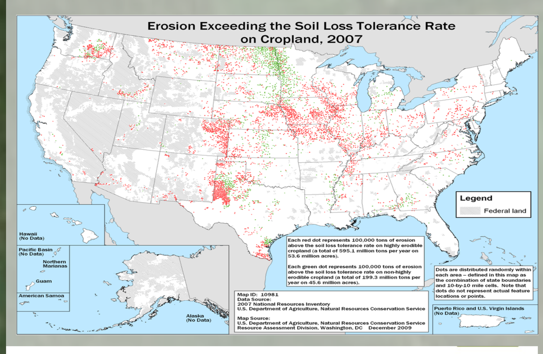
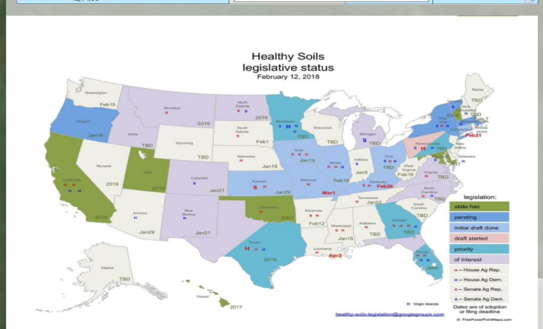
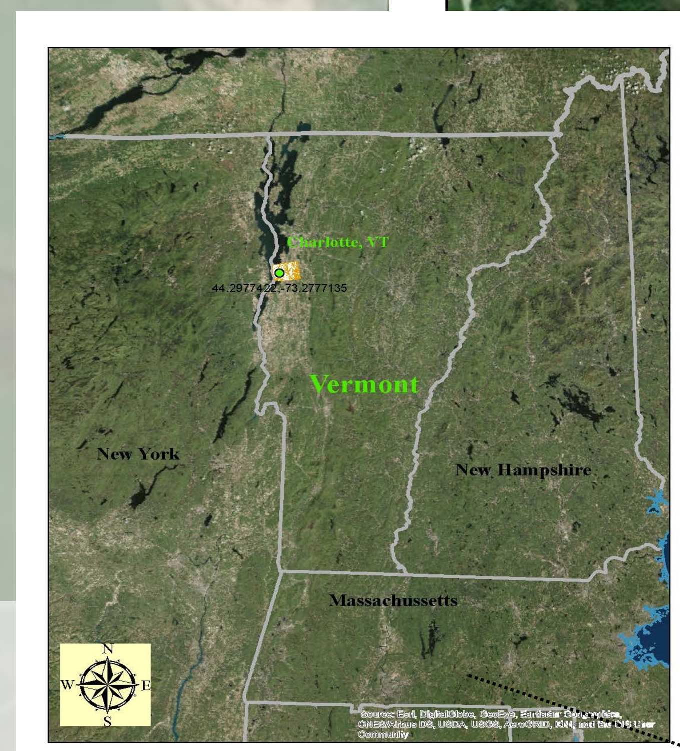
Free Range Soil Salvaging: The Impact of Integrated Livestock Management on Soil Quality

Soil Quality in Vermont

Soil is an endangered resource, though not a nonrenewable one. In the United States, soils are eroding due both to climate-change-induced shifts in hydraulic cycles and the toxic inputs our industrial agricultural system relies on.





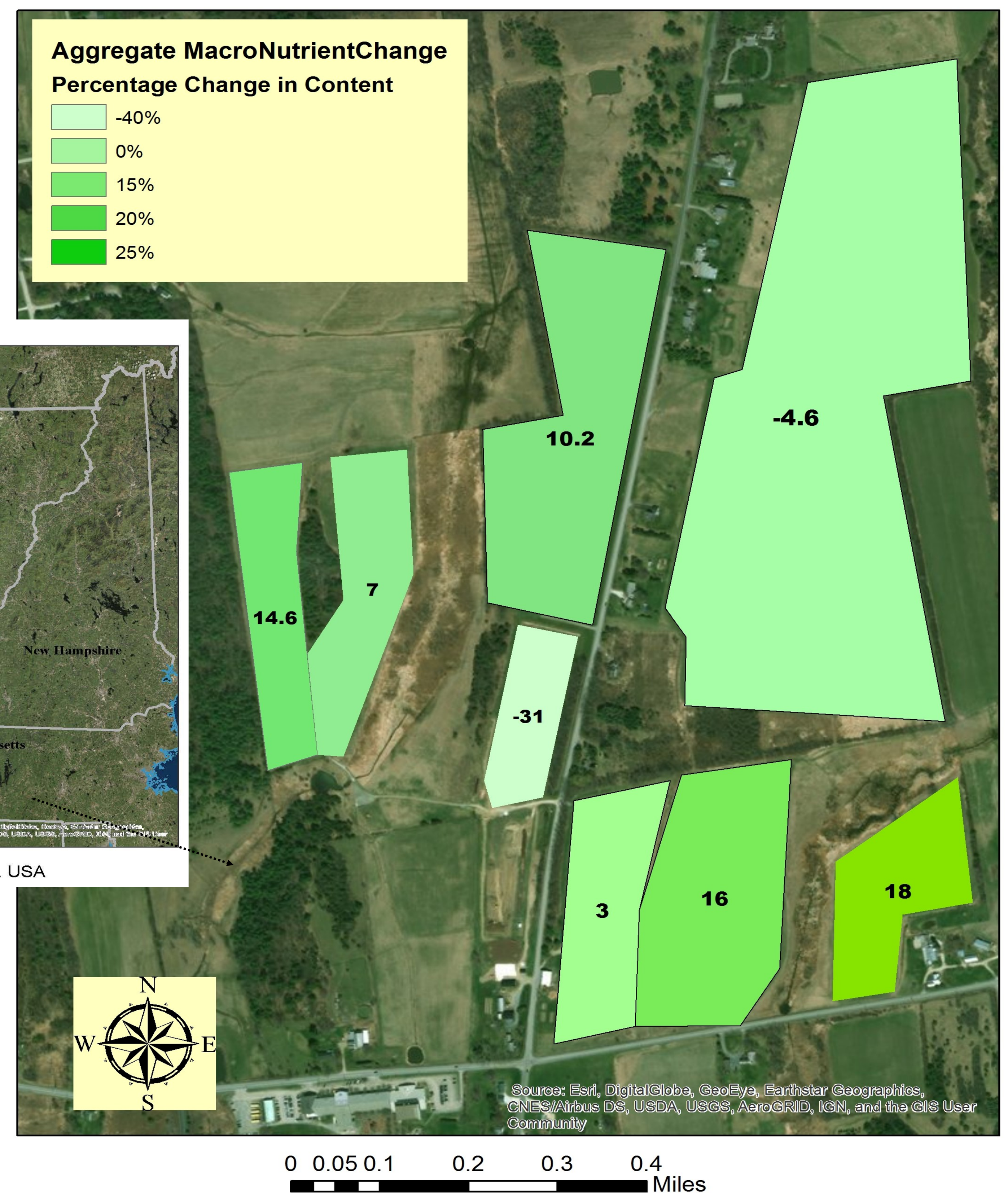


Charlotte, Vermont, USA

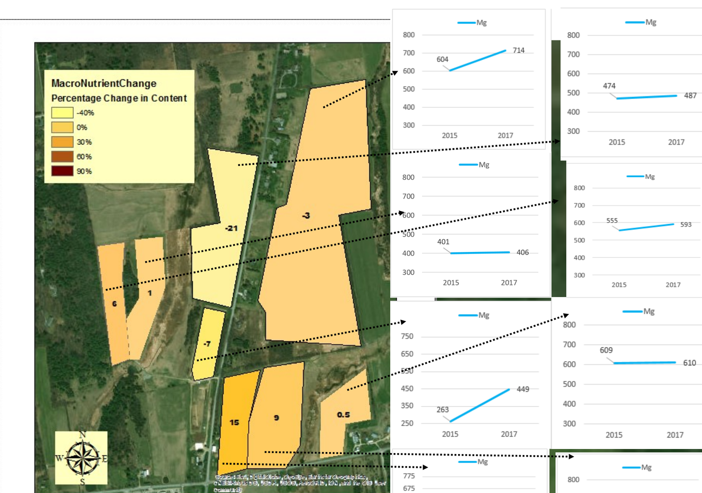
There is significant government policy work that could be done to instate regulations and support farming reform mechanisms for all Vermont farmers. These mechanisms must ensure that farmers are aware of and can implement best management practices agreed on by experts.

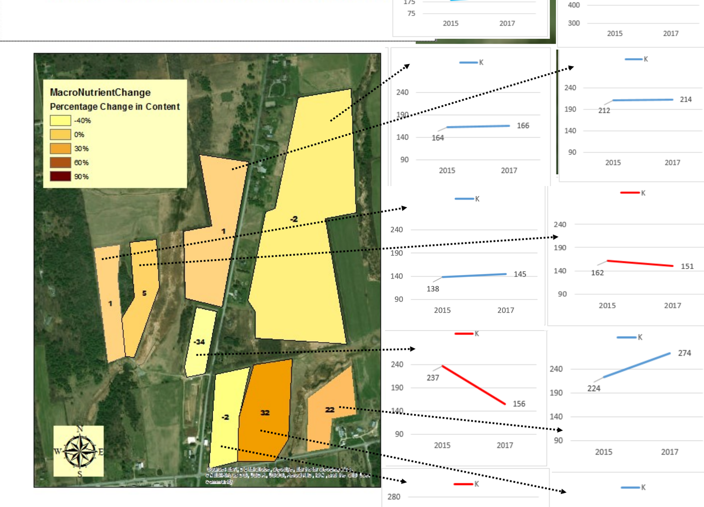
My **Research Goal** was to evaluate the effectiveness of Integrated Livestock Management as a farming practices that can rebuild the complex mixture of matter in spongy, rich brown topsoil, which contains all the Phosphorus, Nitrogen, Zinc, Potassium and Sulfur that a plant needs to grow and thrive, in a matter of years. **Philo Ridge Farm**, a diversified farm in Charlotte, Vermont, just outside of Burlington, has begun to introduce nature's best generator of organic matter and soil fertility, livestock, back across their cropland. Philo Ridge Farm was founded as a dairy farm two centuries ago, then transitioned to being a diversified crop and livestock operation. Already raising cattle, the farm started to incorporate cattle grazing rotations across their land in 2015.

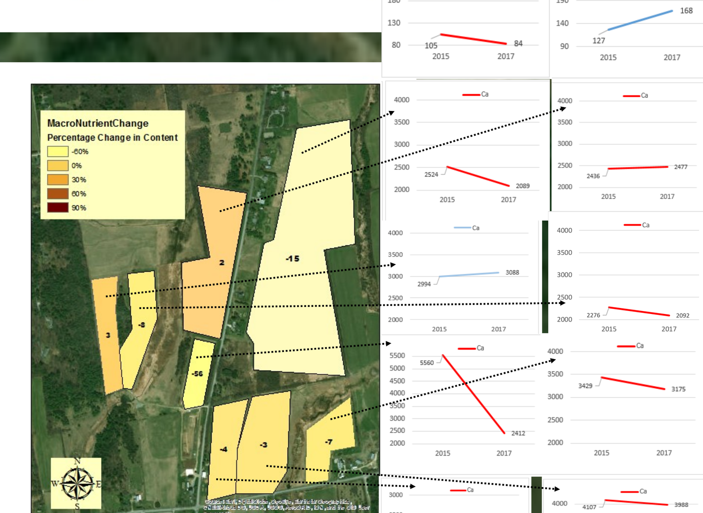
A team of soil experts based out of the University of Vermont (UVM), lead by Juan Alvez, started monitoring the change in soil quality induced by livestock in 2015. Alvez and his team collected samples for two years, 2015-2017 testing them for chemical compounds and biological matter. To develop a format for displaying soil quality change across an area of land, I have generated a map to display the results of these chemical tests across 8 fields. I focused on the shifts in macronutrient content they experienced after the introduction of livestock.



Aggregate Change in Macronutrients P, K, Ca, Mg, S Across 8 Fields (2015-2017)


Change in Macronutrient Magnesium (2015-2017)


Change in Macronutrient Potassium (K, 2015-2017)


Change in Macronutrient Calcium (2015-2017)

Methods

The method I used to demonstrate soil quality change involved a combination of external calculations and the use of ArcMap functions. I started by compiling the results of 25 composite samples from 8 fields at Philo Ridge, collected and processed by Alvez and his UVM team. These fields were located on one square mile of land, which amounted to 640 acres divided into 8 plots. Alvez tested these samples for chemical compounds using the Modified Morgan Soil Testing system at the UVM soil lab and generated (show table) results for the macronutrients Phosphorus, Potassium, Calcium, Magnesium and Sulfur, and the micronutrients Iron, Manganese, Boron, Copper, Zinc, Sodium and Aluminum.

I located the longitude and latitude of the 8 fields on a world imagery basemap of Charlotte, Vermont, and using field descriptions, I created shapefiles and used the Editor tool to draw polygons for each of the 8 fields. I then inputted macro- and micronutrient data into the attribute tables of each field file, so I could adjust the coloring of each polygon according to the concentration of each macronutrient. With the macronutrient values inputted, I took the 2015 and 2017 values and calculated the percentage of change observed across these 8 fields for each nutrient.

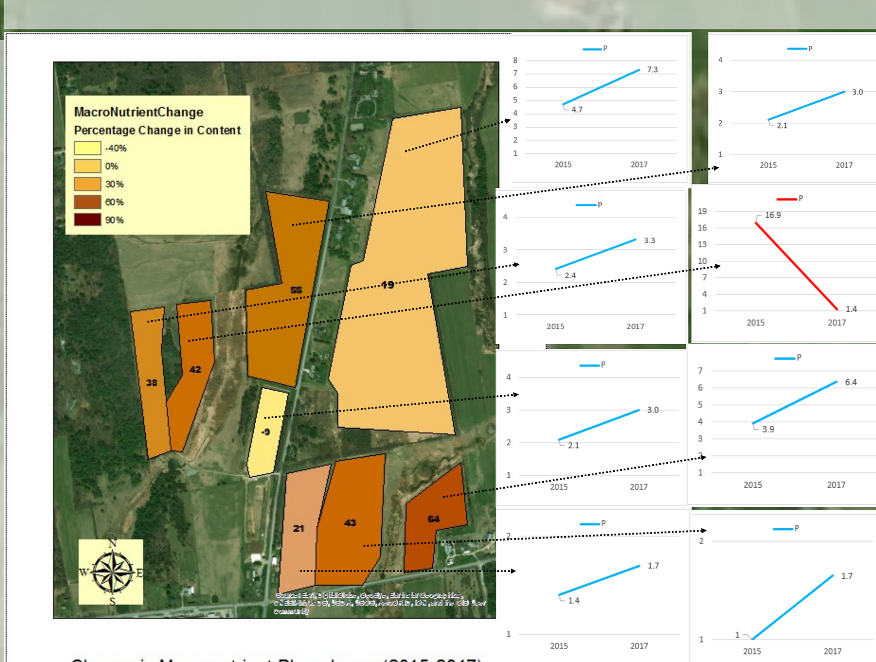
Methods cont.

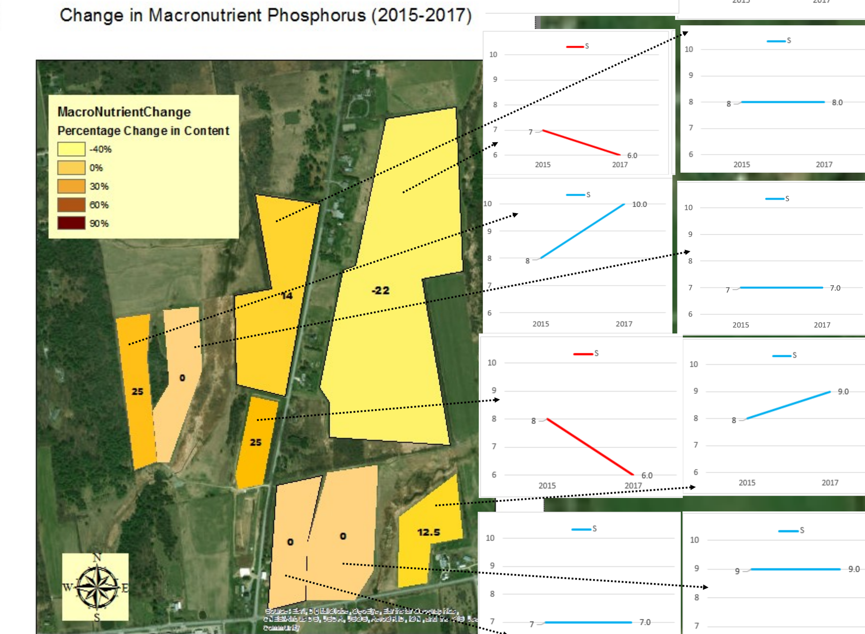
I performed an attribute join for the changes in each layer to compile these results and generate a key for all fields simultaneously. I used the Qualities function in the properties of this file to assign a gradient to the changes in macronutrient content across each field. I then used the same process to calculate and display the average overall macronutrient change across the 8 fields. I overlaid this total change on a map of soil type across the town of Charlotte, to compare and evaluate how effective it would be to expand Philo Ridge Farm's practices throughout neighboring farms in the town.

	Soil attribute >			Quality			Macro nutrients					Micro nutrients						
	Field v		Type	OM	pH	CEC	P	K	Ca	Mg	S	Fe	Mn	B	Cu	Zn	Na	Al
2015	Lower Island Grazing	PRF 1	P	5.1	6.9	20.0	2.4	162	2994	555	8	5.9	6.1	0.3	0.2	1.2	44	21
	Lower Island Grazing	PRF 1-2	P	4	6.7	15.1	2.1	138	2276	401	7	8.7	7.7	0.4	0.2	0.6	30	31
	Philo Rd Grazing Field	PRF 2	P	4	6.8	16.7	4.7	212	2436	474	8	7.5	5.8	0.6	0.3	0.9	38	19
	North Slope Crop Field	PRF 3	H	3.7	7.6	30.6	16.9	237	5560	263	8	3.9	11.4	0.9	0.2	1.1	15	10
	Middle East Field (Sou	PRF 5-3	H	4	7	18.8	1.5	137	2398	772	7	4.9	6.1	0.3	0.2	0.4	40	24
	Sheep Grazing East Sl	PRF 6	P	3.3	6.6	11.3	1.4	105	1890	193	7	2.6	7.4	0.5	0.2	0.9	36	13
	Muddy Brook Lowland	PRF 7	P	4.7	7.3	25.9	2.1	127	4107	610	9	2.6	7	0.7	0.2	0.7	67	13
	Muddy Brook West Slo	PRF 8	P	3.7	7.4	22.8	3.9	224	3429	609	8	3.2	7.2	0.9	0.2	0.8	43	14
			Chg OM															
2017	Lower Island Grazing Fi	PRF 1	17%	6.0	7.1	20.8	3.3	151	3088	593	10.0	7.9	5.6	0.4	0.2	0.6	42.0	26.0
	Lower Island Grazing Fi	PRF 1-2	26%	5.1	6.8	14.2	3.0	145	2092	406	7.0	6.8	4.2	0.4	0.2	3.3	28.0	29.0
	Philo Rd Grazing Field	PRF 2	42%	5.7	6.9	17.0	7.3	214	2477	487	8.0	5.7	4.7	0.6	0.2	1.1	31.0	16.0
	North Slope Crop Field	PRF 3	34%	5.0	6.5	16.2	1.4	156	2412	449	6.0	7.7	4.9	0.2	0.2	0.6	24.0	38.0
	Middle East Field (Nort	PRF 5-3	40%	5.6	6.9	17.5	1.9	142	2176	748	5.0	4.1	3.6	0.2	0.1	0.4	44.0	26.0
	Middle East Field (Mid	PRF 6	37%	4.5	6.8	11.1	1.7	84	1817	221	7.0	2.0	3.9	0.5	0.1	0.7	28.0	12.0
	Middle East Field (Sout	PRF 7	71%	8.1	7.2	25.9	3.0	168	3988	662	9.0	2.6	3.6	0.7	0.2	0.7	59.0	14.0
	Sheep Grazing East Slo	PRF 8	76%	6.5	7.2	21.7	6.4	274	3175	610	9.0	3.5	5.2	0.9	0.2	0.9	35.0	12.0

Change in Micronutrient Content, PRF3

Year	Fe	Mn	B	Cu	Zn	Na	Al	Ca	K
2015	3.9	7.2	0.9	0.2	1.1	15	10	90.9	2
2017	7.7	22.2	0.2	0.2	0.6	24	38	71.7	2.4
Percentage Change	97	208	-350	0	-45	60	280	-22	20


Change in Macronutrient Phosphorus (2015-2017)


Change in Macronutrient Sulfur (2015-2017)

Cartographer: Josie Watson
Course: Introduction to GIS
Date: May 7th, 2018
Projection: NAD 1983 StatePlane Vermont FIPS 4400
GCS: North American 1983
Tufts University

Analysis & Discussion

In two short years, Integrated Livestock Management (ILM) has made a significant difference on the nutrient content of Philo Ridge Farm soils. A diverse range of change can be observed throughout the farm, the majority of which is positive. The corner field 8, middle field 3 and largest field 5 experienced an overall decrease in macronutrients. The data shows that this is due to large, isolated decreases in Potassium, Calcium and Magnesium, which can likely be traced to factors outside of livestock introduction.

Alvez and his team stress that these changes are the consequence of easy, inexpensive changes to livestock grazing patterns, and reduced the farm's need for overall fertilizer inputs. It is clear that ILM, a soil building strategy, is also one that promises to improve the bottom lines of farming operations. One of the huge benefits of mapping this data, rendering it comprehensible and visually engaging, is that the positive changes generated by ILM can be communicated to neighboring farms in Vermont, and state legislators currently debating whether or not to develop and support effective farm Bills. Advocacy groups like Soil 4 Climate and the Northeast Organic Farming Association have developed regenerative soil legislation for Vermont, which would establish knowledge hubs and other capacities farmers could consult to help reform their practices to restore their soil health. Displays of successful case study results like Philo Ridge Farm can be used to persuade legislators to enact these policies and lead to sustainable farm reform.

Limitations

The main limitation I had for accurately depicting soil quality change across these fields was the generalization of the soil test results. I was given data of element change that was averaged around the centroid point of each field. I therefore am making a generalization across multiple acres of land when I assign an element change attribute to each polygon. With more detailed data, I would have generated raster layers from tables of soil quality across every square meter of each field and displayed change across a raster gradient. Additional challenges I faced included an inability to edit attribute tables in Editor after performing joins, which required that I input details needed for each nutrient map before performing any joins.

Recommendations for Future Projects

As they stand, these maps could be greatly enhanced by using knowledge of soil erosion patterns to map other factors in the area that could be contributing to soil organic matter change over time. The Universal Soil Loss Equation could be used to determine which factors should be mapped and spatially analyzed. For instance, if rainfall and watershed patterns, proximity to roads and discharge areas, surrounding soil characteristics, farming practices and landscape features could all be factored in to gain a more holistic picture of why soil quality changed in the way it did.

Sources

1. **Vermont Geodata open portal:** Charlotte Zoning, Soil Quality data <http://maps.vcgi.vermont.gov/gisdata/metadata/GeologicSoils_SOAG.htm#1>
2. **The University of Vermont Extension Soil Testing Lab**: Juan Alvez, UVM Pasture Program. <http://www.philoridgefarm.com/news-1/2016/6/16/philo-ridge-farm-collaborates-on-long-term-research-projects-with-uvm>
3. **ArcGIS portal :** Vermont imagery basemap
4. **Integrated Livestock Management background:** Teague, W.R., et al. "The role of ruminants in reducing agriculture's carbon footprint in North America." Journal of Soil and Water Conservation, vol. 71, no. 2, Mar. 2016, pp. 156–163.,
5. **Macronutrient information:** P. J. White, P. H. Brown; Plant nutrition for sustainable development and global health, Annals of Botany, Volume 105, Issue 7, 1 June 2010, Pages 1073–1080