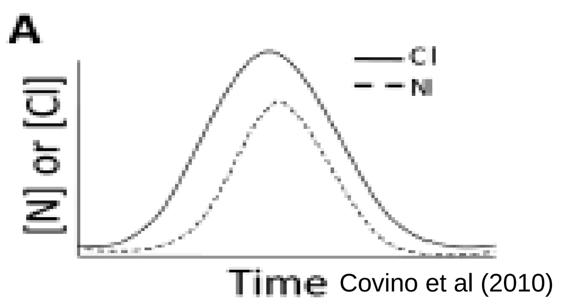
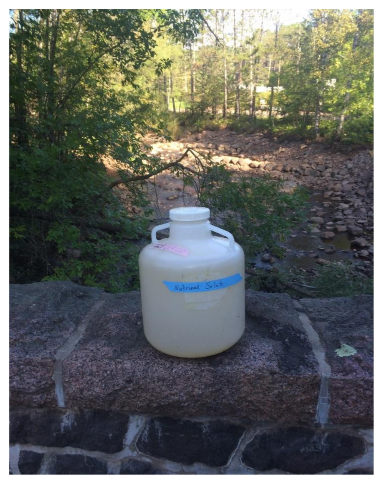
Abstract

We demonstrate the use of the Tracer Addition for Spiraling Curve Characterization (TASCC) method (Covino et al, 2010) as an efficient way to characterize stream health. Indicators of a streams ability to retain or remove nutrients via processes related to physical habitat features can assist restoration and land managers connect restoration habitat for fisheries with nutrient retention and clean water. Understanding a streams proximity to nutrient saturation and its ability to retain or remove nutrients is an important aspect in restoring a stream for long term nutrient retention. A streams inability to process and remove excess nutrients can result in problems such as eutrophication, biological saturation, drinking water contamination, and increased algal blooms in downstream estuaries. Fifteen Twin ports streams were assessed under ambient conditions at baseflow for their ability to retain excess nutrients. Metrics used for evaluation were uptake length, uptake velocity, and areal uptake rate. These metrics were examined across a variety of in-stream and riparian physical habitat measures to visualize the potential drivers of nutrient retention. The driving physical habitat measures shown here are used to demonstrate the effectiveness of TASCC as a restoration tool to identify, discern, and remediate streams that may have a nutrient issue now, or at risk in the future.

Materials & Methods

- 15 streams selected by anthropogenic disturbance (urban, pristine & agriculture) and evaluated during the growing season (June-September) of 2016 and 2017.
- Study Reach length 40x the avg. width. Min=150m
- 4:1:1 $NaCl:KNO_3:NH_4H_2PO_4$ mixed with 5-10L of site water in carboy create the tracer : nutrient injectate for the stream. (Covino et al, 2010)
- Rise and fall of conductivity, Hach HQ40D (Hach inc, Loveland, CO, USA) from conservative tracer, NaCl, was used to indicate the leading edge, peak, and falling edge of the nutrient pulse. (Covino et al, 2010)
- Water samples were collected throughout the entirety of the injectate surge until baseline conductivity was re-established.
- Water samples filtered for dissolved nutrients and anions using 0.45µm membrane filter.
- Nutrient (NO_3-N, PO_4-P, NH_4-N) samples analyzed using flow injected liquid chromatography (QuikChem 8000, Lachat Instruments, Milwaukee, WI, USA).
- Anions stored at 4˚C and ran for chloride values using ion chromatography (Dionex, Sunnyvale, CA, USA).
- Physical habitat was evaluated using NRSA protocols-wadable streams. (*NARS,* National Rivers and Streams Assessment 2008-2009)
- Statistical analyses were generated using SAS PROC GLM and R-Studio for correlations





Results

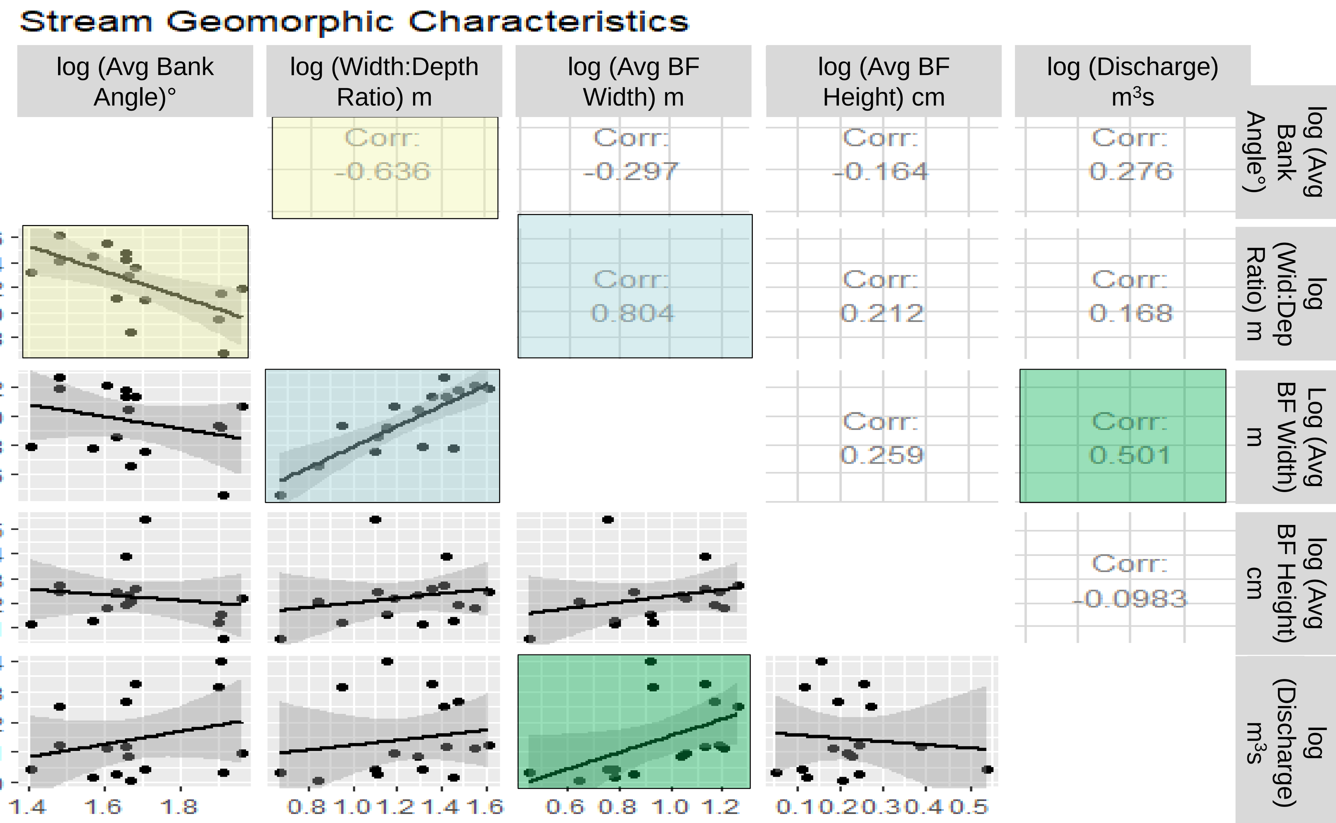


Figure 1: Indicates how the stream morphological traits interact with one another. As streams get wider and shallow, bank angles significantly decrease (p=0.004). Wide and shallow streams have increased bankfull widths (p=0.001) indicating limited scouring is occurring to significantly incise the bank. As discharge increases, bankfull widths increase (p=0.006), demonstrating that higher discharge increases width rather than depth, while bankfull height remains uncorrelated. Significant relationships are color coded above.

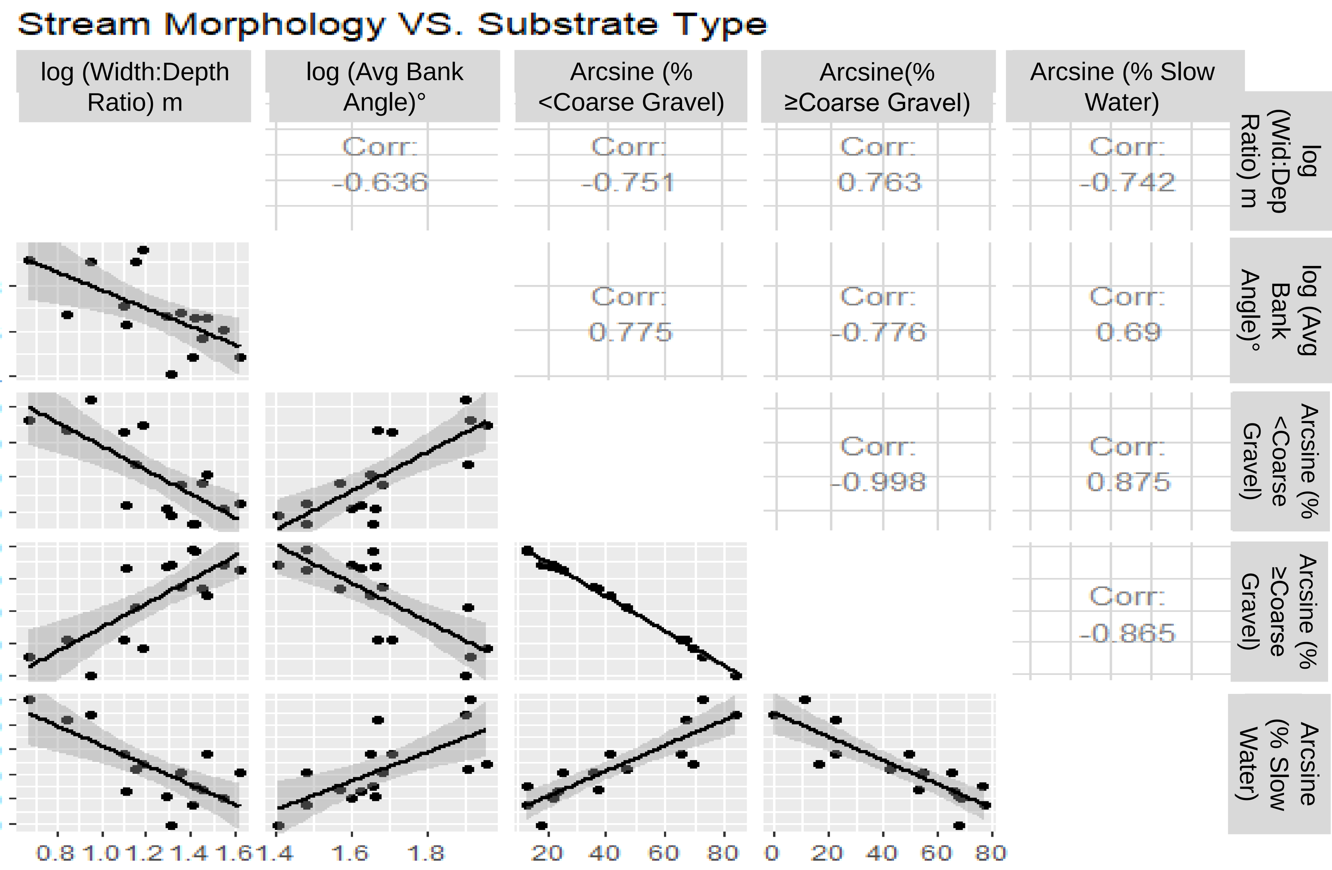


Figure 2: Uses the geomorphological characteristics from **Figure 1**, and correlates them against substrate types and water characteristics. As streams get wider, they become faster, and dominated with rock substrate > coarse gravel. Slower and deeper water with incised banks, significantly decrease the amount of substrate defined by rock, and increase the presence of finer sediments. All correlations are significant (P<0.05). ≥coarse gravel = 6.4cm-1m diameter rock. %Slow water is a combined percentage of pool and glide water features.

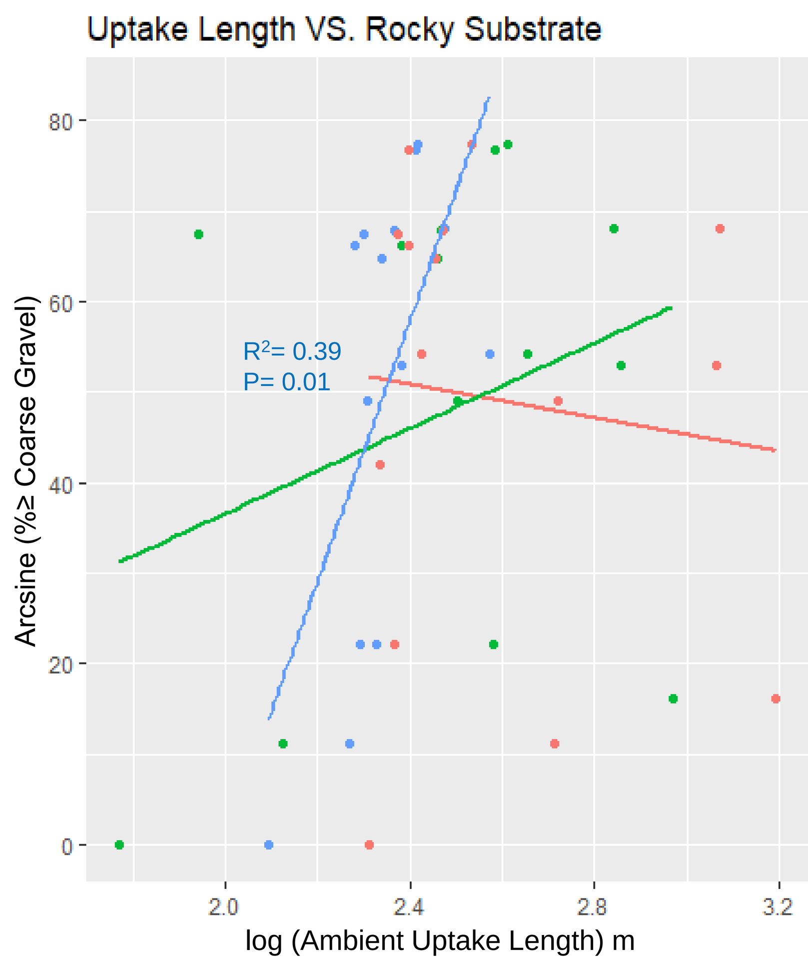


Figure 3 (left): A representation of Uptake lengths for all three nutrients against substrates ≥ coarse gravel. This plot demonstrates that rocky streams are not efficient at retaining nutrients, specifically PO_4, which is often the limiting nutrient in riverain systems.

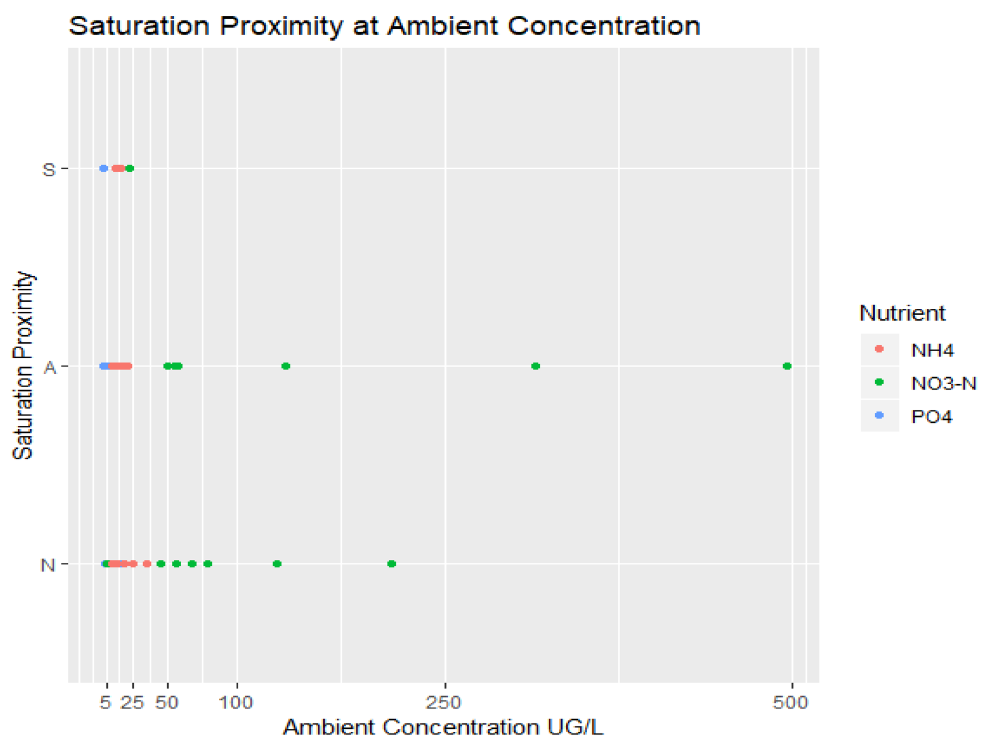
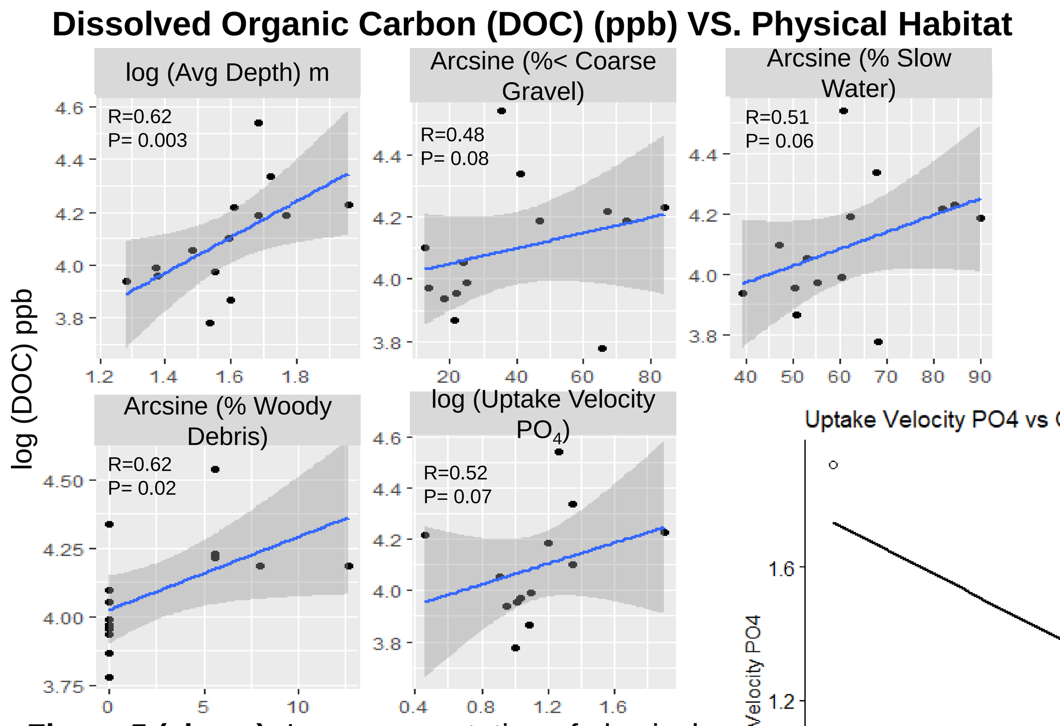


Figure 4 (Left): The y-axis represents each stream's proximity to saturation (N= Not Saturated, A= Approaching Saturation, S= Saturated) at ambient condition. The x-axis represents ambient nutrient concentration. This chart sheds light on why taking only one ambient sample without using the TASCC method is ineffective at evaluating stream health with respect to nutrient loading. Streams vary in their ability to retain nutrients based on a variety of in-stream and landscape-land use conditions. Some streams may have low ambient concentrations, but actually is a saturated system. Others may have high nutrient concentrations, but are adapted to those conditions and are able to retain an increase in loading.



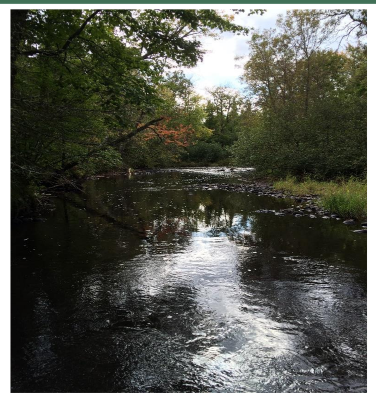


Figure 5 (above): Is a representation of physical habitat measures against DOC. Biological demand (uptake velocity) of PO_4 values correlate with an increased DOC. DOC also correlates similarly as other nutrients, significantly (p= 0.003) with depth and woody debris presence (p= 0.02), found in slower water conditions where decomposition is more favorable.

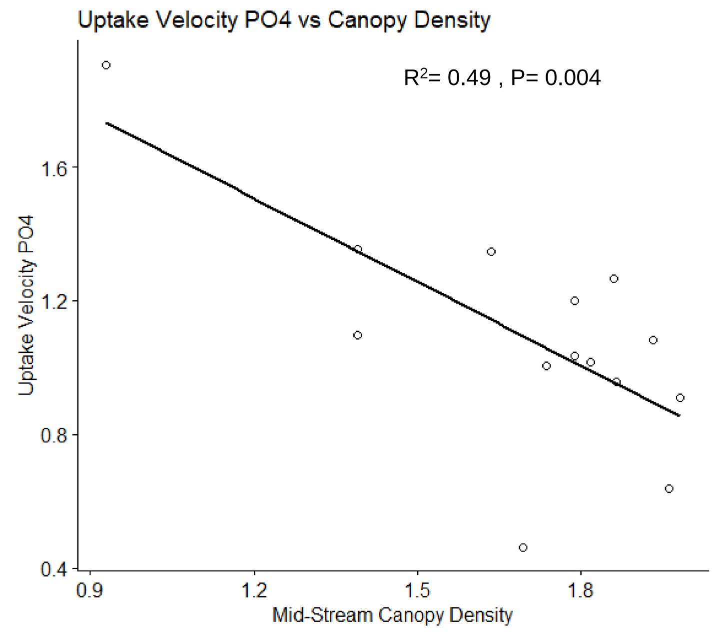


Figure 6 (above): Demonstrates that there is a significant (p= 0.004) light sensitive-biological demand for PO_4, aside from our measured biological habitat. Other nutrient correlations insignificant, indicating that PO_4 is a limiting nutrient in studied systems

Conclusions

- TASCC can be used to evaluate a stream's nutrient retention based on a wide range of NRSA physical habitat measures
- Most favorable conditions for retaining nutrients are deep thalwegs with slower moving water and steeper. Which promotes the aggregation of finer sediments, and has been demonstrated via Uptake Length metrics to retain a higher percentage of nutrients than wide and rocky streams.
- As Figure 4 shows, ambient nutrient concentration of streams alone does not provide the information that project managers and land managers need to adequately evaluate a streams health with respect to nutrient loading. TASCC is a low cost method that can help make management decisions efficiently and more effectively.
- Streams may also be carbon, as well as nutrient limited. For carbon limited streams, allowing allochthonous detritus to accumulate by providing slower flowing stream segments promotes decomposition and thereby increased nutrient retention.
- To promote nutrient retention and to protect drinking water, land managers may want to consider allowing streams to naturally meander, aggregate finer sediments, and slow down. Current practices often include installing features to make faster – rocky habitat with armored banks, typically used to promote fish habitat. Nutrients retention and ecosystem function are important too!

Further Investigation

- Investigate nutrient retention via transient storage. What types of features promote transient storage, and what connections can we draw from stream-ground water interactions.
- Using enzyme data we can investigate potential microbial users of nutrients across physical habitat measures.
- Examine nutrient retention in relation to slope variance

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