Long-Term Monitoring Program for Evaluating Changes in Water Quality in Adirondack Lakes

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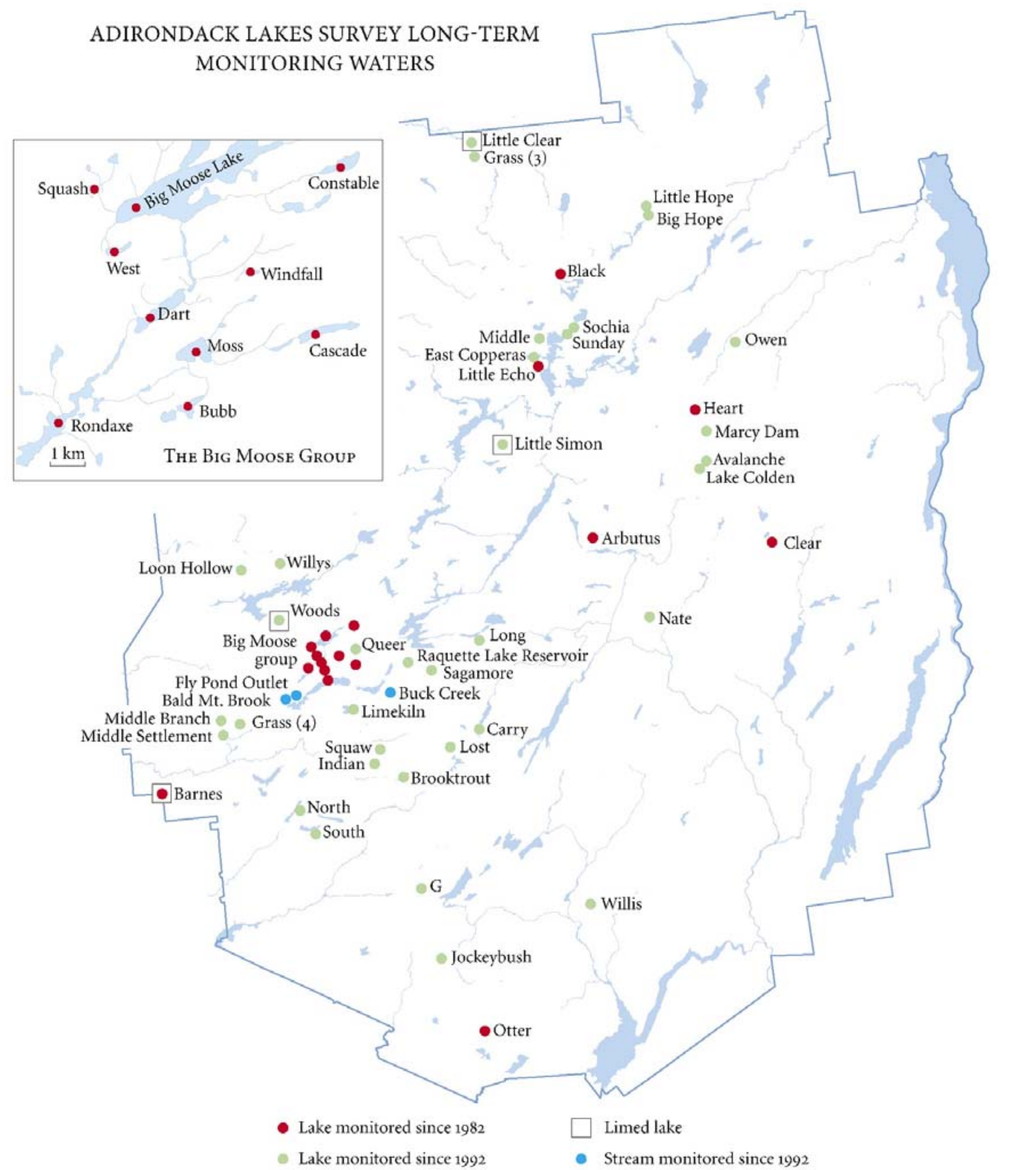
Adirondack Long Term Monitoring Program - 1982 to present

* Why? To monitor changes to ecosystems arising from acid rain precursors.

* How? Year-round sampling of 52 lakes on a monthly basis and 3 streams on a weekly basis.

Approach

» Monthly time series of lake chemistry
» Comparisons with other regions
» Comparisons between lake classes
» Aluminum trends and critical levels
» Weekly snowmelt chemistry
» Climatic effects/hydrology



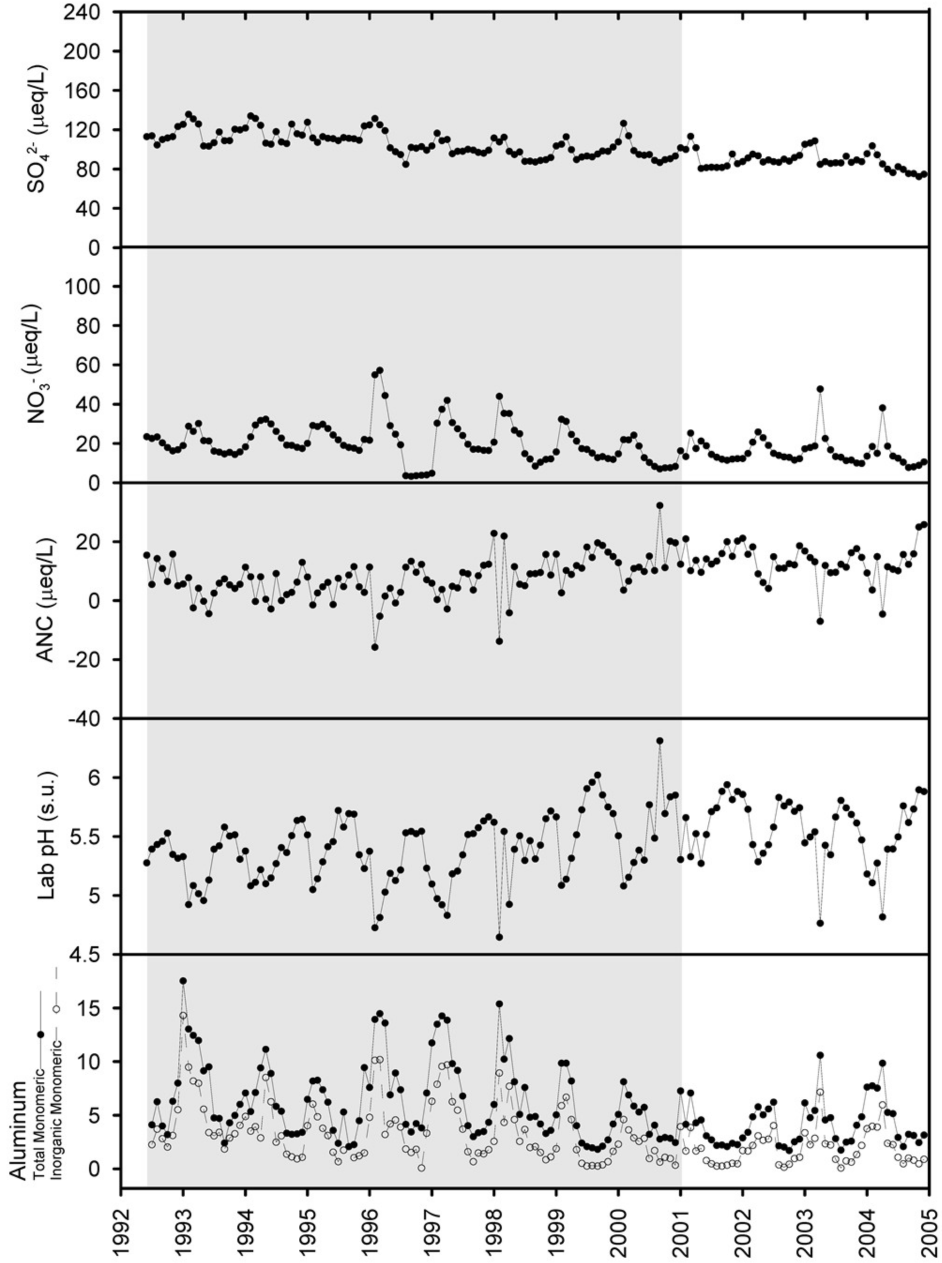
ADIRONDACK LAKES SURVEY LONG-TERM MONITORING WATERS
Squash
Big Moose Lake
Constable
West
Windfall
Dart
Moss
Cascade
Bubb
Rondaxe
1 km
The Big Moose Group
Little Clear
Grass (3)
Little Hope
Big Hope
Black
Middle
Sochia
Sunday
East Copperas
Little Echo
Owen
Heart
Marcy Dam
Little Simon
Avalanche
Lake Colden
Arbutus
Clear
Loon Hollow
Willys
Woods
Big Moose group
Queer
Long
Raquette Lake Reservoir
Sagamore
Nate
Fly Pond Outlet
Bald Mt. Brook
Buck Creek
Limekiln
Middle Branch
Middle Settlement
Grass (4)
Carry
Squaw
Indian
Lost
Brooktrout
Barnes
North
South
G
Willis
Jockeybush
Otter
Lake monitored since 1982
Lake monitored since 1992
Limed lake
Stream monitored since 1992

Trends of Adirondack Lakes Comparisons Over Time Periods, Lake Classes and With Other Studies

pH of wet deposition at NADP sites in the Adirondacks (Driscoll et al. 2003, 2005)

NADP Site	1979-1981	1998-2000	2001-2004
Huntington Forest	4.18	4.5	4.6
Whiteface Mountain	4.1	4.5	4.6

BIG MOOSE LAKE 1992 - 2004



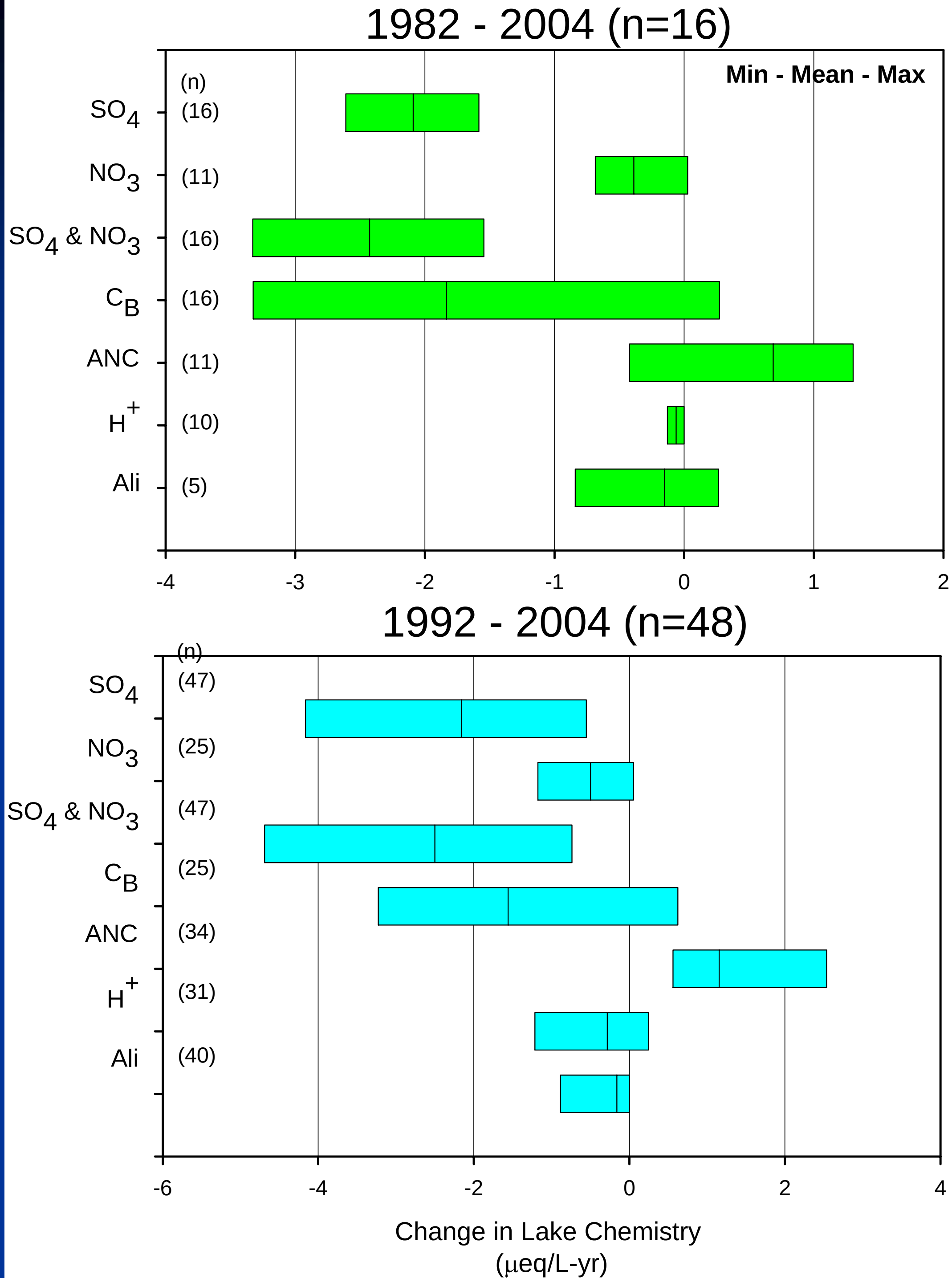
Graphic prepared by: Adirondack Lakes Survey Corporation 10/05

Significant Trends in ALTM Lakes

Values Are Mean Rates of Change $p < 0.10$

(units : µeq/L-yr, pH units, µmol/L-yr, µmol C/L-yr)

Time Period	SO_4^{2-} ↓	NO_3^- ↓	C_B ↓	ANC ↑	pH ↑	Al_{im} ↓	DOC ↑
1992-2000 48 lakes	44 -2.57	15 -1.03	26 -3.33	29 1.60	18 0.04	28 -0.31	7 15.7
1992-2004 48 lakes	47 -2.11	22 -0.50	24 -1.62	37 1.13	29 0.02	40 -0.16	12 9.6



1982 - 2004 (n=16)
Min - Mean - Max
(n)
SO4 (16)
NO3 (11)
SO4 & NO3 (16)
CB (16)
ANC (11)
H+ (10)
Ali (5)
-4 -3 -2 -1 0 1 2
1992 - 2004 (n=48)
(n)
SO4 (47)
NO3 (25)
SO4 & NO3 (47)
CB (25)
ANC (34)
H+ (31)
Ali (40)
-6 -4 -2 0 2 4
Change in Lake Chemistry
(µeq/L-yr)

ALTM Lake Classifications

(Hydrology, Flowpath, Chemistry, Watershed Characteristics)

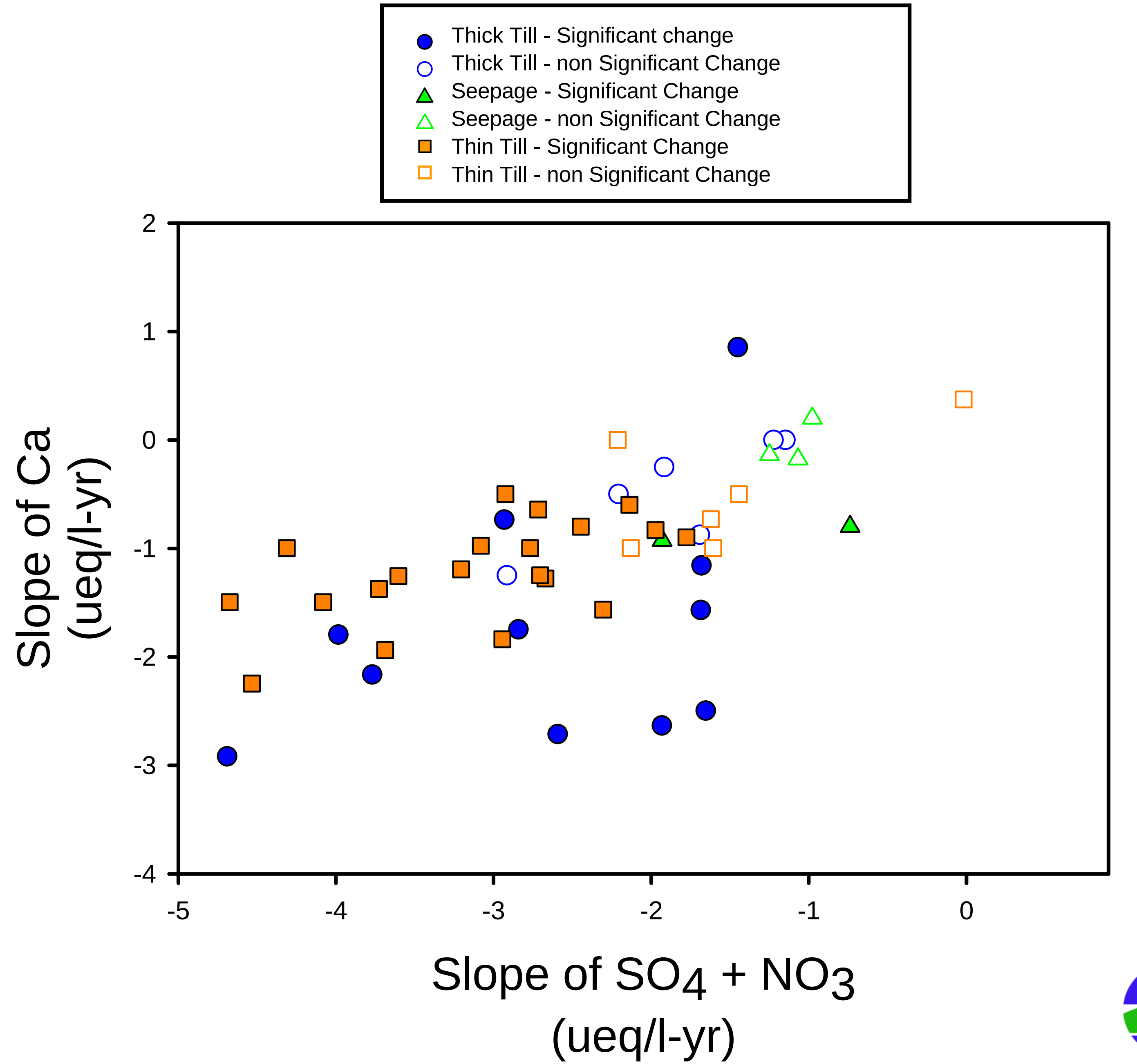
- Thick Till/Carbonate 5 lakes
- Medium Till 13 lakes
- Thin Till 27 lakes
- Mounded Seepage 7 lakes

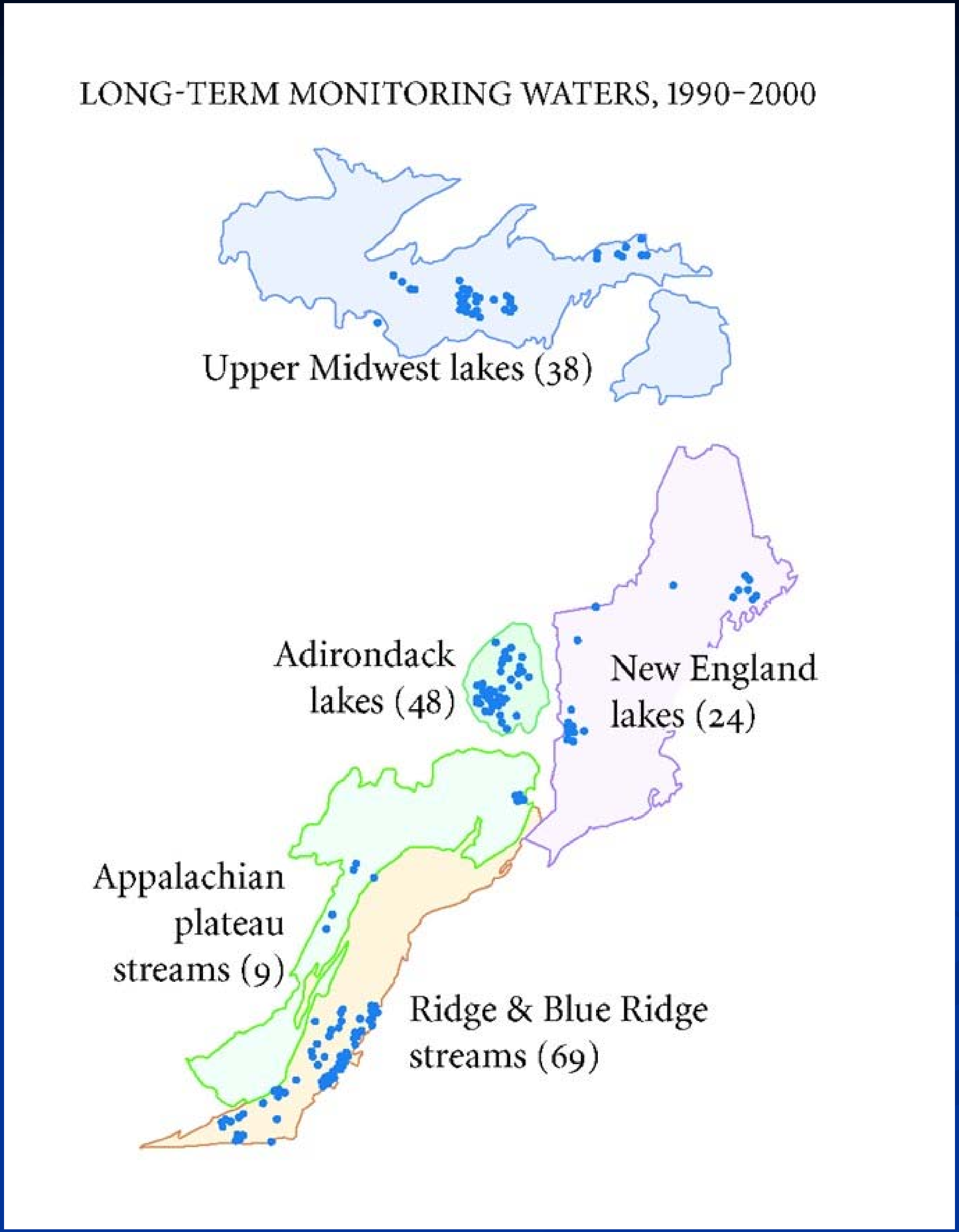
TOTAL 52 lakes

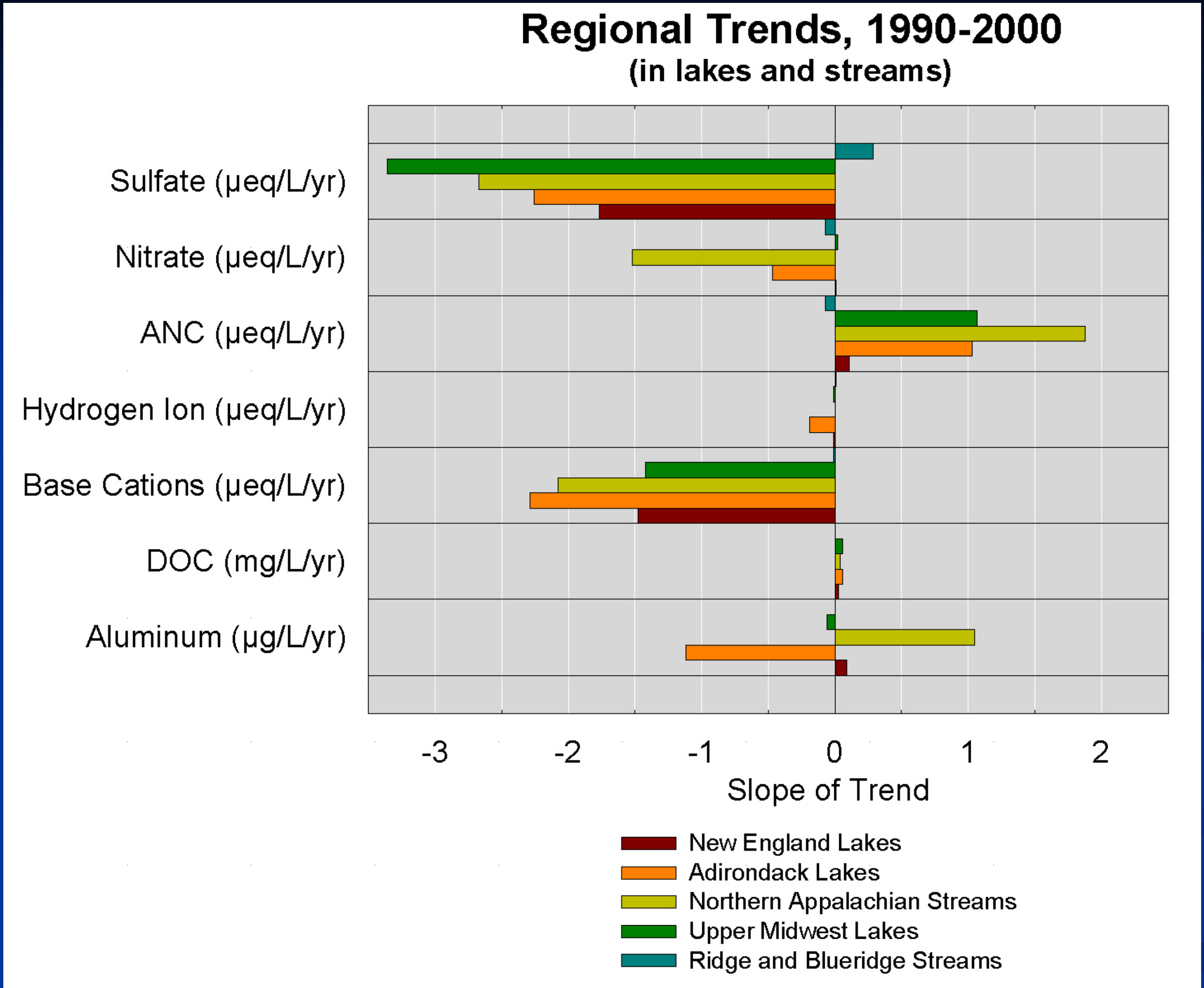
Acid-base Stoichiometry

$$\Delta ANC = \frac{\text{slope } ANC}{\text{slope } (SO_4^{2-} + NO_3^{-})}$$

$$\Delta C_B = \frac{\text{slope } C_B}{\text{slope } (SO_4^{2-} + NO_3^{-})}$$


Thick Till - Significant change
Thick Till - non Significant Change
Seepage - Significant Change
Seepage - non Significant Change
Thin Till - Significant Change
Thin Till - non Significant Change
Slope of Ca
(ueq/l-yr)
2
1
0
-1
-2
-3
-4
-5
-4
-3
-2
-1
0
Slope of SO4 + NO3
(ueq/l-yr)


LONG-TERM MONITORING WATERS, 1990-2000
Upper Midwest lakes (38)
Adirondack lakes (48)
New England lakes (24)
Appalachian plateau streams (9)
Ridge & Blue Ridge streams (69)



Stoddard et al. 2003. EPA Response of Surface Water Chemistry to the Clean Air Act Amendments of 1990

U.S. Trends (µeq/L – yr)

1990-2000 Stoddard et al. 2003

Region	SO_4^{2-}	NO_3^-	C_B	ANC
Adirondacks	-2.3	-0.5	-2.3	+1.0
New England	-1.8	NS	-1.5	NS
Appalachian	-2.3	-1.4	-3.4	+0.8
Upper Midwest	-3.4	NS	-1.4	+1.1
Ridge/Blue Ridge	0.3	-0.1	NS	NS

NS – Not Significant

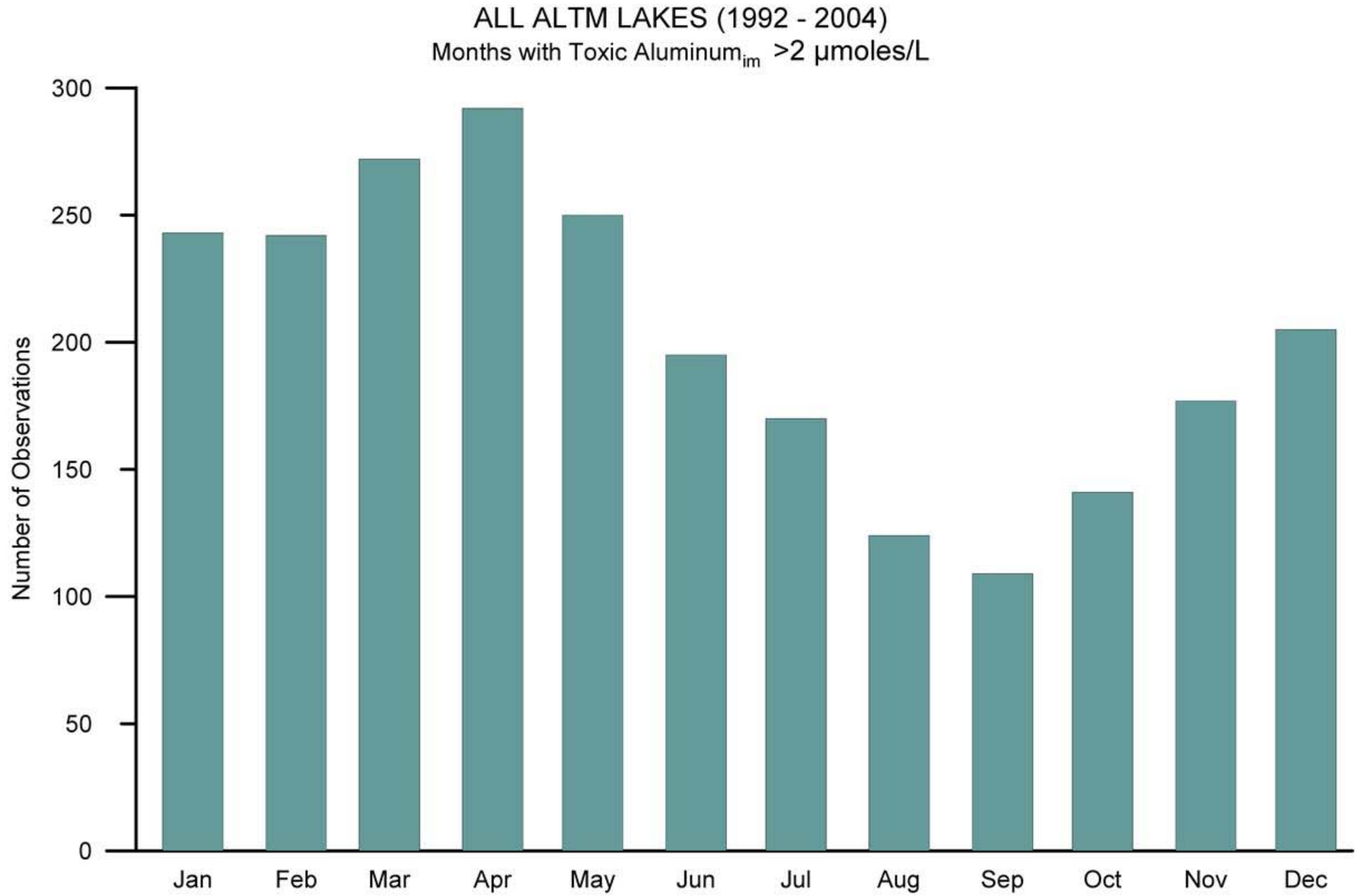
Critical Chemical Thresholds

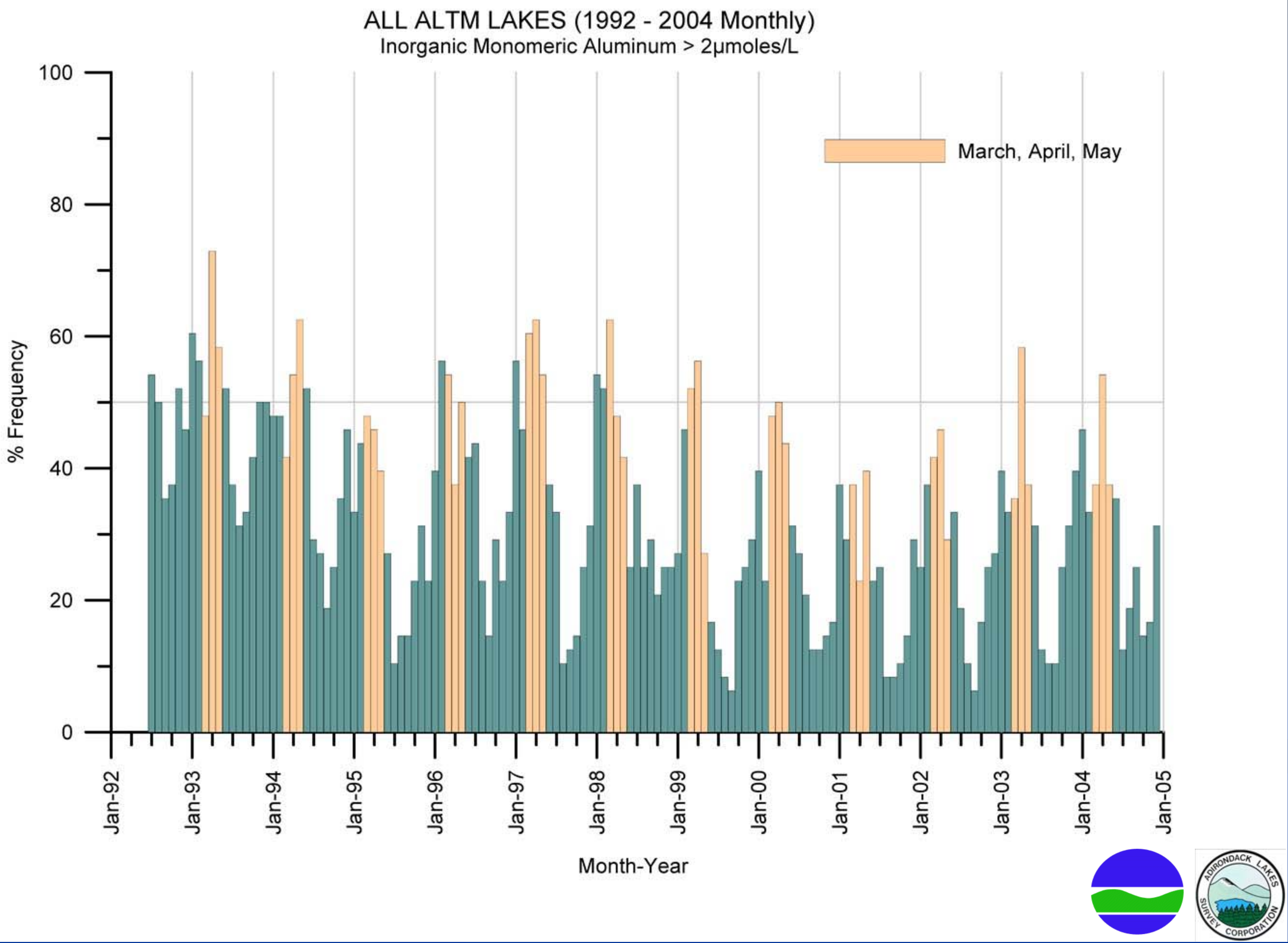
- pH less than 6.0
- ANC less than 50 $\mu eq\ L^{-1}$
- Al_{im} less than 2 $\mu mol\ L^{-1}$

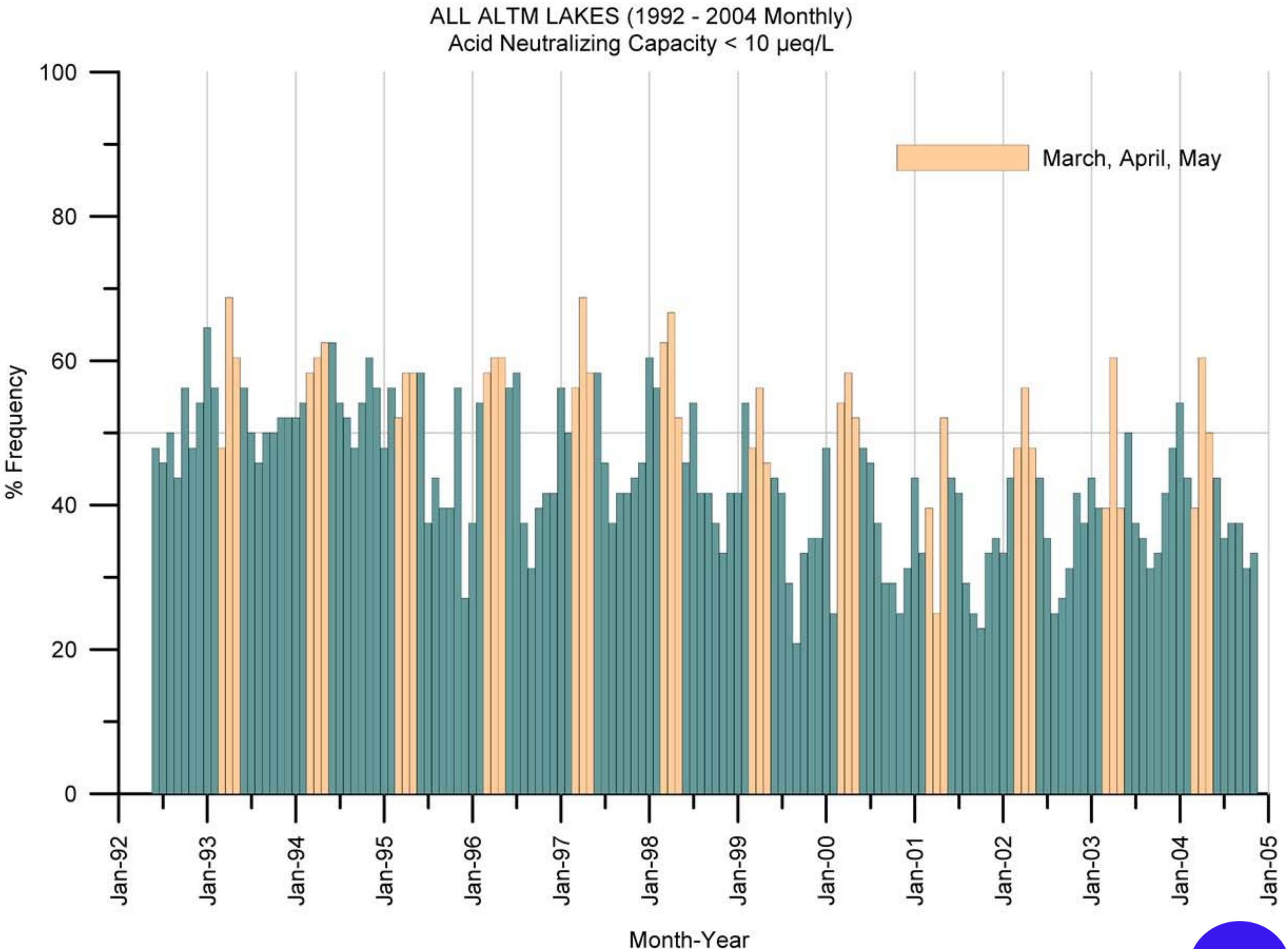
These indicate that aquatic biota are at risk from surface water acidification because of acidic deposition (Driscoll et al. BioScience Vol. 51, 2001).

Aluminum (Al_{im}) Trends in Lakes

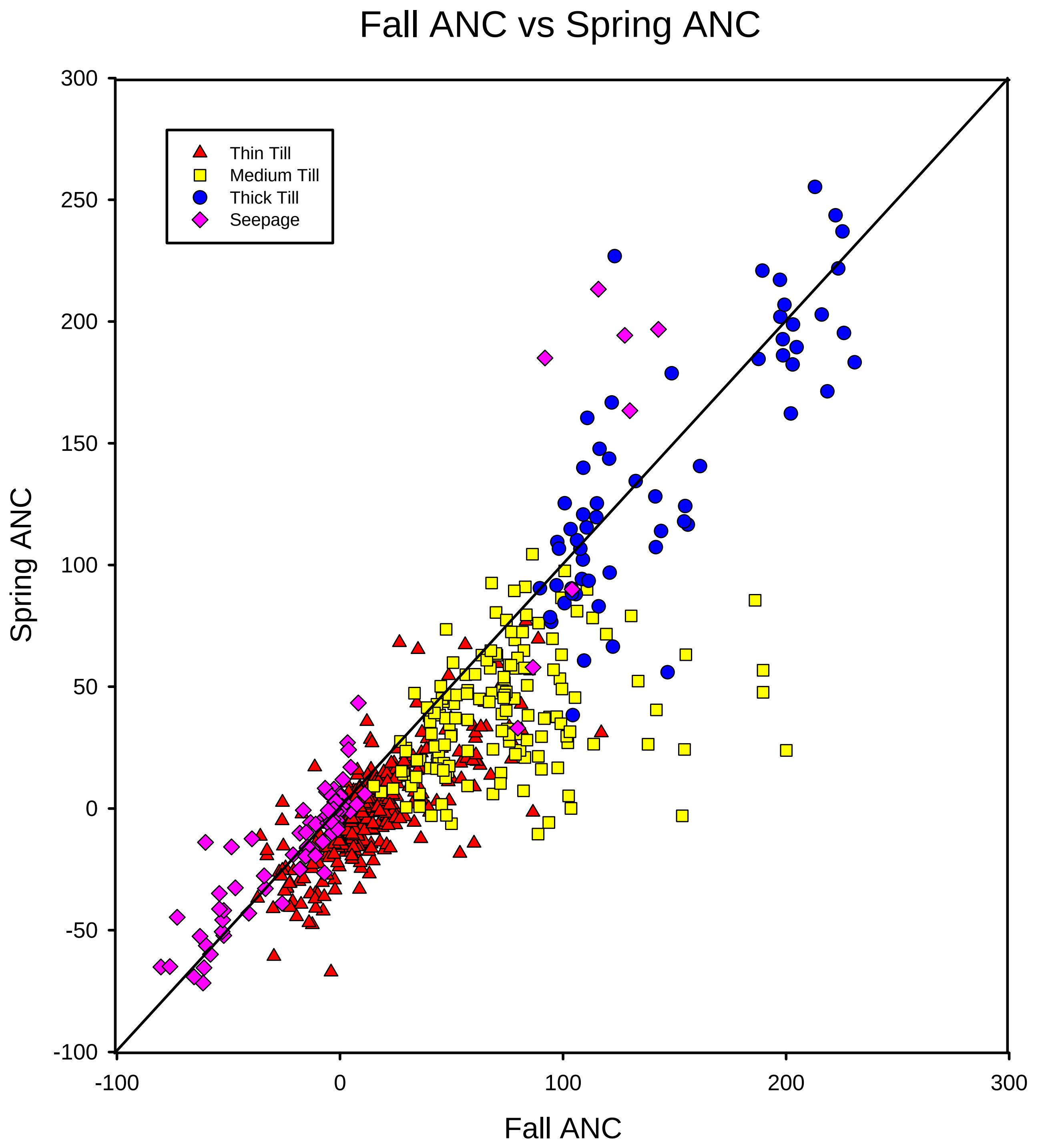
Year	Lakes With Decreasing Trend	Trend Mean (Range) µmols/L-yr	Lakes With Annual Value > 2 µmols/L
2000	28	-0.31 (-0.02 to -1.15)	16
2004	40	-0.16 (-0.02 to -0.89)	17


ALL ALTM LAKES (1992 - 2004)
Months with Toxic Aluminum$_{im}$ >2 µmoles/L
Number of Observations
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


ALL ALTM LAKES (1992 - 2004 Monthly)
Inorganic Monomeric Aluminum > 2µmoles/L
March, April, May
% Frequency
0
20
40
60
80
100
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Month-Year
ADIRONDACK LAKES SURVEY CORPORATION



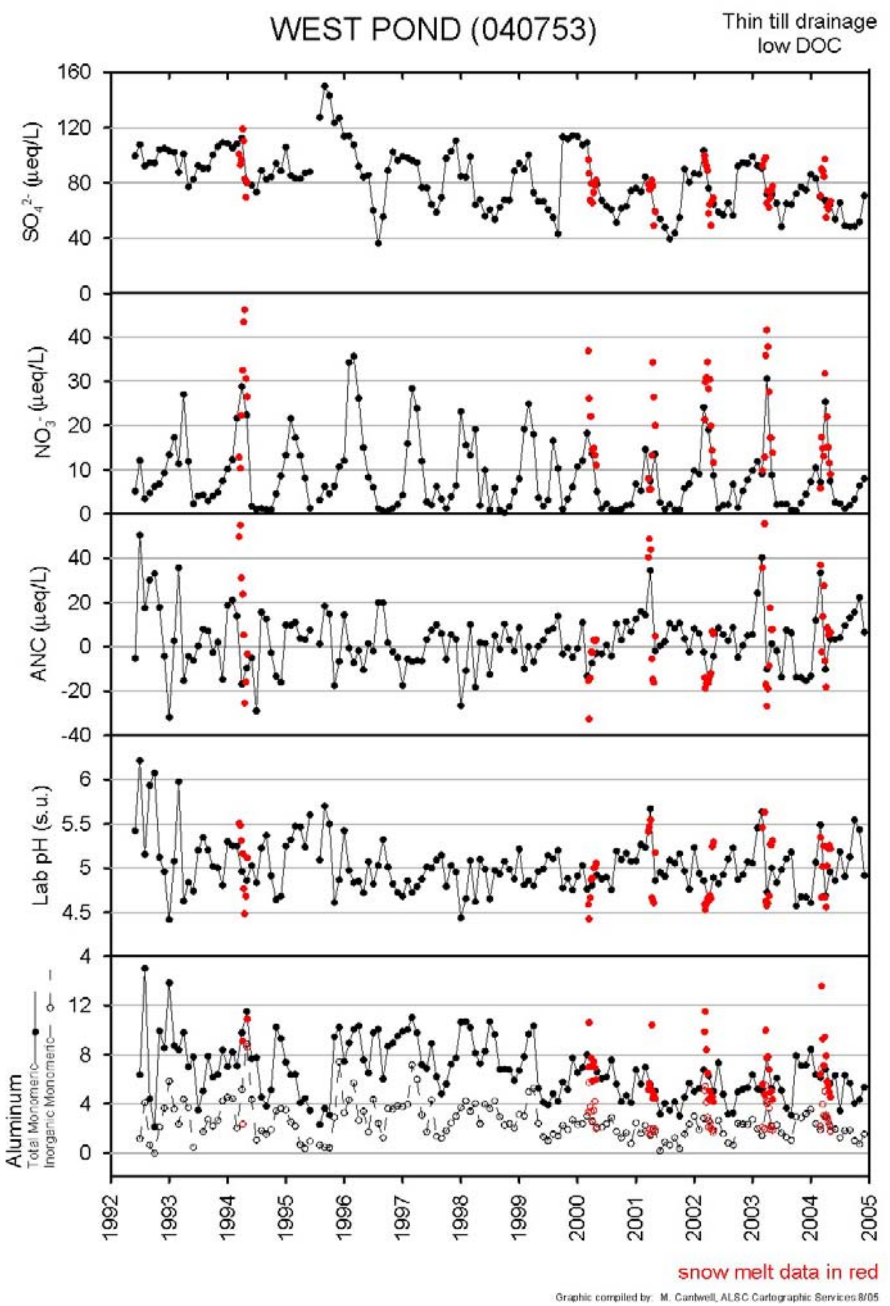
ALL ALTM LAKES (1992 - 2004 Monthly)
Acid Neutralizing Capacity < 10 μeq/L
March, April, May
% Frequency
100
80
60
40
20
0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Month-Year


Fall ANC vs Spring ANC
Thin Till
Medium Till
Thick Till
Seepage
300
250
200
150
100
50
0
-50
-100
-100
0
100
200
300
Spring ANC
Fall ANC

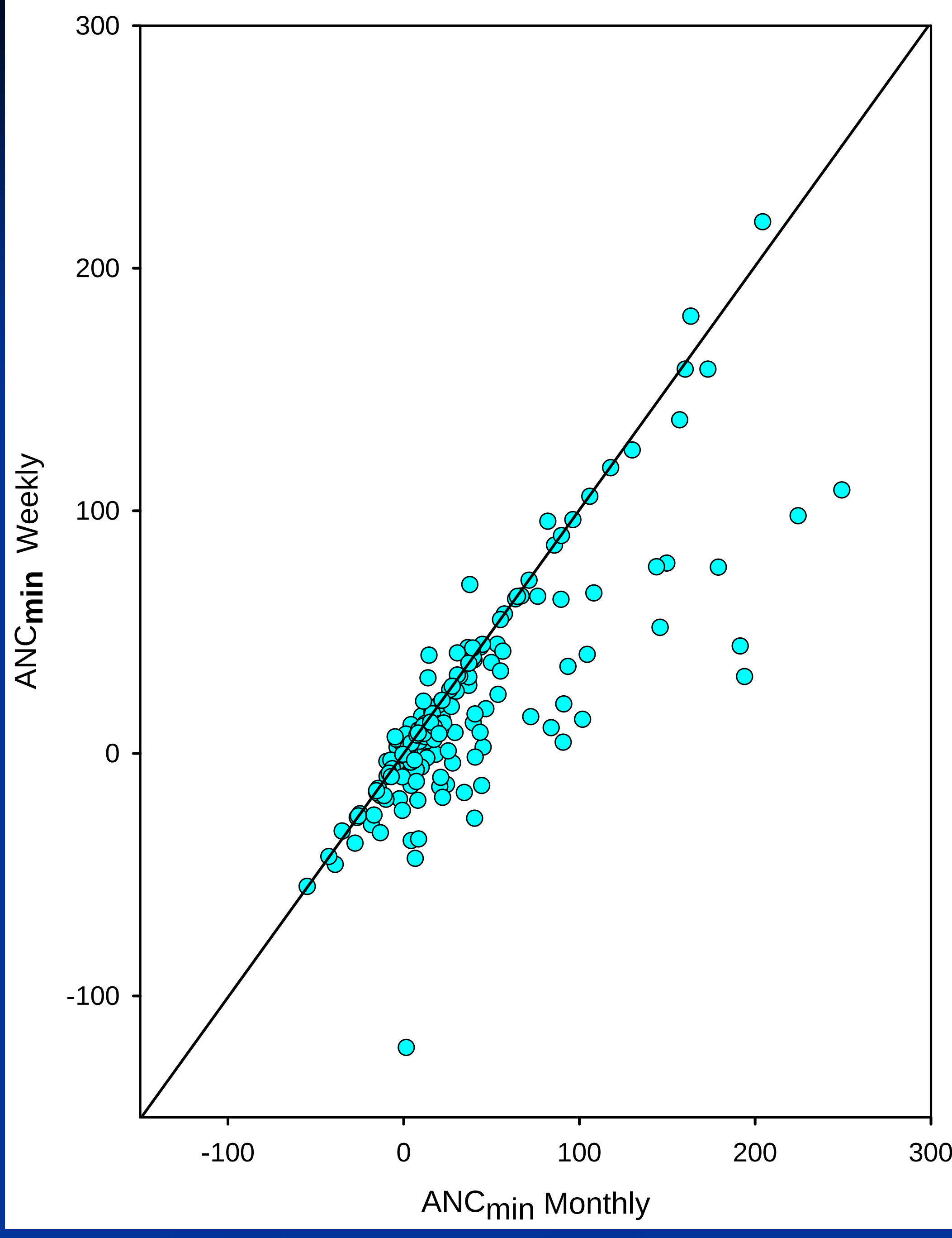
Current status based upon sampling of Adirondack lakes over two decades:

- Overall lake chemistry indicators show improvements, but not necessarily full recovery.
- Improvement is non-uniform across the region.
- Current measurements indicate many of the lakes continue to show critical levels of pH , ANC and toxic aluminum.

Snowmelt Chemistry



WEST POND (040753)
Thin till drainage
low DOC
SO4 2- (µeq/L)
NO3- (µeq/L)
ANC (µeq/L)
Lab pH (s.u.)
Aluminum
Total Monomeric
Inorganic Monomeric
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
snow melt data in red
Graphic compiled by: M. Cantwell, ALSC Cartographic Services 8/05



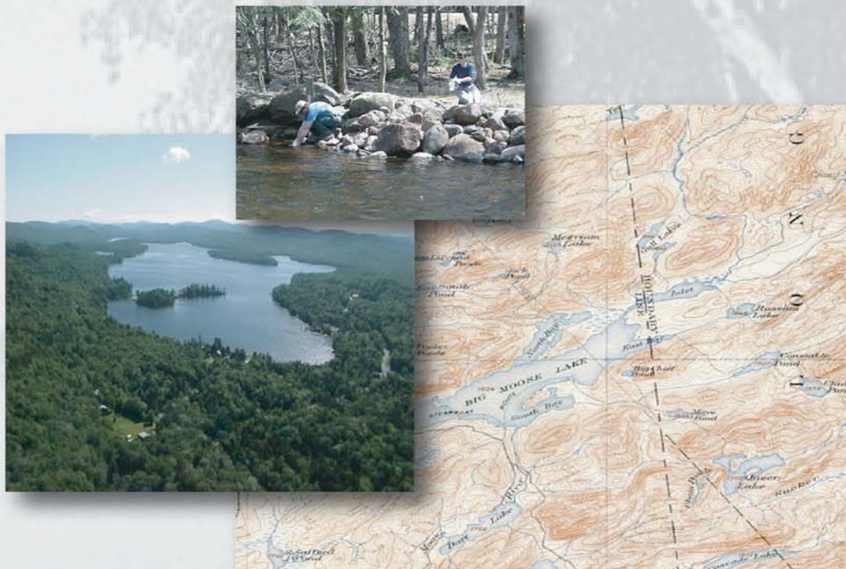
300
200
100
0
-100
-100
0
100
200
300
ANCmin Weekly
ANCmin Monthly

Climatic Factors - Flow Gauging

- Recent studies have shown linkages between climatic factors and the dynamics of SO_4^{2-} and NO_3^- in the Adirondacks influencing response.
- ALTM program is examining the feasibility of gauging flows at lake outlets.

Acid Rain and the Adirondacks: A Research Summary

Jerry Jenkins
Karen Roy
Charles Driscoll
Christopher Buerkett



Prepared by the Adirondack Lakes Survey Corporation
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Adirondack Long Term Monitoring Collaborators

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Institute of Ecosystem Studies
(G. Lovett, C. Canham, M.Pace)

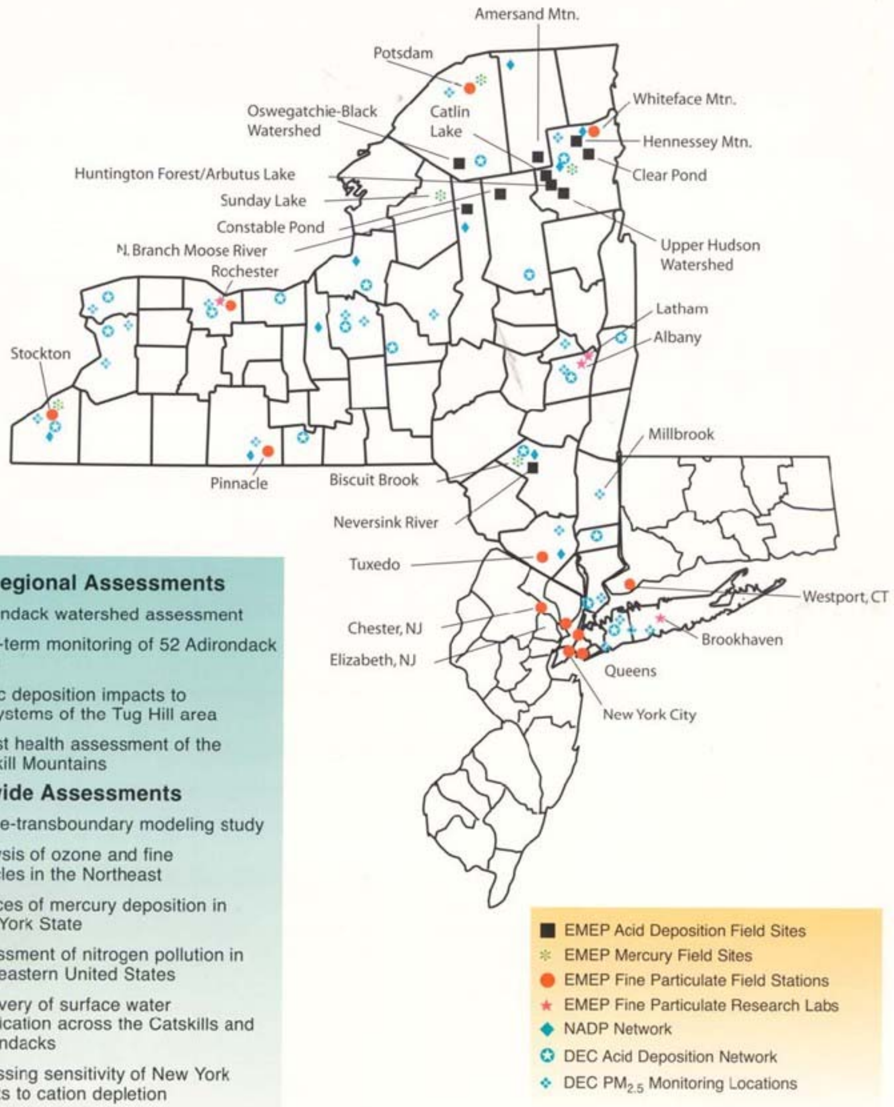
US EPA Corvallis (S. Paulsen, J. Stoddard)

NYSERDA Environmental Monitoring, Evaluation and Protection Program

DEC Air Resources; Fish,Wildlife and Marine Resources; Water Resources

Others

NYSERDA's EMEP Program: Field Stations and Research Sites



NYS Regional Assessments

- Adirondack watershed assessment
- Long-term monitoring of 52 Adirondack lakes
- Acidic deposition impacts to ecosystems of the Tug Hill area
- Forest health assessment of the Catskill Mountains

Statewide Assessments

- Ozone-transboundary modeling study
- Analysis of ozone and fine particles in the Northeast
- Sources of mercury deposition in New York State
- Assessment of nitrogen pollution in northeastern United States
- Recovery of surface water acidification across the Catskills and Adirondacks
- Assessing sensitivity of New York forests to cation depletion
- Carbonaceous fine particle assessment
- Mercury monitoring in New York fish