Dissolved organic carbon uptake in streams: A review and assessment of reach-scale measurements

University of New Hampshire

Madeleine Mineau[1], Wilfred Wollheim[1], Ishi Buffam[2], Stuart Findlay[3], Robert Hall[4], Erin Hotchkiss[5], Lauren Koenig[1], William McDowell[1], and Thomas Parr[6]

1. UNH, 2. U of Cincinnati, 3. Cary IES, 4. U Wyoming, 5. Umea U, 6. U Delaware

Introduction

Quantifying the role of freshwater ecosystems in large scale carbon cycling requires accurate measurement and scaling of dissolved organic carbon (DOC) processing in river networks. Despite this need for large-scale assessment, most measurements of DOC processing are made at the scale of bottles or, at most, stream reaches.

We reviewed reach-scale measurements, evaluated potential drivers of DOC uptake in streams, and assessed the scalability of reach-scale measurements to whole river networks.

Methods

We conducted a literature review of reach-scale DOC uptake measurements and bioassays to compare ambient stream water DOC and leaf leachate DOC bioavailability.

To scale uptake velocity to whole river networks, we used the Framework for Aquatic Ecosystem Modeling of the Earth System (FrAMES) to model hydrology and DOC inputs, removal, and in-stream concentration.

Results

Median uptake velocity was faster for simple compounds (2.94 mm min^{-1}) than for leachates (1.11 mm min^{-1}, Figure 1).

The median ratio of ambient DOC k to leaf leachates DOC k in reviewed bioassays is 0.234 (Table 1). Scaling leaf leachate v_f with this bioavailability ratio, we estimate an ambient DOC v_f of 0.26 mm min-1.

DOC vf was negatively correlated with ambient DOC concentration, SRP concentration, mean annual temperature, and mean annual precipitation (Figure 2).

Results

When scaled to whole river networks in NE USA, the bioavailability scaled stream water DOC v_f resulted in plausible DOC runoff concentration and watershed yield (Figure 3). Leachate v_f may also be plausible, especially in hot spot or hot moment of DOC processing.

Conclusion

At river network scale DOC v_f must be lower than reach-scale measurements but is still likely significant with the lowest v_f used in figure 3 still reducing in-stream DOC concentrations by 27 to 45%

Figure 1. DOC uptake velocity (v_f) from reach-scale additions of simple compounds and leachates

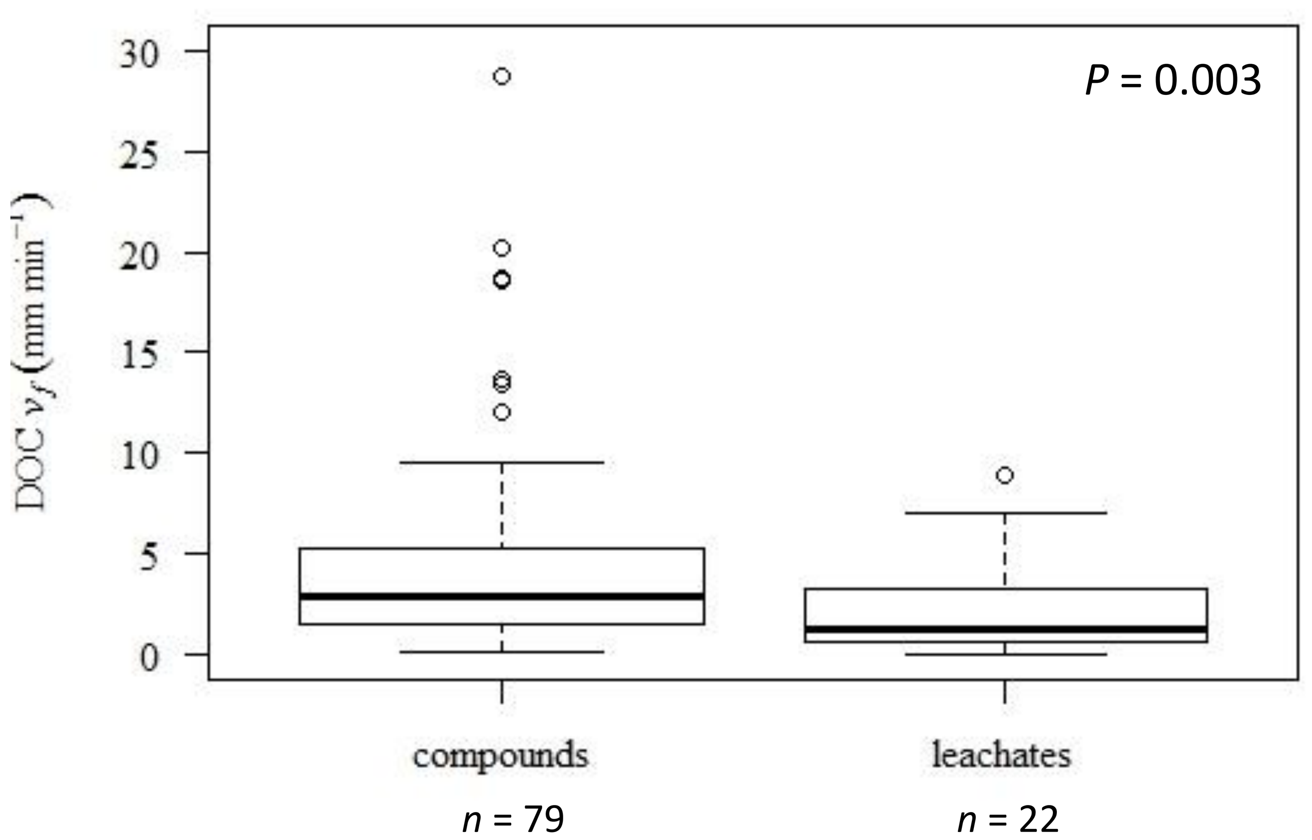


Table 1. Review of bioassays to scale leaf leachate DOC uptake to ambient stream water DOC based on bioavailability.

Ambient DOC k day^{-1}	Leaf leachate DOC k day^{-1}	Ambient k:leachate k
0.011	0.086	0.128
0.009	0.085	0.106
0.104	0.363	0.287
0.010	0.018	0.556
0.013	0.033	0.394
0.014	0.026	0.538
0.229	0.978	0.234
7.698	62.807	0.123
0.051	0.245	0.208
	Median	**0.234**

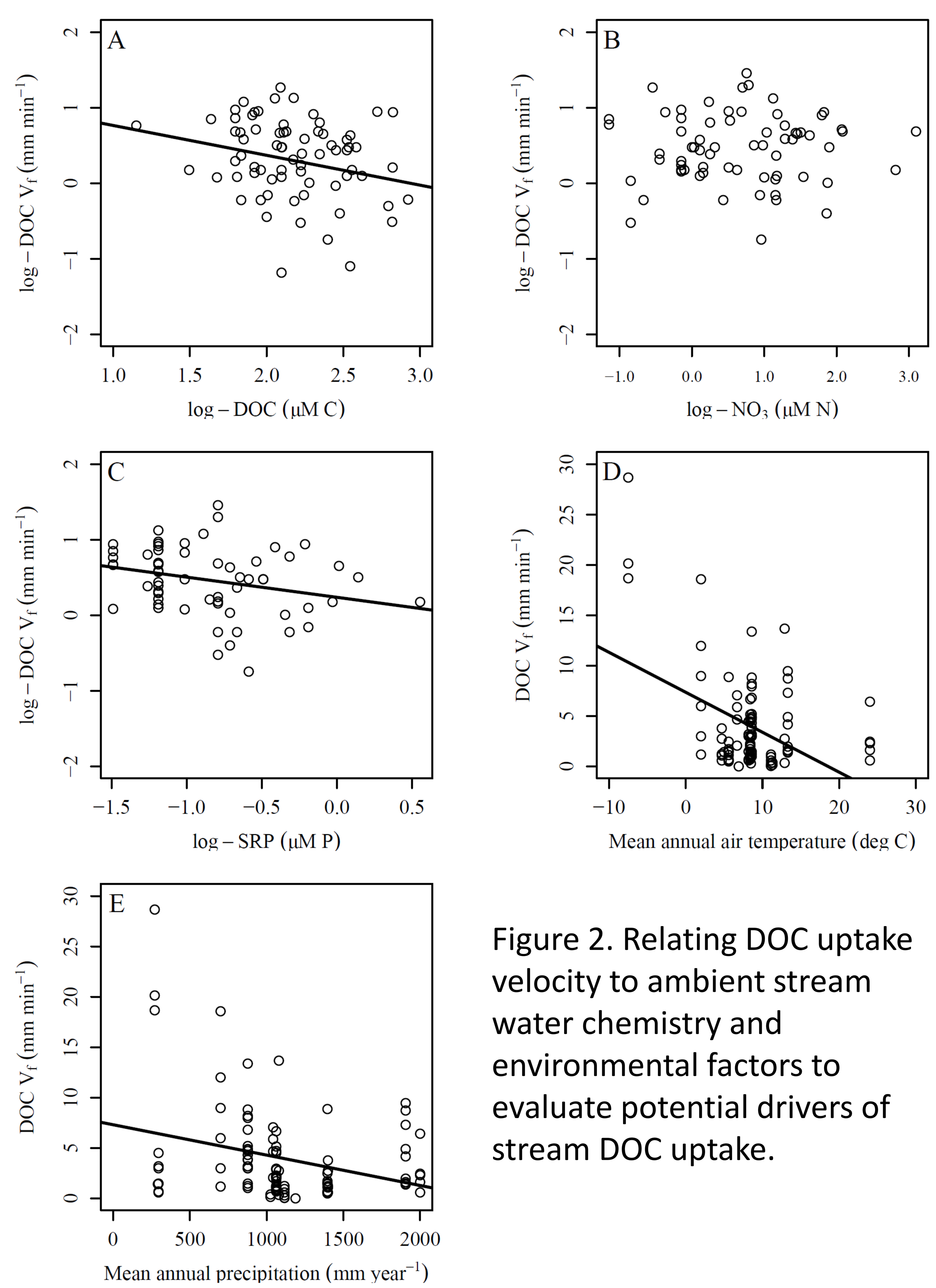
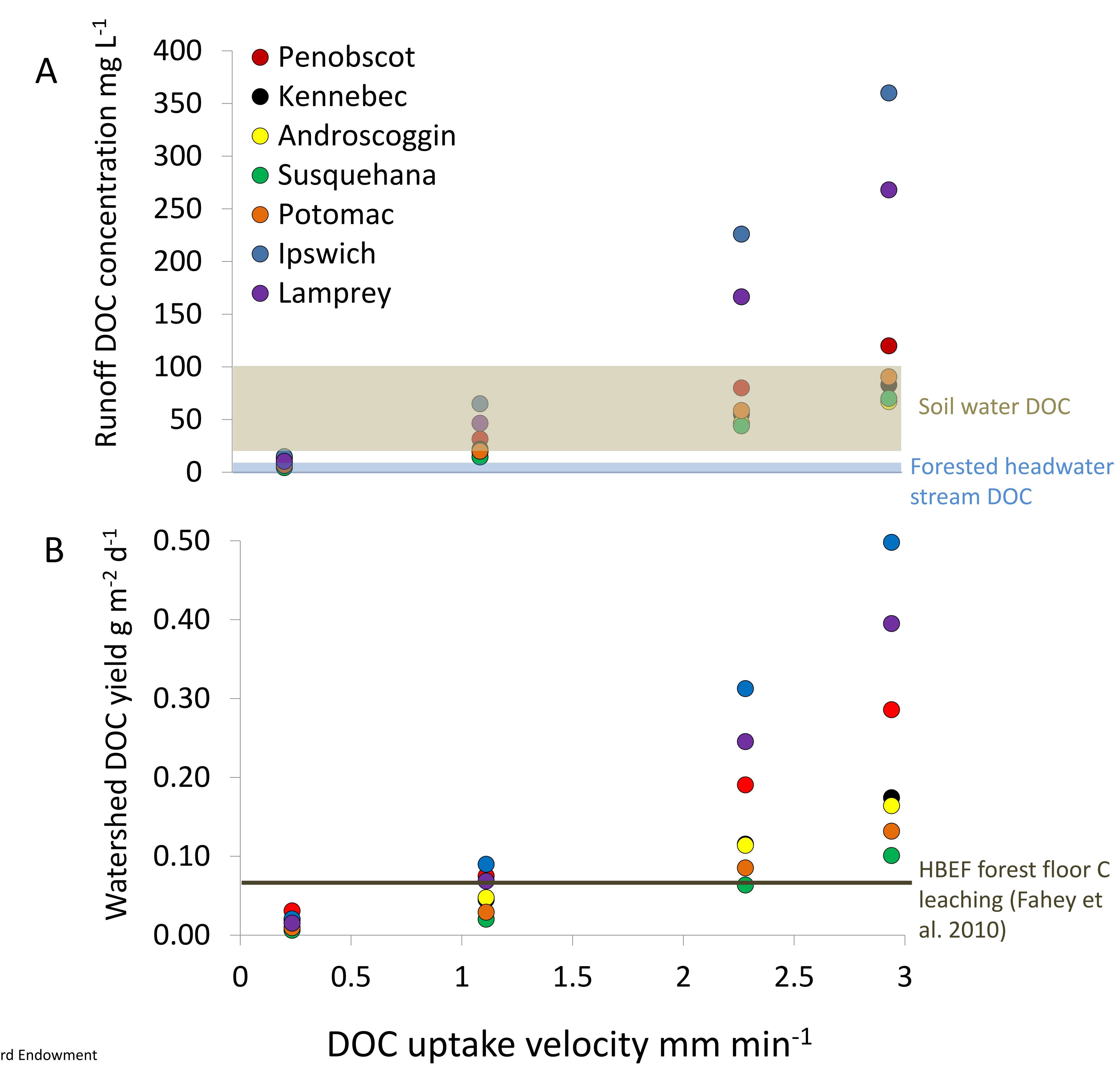


Figure 2. Relating DOC uptake velocity to ambient stream water chemistry and environmental factors to evaluate potential drivers of stream DOC uptake.

Figure 3. Scaling reach-scale DOC v_f to whole river networks. Panel A shows DOC runoff concentration necessary to generate mean annual DOC concentration at basin mouth for a given DOC v_f. Panel B shows watershed DOC yield necessary to generate mean annual DOC concentration at basin mouth for a given DOC v_f. Reference lines are shown for typical forested headwater stream DOC and organic soil water DOC, and estimate of forest floor leaching from Hubbard Brook.



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