

Report as of FY2007 for 2006VT27B: "Phosphorus availability from the soils along two streams of the Lake Champlain Basin: mapping, characterization and seasonal mobility"

Publications

- Conference Proceedings:
 - Young, E.O., D.S. Ross, J.P. Tilley, K. Underwood, C. Alves, and T. Villars. 2006. Phosphorus availability along two small streams in Vermont: Mapping, characterization and potential mobility. ASA-CSA-SSSA Annual Meeting. Indianapolis, IN. In Agronomy Abstracts.
 - Alves, C., E.O. Young, and D.S. Ross. 2007. Phosphorus availability in some Vermont floodplain soils. ASA-CSA-SSSA Annual Meeting. New Orleans, LA. In Agronomy Abstracts.

Report Follows

1. Title: Phosphorus availability from the soils along two streams of the Lake Champlain Basin: Mapping, characterization and seasonal mobility

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9. Congressional District: Vermont-at-large

10. Abstract

Nonpoint source phosphorus (P) inputs into lakes and streams can be a major source of nutrient loading. A critical need is a better understanding of the relative importance of various P sources (e.g. sediment from streambank erosion, runoff from agricultural fields, or release from aquatic sediments). The use of the Vermont (VT) soil survey to help predict P losses may be limited by outdated mapping and a lack of information on P variability among soil series. We hypothesize that soil-landscape variability could be an important constraint on the amount of total and potentially mobile P along stream banks and in riparian areas. Our project will perform an extensive remapping, soil sampling and P analysis along areas of Lewis Creek and Rugg Brook in the Lake Champlain Basin. The objective is to determine the adequacy of the original map unit delineations and examine the relationship between soil series variability and profile P concentrations. Soils will be sampled at two riparian restoration sites, and at a number of other locations within the respective corridors. Results will include a new digital soils map of the two sites, and a data layer that includes total P concentration and a range of availability indices. Phosphorus availability will be evaluated by extraction with ammonium acetate (available P) and total P will be estimated by nitric acid digestion. A subset of soils representing the range of observed soil properties will be analyzed for additional availability indices (e.g., water-soluble, dilute electrolyte, ammonium acetate + fluoride, and soluble organic P). A subset of these soils will be used in laboratory microcosm experiments that will assess the potential for P release to solution under flooded conditions. Laboratory-based measures of P solubility will be compared to porewater P concentrations in the field at several locations. Phosphorus concentrations in stream channel sediments of differing physical properties will also be characterized. This project will be a collaborative effort between UVM and NRCS soil scientists. Results will contribute to a greater understanding of soil map unit variability and P levels in floodplains, and clarify relationships among fundamental soil properties, P availability, and the potential for P release to water.

Project Overview

Most soil surveys in VT were originally mapped at a scale of 1: 20000, with minimum mapping units of about 3 acres. Floodplain soils are often too small to be delineated at this scale. There is currently little information on the adequacy of map unit delineations and/or P levels for floodplain areas in VT. We hypothesize that subsoils of series with similar parent material will have comparable levels of total and available P. Though analysis of total P provides an estimate of the total quantity of P, P forms range from readily soluble to those occluded in crystalline soil minerals. Our project will characterize relations among total, available, and soluble P forms. The project is divided into three basic components: (i) a soil sampling and remapping for the Rugg Brook and Lewis Creek restoration sites, with additional soil sampling and series verification at selected locations within each stream corridor, (ii) an analysis of the total and available P concentration (and Fe, Al, Mn, Ca, Mg, and K), organic matter content, and pH, and (iii) laboratory and field-based experiments to determine the P release potential of soils.

Progress

The high-intensity mapping at the two study sites was completed in the fall of 2006. Available P concentrations, background soil test data (organic matter, pH, and available cations), and total P and cations (Fe, Al, Mn, Ca, Mg, K) have been determined for soil and sediment samples collected in 2006 (see Results). A subset of samples is currently being analyzed for additional extractable P forms. Eighteen porous cup lysimeters were installed in May 2007 between the two sites. Porewater samples are being collected and analyzed for dissolved reactive P concentrations (DRP). Additionally, floodwater from isolated areas and stream water are also being analyzed for DRP. Five additional soil sampling sites within the Lewis Creek corridor have been identified and are currently being sampled by UVM and NRCS. The soil series sampled at the additional sites will be verified (but not remapped) and profile samples will be analyzed for total and available P in 2007.

Results: Mapping

The Rugg Brook study area was mapped as one series by the 1979 Franklin County Soil Survey. Following the higher intensity mapping, five additional soil series were identified and mapped (Fig. 1a). At the Lewis Creek site, the 1971 survey mapped the area as three series; the remapping revealed three additional series that together accounted for about 90% of the site area (Fig. 2b). Results indicate that the SSURGO-level mapping differed significantly from the high-intensity remapping.

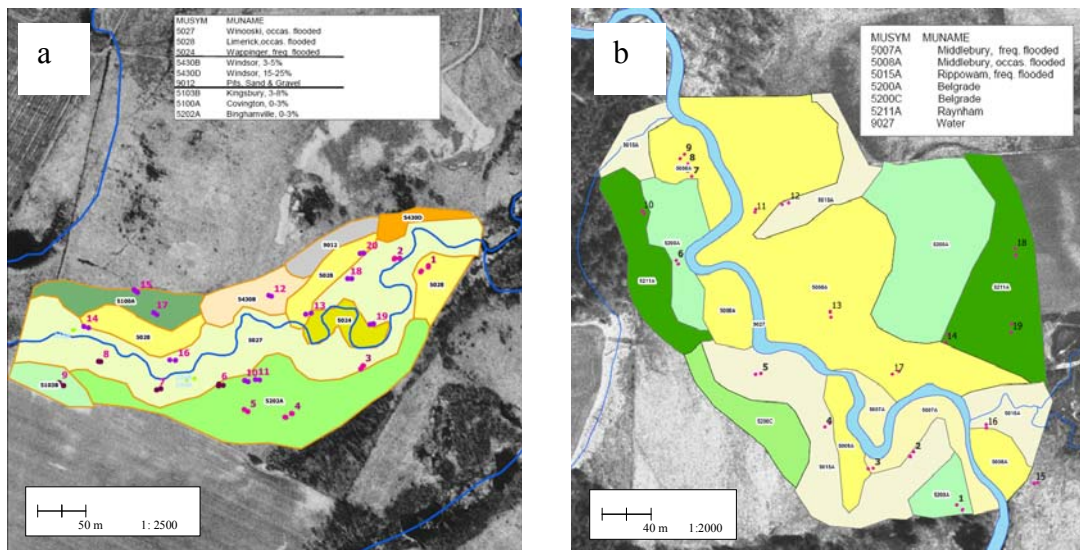


Figure 1. High intensity soil maps for the Rugg Brook (a) and Lewis Creek (b) sites. Map unit symbols correspond to the soil series listed at the top of the figure. Numbered points on the map are individual soil sampling locations taken for P analysis. Map unit delineations drawn by Thomas Villars, USDA-NRCS; maps prepared by Caroline Alves, USDA-NRCS.

Available and Total P Concentrations

Analysis of Variance revealed that available P did not vary significantly ($p = 0.64$) by depth (pooled across series). Total P concentrations varied significantly by depth ($p = 0.009$), but there were few meaningful differences among depths other than the notably

greater P at 0–15 cm (Table 1). Available and total P varied significantly ($p < 0.0001$) by series (pooled across depth) (Table 2). The Raynham and Rippowam series (both poorly

Table 1. Mean available and total P (mg kg^{-1}) by depth pooled across series.

Depth	<i>n</i>	Available P	SEM†	Total P	SEM
0–15	33	1.44	0.14	661a‡	36
15–30	33	1.35	0.20	568b	36
30–45	33	1.42	0.27	491b	35
45–60	36	1.46	0.21	522b	34
60–75	38	1.65	0.21	537b	26
75–90	37	1.74	0.22	534b	24
90–105	36	1.80	0.19	533b	24

† standard error of the mean

‡ total P means with different letters are significantly different at $p \leq 0.0024$

Table 2. Mean available and total P (mg kg^{-1}) for select soil series pooled across depth intervals.

Series	<i>n</i>	Available P	SEM	Total P	SEM
Belgrade	28	1.35b	0.17	459b†	38
Binghamville	28	1.17b	0.11	549b	26
Covington	14	0.71b	0.06	515b	72
Limerick	33	0.93b	0.07	577b	41
Middlebury	36	1.59b	0.08	557b	14
Raynham	28	3.27a	0.45	669a	23
Rippowam	23	2.50a	0.16	694a	32
Wappinger	14	0.59b	0.06	458b	24
Winooski	35	1.23b	0.08	506b	26

† means with different letters are significantly different at $p \leq 0.03$

drained) had greater ($p \leq 0.001$) average available P concentrations compared to other series (Table 2). Additionally, when all soils were grouped by drainage class, poorly drained soils had significantly ($0.0001 \leq p \leq 0.0024$) greater total P concentrations (605 mg kg^{-1}) compared to moderately well (512 mg kg^{-1}) and well drained (458 mg kg^{-1}).

The similarity in average available P concentrations across depths was relatively consistent *within* individual series. Only two series (Belgrade and Covington) showed significantly different available P concentrations with depth, and both had greater available and total P at the lowest two depths (Table 3). Total P levels varied widely within and among series and by depth, and the main effect of depth on average total P concentration was not significant ($p \geq 0.15$). However, there were some significant differences in mean total P concentrations among depths for some series (Table 3).

Since previous P applications influence soil P availability, landuse history can be an important factor affecting P levels. It should be noted that the samples were taken from pasture areas restored to permanent riparian buffers, and have not received any P applications in several decades. The fact that available P levels were not significantly greater in the upper horizons also suggests that previous landuse history had little impact

on P availability as sampled at this point in time. Upper horizon samples in adjacent cornfields confirmed that P levels were much greater in actively cropped fields.

Table 3. Mean available and total P (mg kg⁻¹) for select soil series sampled in 2006.

Series/depth	<i>n</i>	Available P	SEM	Total P	SEM
Belgrade					
0–15	4	0.87a†	0.09	437ab	91
15–30	4	0.70a	0.07	305a	51
30–45	4	0.88a	0.17	283a	63
45–60	4	0.98a	0.21	510ab	201
60–75	4	1.65ab	0.45	519ab	42
75–90	4	2.18b	0.54	559b	18
90–105	4	2.18b	0.58	601b	53
Covington					
0–15	2	0.85ab	0.05	650	133
15–30	2	0.45a	0.05	455	168
30–45	2	0.60a	0.00	272	83
45–60	2	0.50a	0.00	206	95
60–75	2	0.65a	0.05	578	245
75–90	2	0.95b	0.15	721	216
90–105	2	1.00b	0.10	721	198
Limerick					
0–15	5	1.12	0.15	787b	140
15–30	5	1.00	0.18	695ab	141
30–45	5	0.94	0.33	570ab	144
45–60	4	0.74	0.07	476a	69
60–75	5	0.86	0.26	500a	50
75–90	4	0.82	0.10	480a	44
90–105	5	1.04	0.21	488a	32
Rippowam					
0–15	4	2.27	0.47	810b	51
15–30	4	2.23	0.55	793ab	59
30–45	4	2.37	0.93	740ab	42
45–60	4	2.40	0.33	737ab	32
60–75	4	2.90	0.26	662ab	57
75–90	4	2.73	0.23	538a	110
90–105	3	2.40	0.60	586ab	184
Winooski					
0–15	5	1.72	0.23	656b	50
15–30	5	1.14	0.15	585ab	59
30–45	5	1.08	0.22	469a	44
45–60	5	1.00	0.32	455a	83
60–75	5	1.06	0.18	460a	96
75–90	5	1.22	0.20	465a	58
90–105	5	1.36	0.14	455a	52

† means with different letters are significantly different at $p \leq 0.05$

Correlations between available P and ammonium acetate-extractable cations known to affect P sorption (e.g., Al, Fe, Mn, Ca) were weak across series, with some significant correlations within series. Across all samples and depths, total P was positively correlated ($0.0001 \leq p \leq 0.01$) with total Al, Fe, Mn, Ca, organic matter, and available P. In general,

these correlations tended to be higher within individual series. These relationships will be explored more fully following collection and analysis of all samples in 2007. We will also select a subset of soils to determine the influence of soil textural variation on total and available P concentrations.