Phosphorus Contribution from Eroding Streambank Soils of Vermont's Lake Champlain Basin

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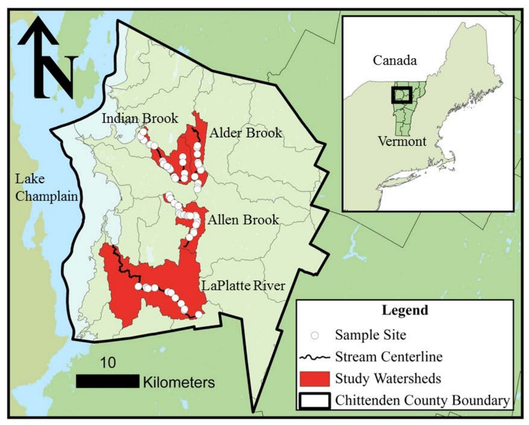
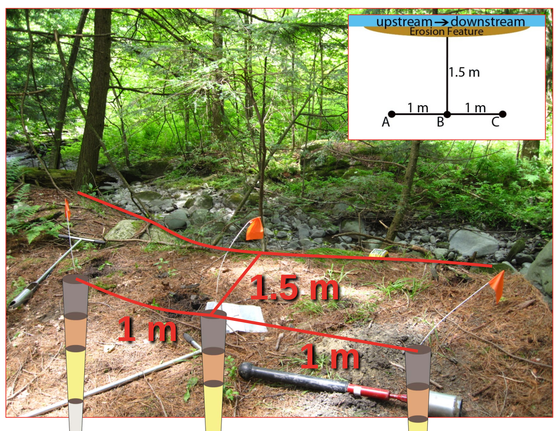
Introduction

- Many lakes experience harmful algal blooms that are linked to elevated inputs of phosphorus.
- The sources of this phosphorus are often varied and difficult to control.
- Streambank erosion can be a significant contributor but there is limited information on erosion rates and the phosphorus content of riparian soils.

Research Goals

1) Characterize P in eroding streambank soils in Chittenden County, VT; land-use includes ag, forest and urban.
2) Assess relationship between P in these soils and other soil characteristics as well as land use/land cover (LULC)
3) Calculate actual erosion using remote sensing and estimate potential P loading from eroding streambank soils

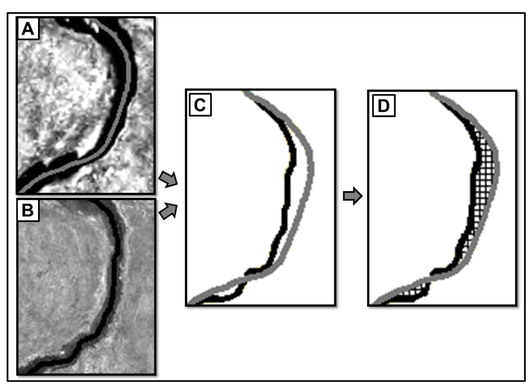




Methods

- We sampled streambank soils on the edge of 76 erosion features on 4 streams in Chittenden County, VT (see map above). Sampled each erosion feature in triplicate to a depth of 90 cm in 4 increments: 0-15, 15-30, 30-60 and 60-90 cm (see diagram above).
- Quantified particle size, total P (TP), Modified Morgan's P (MM-P), and acid ammonium oxalate extractable P (P_{ox}).
- Identified LULC for each site using ArcGIS and the 2006 NOAA C-CAP LULC database based on a buffered distance from sample site.
- Determined three-year erosion rates using LiDAR and ortho-photography by digitizing stream centerlines and measuring change (see below).

Identification of erosion features. Stream channel centerlines were digitized for the 2004 (A) and 2007 (B) images and overlaid (C) to map stream centerline migration over time. The resultant eroded areas (D) are shown with hatched lines.

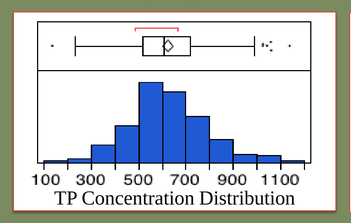


Results

Watershed characteristics and streambank soil texture.

Stream	Allen Brook	Indian Brook	Alder Brook	LaPlatte River
Watershed Area, km^2	28.0	30.9	27.0	137.3
Water Quality Status	Impaired	Impaired	Attainment	Attainment
%-Agriculture	37.4%	17.8%	40.3%	47.2%
%-Forested	40.7%	53.0%	43.8%	39.9%
%-Urban	9.2%	14.0%	8.5%	2.6%
%-Urban open	4.9%	5.0%	2.2%	1.1%
Sand, g kg^{-1}	571	530	326	339
Silt, g kg^{-1}	322	368	497	445
Clay, g kg^{-1}	107	101	176	216

Distribution of total phosphorus (TP) and Modified Morgan's P (MM-P) concentrations .



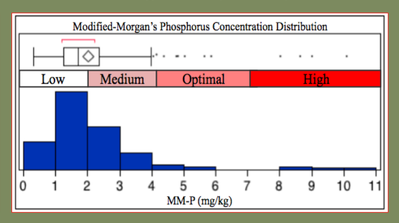


Table 1. Results by watershed. Most soils had a low % P saturation.

Watershed	n	Total P (mg kg^{-1})	Total Ca (mg kg^{-1})	pH	Oxalate-P (mg kg^{-1})	Degree of P saturation (%)
Allen Brook	112	592	3684	6.25	133	15.7
SE		16	239	0.10	6	0.7
Alder Brook	60	608	2376	5.64	160	17.3
SE		29	102	0.07	22	3.2
Indian Brook	120	619	2396	5.65	146	16.2
SE		17	132	0.13	9	0.9
LaPlatte	59	674	3321	6.29	164	15.8
SE		30	149	0.10	8	0.9

Table 2. Correlation matrix for land use/land cover variables versus TP.

Depth	Extent	%Agriculture r value	%Urban r value	%Urb-comb r value	%Wetland r value	%Forested r value	%Natural r value
0-15	100 m	0.34*	-	nt	+	-0.49*	-0.53**
	200 m	0.37*	-	nt	0.34*	-0.49*	-0.53**
	500 m	0.42*	-	-	+	-0.34*	-0.37*
15-30	100 m	+	+	nt	+	-	-
	200 m	+	nt	nt	0.34*	-	-
	500 m	+	-	-	0.30*	nt	nt
60-90	100 m	+	nt	nt	0.38*	nt	-
	200 m	nt	-	-	+	-	-
	500 m	+	-	-	0.37*	nt	-

* denotes significance at <0.05.
** denotes significance at <0.0001.
nt denotes no trend, + positive trend, - negative trend.

Table 3. Erosion and phosphorus loss estimates.

Stream	Mean Lateral Migration (m)	Eroded Stream Length (%)	Streambank Erosion Load (Mg)	Normalized Streambank Erosion (Mg km^{-1})	**TP loss 2004-2007 (Mg)**	Normalized TP Loss (kg km^{-1})	MM-P loss 2004-2007 (kg)
Allen Brook	1.4	38	6505	350	**3.94** (3.75-4.13)	212 (202-222)	10.9 (9.9-12.0)
Alder Brook	1.3	33	5599	400	**3.39** (3.23-3.55)	242 (231-254)	9.4 (8.5-10.3)
Indian Brook	1.0	48	3184	130	**1.93** (1.84-2.02)	79 (75-82)	5.3 (4.8-5.9)
LaPlatte River	0.7	30	865	60	**0.52** (0.50-0.55)	36 (35-38)	1.4 (1.3-1.6)

Implications

Total P and soil test P concentrations were relatively low and consistent both among depths and among streams.

Total P variation was weakly predicted by LULC variables.

Rough estimate: Total P from streambank erosion could potentially be 6–30% of total P stream export.

However, low overall soil test P concentrations and low degree of P saturation suggest that there will be a low release of P from these eroding streambank soils. They may actually be sinks.

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