Quantifying Gully Erosion and Potential for Sediment and Phosphorus Pollution Reductions Achieved by Erosion Remediation Projects on Vermont's Roads

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Introduction and Project Overview

Erosion at road drainage outfalls and culvert outlets contributes to water quality impairment by discharging stormwater and contaminants to receiving waters. This study documented rates of gully erosion at road drainage outfalls in northern Vermont, quantified phosphorus content of eroded soils, assessed efficacy of erosion mitigation practices, and provided a first-order estimate of the magnitude of gully erosion relative to base loads for phosphorus contributions to receiving waters. We used terrestrial LiDAR scanning to conduct ground surveys at 13 intensively monitored sites and multi-date airborne LiDAR data to conduct GIS-based assessments at culverts in 35 northern Vermont towns. This poster briefly describes findings from the terrestrial and airborne LiDAR surveys and a first order "upscaling" of the study observations to estimate the contribution of gully erosion to loads of phosphorus in receiving waters of the Lake Champlain basin. Full details of the study methods and findings are available in the final project report.

Ground-based LiDAR surveys

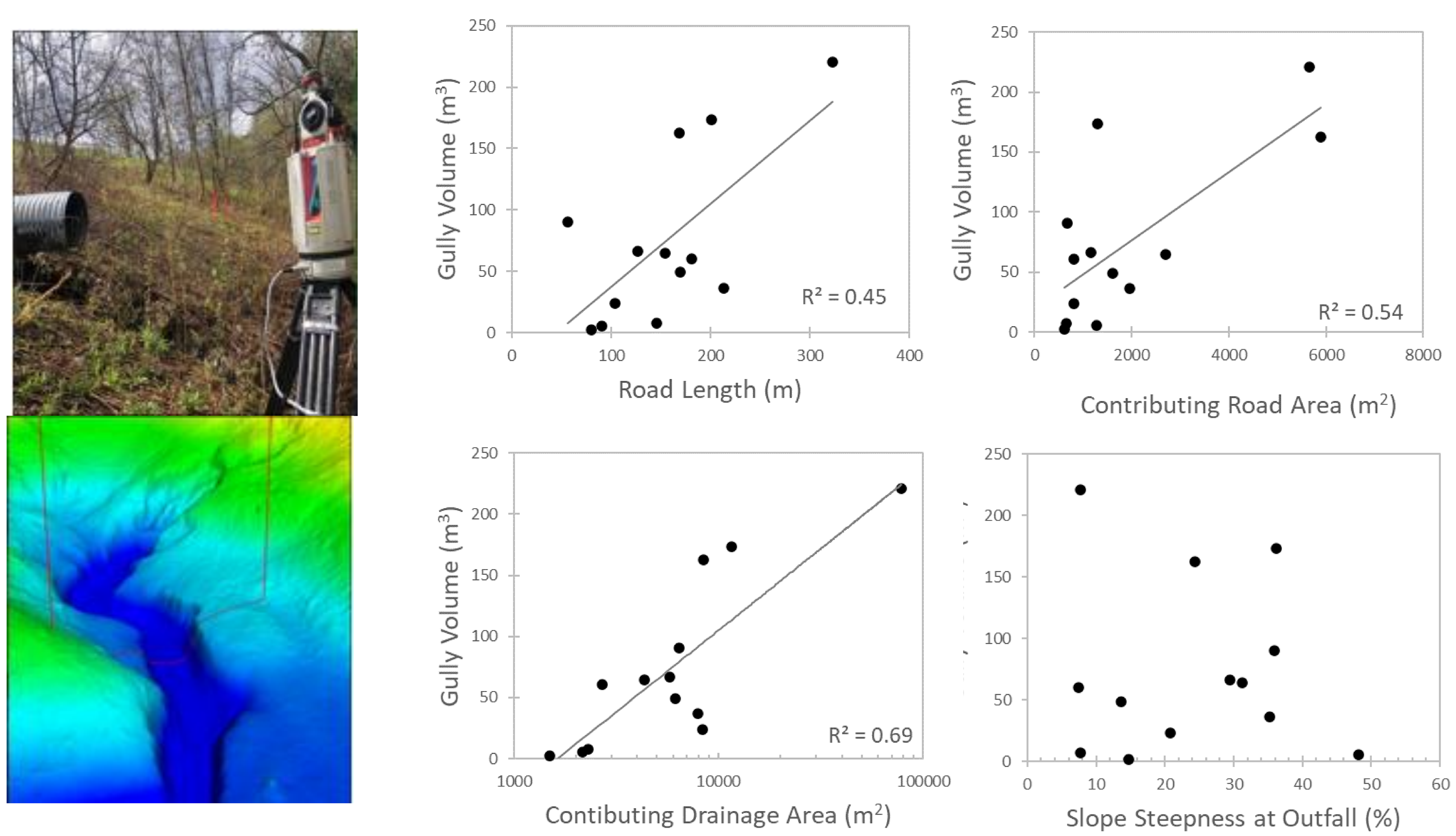

Figure 1. Left: terrestrial LiDAR scanner positioned near culvert outlet and DEM of gully topography. Right: May 2020 gully volume estimated at 13 intensively monitored sites vs. measures of road length, contributing area, and slope gradient.

Airborne LiDAR surveys

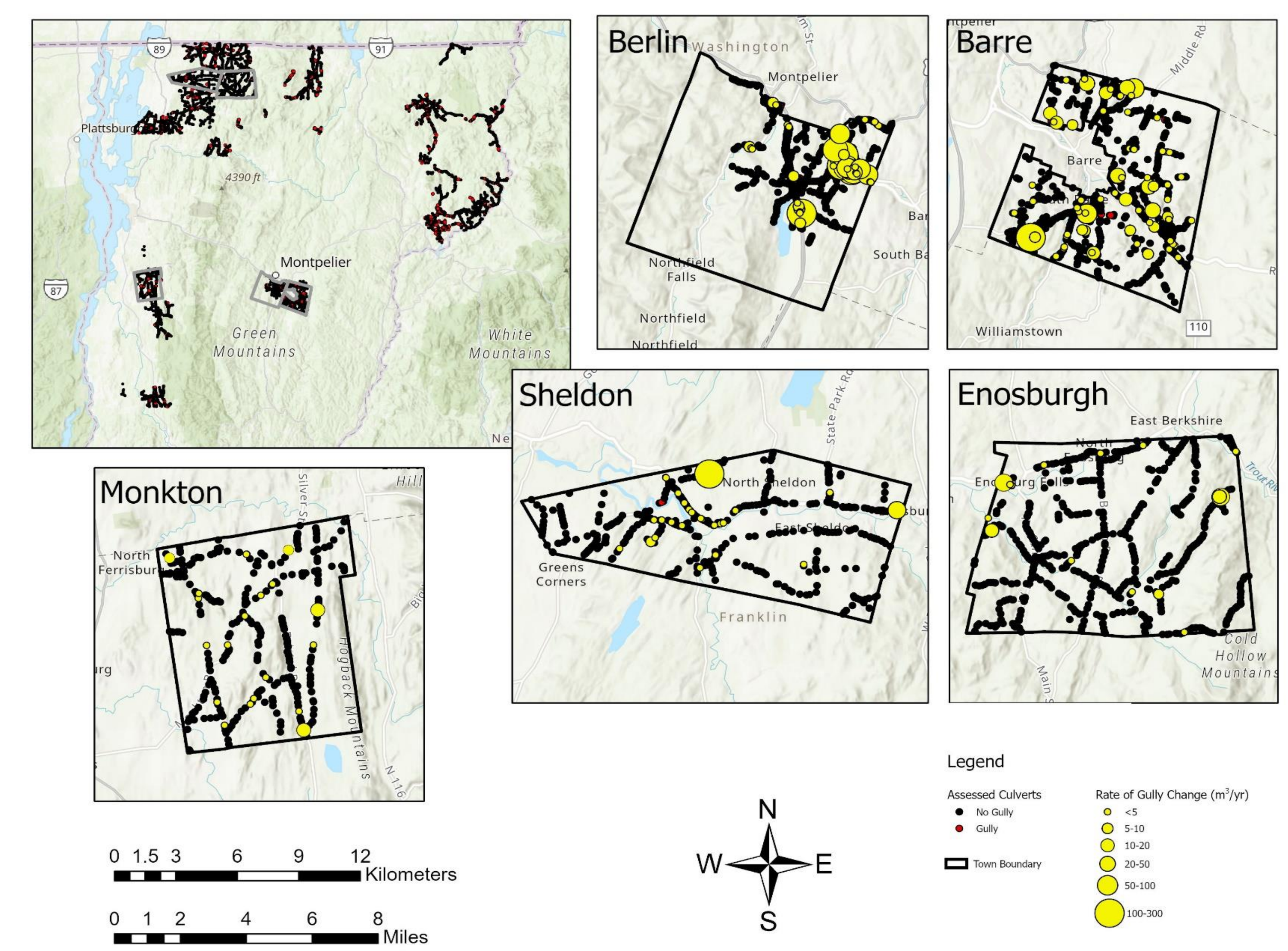

Figure 2: Locations of culverts inspected using multi-date airborne LiDAR (top left map) with estimates of erosion rates for selected towns taken from volume differences between LiDAR acquisition dates.

Road gully erosion contribution to phosphorus (P) loads

We estimated the contribution of gully erosion to P loads of receiving waters using the Clean Water Roadmap tool and results of our airborne surveys. In most cases, road gully erosion is a minor fraction of the P load in receiving waters, but in some towns, where erosion rates are high, gully erosion may constitute a significant fraction of the receiving water load.

	Barre	Berlin	Enosburgh	Monkton	Sheldon
Road length (km)	180.8	101.1	154.6	118.1	116.9
Culverts - Small culvert inventory (no.)	258	626	132	0	212
Culverts - VT culverts (no.)	503	248	459	304	227
Culverts - total (no.)	761	874	591	304	439
Culvert frequency (no./km)	4.2	8.6	3.8	2.6	3.8
Gullies at culvert outlets (no.)	102	48	15	19	33
Percent assessed outlets with gullies	13.4%	5.5%	2.5%	6.3%	7.5%
Gullies with multi-date lidar for assessment	69	42	15	19	25
No. of culverts with net erosion	56	33	14	16	14
Max. gully change (m^3/yr)	213.2	268.5	42.8	14.7	100.9
Median gully change (m^3/yr)	3.4	6.8	4.2	2.5	3.4
No. of eroding gullies with change > 10 m^3/yr	14	11	5	2	2
Percent eroding gullies with change > 10 m^3/yr	25%	33%	36%	13%	14%
Sum - P production from gullies (kg/yr)	666	1210	110	53	137
HUC 12 phosphorus load (kg/yr)	4419	3802	6174	9188	5640
Gully erosion as percent of HUC12 P load	15.1%	31.8%	1.8%	0.6%	2.4%

Mitigation of gully erosion in these cases may lead to meaningful improvements in water quality. See full details and recommendations in final project report.

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Final Report citation

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