Monitoring Soil Response to Decreasing Acidic Deposition in a Western Adirondack Tributary Over a 16 Year Period

Prepared by

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Acidic Deposition

- Acid Rain is referring to the wet deposition of nitric and sulfuric acids (power generation industry)

Acid rain …

1) Lowers the pH of soils and water
2) Causes leaching of nutrients from soils
3) Lowers the stress tolerance of vegetation
4) Mobilize toxic Aluminum

Other Adirondack Resampling Findings

Site	pH	Al	Mg^{2+} & Ca^{2+}	Na^{+}	Conclusion
Big Moose G. Lawrence 1992 - 2004	Decreased	Increased	No change	Decreased	More Acidic
DDRP Sites R. Warby 1984 – 2001	Decreased	Increased	Decreased	Decreased	More Acidic
Adirondacks A. Johnson 1930-1984-2004	Decreased (storage effect?)	Increased	Ca^{2+} decreased	Did not measure	More Acidic

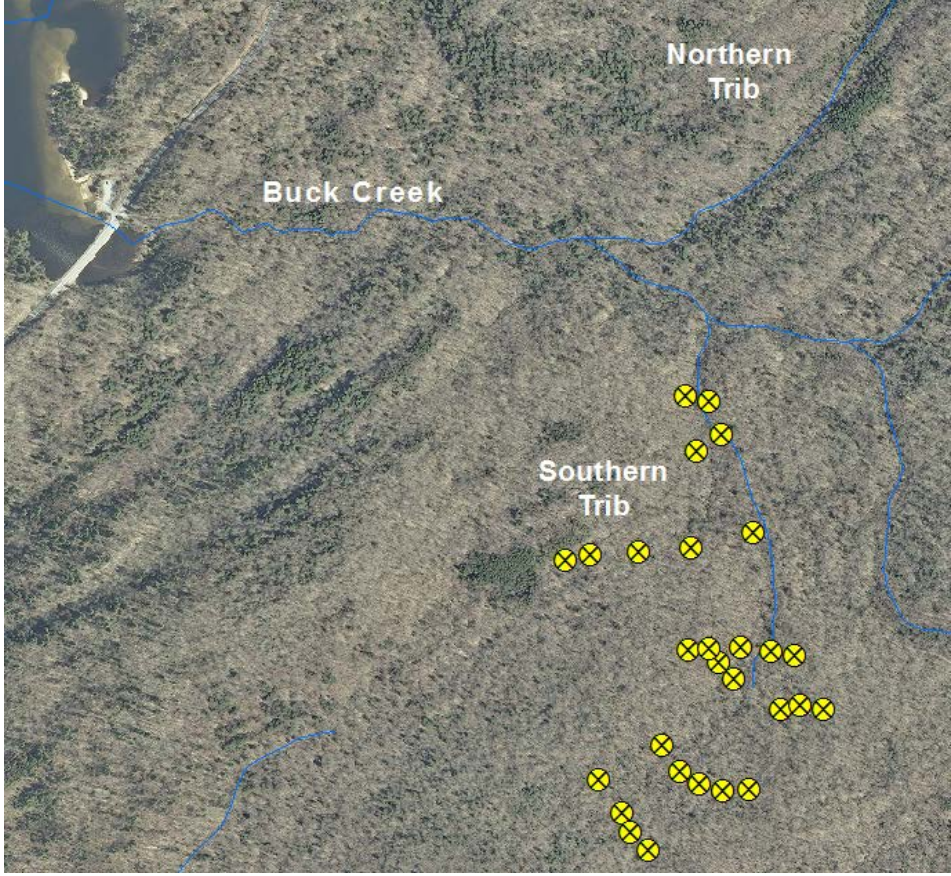
Thesis Methodology

- 2014 resampled 28 of 30 soil sites originally established in 1998 by Greg Lawrence

- Soil sampling was repeated using the same techniques employed in the 1998 study

- Analysis was done to analyze pH, exchangeable Al and H, Ca concentration, Mg concentration, Na concentration, K levels, % Loss of Ignition, total % N, and total % C

- Important to monitor the recovery of soil and streams in areas that were most affected by deposition. Monitoring and analysis of nutrient concentrations are essential to assessing trends in recovery.



Sampling

- Sampling was repeated in the Southern Tributary (Basic Buck) of the Buck Creek Watershed (Hamilton County, NY)
  - predominantly hardwoods

- Samples were collected from the middle of the Oe & Oa horizons, as well as the upper 10cm of the B horizon.

- Sampling, in-lab preparation, and analysis followed the same procedures as Lawrence in 1998

(Exchangeable Al & pH analyzed at UVM)

Re-Runs/Archived Samples

- 27 of the original 90 samples (9 - Oe, Oa, B) were retrieved from archives and reanalyzed to evaluate possible errors associated with laboratory analyses or long term storage.

- The most recent analysis of the ‘98 samples was assumed to be most accurate with the exception of pH and exchangeable H^+.

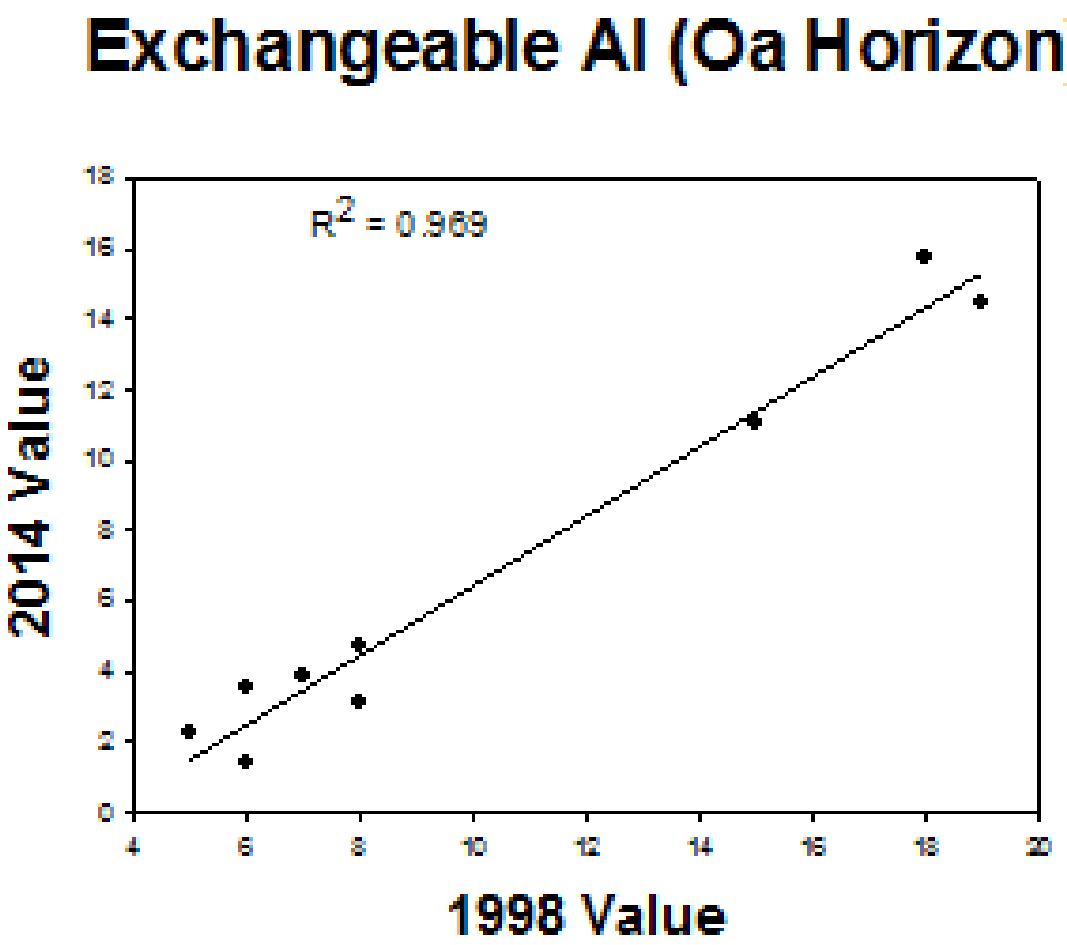
- ‘98 original data were matched up with re-runs of the same samples. Any results with a significant ($p<0.05$) difference were plotted on a linear regression and adjusted for bias.

- Then current 2014 samples were compared against the adjusted 1998 values. Significant changes ($p< 0.05$) seen were assumed to be due to natural processes rather than due to error.

Exchangeable Al (Oa Horizon)

Transect	Pit	Horizon	1998 Value	2014 Re-Run	= -3.424 + (0.988 * Ex Al 98)
1	1	Oa	5		
1	2	Oa	5		
1	3	Oa	Missing	Missing	Missing
1	4	Oa	6	3.51	3.51
1	5	Oa	7		
2	1	Oa	5		
2	2	Oa	7	3.87	3.87
2	3	Oa	12		
2	4	Oa	11		
2	5	Oa	17		
3	1	Oa	7		
3	2	Oa	9		
3	3	Oa	11		
3	4	Oa	6		
3	5	Oa	15	11.07	11.07
4	1	Oa	14		
4	2	Oa	4		
4	3	Oa	8	3.13	3.13
4	4	Oa	6		
4	5	Oa	19	14.49	14.49
5	1	Oa	7		
5	2	Oa	9		
5	3	Oa	7		
5	4	Oa	18	15.76	15.76
5	5	Oa	7		
6	1	Oa	5	2.21	2.21
6	2	Oa	16		
6	3	Oa	8	4.71	4.71
7	1	Oa	6	1.36	1.36
7	2	Oa	4		0.53

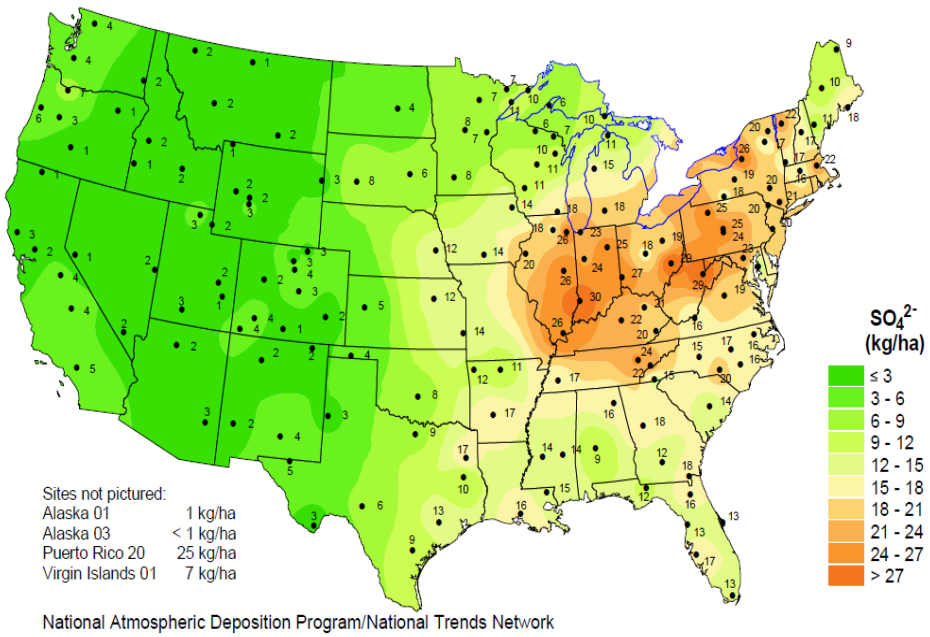
Regression Example



Transect	Pit	Horizon	1998 Value	2014 Re-Run	= -3.424 + (0.988 * Ex Al 98)
1	1	Oa	5		1.52
1	2	Oa	5		1.52
1	3	Oa	Missing	Missing	Missing
1	4	Oa	6	3.51	3.51
1	5	Oa	7		3.49
2	1	Oa	5		1.52
2	2	Oa	7	3.87	3.87
2	3	Oa	12		8.43
2	4	Oa	11		7.44
2	5	Oa	17		13.37
3	1	Oa	7		3.49
3	2	Oa	9		5.47
3	3	Oa	11		7.44
3	4	Oa	6		2.50
3	5	Oa	15	11.07	11.07
4	1	Oa	14		10.41
4	2	Oa	4		0.53
4	3	Oa	8	3.13	3.13
4	4	Oa	6		2.50
4	5	Oa	19	14.49	14.49
5	1	Oa	7		3.49
5	2	Oa	9		5.47
5	3	Oa	7		3.49
5	4	Oa	18	15.76	15.76
5	5	Oa	7		3.49
6	1	Oa	5	2.21	2.21
6	2	Oa	16		12.38
6	3	Oa	8	4.71	4.71
7	1	Oa	6	1.36	1.36
7	2	Oa	4		0.53

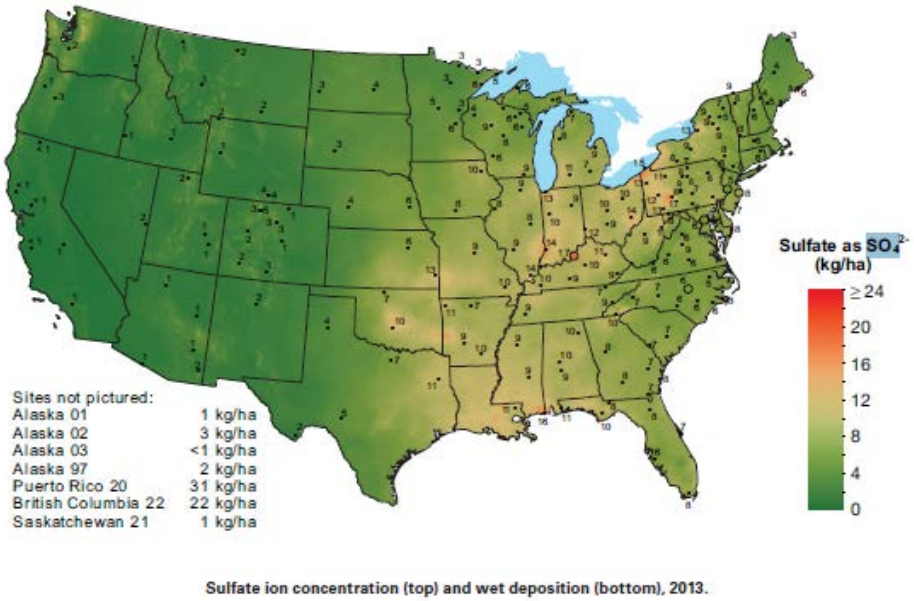
Decrease in SO_4^{2}

1998 NADP SO_4^{2}



National Atmospheric Deposition Program/National Trends Network

2014 NADP SO_4^{2}



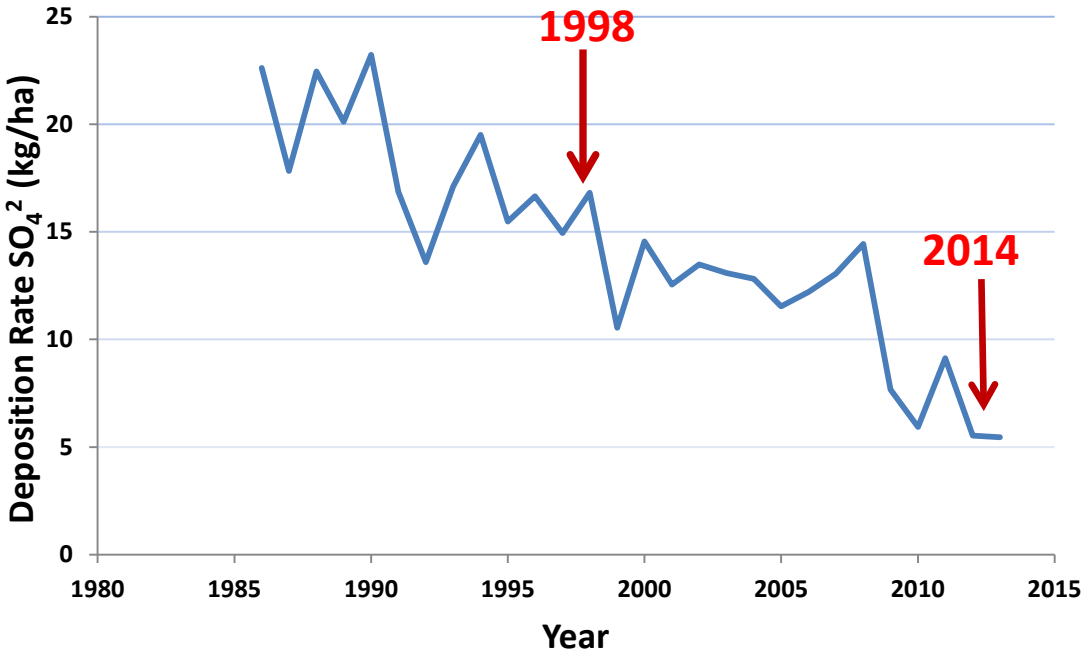
Sulfate ion concentration (top) and wet deposition (bottom), 2013.

Annual SO_4^{2} deposition at (NY-20) in 1998 = 16.81 kg/ha

Annual SO_4^{2} deposition at (NY-20) in 2014 = 5.46 kg/ha

Source: **National Atmospheric Deposition Program/NTN**

Where the sampling fits in



Annual SO_4^2 deposition at (NY-20) in 1998 = 16.81 kg/ha
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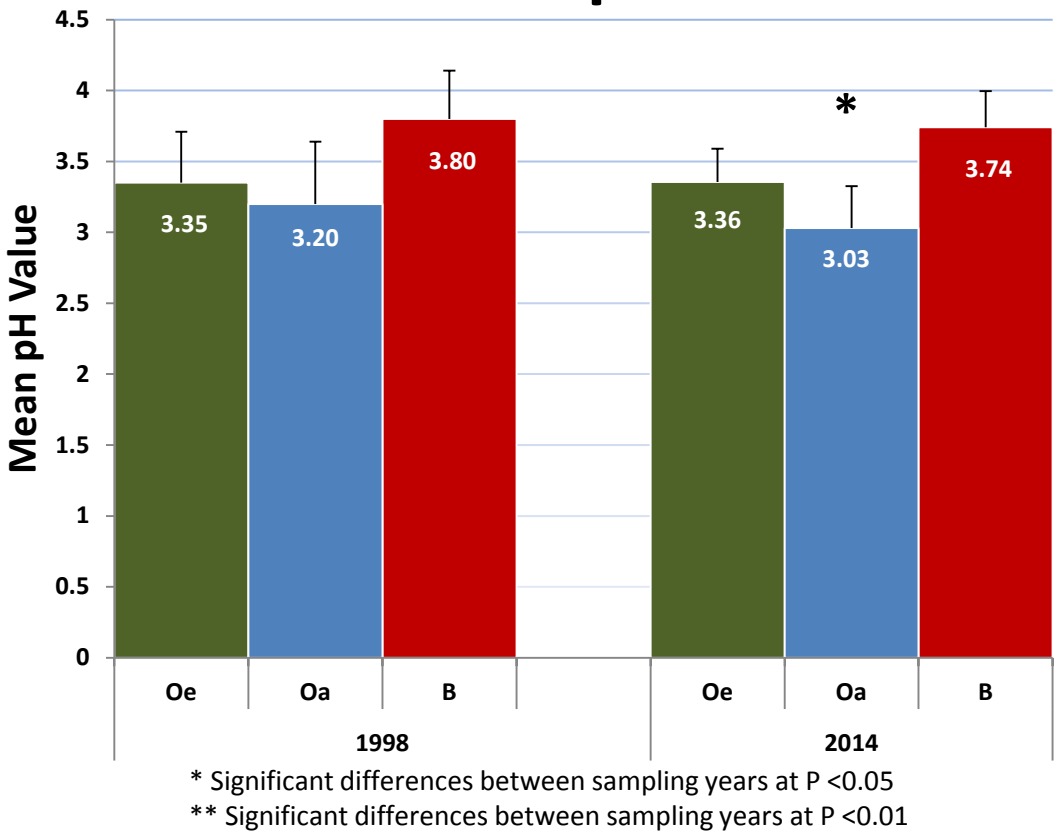
Source: **National Atmospheric Deposition Program/NTN**

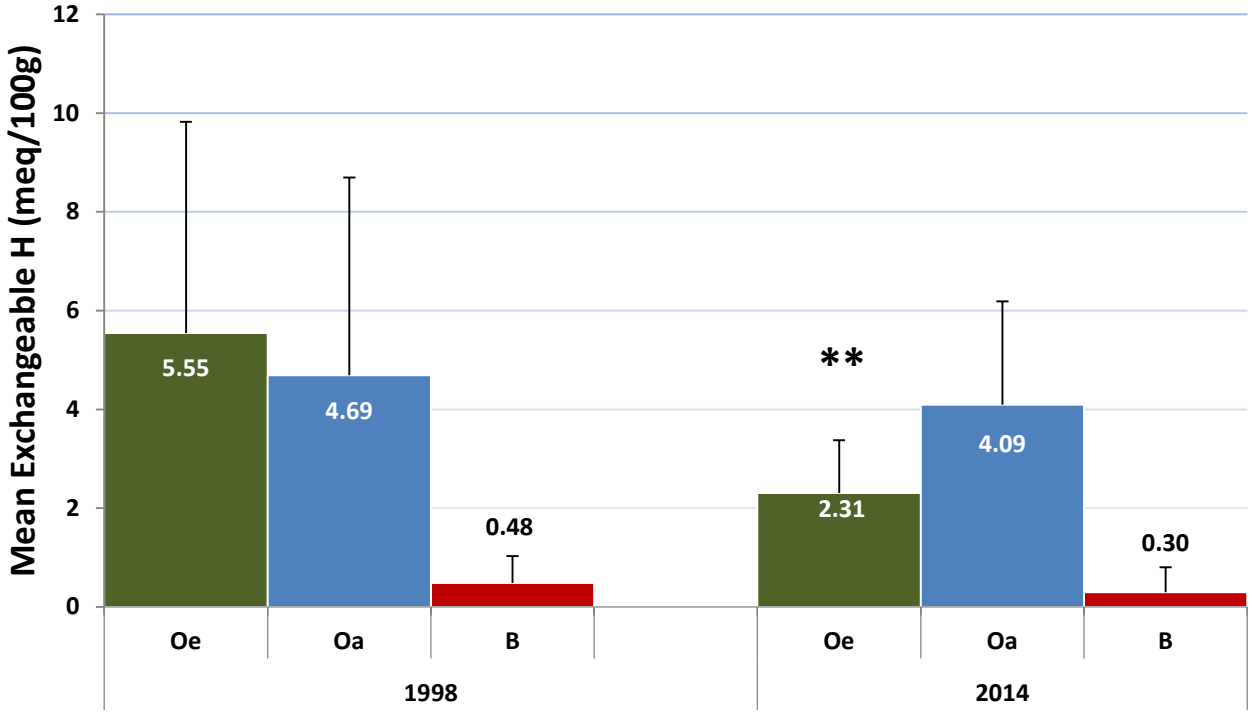
Soil pH



* Significant differences between sampling years at P <0.05
** Significant differences between sampling years at P <0.01

- No difference in pH of the Oe or B Horizon.
- Decrease in Oa horizon, reasoning is unclear.

Exchangeable H^+



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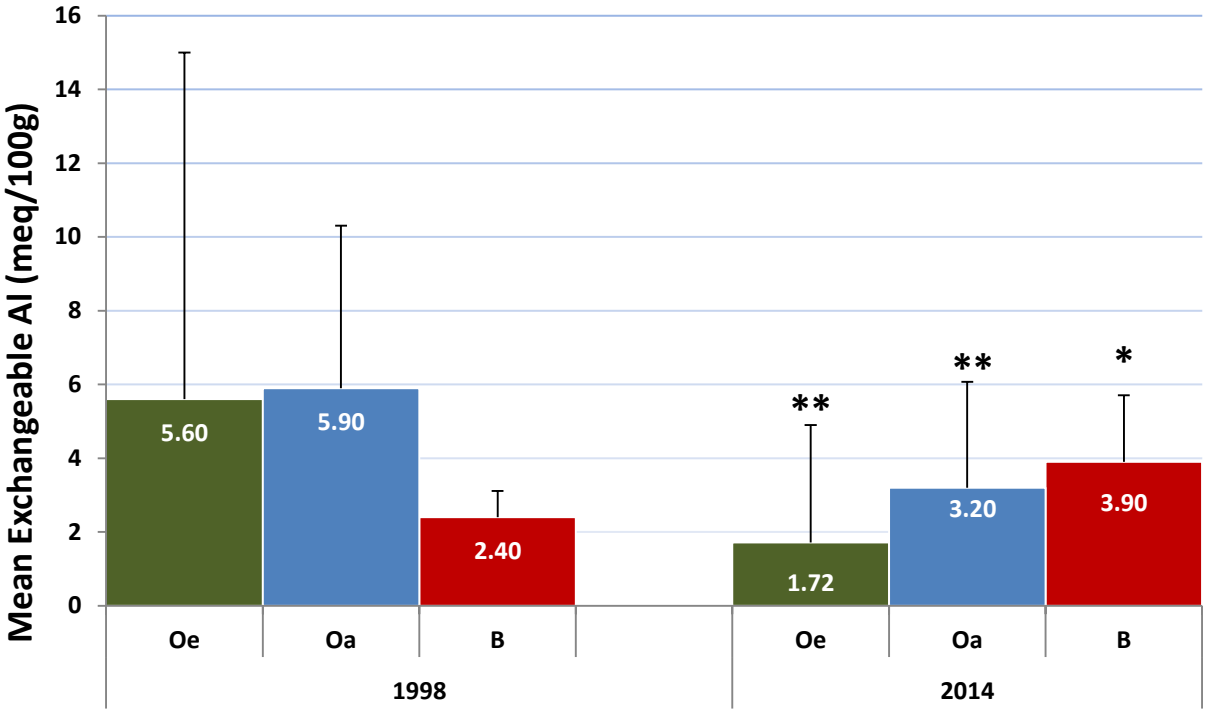
- Suggested decreases in all three horizons of exchangeable H^+ but only the Oe were significant.

- Some indication that the soils are becoming less acidic.

- Expect to see increases in pH over time, however, that is not the case.

Exchangeable Al



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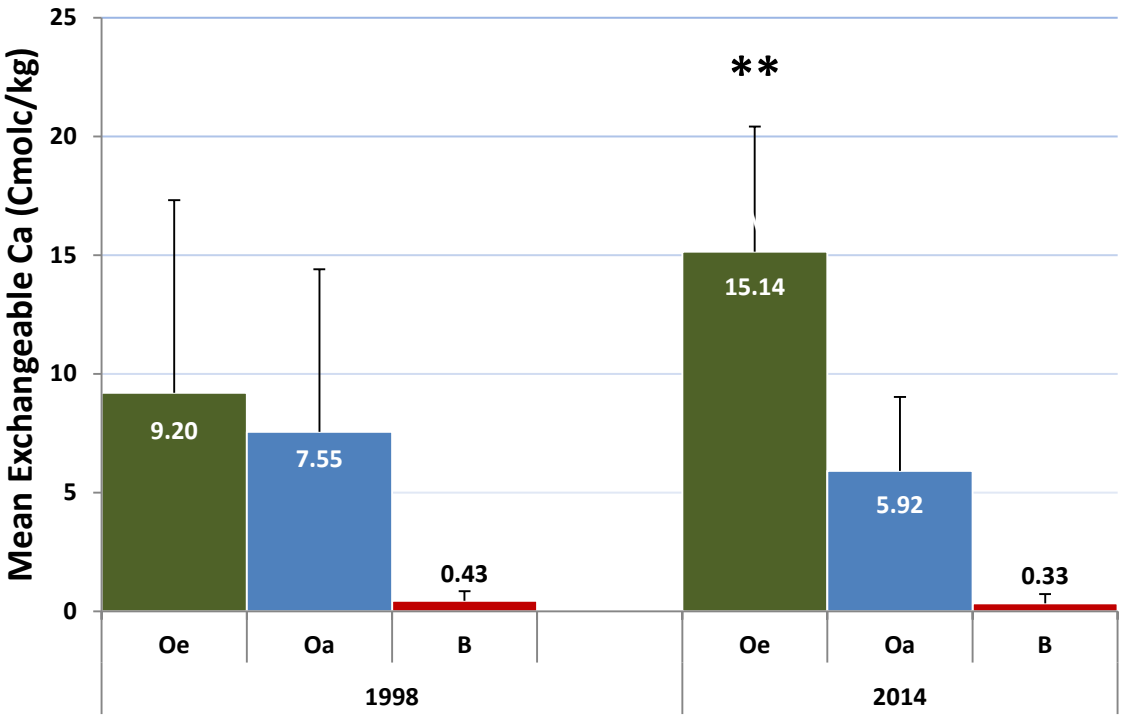
** Significant differences between sampling years at P <0.01

- Decrease of Exchangeable Al is observed in Oe & Oa Horizon.

- Decreases in Oe and Oa concentrations suggest recovery, but the B horizon response differs.

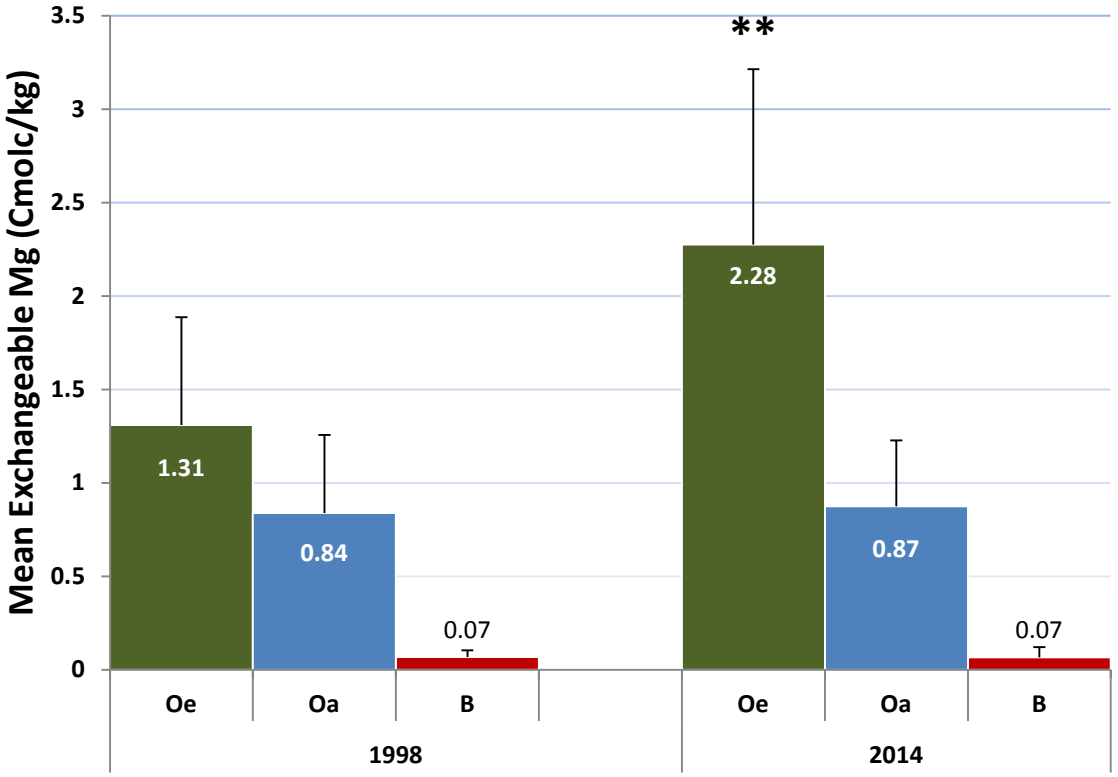
Exchangeable Ca^{2+}



* Significant differences between sampling years at P <0.05
** Significant differences between sampling years at P <0.01

- Large increase of Ca^{2+} in the Oe Horizon suggests that Ca uptake by vegetation has increased.

Exchangeable Mg^{2+}



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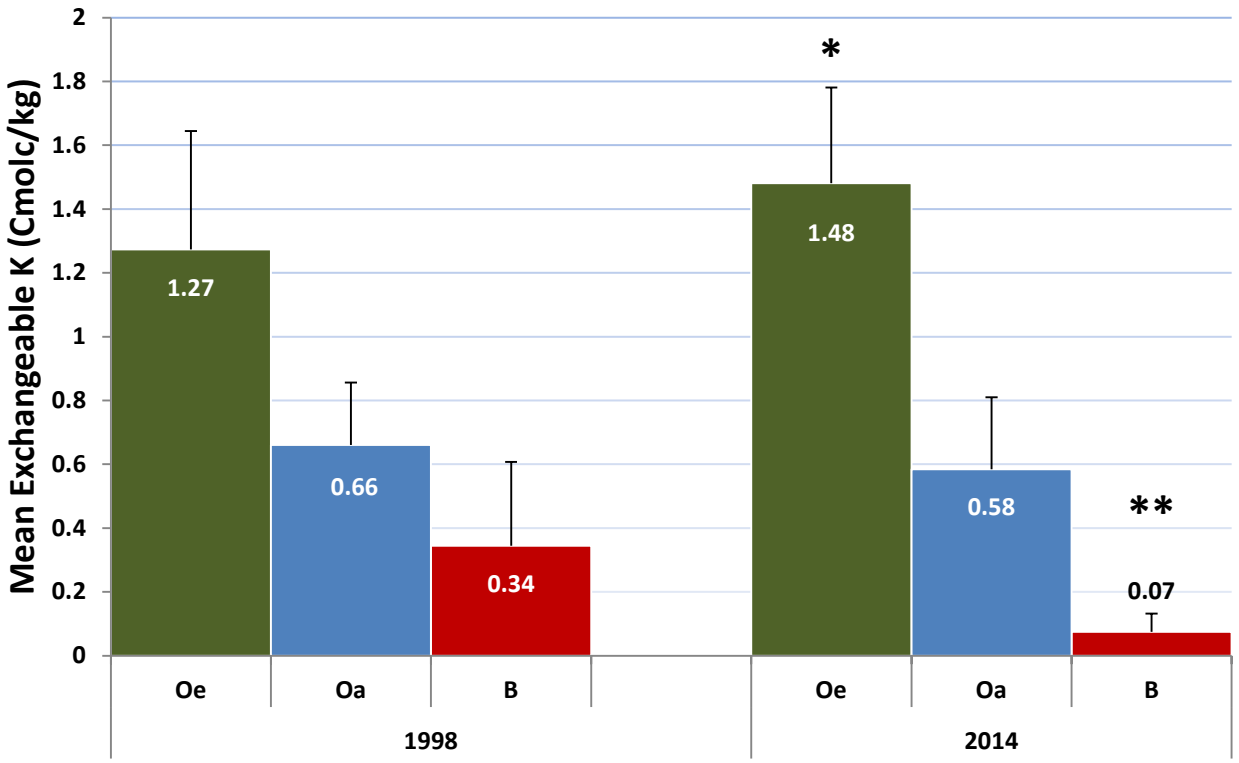
** Significant differences between sampling years at P <0.01

- Large increase Mg^{2+} in Oe Horizon is similar to the Ca increase.

- Increase in concentration of Mg^{2+} & Ca^{2+} in the Oe horizon along with observed decrease of Al in Oe indicates a decrease in acidity.

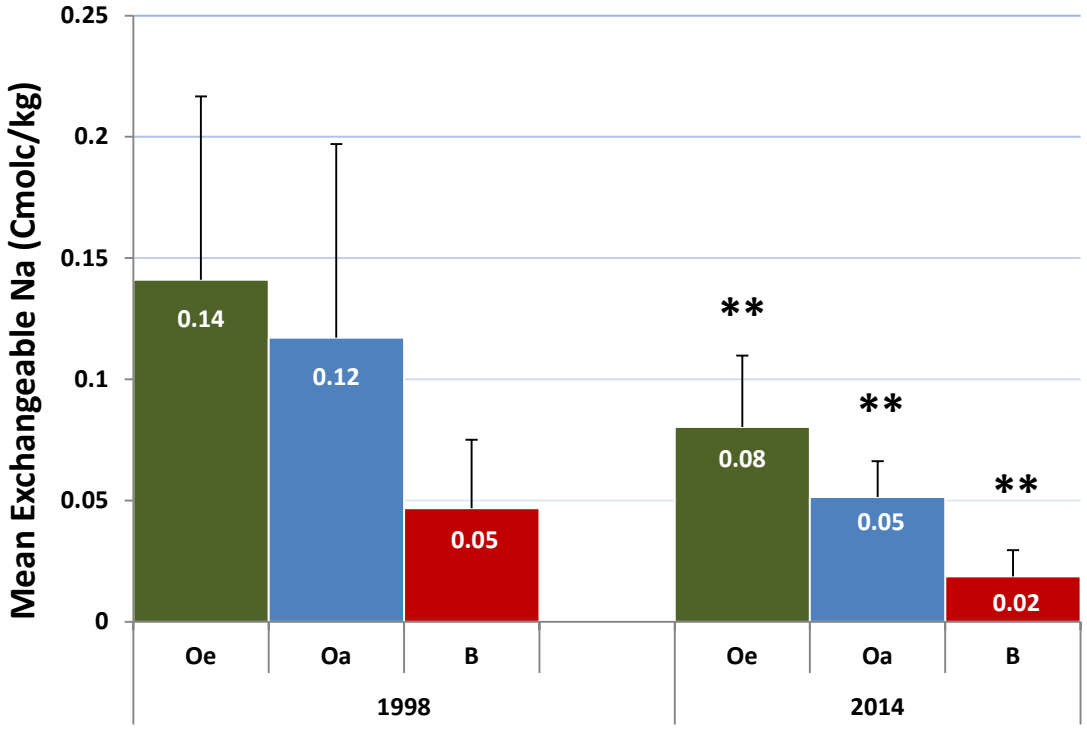
Exchangeable K^+



* Significant differences between sampling years at P <0.05
** Significant differences between sampling years at P <0.01

- Increase of K^+ in the Oe which suggests recovery differs with response of the B which suggests acidification.

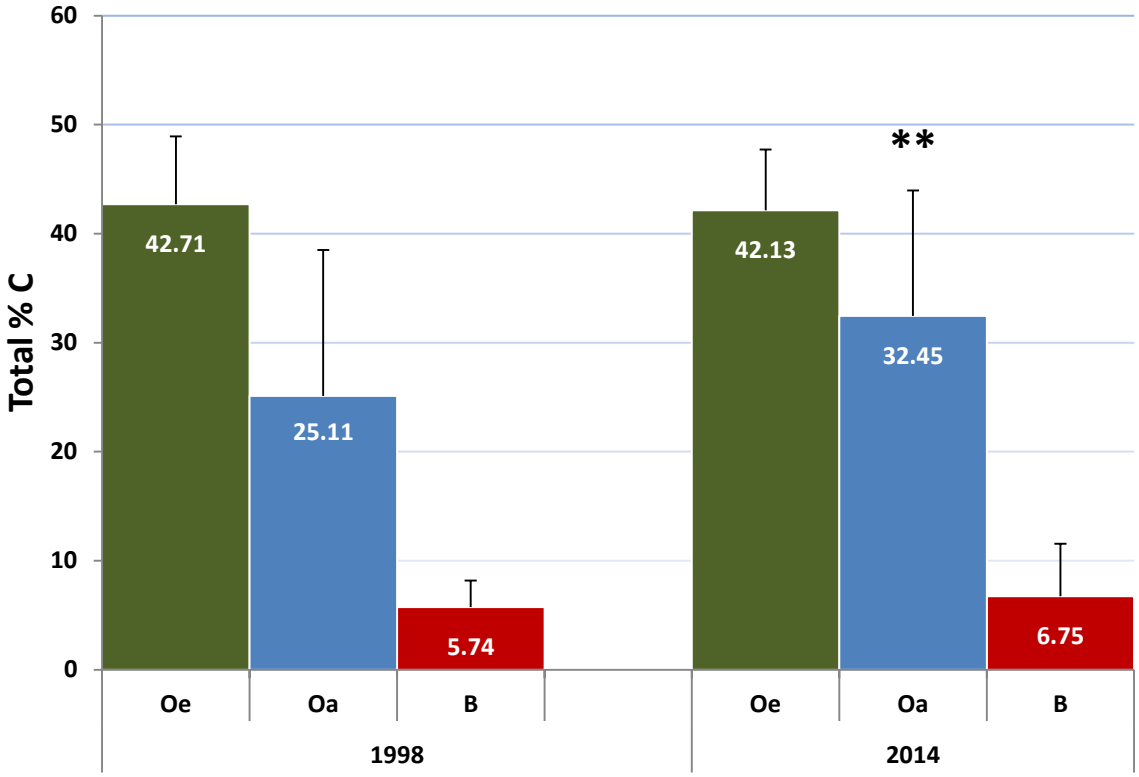
Exchangeable Na^+



* Significant differences between sampling years at P <0.05
** Significant differences between sampling years at P <0.01

- Na^+ shows statistical decreases in all three horizons. Na^+ is fairly easily leached and continues to decrease under the declining acid rain trend.

Total % C



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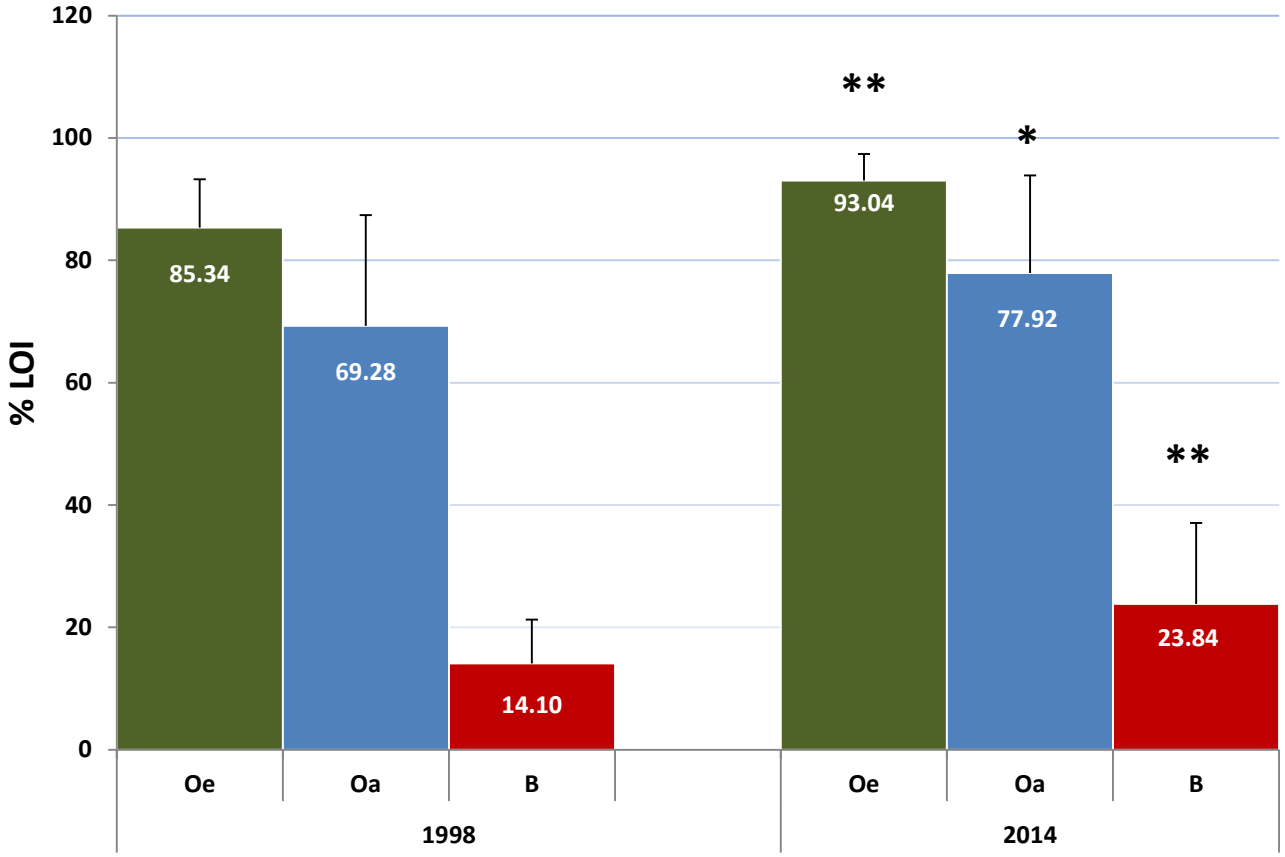
-A significant increase in Total % C is seen in only the Oa horizon.

% LOI



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-Results are similar to Organic C but changes are stronger.

Future Questions

- Will increased levels of organic matter coupled with decreased deposition of SO_4^{2-} eventually yield higher concentrations of Ca^{2+}/Mg^{2+} in the Oa and the B Horizon?

- Will base cations increase in the B horizon as dissolved organic matter works its way down from Oe→ Oa → B, creating opportunity for cation exchange?

- How long will it take for Ca^{2+} availability to increase in the B horizon, and how long will it take for exchangeable Al decrease?

- Are the significant decreases in Al concentrations of Oe and Oa horizons beneficial or harmful? Observed decreases in soil indicates an increased amount of Al leached to other parts of the watershed.

Citations

- Lawrence, Gregory B. "Early Indications of Soil Recovery from Acidic Deposition in U.S. Red Spruce Forests." *Soil Science Society of America Journal* 76 (2011): 1407-417. Print
- Johnson, A. H. "Seven Decades of Calcium Depletion in Organic Horizons of Adirondack Forest Soils." *Soil Science Society of America Journal* 72.6 (2008): 1824-830. Print.
- Warby, Richard A. "Continuing Acidification of Organic Soils Across the Northeastern USA :1984-2001." *Soil Science Society of America Journal* 73.1 (2009): 274-84. Print.
- *National Atmospheric Deposition Program: 1998 Wet Deposition*. Champaign, IL: Illinois State Water Survey, 2000. *National Atmospheric Deposition Program*. Web. 9 Mar. 2014.
- "2013 Annual Summary Report." *National Atmospheric Deposition Program 2013 Annual Summary* (2014): n. pag. *Illinois State Water Survey*. Web. 1 Mar. 2015.