Opportunities for climate resilience on Vermont's rural roads: lessons from water quality studies

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Vermont Department of Environmental Conservation
Clean Water Lecture Series
May 12, 2022

Catherine Webster
RSENR

Joanne Garton
RSENR
now Vermont FP&R

Scott Hamshaw
Civil & Environmental Engineering
now USGS

Frank Piasecki
Environmental Sciences
now Fitzgerald Environmental

Emma Estabrook
RSENR
now Woodard & Curran

Don Ross
Plant & Soil Science

Mandar Dewoolkar
Civil & Environmental Engineering

and UVM Students:
Carly Alpert, Luc Burnier, Jake Campbell, Chris Carlos, Gordon Clark, Kathryn Koberna, Andrew Larson, Emma Parks, Noelle Mesbah, Travis Miller, Rebecca Zeyzus and others!

Quantifying Nutrient Reductions Achieved by Erosion Remediation Projects on Vermont's Roads (VTRANS 19-02)

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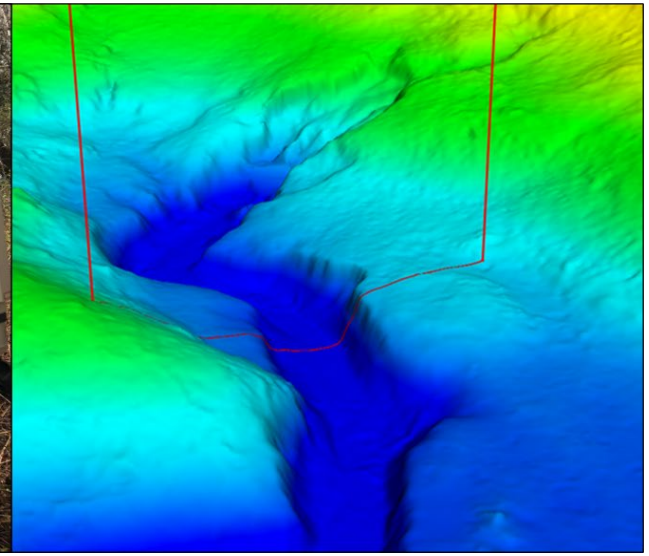

Lake Champlain Basin Program

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Vermont’s changing climate

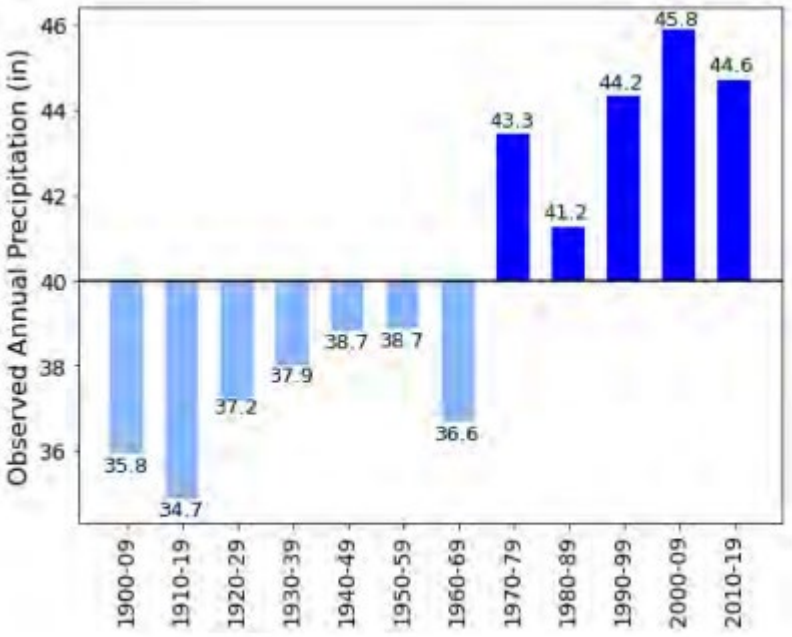


Figure 1-8: Decadal averages of observed annual precipitation

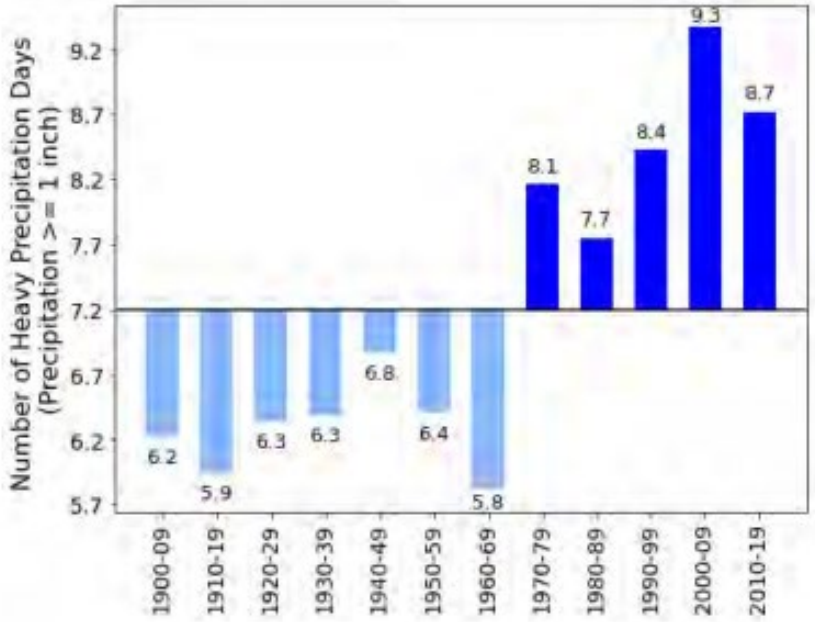
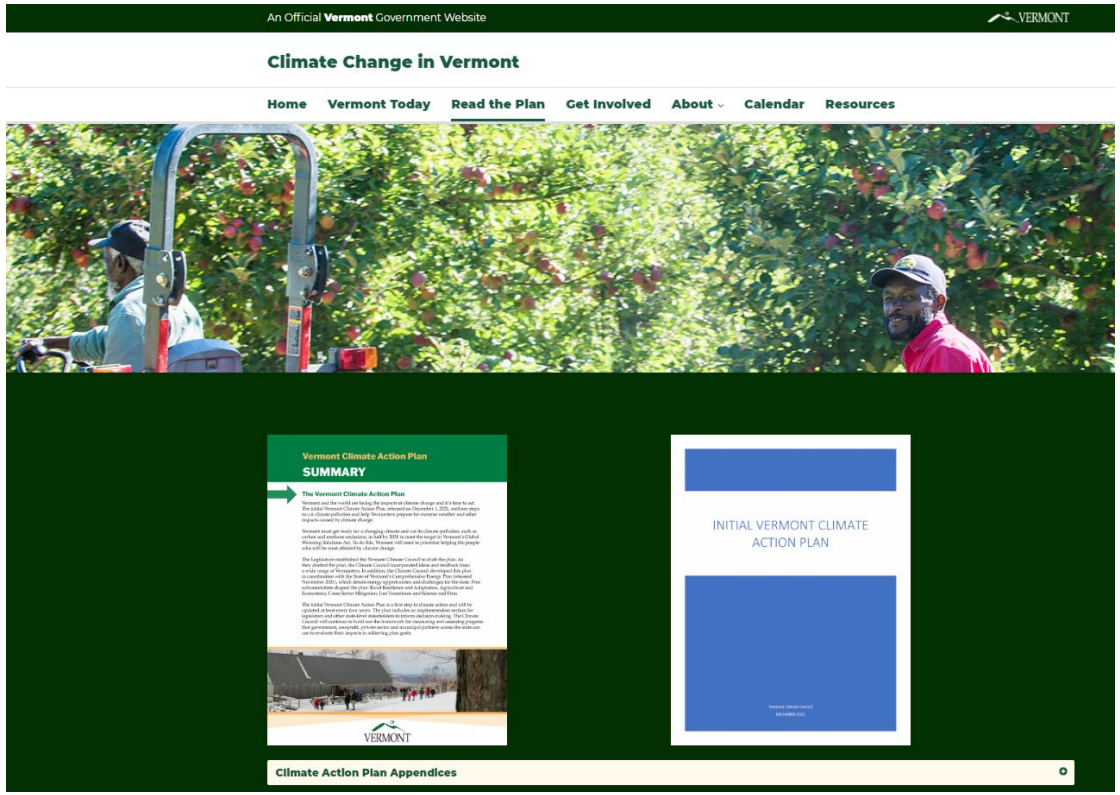


Figure 1-9: Decadal averages of the observed number of days per year with heavy precipitation in Vermont

Vermont Climate Assessment
https://site.uvm.edu/vtclimateassessment/files/2021/11/VCA-11-9-2021.pdf

CANADA
Quebec
Ontario
Maine
New Brunswick
Nova Scotia
Lake Champlain Basin
VT
NH
New York
MA
CT
RI
PA
NJ
UNITED STATES
Atlantic Ocean


An Official Vermont Government Website
VERMONT
Climate Change in Vermont
Home
Vermont Today
Read the Plan
Get Involved
About
Calendar
Resources
Vermont Climate Action Plan
SUMMARY
The Vermont Climate Action Plan
VERMONT
INITIAL VERMONT CLIMATE ACTION PLAN
Climate Action Plan Appendices

The Vermont Climate Action Plan is organized into five impact areas:

Cutting Climate Pollution

Reducing emissions from transportation, buildings, energy and products.

Capturing Carbon

Removing carbon from the air and storing it in soil or plants.

Resilient Working and Natural Lands

Preparing farms, forests and ecosystems for climate change.

Cross-Cutting Solutions

Investing in communities and workforce development.

Vital Communities

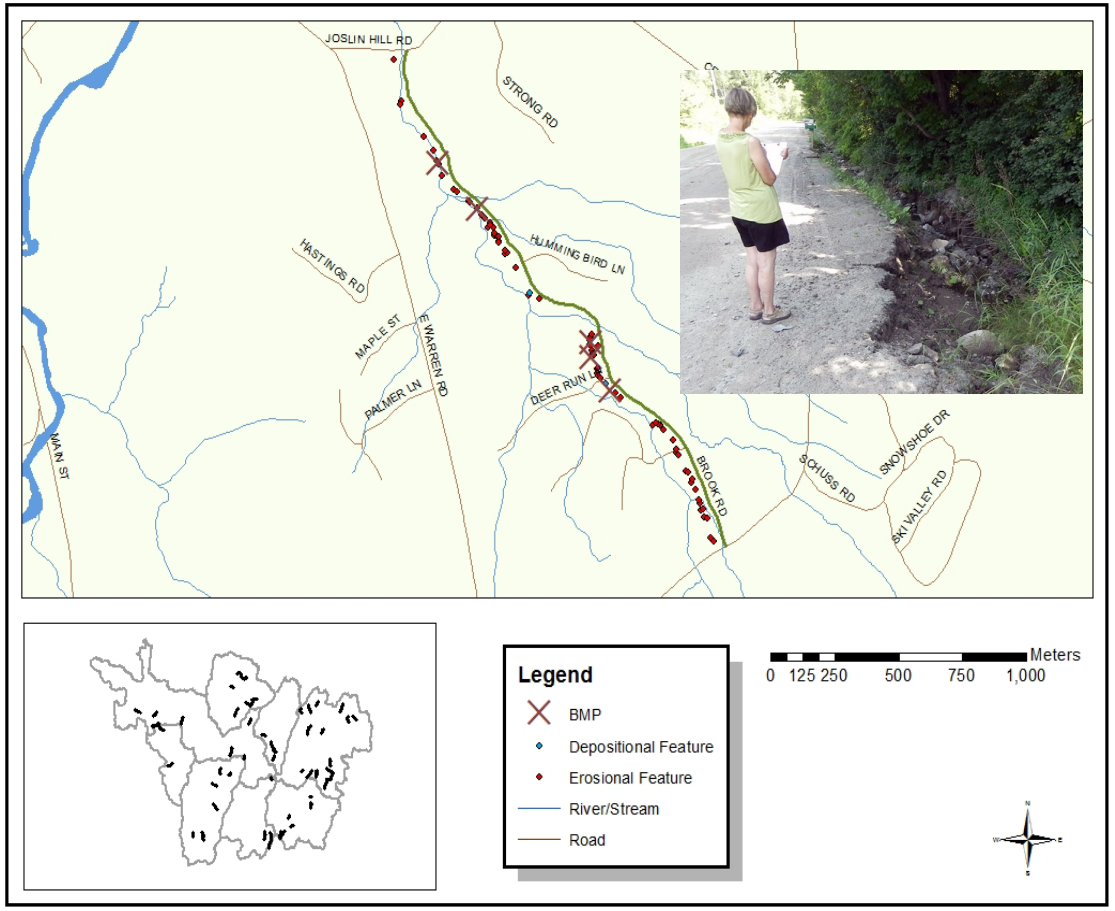
Protecting people and infrastructure from climate impacts.

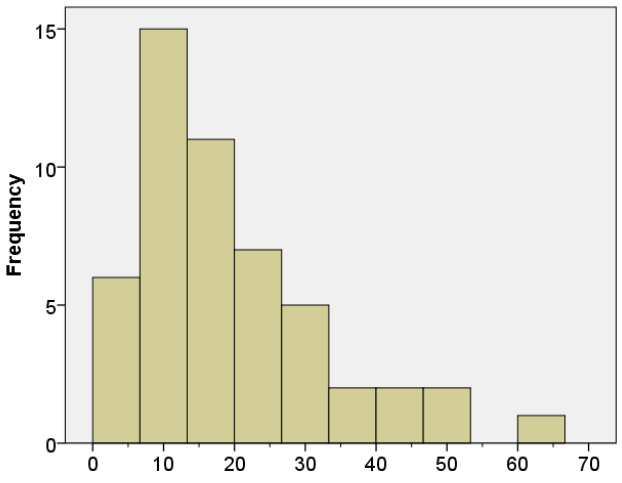
https://climatechange.vermont.gov/readtheplan

Presentation road map

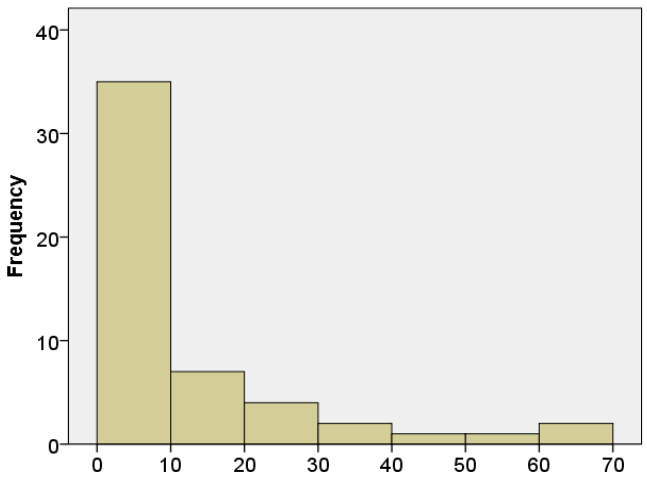
- Road surface and ditch erosion as source of sediment and phosphorus production
- Road contributions to receiving water loads
- Road outfall erosion
- Mitigating road erosion using best practices (and building resilience to flooding)
- Lessons for building resilient communities

Road erosion inventories

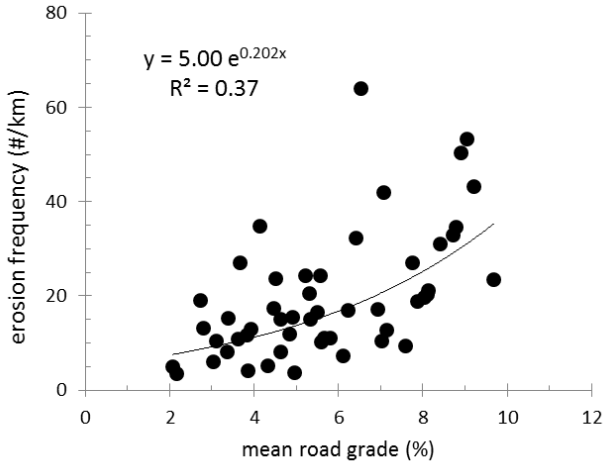


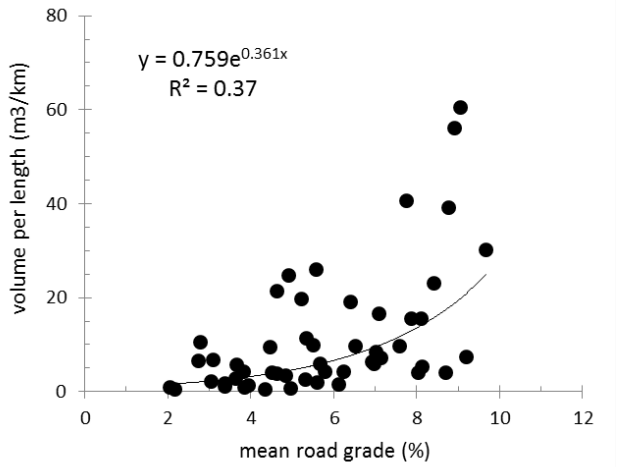


Erosional feature frequency (#/km)



Volume of eroded sediment (m^3/km)





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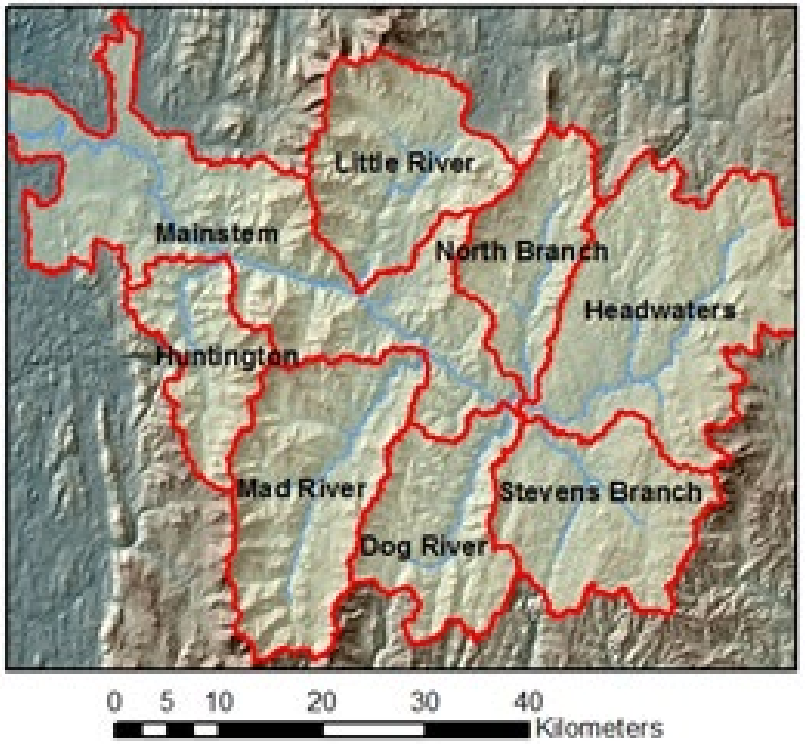
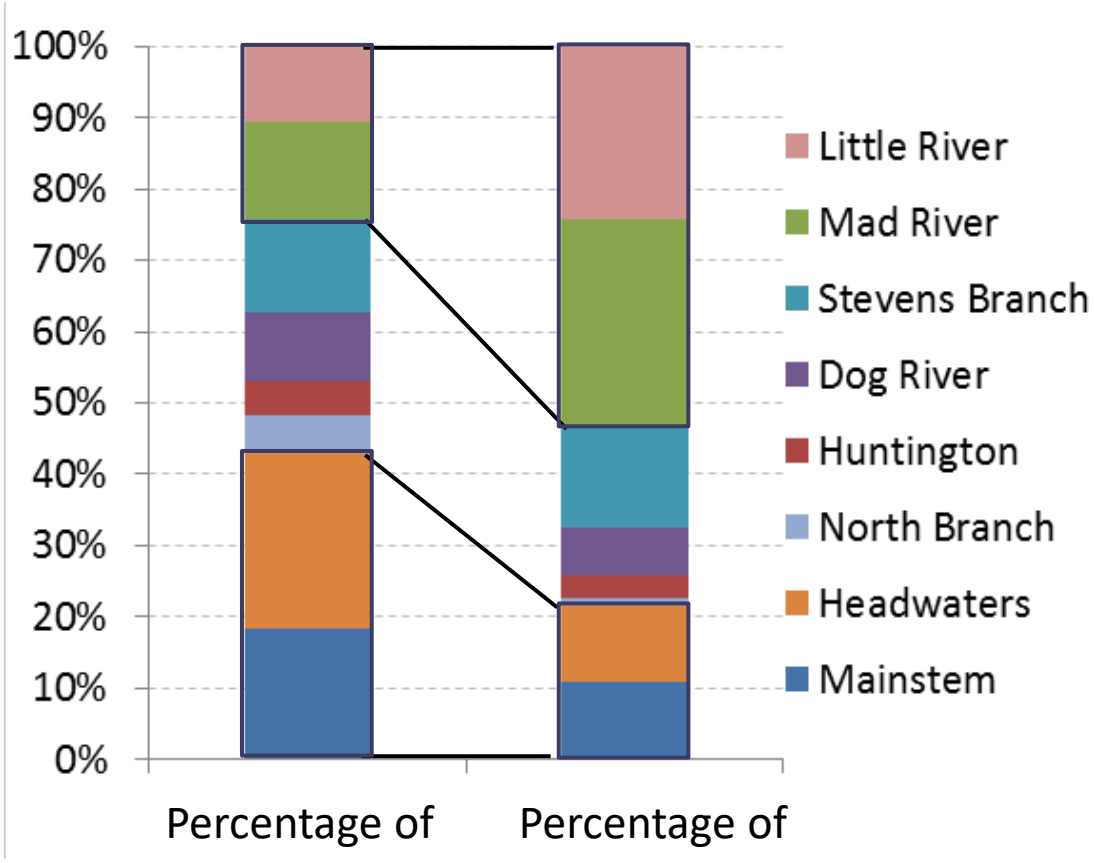
Identifying “hot spots” of erosion





Percentage of unpaved road network (2510 km)

Percentage of sediment eroded from roads (40357 Mg)

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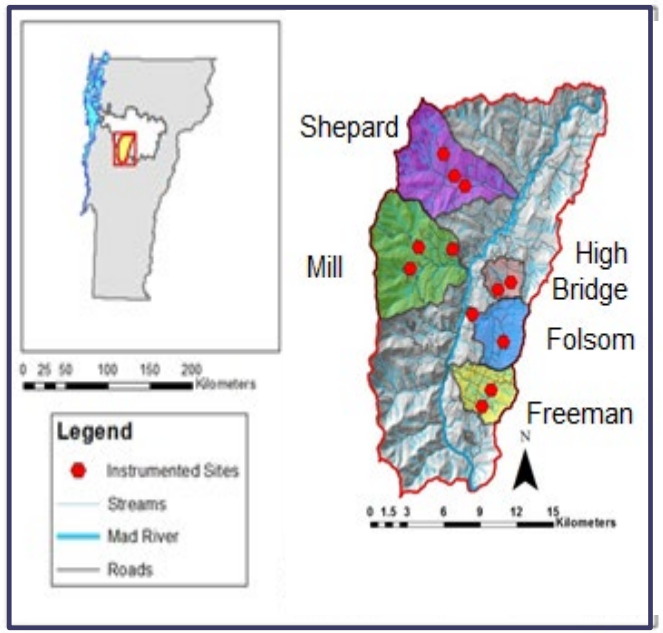
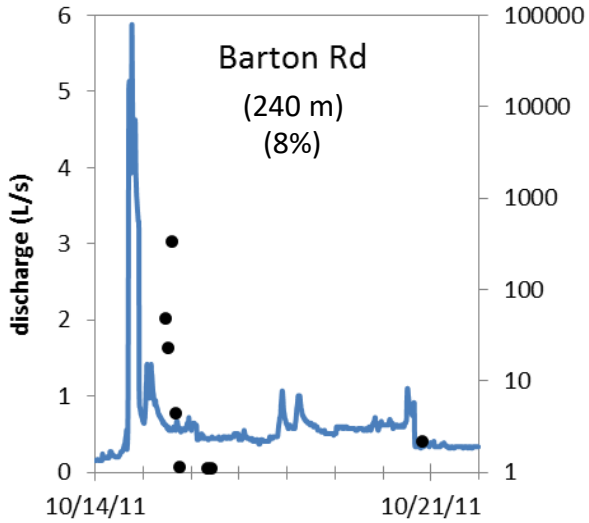
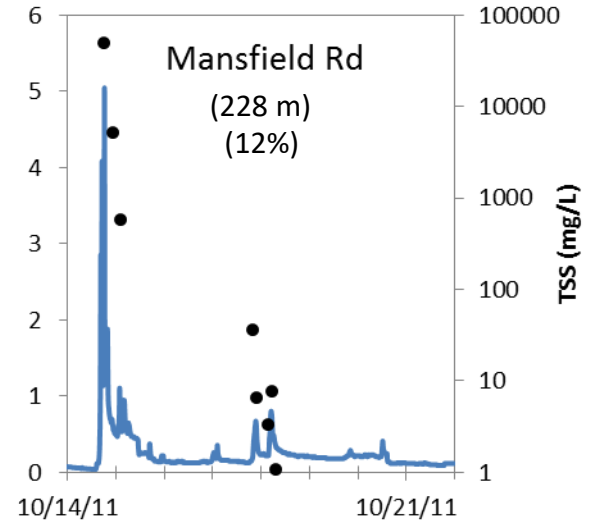
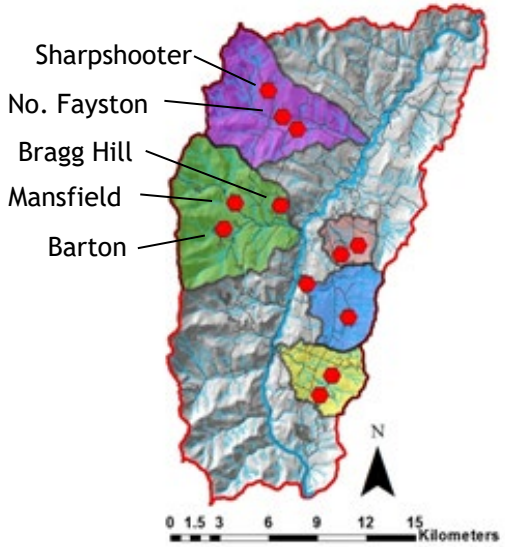
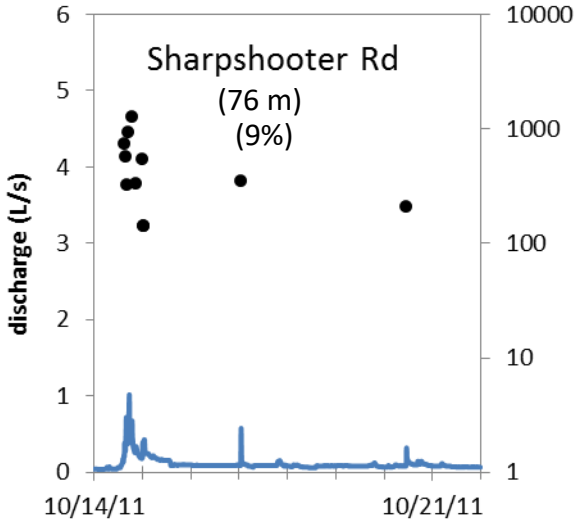
Storm-based monitoring & sampling

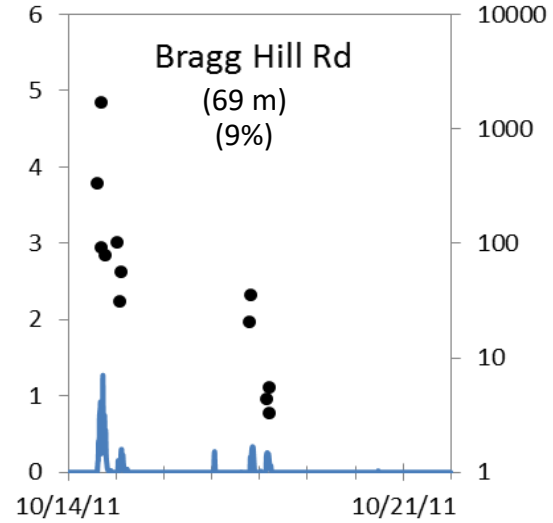


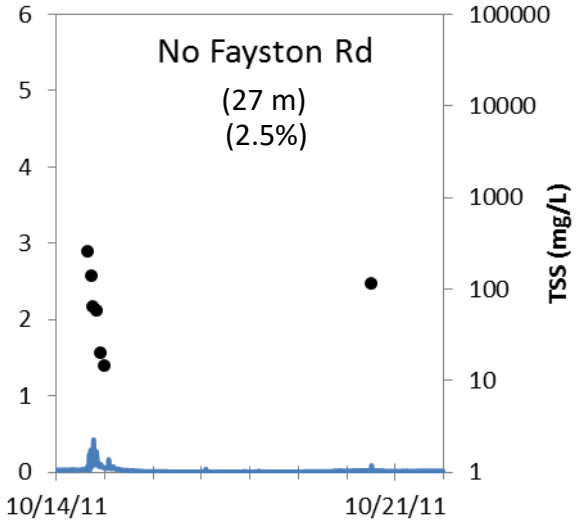












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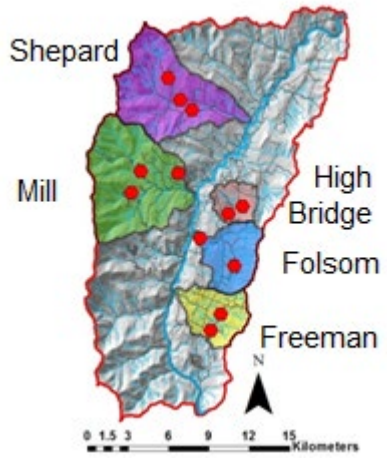
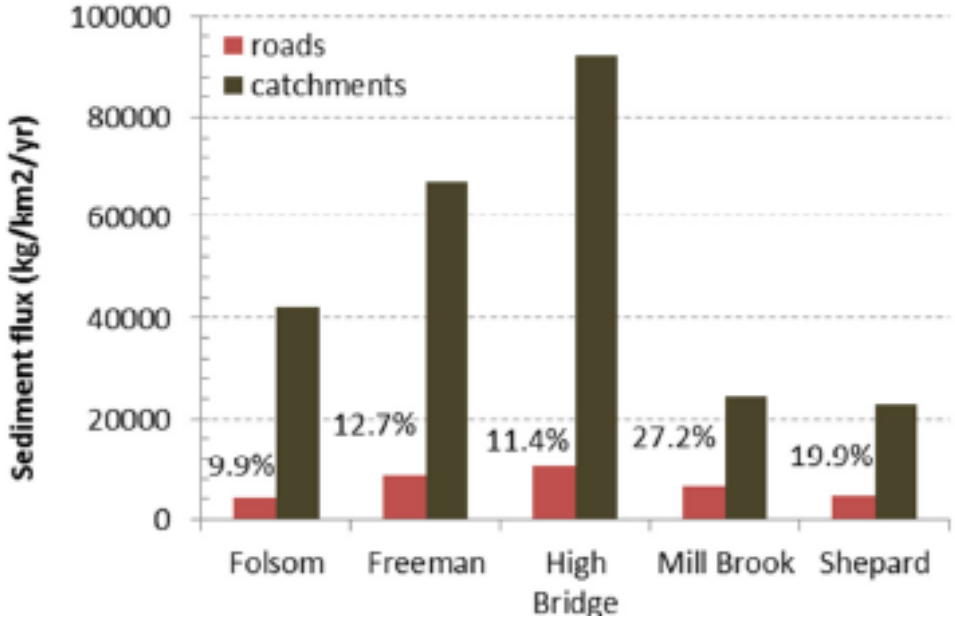
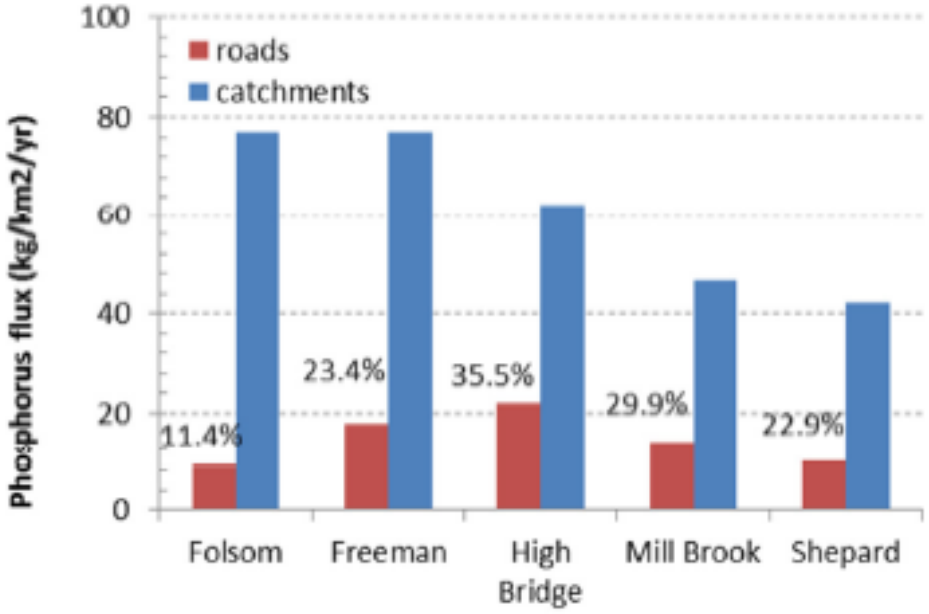
Back road contributions to sediment and phosphorus in streams



Suspended Sediment



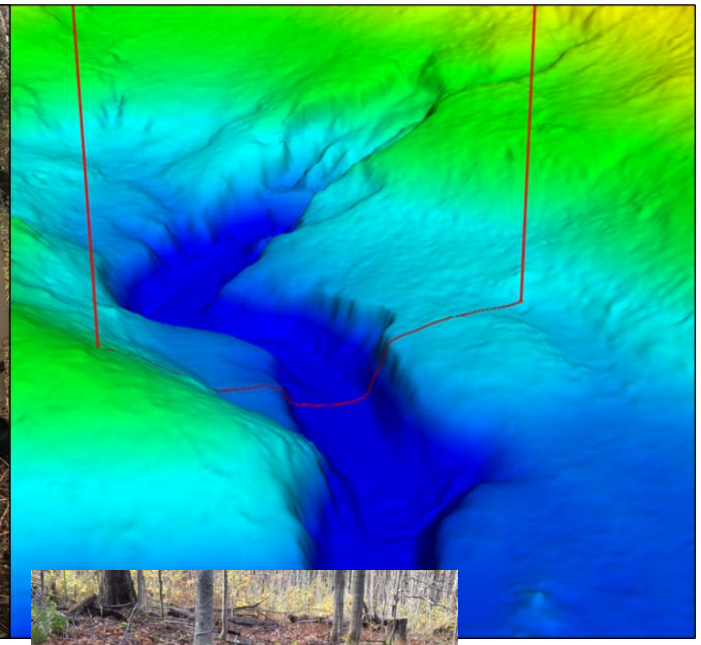
Total Phosphorus

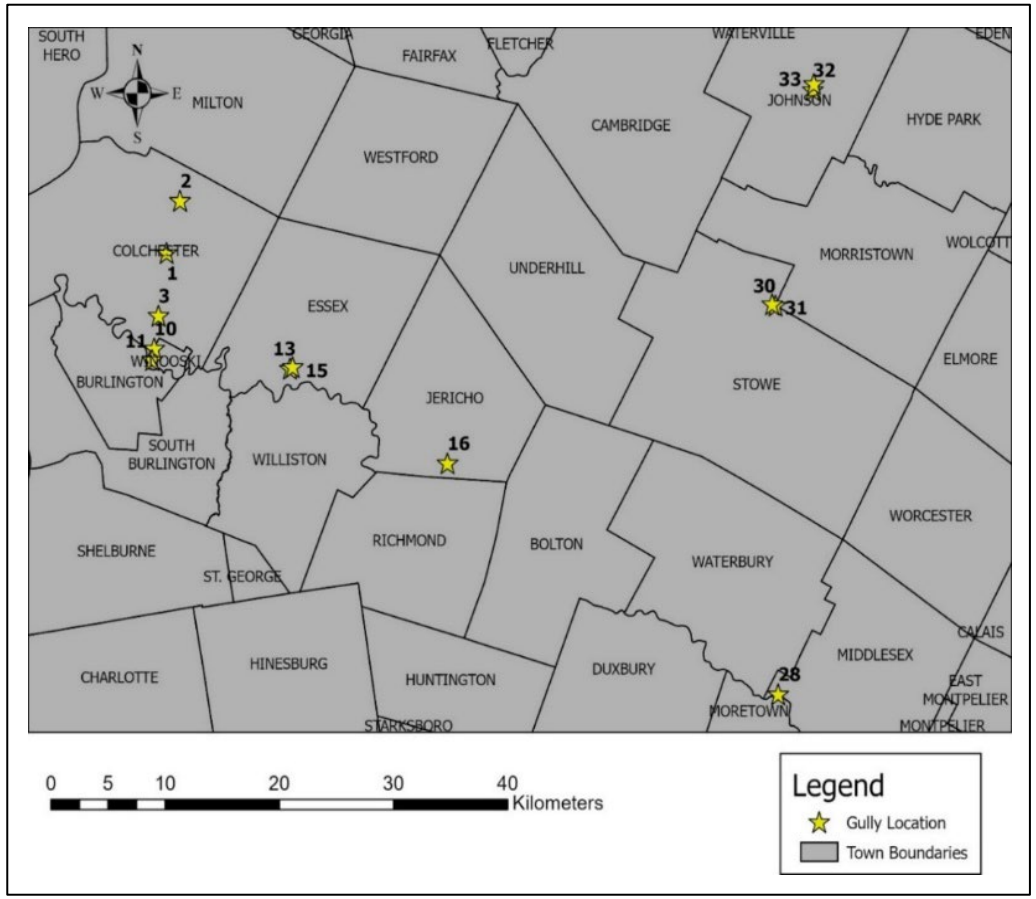


Lake Champlain Basin Program

Catchment loads generated using Mad River Watch data, Friends of the Mad River

Outlet erosion by gullying – intensive assessment





13 sites | pre-treatment monitoring | installation of erosion control structures with post-treatment monitoring

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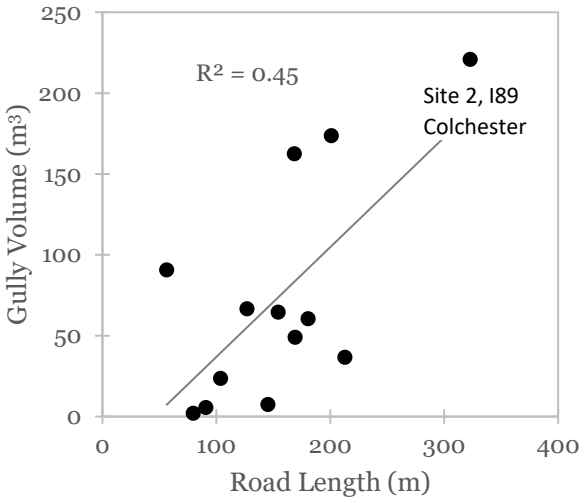
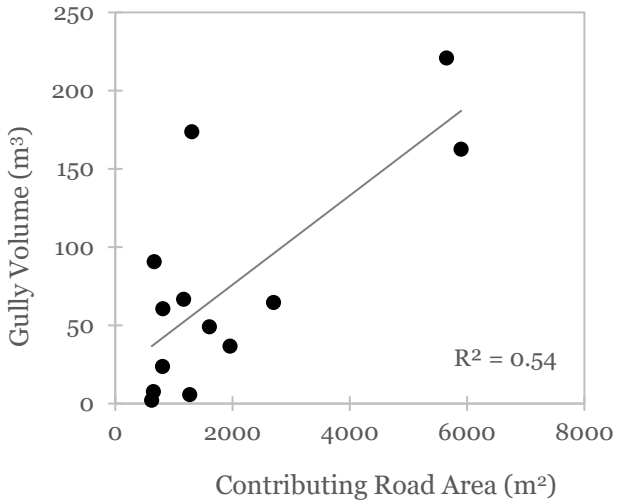
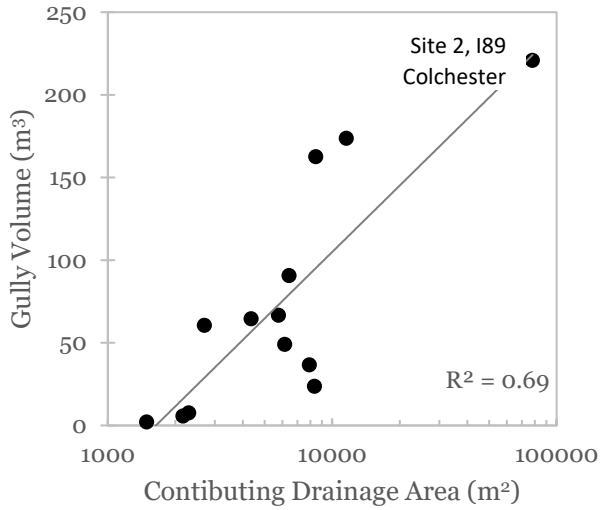
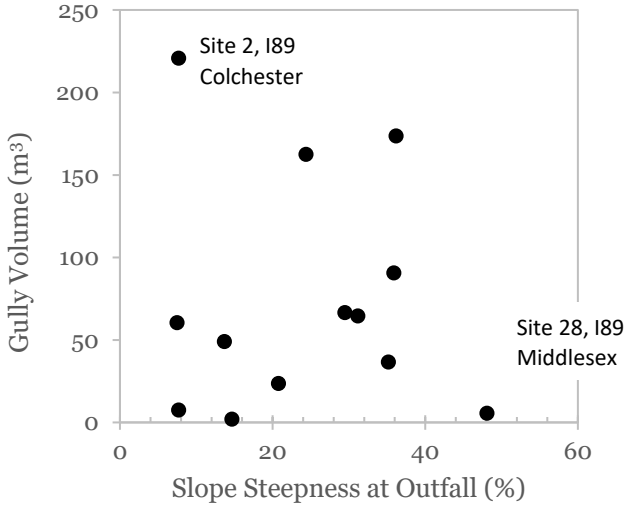
Controls on gully erosion

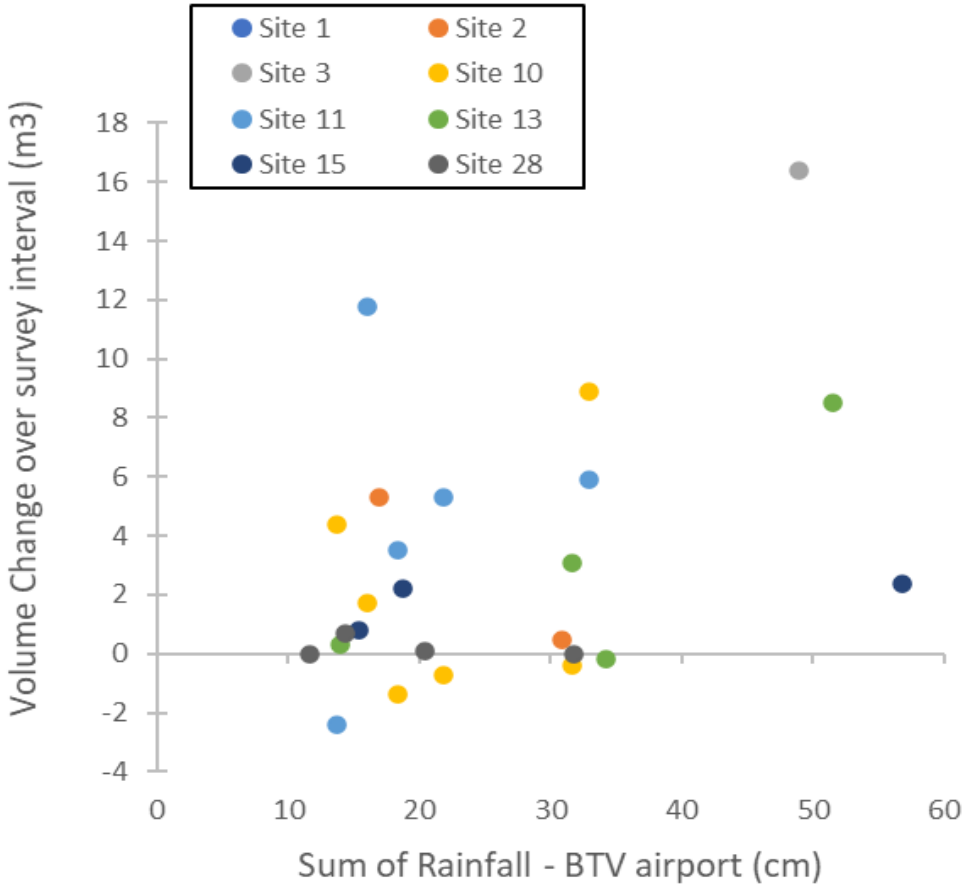








Results of single day survey, May 2021



Results from repeated surveys. Additional sites in Lamoille County, near Morrisville airport weather station, not shown

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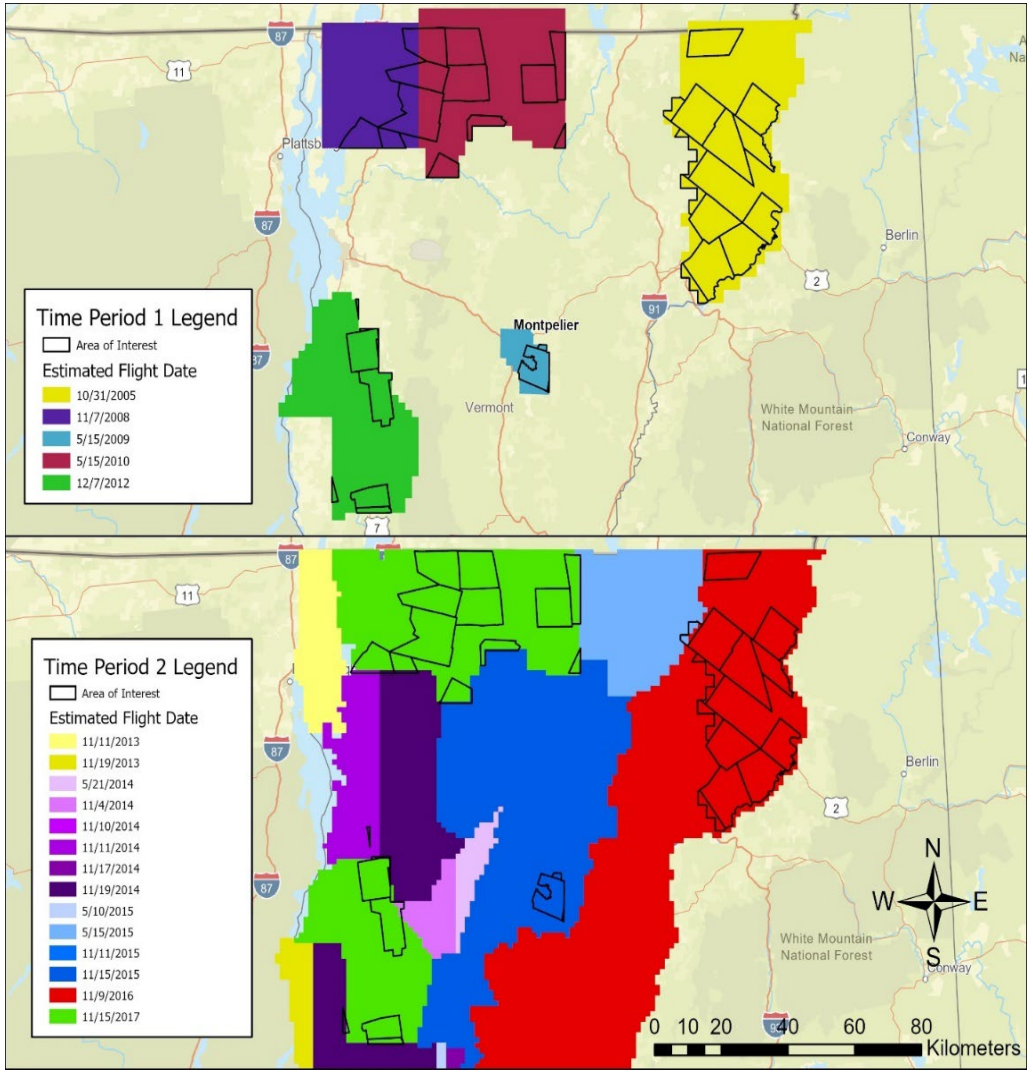
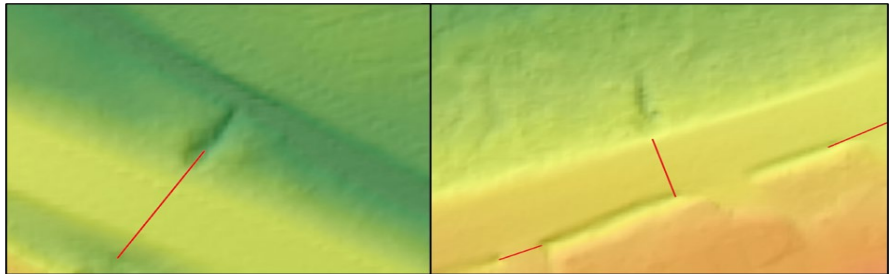
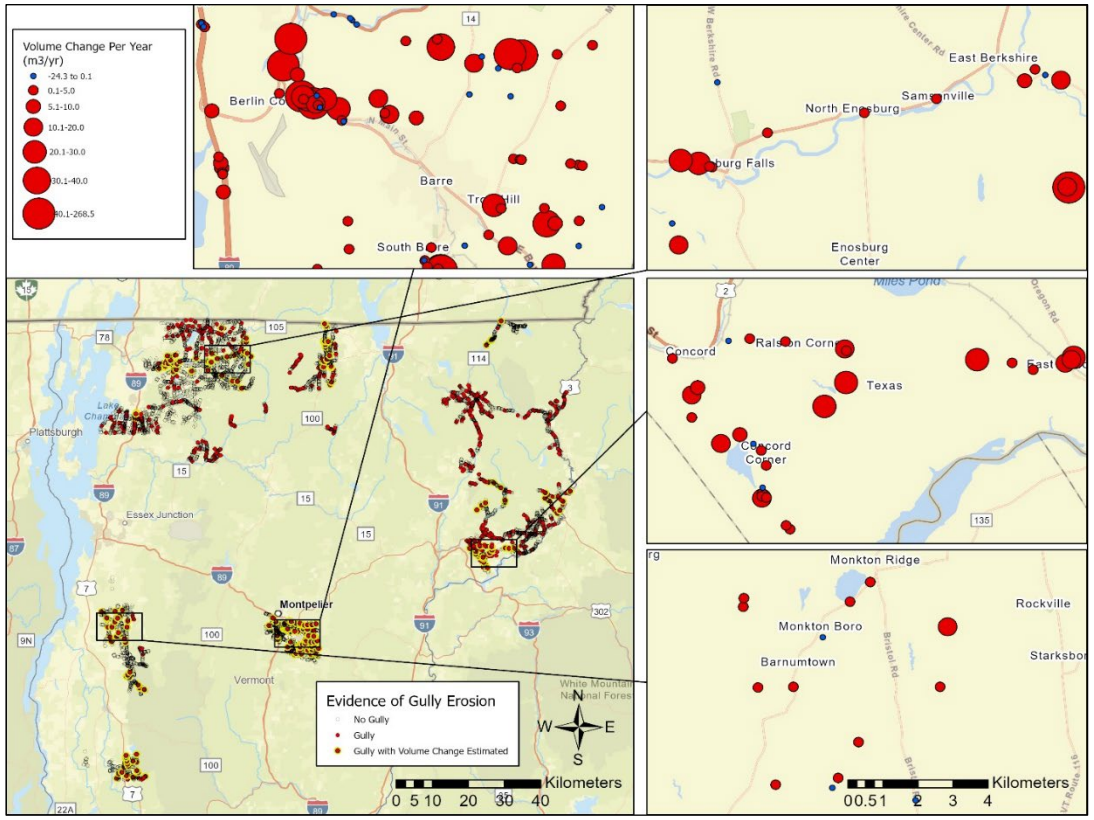
Outlet erosion by gullying – extensive assessment







9823 Culverts inspected in 35 towns | 933 Gullies identified | 303 Gully volumes measured to quantify change over time

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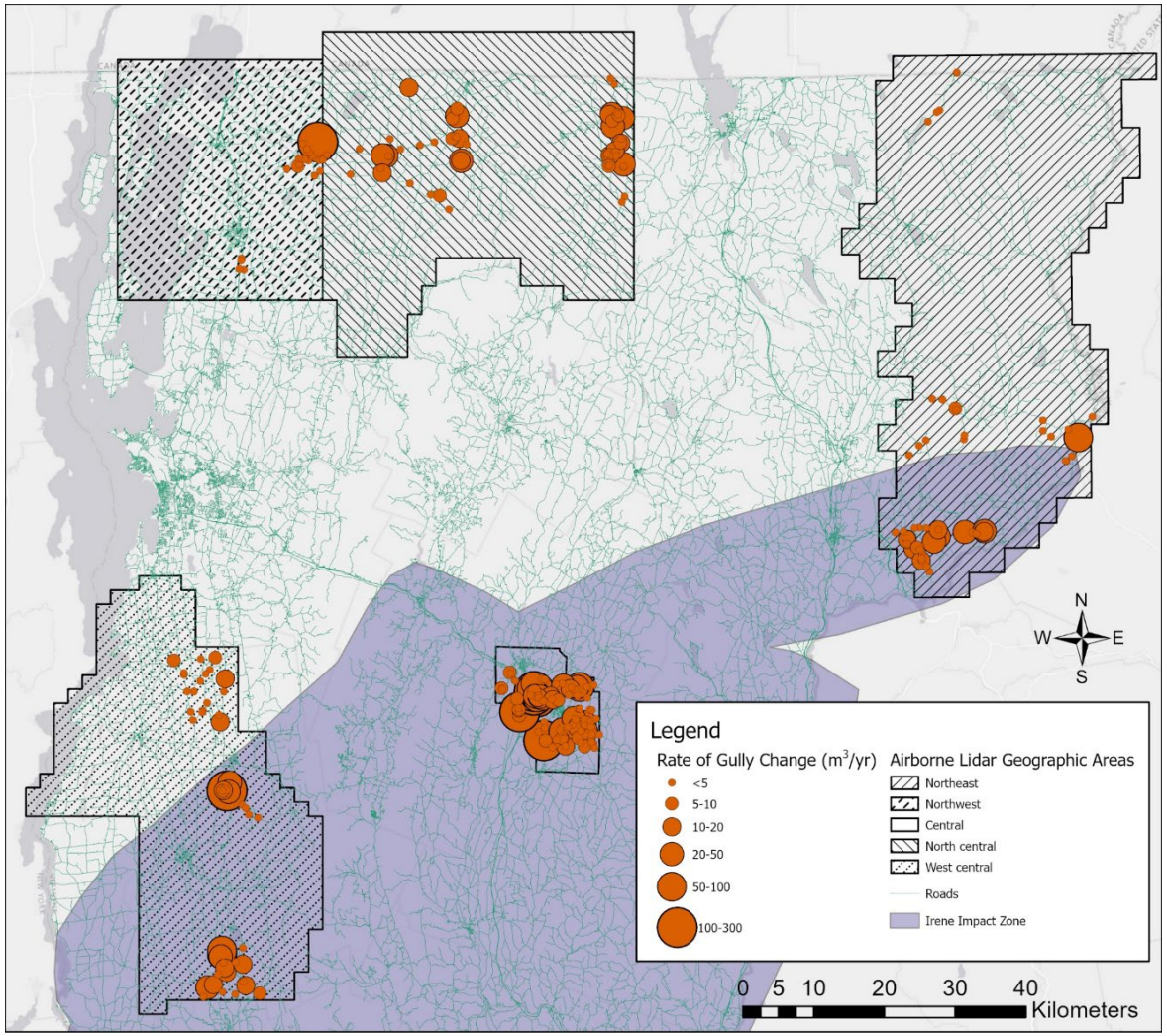
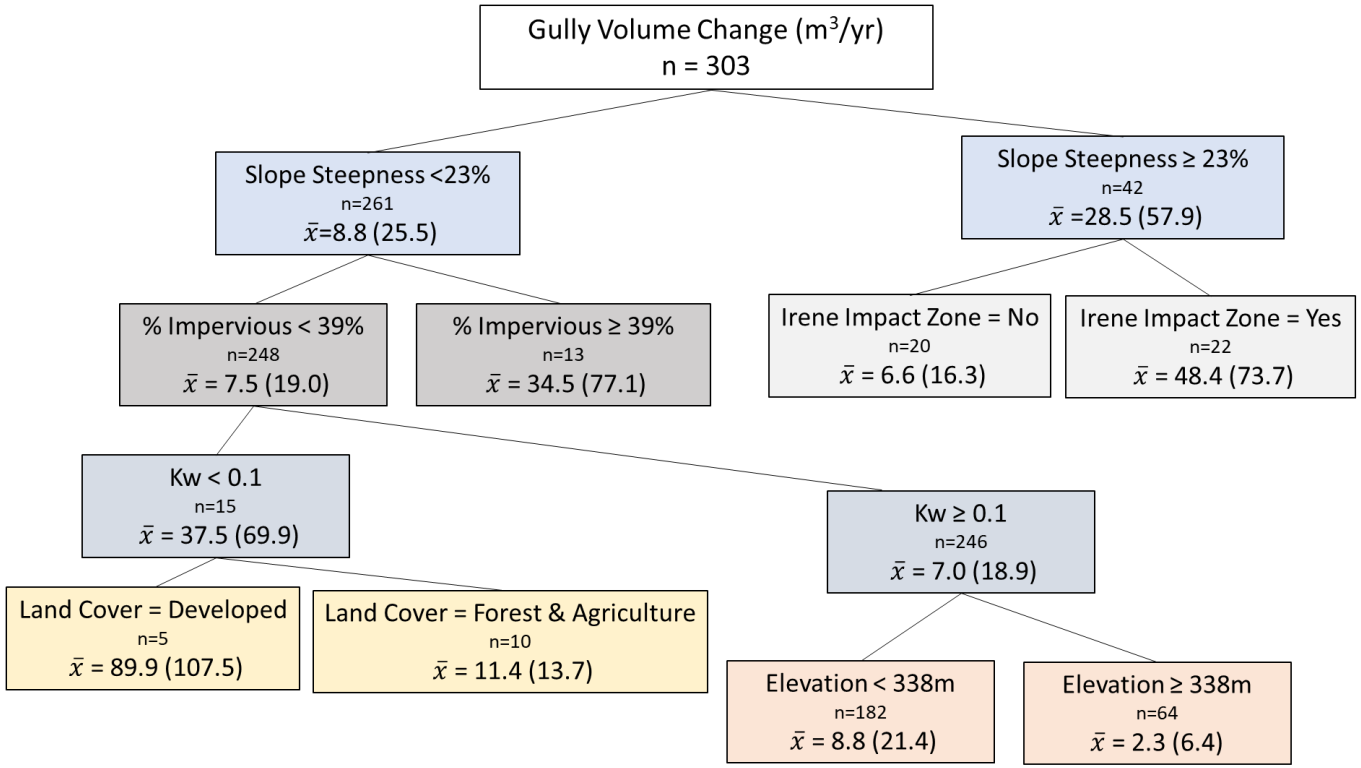
Controls on gully erosion



Road length	Elevation	Landcover
Slope steepness	Soil erodibility	Irene exposure
Road gradient	Parent material	



Gully change rates measured over intervals from 5 to 11 years, depending upon repeat LiDAR data availability

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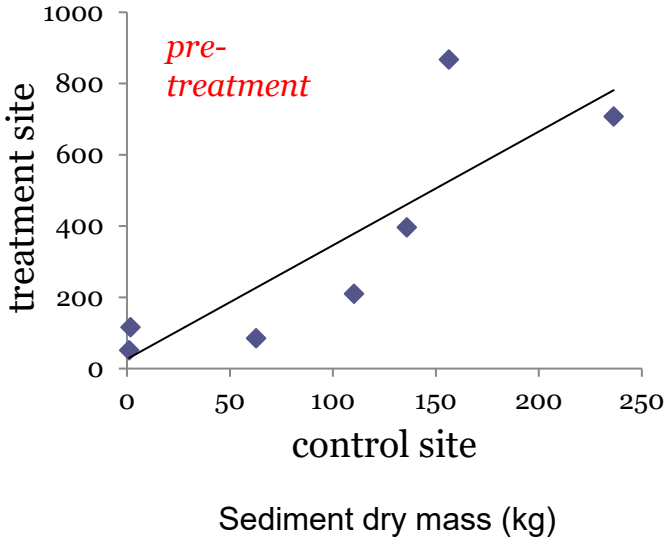
BMP effectiveness – experimental manipulations

Three treatments studied
- stoned lined ditches
- check dams & turnouts
- compost socks

Control site

Treatment site



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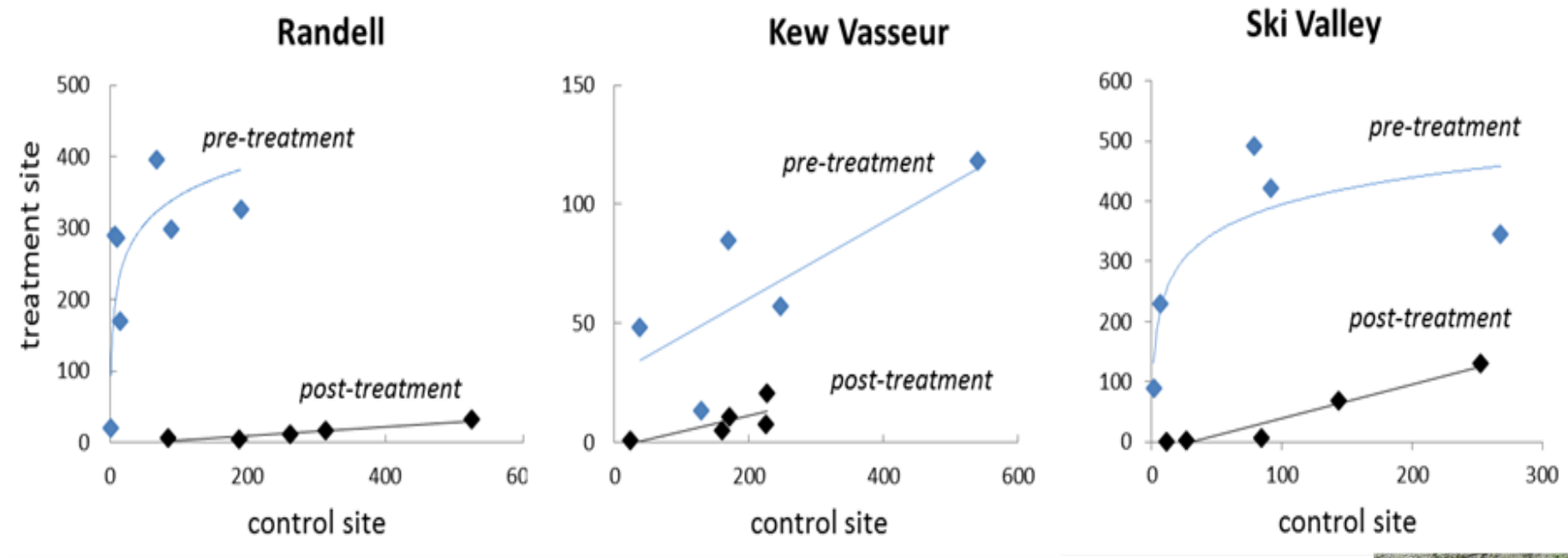
BMP effectiveness

Treatment: Stone lined ditches



Sediment dry mass (kg)

Treatment costs average $4000/100 feet

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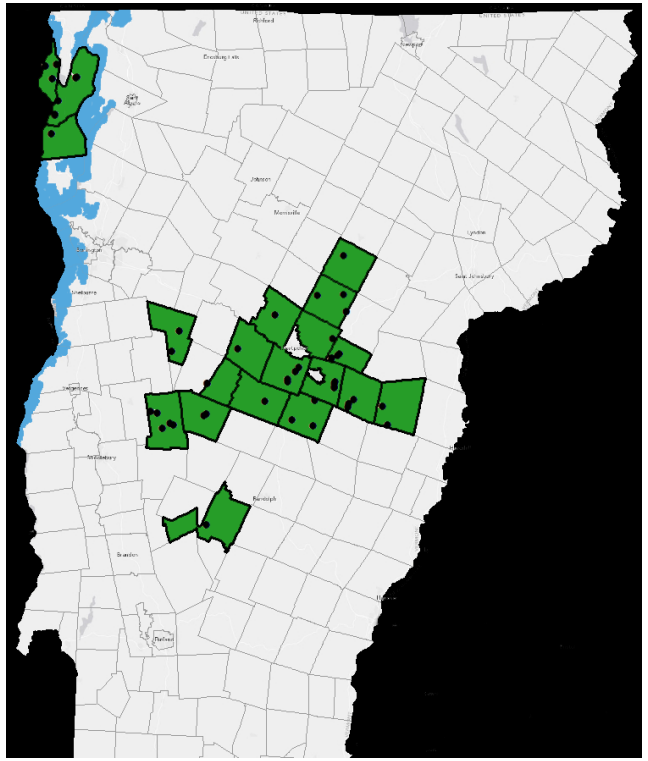
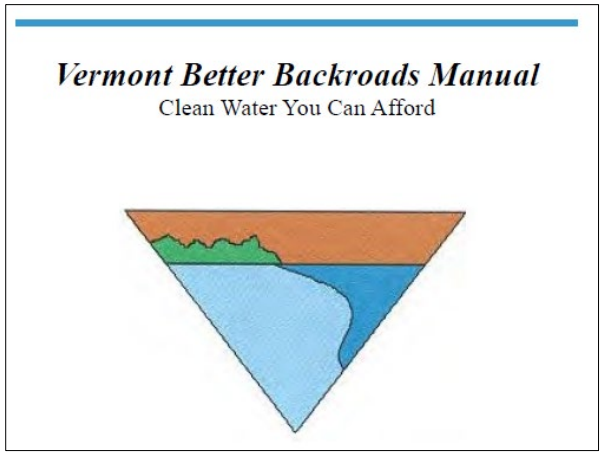
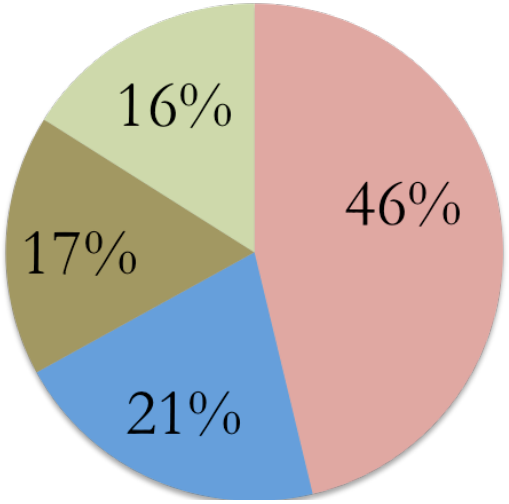
BMP effectiveness – retrospective assessments







intact

compromised

failed

Field Visits

46 Sites

100 BMPs

Age 1-8 years

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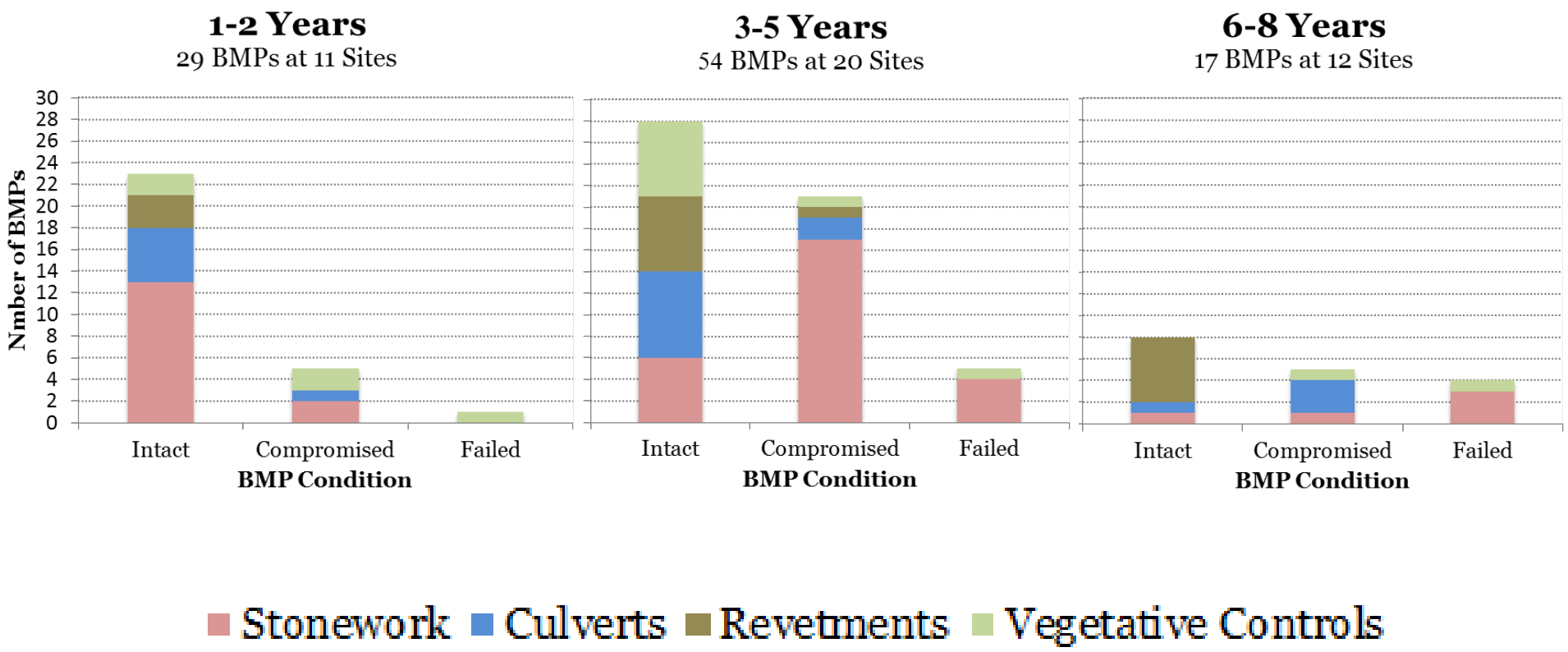
BMP effectiveness with time



100 BMPs assessed
Age 1-8 years

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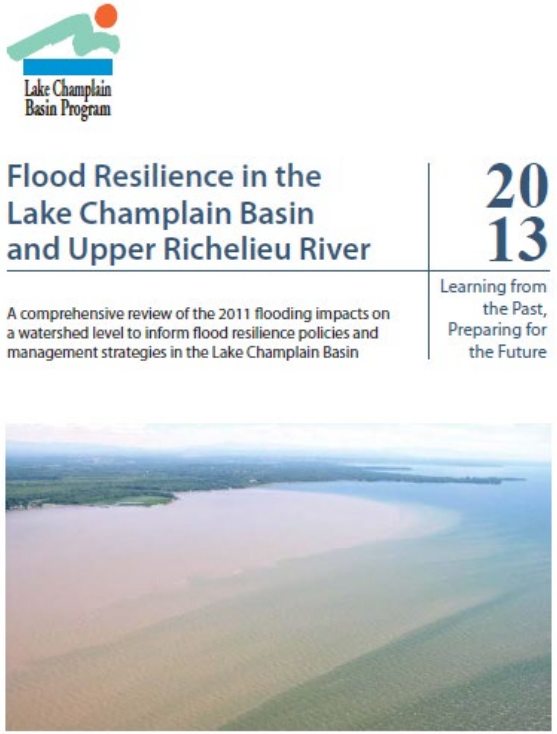
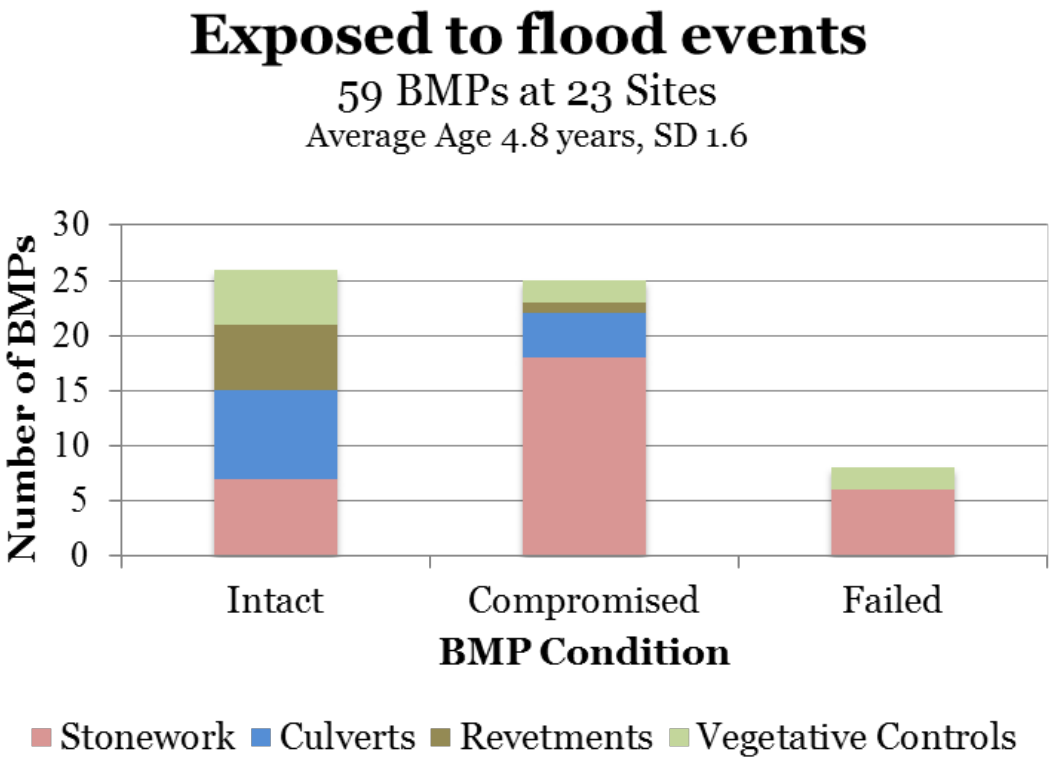
BMP effectiveness with flood exposure





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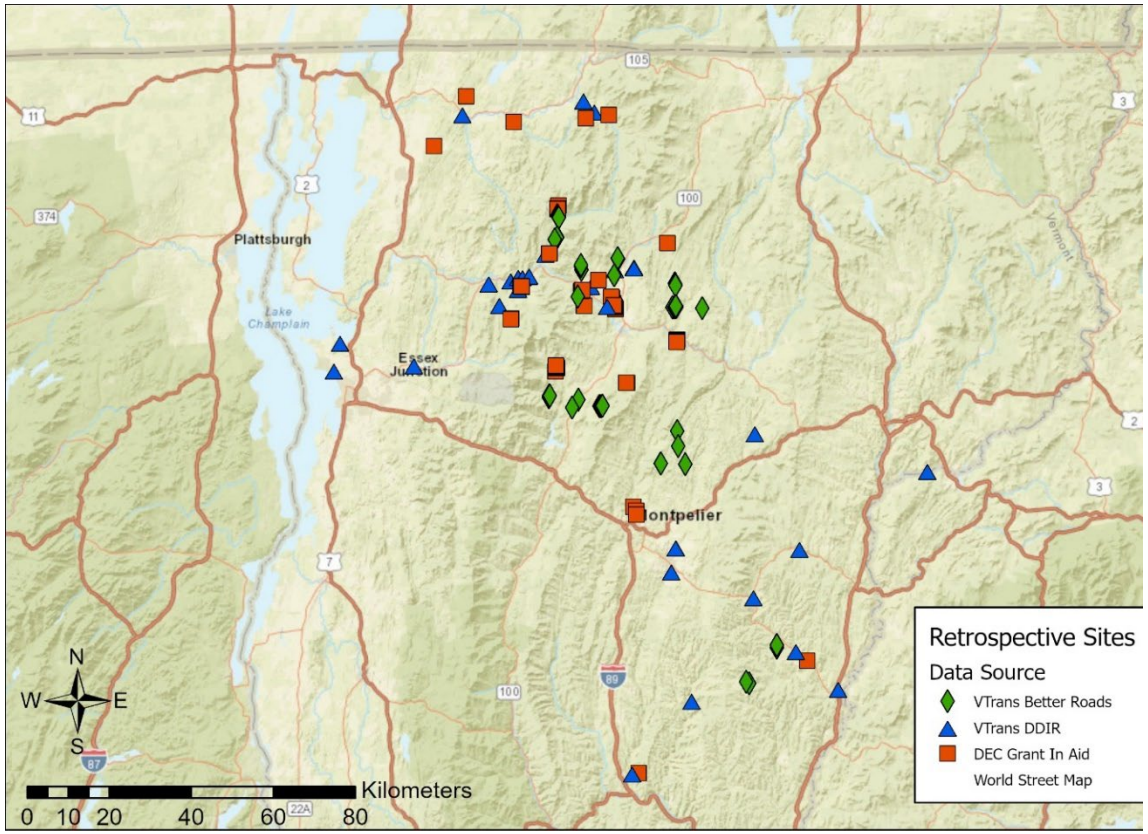
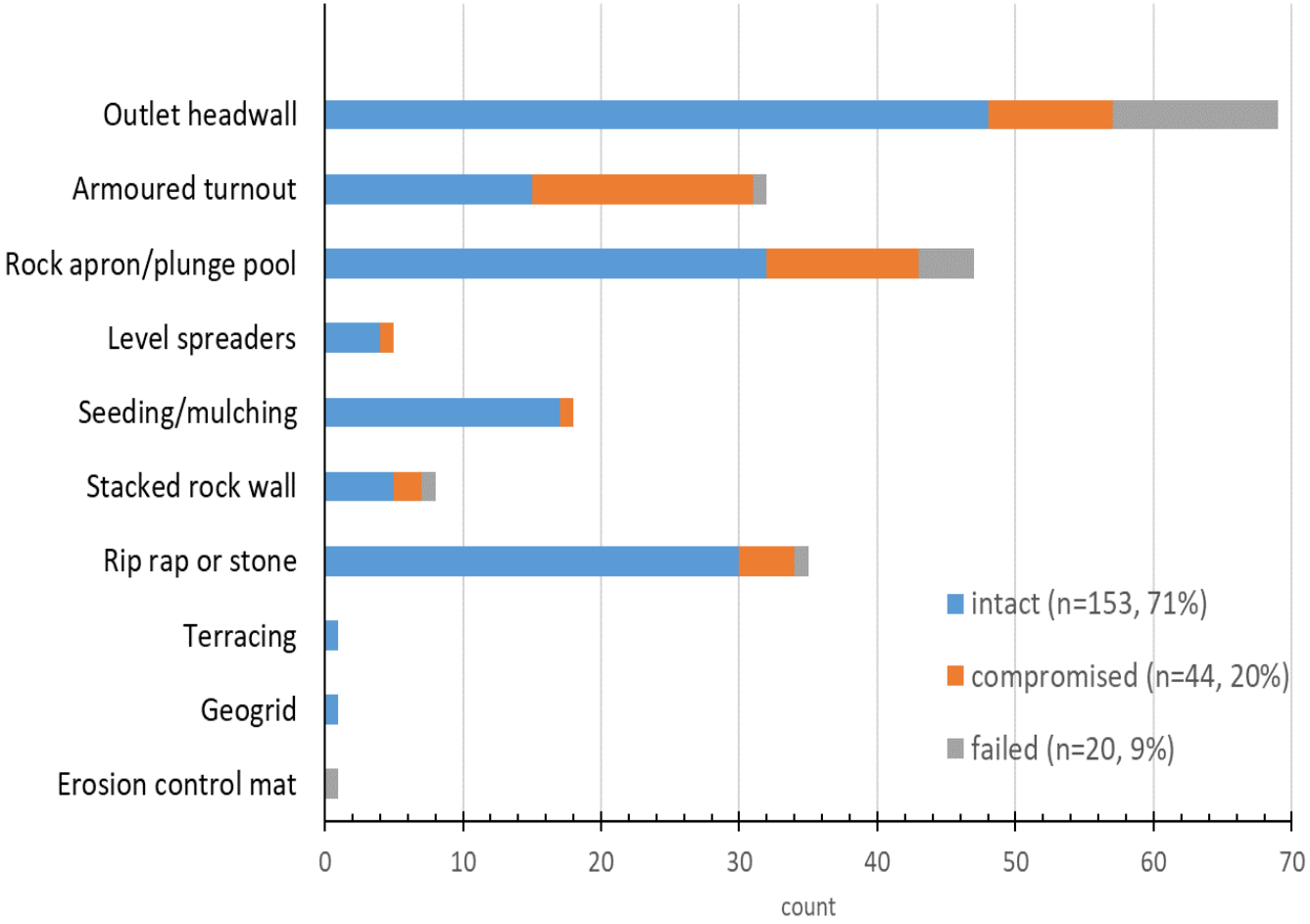
BMP effectiveness by practice





149 project sites visited | 217 slope stabilization and outfall practices assessed (*intact, compromised, failed*)

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Take aways

- Road erosion (surface, ditch, outlets) is a substantial source of sediment and phosphorus production

- Runoff and pollutant production increase with road length, slope steepness/road gradient, and rainfall

- Use of erosion control measures reduces pollutant production and persists over time, even when exposed to extreme floods

Connections to community vitality?

Addressing road erosion – building resilient communities

Waitsfield, VT Town administration, 2014

Duxbury, VT Road Crew, 2013

	Corinth	Huntington	Hyde Park	Waitsfield	West Windsor
Total Road Miles	93.74	43.96	63.45	29.67	51.28
% Unpaved	77	75	61	75	85
Population 2010	1,367	1,938	2,954	1,719	1,099
Road Budget (Year)	$1,076,891 (FY 2014)	$867,717 (FY 2013)	$677,707 (FY 2014)	$431,615 (CY 2013)	$876,088 (CY 2013)
Budget $/mile	$11,488	$19,739	$10,680	$14,547	$17,084
Road crew Employees	3 FT 1 PT	4 FT	4 FT 1 PT	3 FT	3 FT 1 PT

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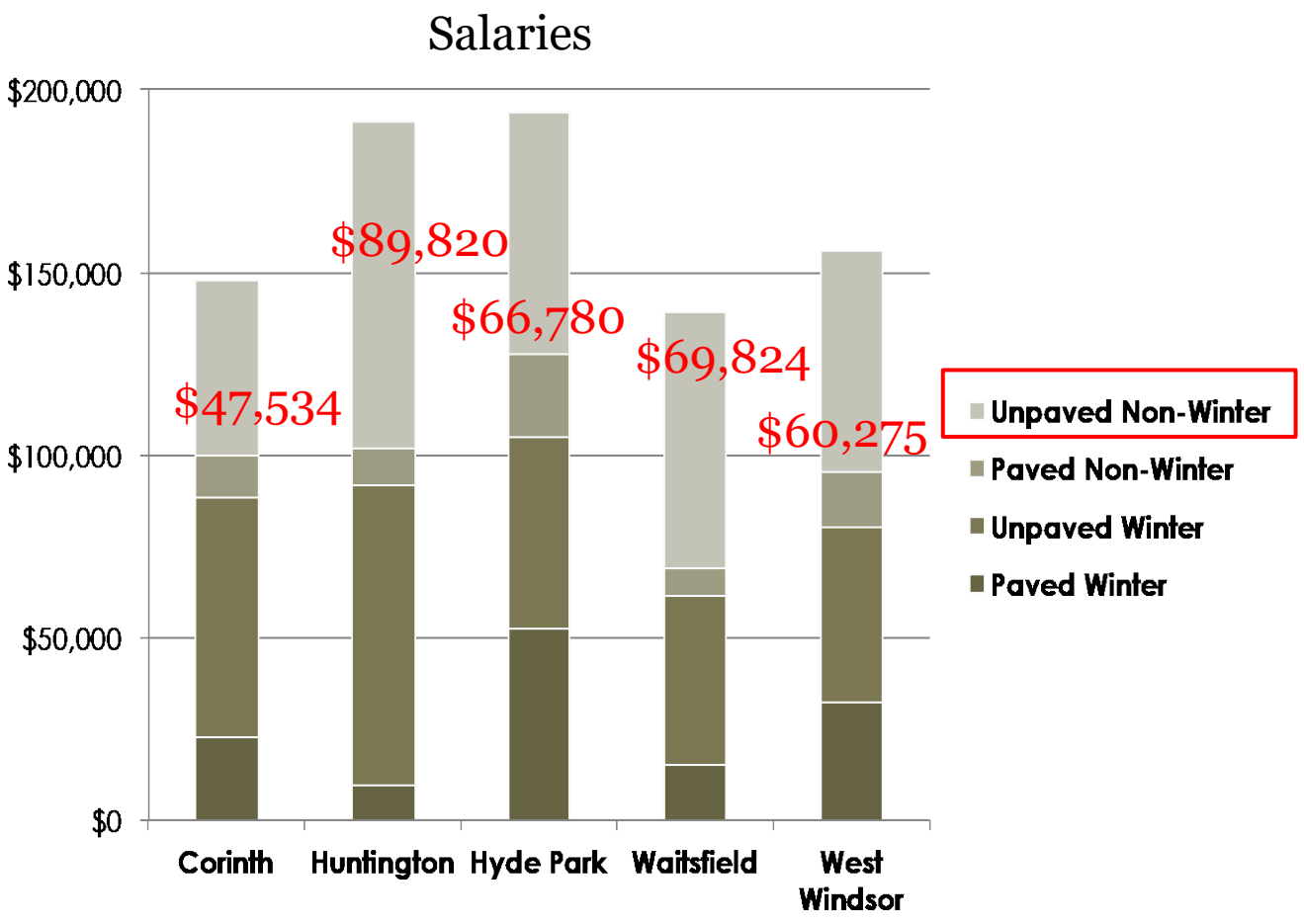
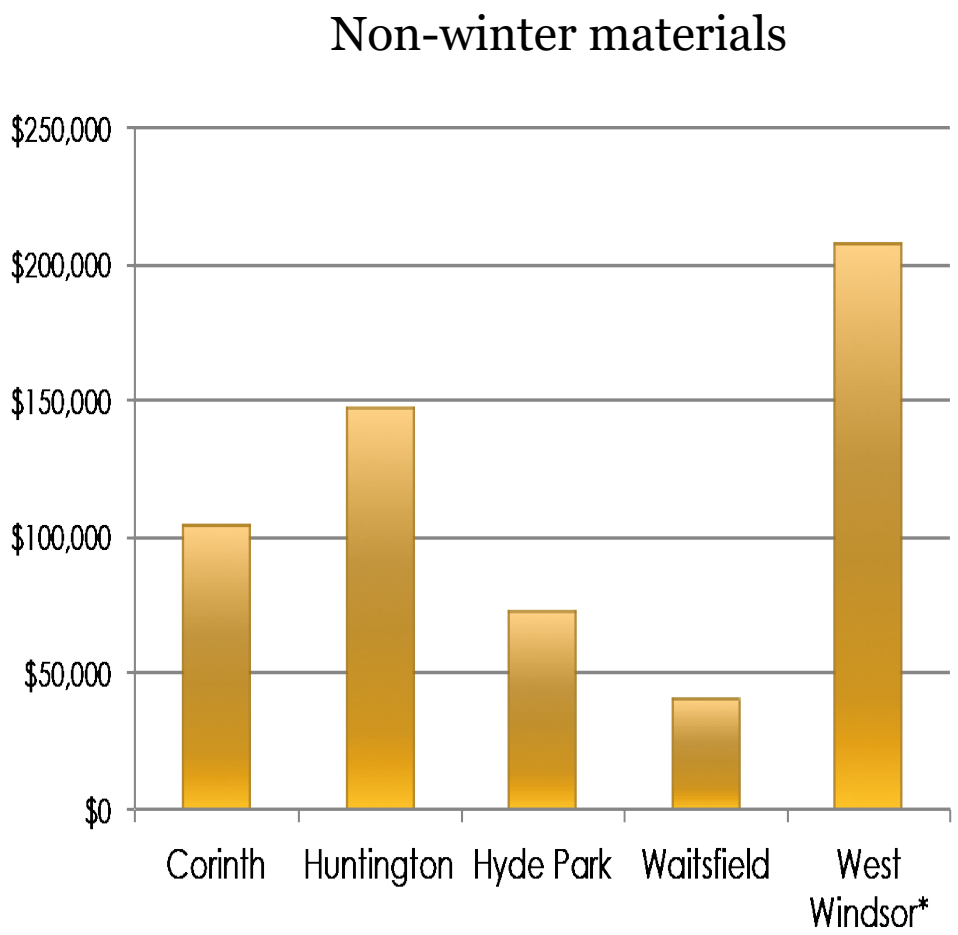
Municipal road costs





* West Windsor materials total includes $55,687 of itemized equipment rental, materials and trucking to address 2013 flood repairs.

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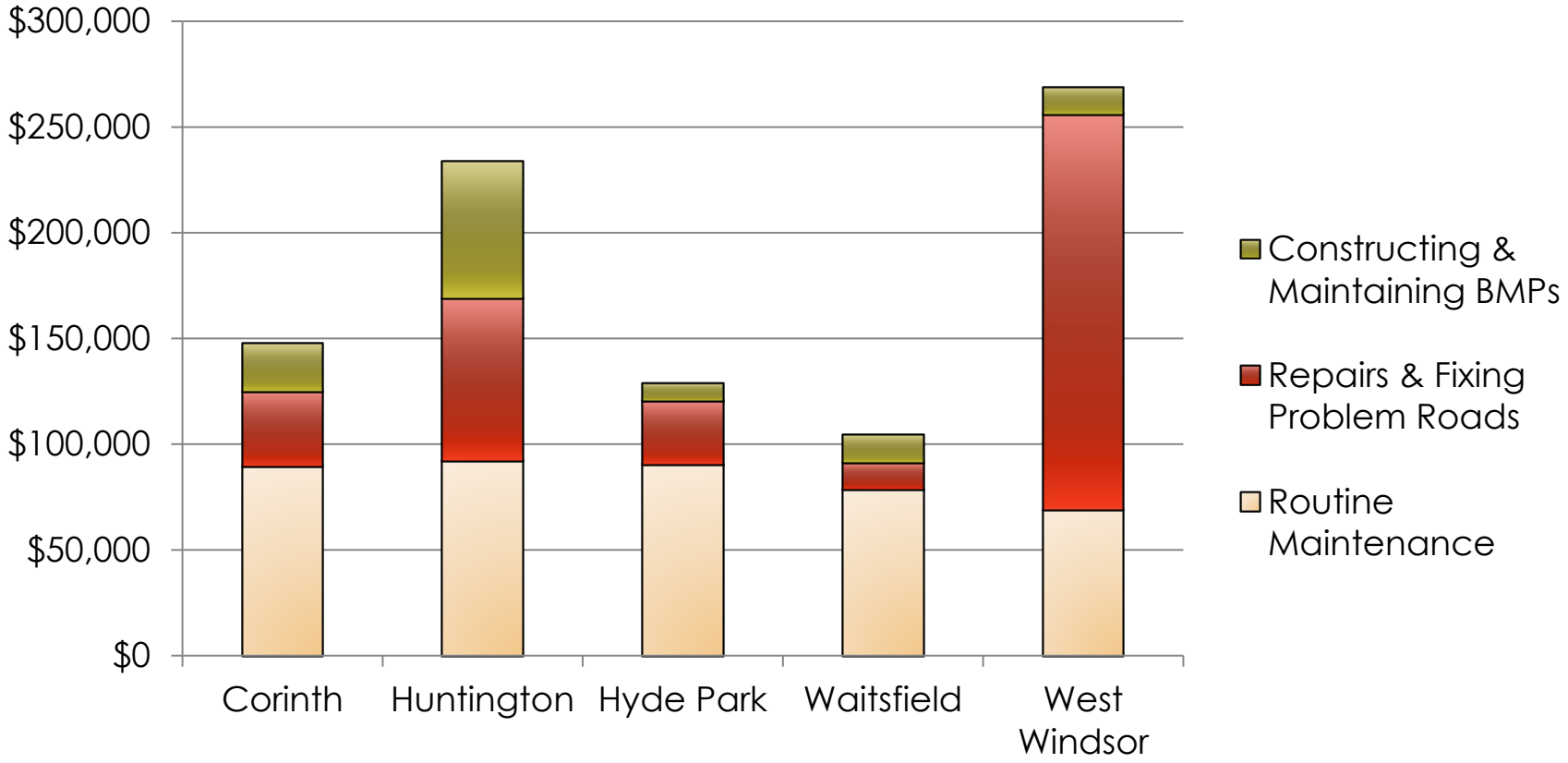
Total salary and materials costs

unpaved non-winter road work



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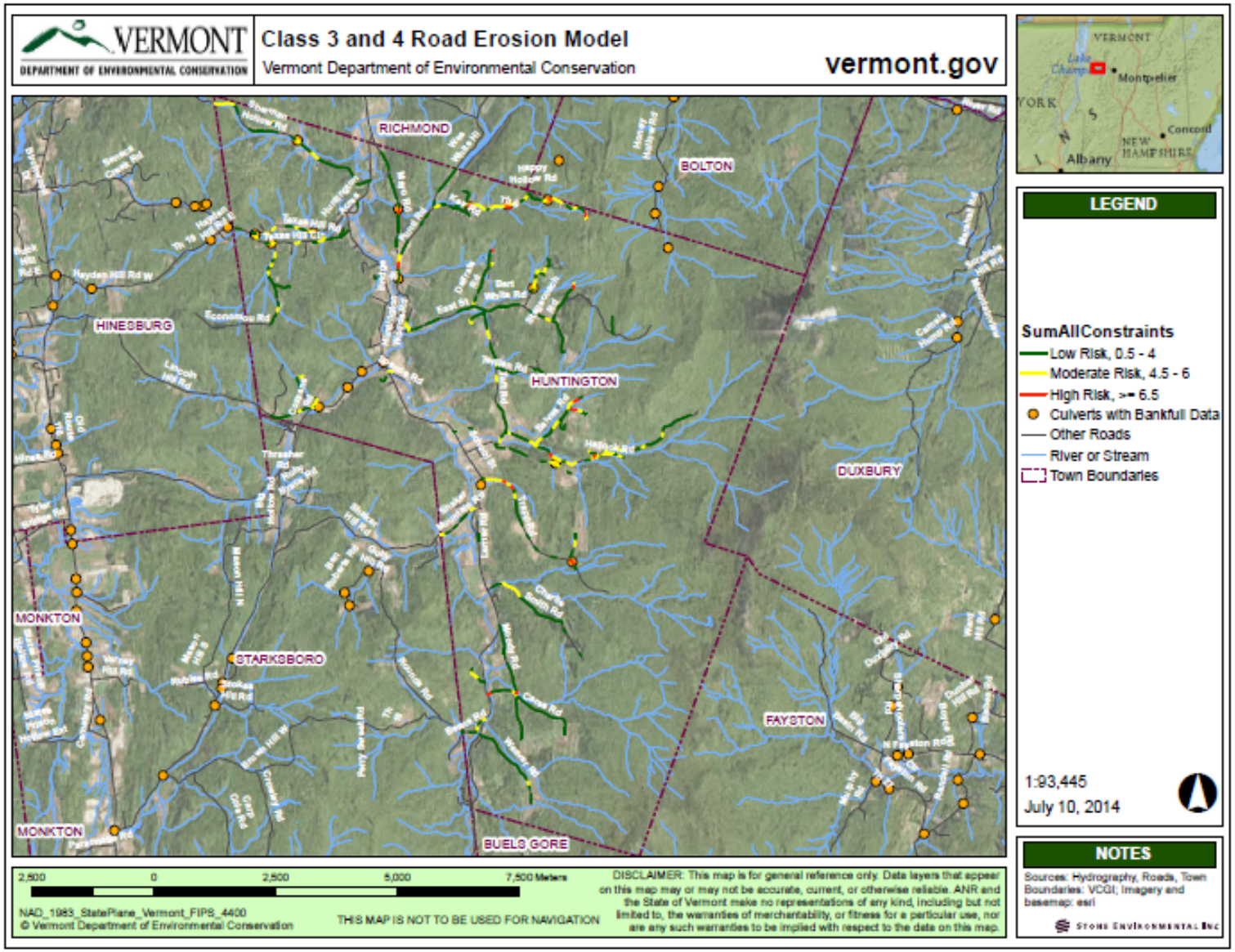
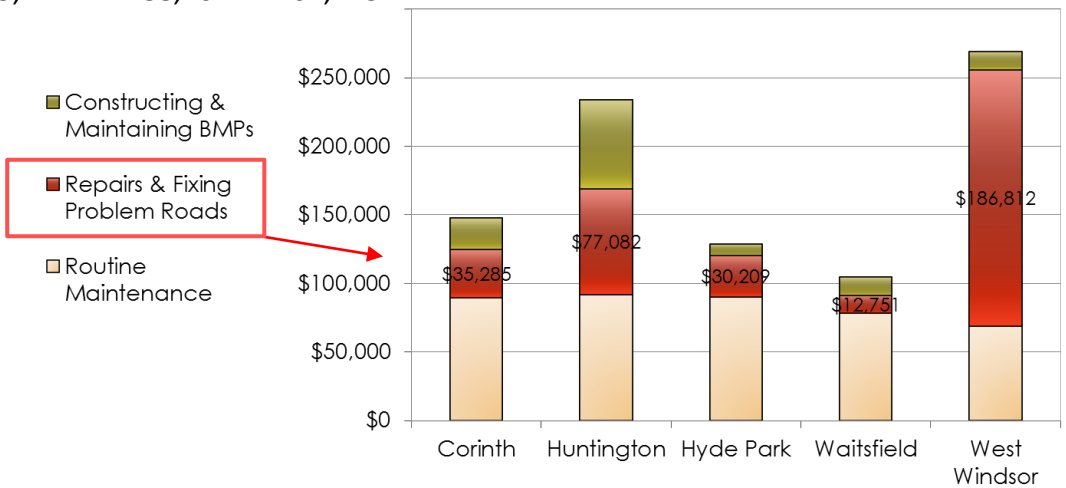
Road erosion prioritization



Estimated need & treatment costs

	Corinth	Huntington	Hyde Park	Waitsfield	West Windsor
Estimated mileage					
High priority	2.02	1.34	1.47	1.23	2.59
Medium priority	13.71	6.40	5.13	7.13	9.93
Low priority	57.61	22.76	32.48	18.83	38.21
Cost of treament (@ $4000/100 feet)					
High priority	$425,675	282,816	311,452	260,529	546,174
Medium priority	$2,895,892	1,351,951	1,083,773	1,505,657	2,096,981
Treatment cost over 8 years					
High	$53,209	35,352	38,932	32,566	68,272
Medium	$361,987	168,994	135,472	188,207	262,123

Allocations under current practices



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The Vermont Climate Action Plan is organized into five impact areas:

Cutting Climate Pollution

Reducing emissions from transportation, buildings, energy and products.

Capturing Carbon

Removing carbon from the air and storing it in soil or plants.

Resilient Working and Natural Lands

Preparing farms, forests and ecosystems for climate change.

Cross-Cutting Solutions

Investing in communities and workforce development.

Vital Communities

Protecting people and infrastructure from climate impacts.

For more information

Wemple, B. C., 2013. Assessing the Effects of Unpaved Roads on Lake Champlain Water Quality. Technical Report No. 74. Lake Champlain Basin Program. Available at http://www.lcbp.org/wp-content/uploads/2013/07/74_Road-Study_revised_June2013.pdf

Wemple, B.C. 2016. Controlling polluted stormwater runoff from roads. *Vermont Journal of Environmental Law*, 17: 785-810. Available at https://www.jstor.org/stable/vermjenvilaw.17.issue-4

Wemple, B.C., G.E. Clark, D.S. Ross and D.M. Rizzo. 2017. Identifying the spatial pattern and importance of hydro-geomorphic drainage impairments on unpaved roads in the northeastern USA. *Earth Surface Processes and Landforms*. DOI: 10.1002/esp.4113. Reprint available by request.

Wemple, B.C., E. Estabrook, M. Dewoolkar, S. Hamshaw. 2021. Quantifying Nutrient Pollution Reductions Achieved by Erosion Remediation Projects on Vermont's Roads. Vermont Agency of Transportation Technical Project Report no. 2021-02. Available at https://vtrans.vermont.gov/sites/aot/files/

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