Assessment of Adirondack Watersheds

T. Sullivan, K. Snyder, D. Moore
E&S Environmental Chemistry, Inc.

B. Cosby
University of Virginia

C. Driscoll, J. Zhai
Syracuse University

I. Fernandez
University of Maine, Orono

A. Herlihy
Oregon State University

R. Stemberger
Dartmouth College

C. Boylen, S. Nierzwicki-Bauer
Rensselaer Polytechnic Institute

T. McDonnell, N. Nowicki
SUNY College of Environmental Science and Forestry

J. Sutherland

NYS Department of Environmental Conservation

Research Partners:

- Adirondack Lakes Survey Corporation
- Dartmouth College
- New York Department of Environmental Conservation
- New York State Energy Research and Development Authority
- Oregon State University
- Rensselaer Polytechnic Institute
- Syracuse University
- University of Maine
- University of Virginia

OUTLINE

Background and Objectives

Approach

Results

- Soils
- Lakewater
  - Past and Future Projections
  - Linkage to Biology
- How Well Do ALTM/AEAP Watersheds Represent the Adirondack Lake Population?

Preliminary Conclusions

MAJOR OBJECTIVES:

- Develop approaches for extrapolating spatially-limited knowledge regarding chemical and biological recovery of acid-sensitive lakes and their watersheds to the regional population of Adirondack lakes and watersheds

- Develop a statistically-representative soils database for the Adirondack region

- Classify watersheds according to their responsiveness to ongoing and future changes in S and/or N deposition

APPROACH:

- Statistically select a subsample of watersheds for regional characterization
- Compile watershed data
- Conduct a soil survey
- Implement Quality Assurance/Quality Control (QA/QC) procedures
- Apply the MAGIC and the PnET-BGC models to 70 study watersheds
- Classify watersheds according to responsiveness
- Compare and contrast model output from MAGIC and PnET-BGC

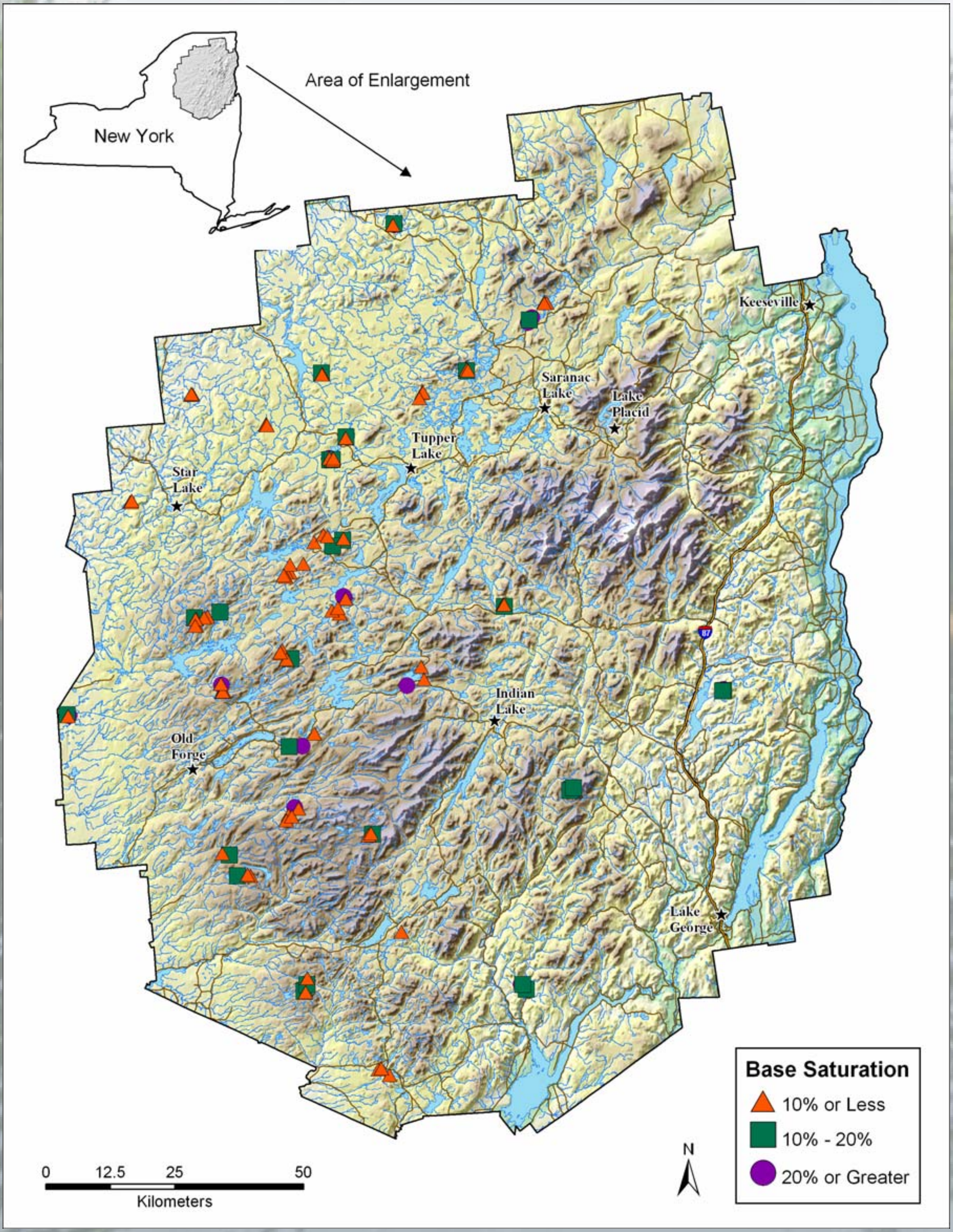
RESULTS TO DATE:

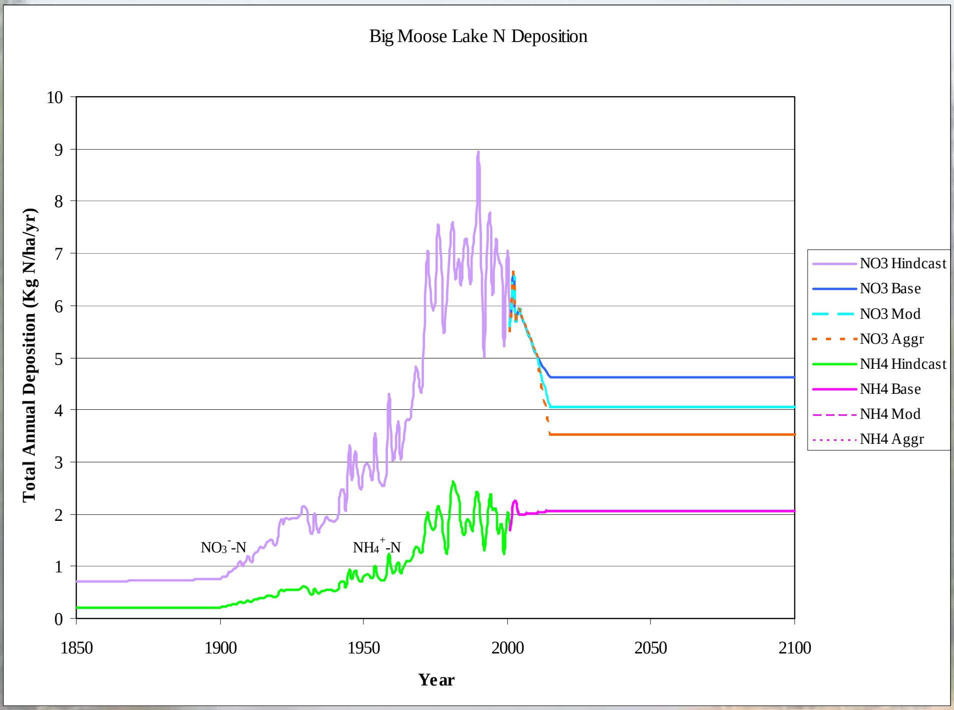
Soil Conditions

70 Watersheds

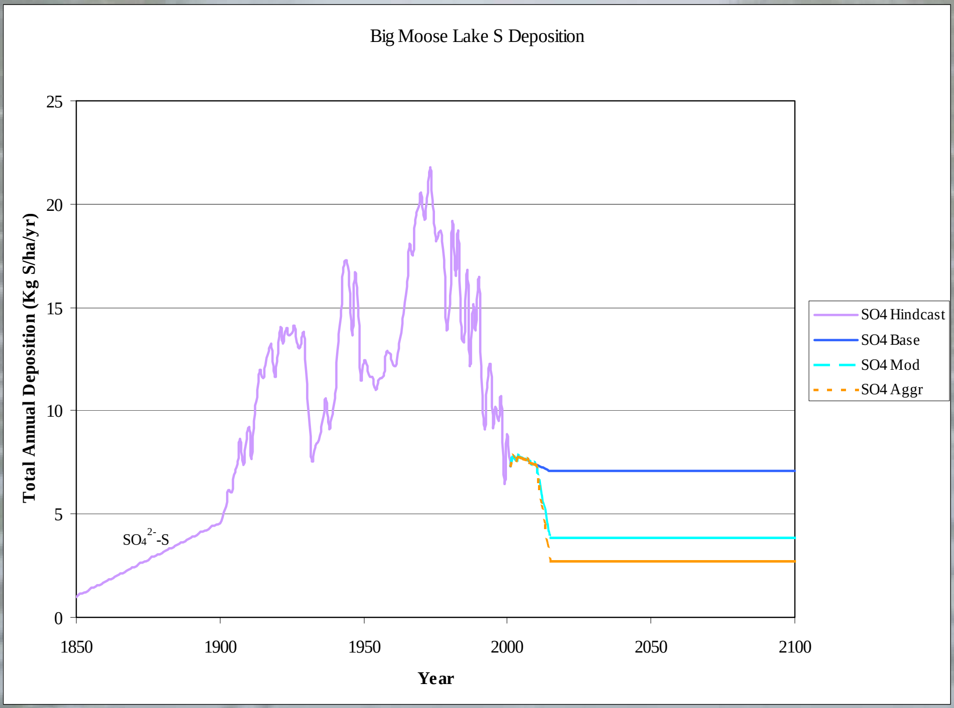
199 Locations


I-2

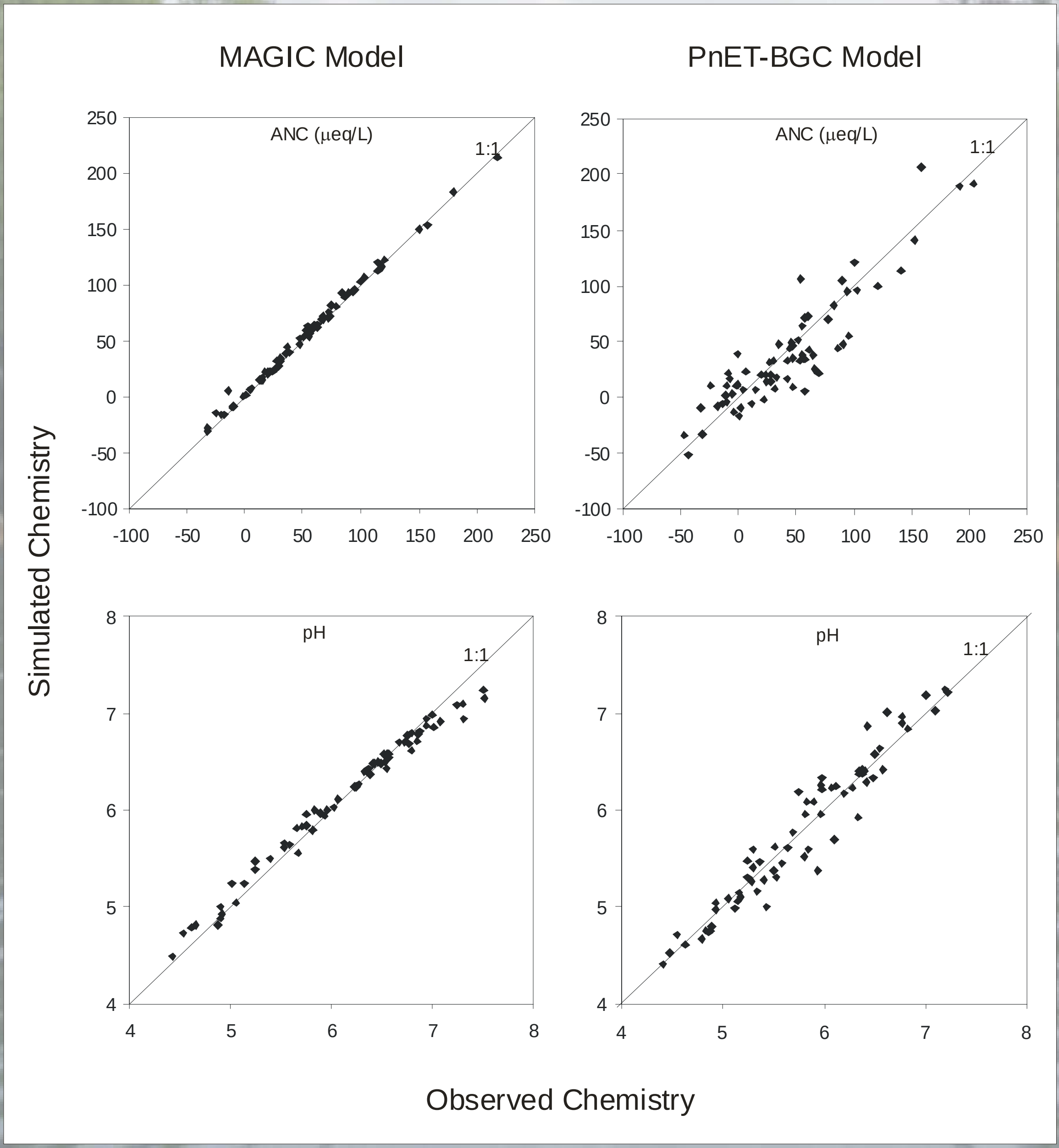

Area of Enlargement
New York
Keeseville
Saranac Lake
Lake Placid
Tupper Lake
Star Lake
Indian Lake
Old Forge
Lake George
87
Base Saturation
10% or Less
10% - 20%
20% or Greater
N
0
12.5
25
50
Kilometers



Big Moose Lake N Deposition
Total Annual Deposition (Kg N/ha/yr)
Year
NO3⁻-N
NH4⁺-N
NO3 Hindcast
NO3 Base
NO3 Mod
NO3 Aggr
NH4 Hindcast
NH4 Base
NH4 Mod
NH4 Aggr



Big Moose Lake S Deposition
Total Annual Deposition (Kg S/ha/yr)
Year
SO4²⁻-S
SO4 Hindcast
SO4 Base
SO4 Mod
SO4 Aggr


MAGIC Model
PnET-BGC Model
ANC (µeq/L)
1:1
pH
Simulated Chemistry
Observed Chemistry

Simulated water chemistry percentile values for the population* of potentially acid-sensitive Adirondack lakes, based on the MAGIC model, for the period from 1850 to 2100, assuming existing S and N emissions control regulations.

Variable	Year	Percentile				
		10	25	50	75	90
ANC	1850	28	72	95	174	253
	1900	29	69	97	180	259
	1980	4	25	64	133	189
	1990	4	31	63	118	180
	2000	6	35	67	117	183
	2050	0	35	67	129	200
	2100	-7	32	61	132	200

* Percentages are based on the population of 1,320 Adirondack lakes having ANC less than 200 µeq/L. This population constitutes a subset (based on having ANC ≤ 200 µeq/L) of the larger population of 1,817 Adirondack lakes greater than 1 ha depicted on 1:100,000-scale topographic maps

REPLACE BASE CASE WITH MODERATE ADDITIONAL EMISSIONS CONTROLS

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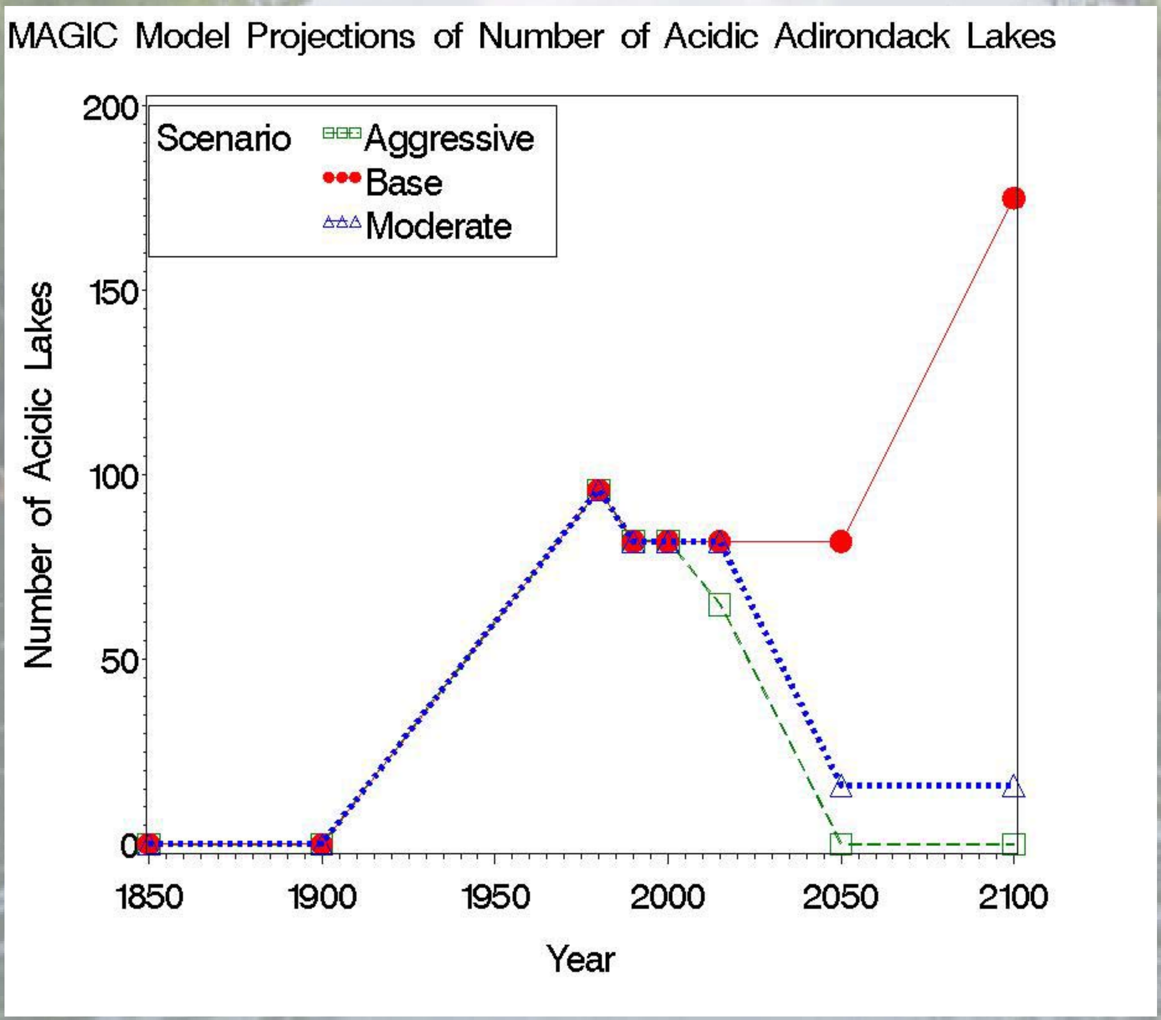
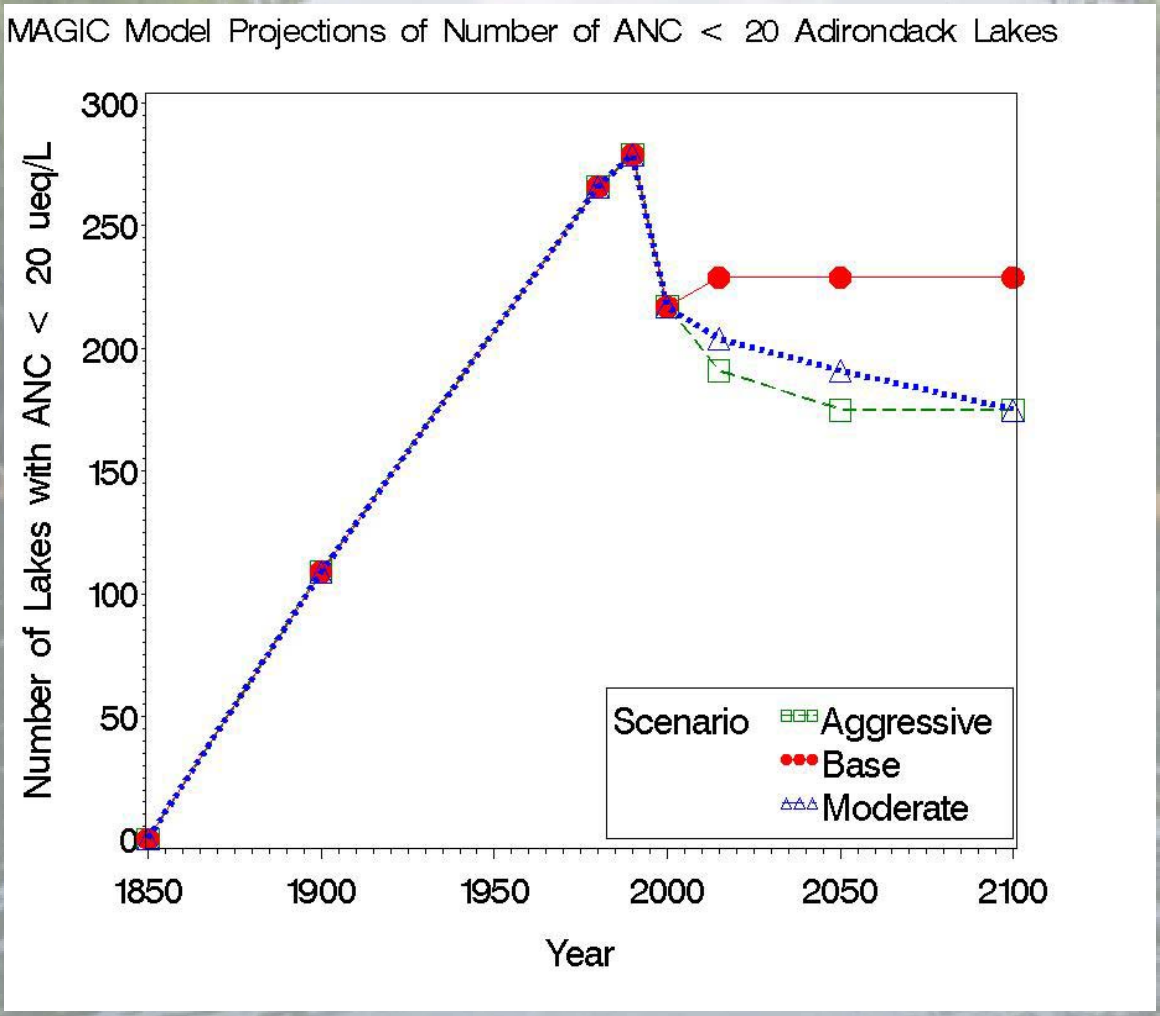
	2000	6	35	67	117	183
	2050	~~0~~ 9	~~35~~ 47	~~67~~ 79	~~129~~ 144	~~200~~ 217
	2100	~~-7~~ 6	~~32~~ 45	~~61~~ 74	~~132~~ 153	~~200~~ 223

* Percentages are based on the population of 1,320 Adirondack lakes having ANC less than 200 µeq/L. This population constitutes a subset (based on having ANC ≤ 200 µeq/L) of the larger population of 1,817 Adirondack lakes greater than 1 ha depicted on 1:100,000-scale topographic maps


MAGIC Model Projections of Number of Acidic Adirondack Lakes
Scenario
Aggressive
Base
Moderate
Number of Acidic Lakes
0
50
100
150
200
1850
1900
1950
2000
2050
2100
Year


MAGIC Model Projections of Number of ANC < 20 Adirondack Lakes
Number of Lakes with ANC < 20 ueq/L
300
250
200
150
100
50
0
1850
1900
1950
2000
2050
2100
Year
Scenario
Aggressive
Base
Moderate

Estimated number of Adirondack lakes below ANC and pH criteria values for the population of 1,320 Adirondack lakes larger than 1 ha that have ANC less than 200 μeq/L, based on MAGIC model simulations for 44 statistically-selected lakes

Year	ANC (μeq/L)			pH		
	≤0	≤20	≤50	≤5.0	≤5.5	≤6.0
1850	0	0	174	93	93	186
1900	0	104	216	93	93	186
1980	96	266	505	175	330	443
1990	82	279	505	175	326	426
2000	82	217	399	159	268	381
2050*	82	229	437	142	268	379
2100*	175	229	437	159	284	422

* Percentages are based on the population of 1,320 Adirondack lakes having ANC less than 200 μeq/L. This population constitutes a subset (based on having ANC ≤ 200 μeq/L) of the larger population of 1,817 Adirondack lakes greater than 1 ha depicted on 1:100,000-scale topographic maps

REPLACE BASE CASE WITH MODERATE ADDITIONAL EMISSIONS CONTROLS

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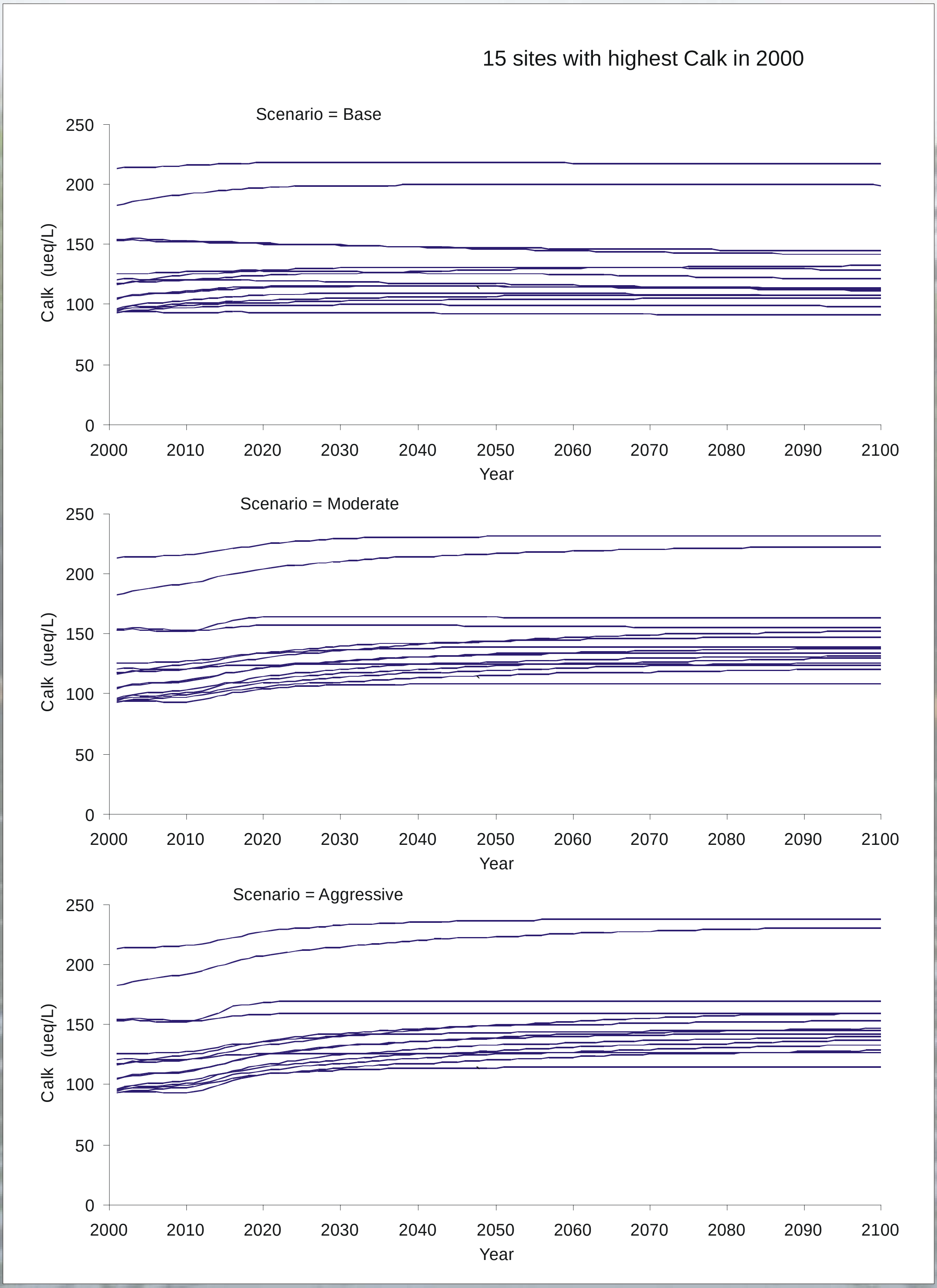
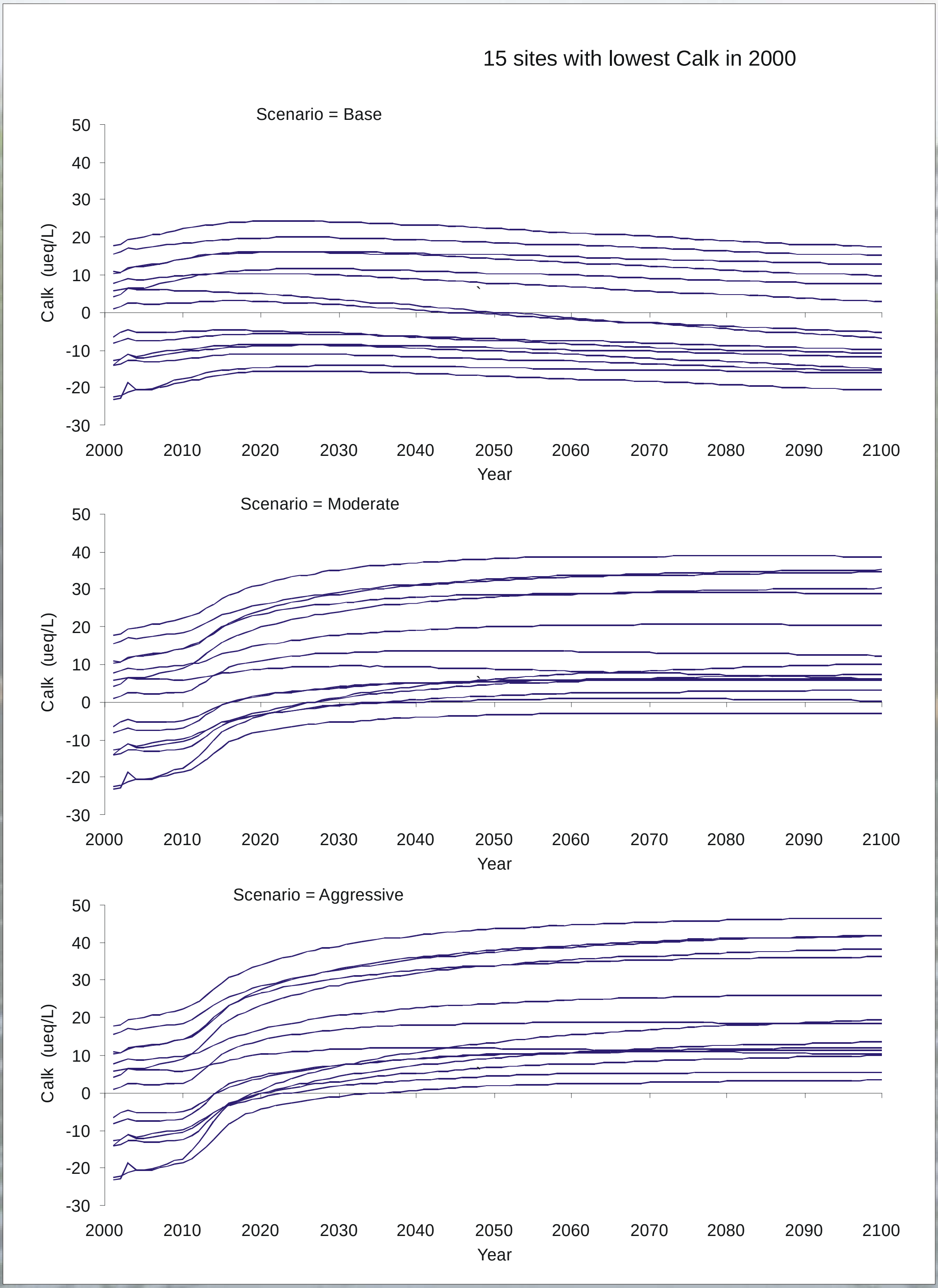
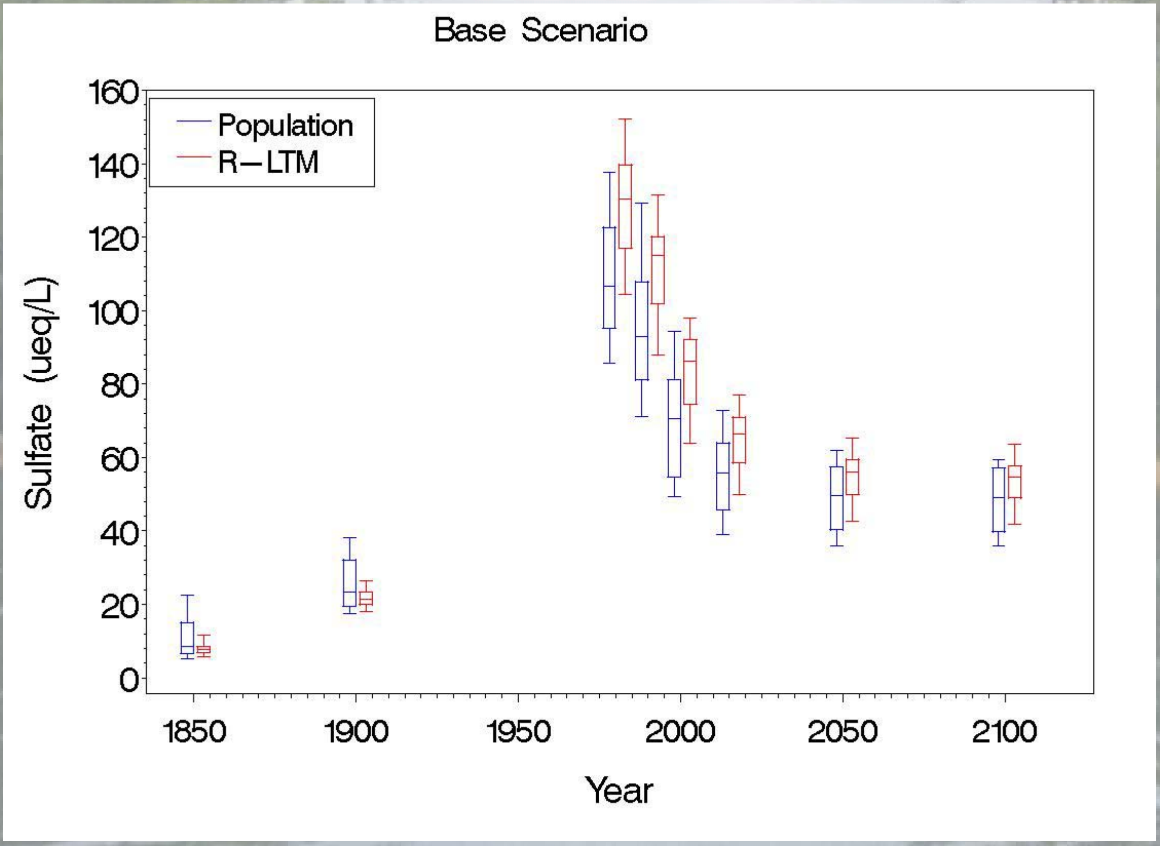
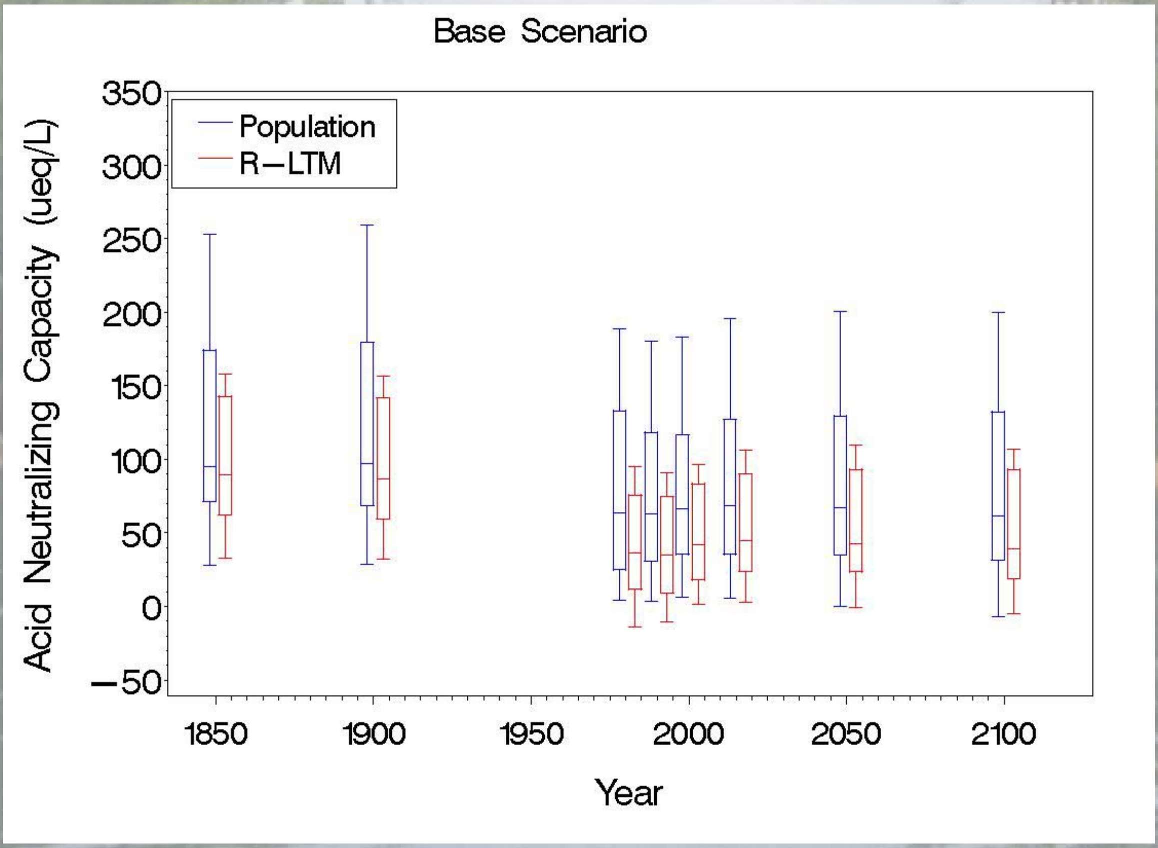
2000	82	217	399	159	268	381
2050*	~~82~~ 16	~~229~~ 191	~~437~~ 398	~~142~~ 93	~~268~~ 125	~~379~~ 330
2100*	~~175~~ 16	~~229~~ 175	~~437~~ 398	~~159~~ 93	~~284~~ 109	~~422~~ 330

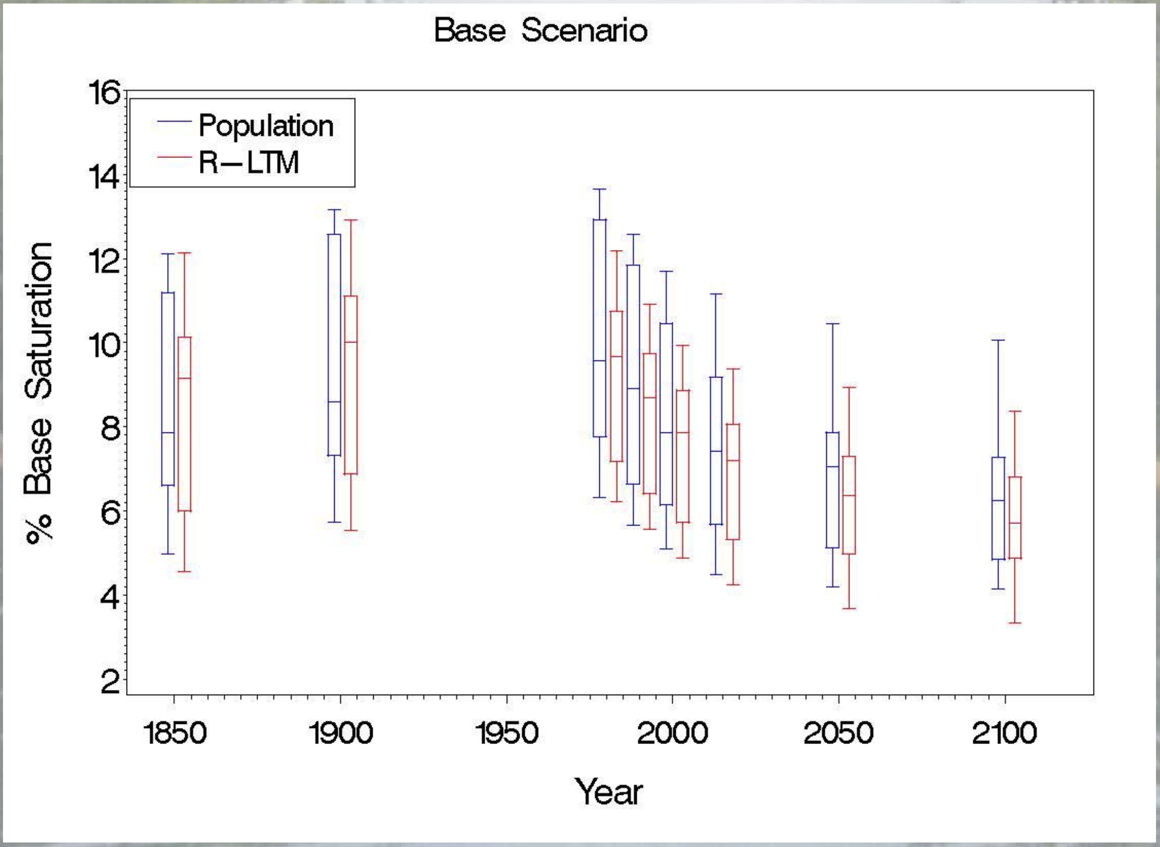

15 sites with highest Calk in 2000
Scenario = Base
Scenario = Moderate
Scenario = Aggressive
Calk (ueq/L)
0
50
100
150
200
250
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Year


15 sites with lowest Calk in 2000
Scenario = Base
Calk (ueq/L)
50
40
30
20
10
0
-10
-20
-30
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Year
Scenario = Moderate
Calk (ueq/L)
Year
Scenario = Aggressive
Calk (ueq/L)
Year

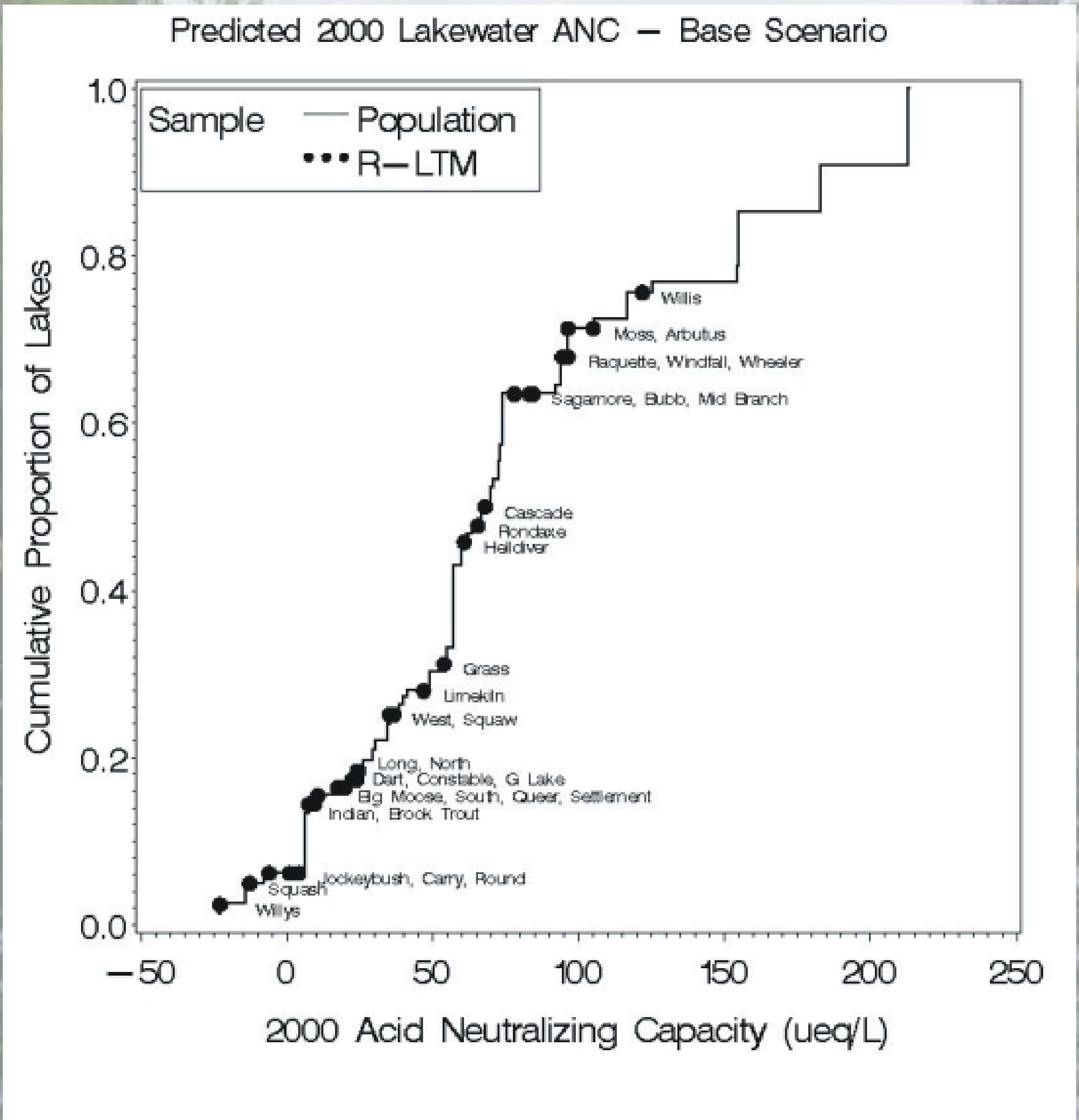
REPRESENTATIVENESS OF ALTM/AEAP LAKES

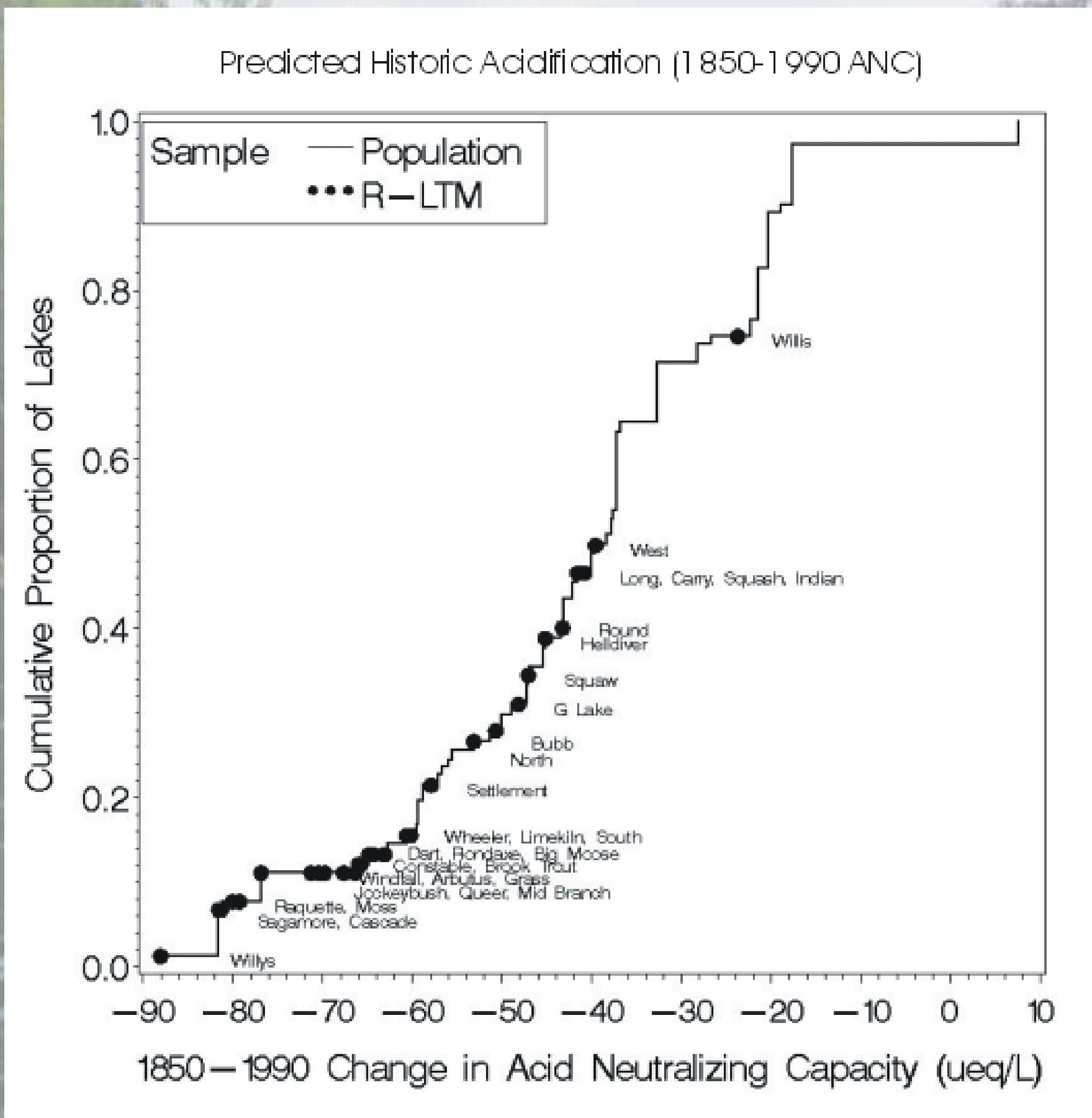


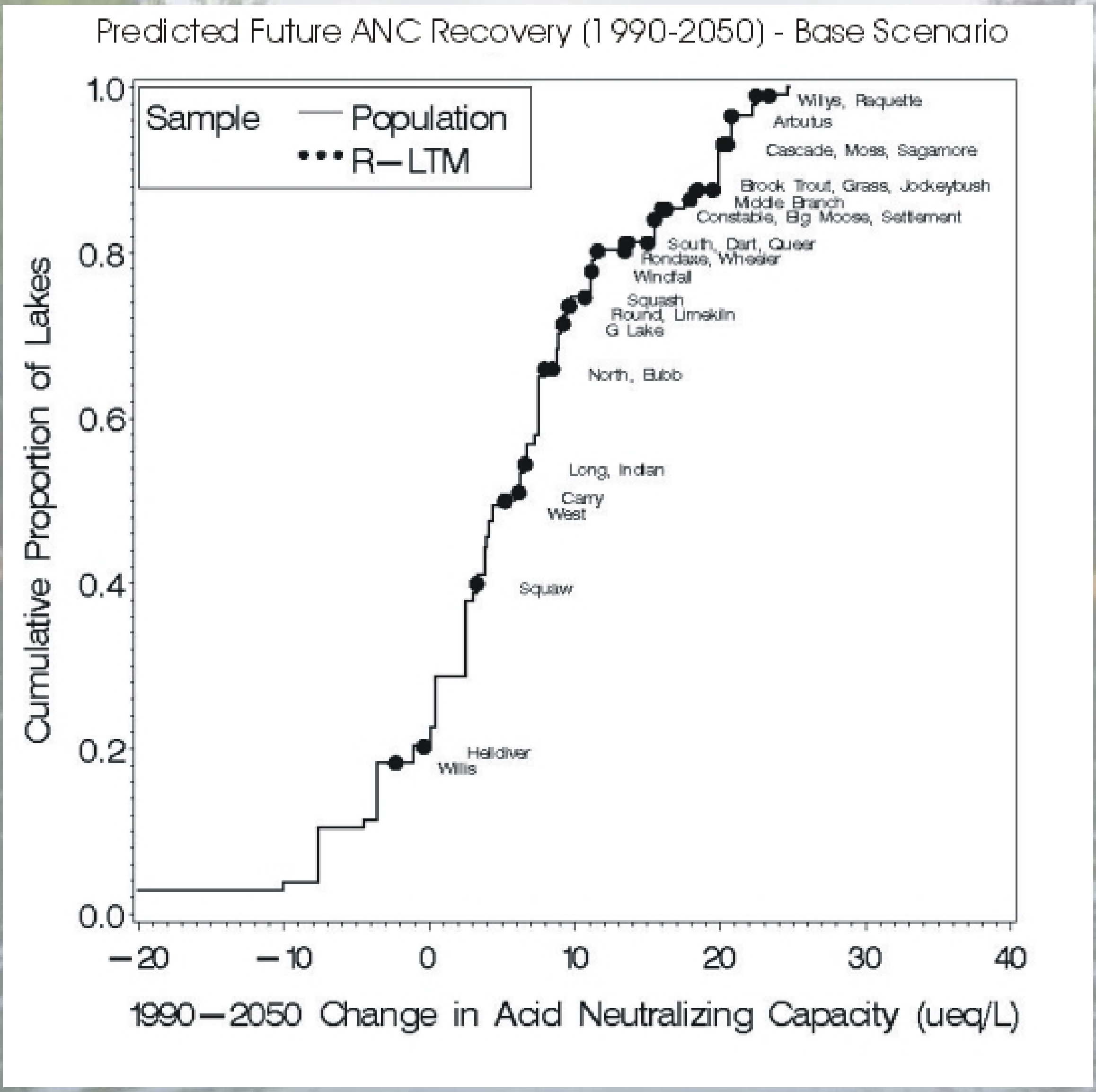

Base Scenario
Population
R−LTM
Acid Neutralizing Capacity (ueq/L)
350
300
250
200
150
100
50
0
−50
1850
1900
1950
2000
2050
2100
Year


Base Scenario
Population
R–LTM
% Base Saturation
16
14
12
10
8
6
4
2
1850
1900
1950
2000
2050
2100
Year

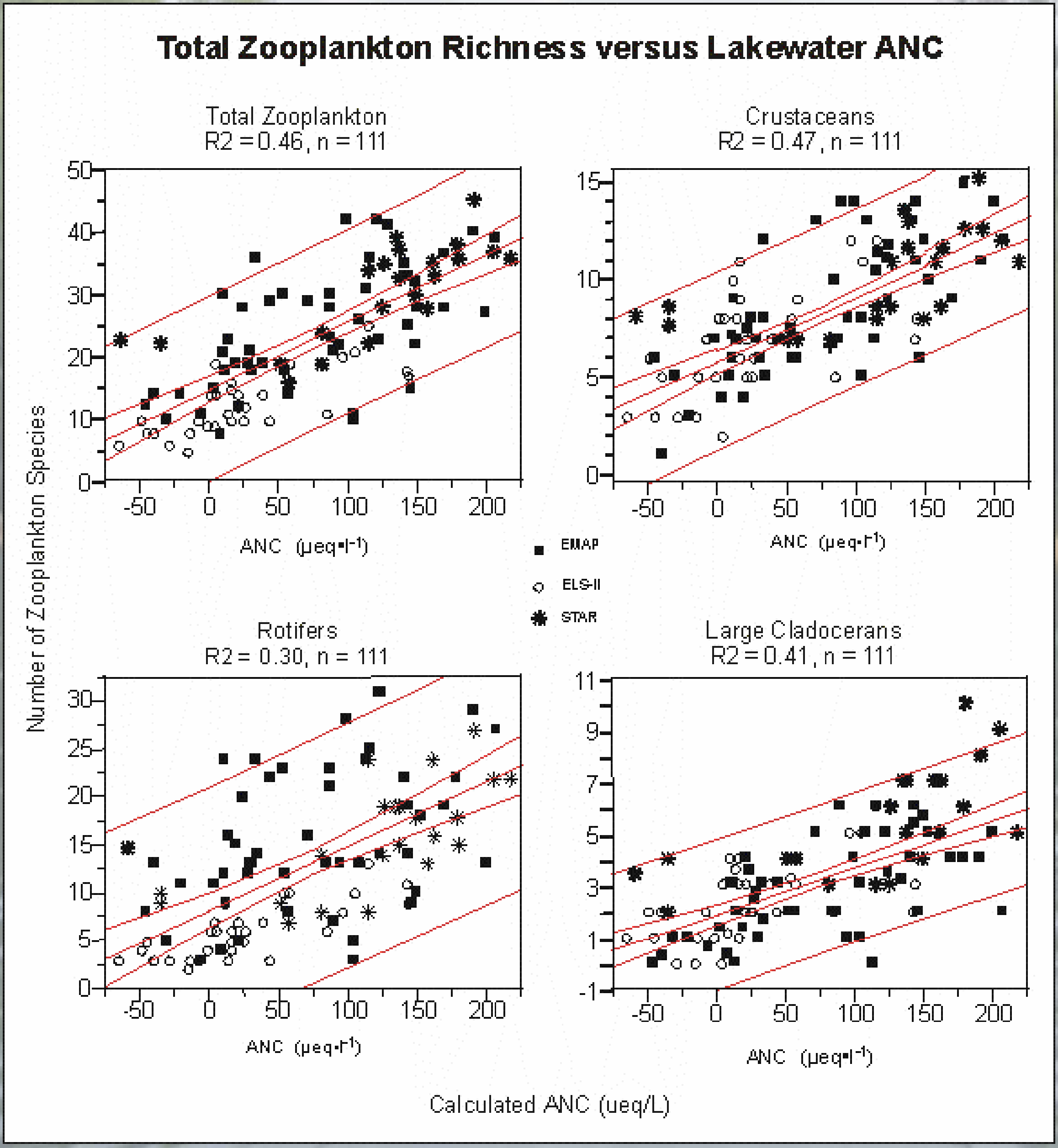
Modeled relationship between some of the studied ALTM/ AEAP lakes and the population of Adirondack lakes with respect to acid-base chemistry status, acidification, and recovery responses					
ALTM Lake			Estimated Percentage of Lakes in the Population Having:		
Name	ID	1990 ANC	Lower 2000 ANC	Greater Historical Acidification (1850 to 1990)	Greater ANC Recovery Under Base Case Scenario (1990 to 2050)
Most Acidic ALTM Lakes					
Willys Lake	040210	-37.1	2.4	1.3	1.0
Squash Pond	040754	-21.0	5.0	46.6	25.4
Carry Pond	050669	-13. 8	6.2	46.6	49.0
Round Pond	040731A	-10.2	6.2	40.1	26.4
Jockeybush Lake	050259	-9.0	6.2	11.1	12.3
Most Responsive ALTM Lakes					
Willys Lake	040210	-37.1	2.4	1.3	1.0
Cascade Lake	040747	56.3	50.0	6.7	6.9
Sagamore Lake	060313	74.4	63.5	6.7	6.9
Raquette Lake Reservoir	060315A	86.2	67.9	7.7	1.0
Moss Lake	040746	94.9	71.3	7.7	6.9
Arbutus Pond	050684	86.1	71.3	11.1	3.5


Predicted 2000 Lakewater ANC – Base Scenario
Sample
Population
R–LTM
Cumulative Proportion of Lakes
0.0
0.2
0.4
0.6
0.8
1.0
–50
0
50
100
150
200
250
2000 Acid Neutralizing Capacity (ueq/L)
Willis
Moss, Arbutus
Raquette, Windfall, Wheeler
Sagamore, Bubb, Mid Branch
Cascade
Rondaxe
Helldiver
Grass
Limekiln
West, Squaw
Long, North
Dart, Constable, G Lake
Big Moose, South, Queer, Settlement
Indian, Brook Trout
Jockeybush, Carry, Round
Squash
Willys


Predicted Historic Acidification (1850-1990 ANC)
Sample
Population
R—LTM
Cumulative Proportion of Lakes
1850—1990 Change in Acid Neutralizing Capacity (ueq/L)
1.0
0.8
0.6
0.4
0.2
0.0
−90
−80
−70
−60
−50
−40
−30
−20
−10
0
10
Wills
West
Long, Carry, Squash, Indian
Round
Helldiver
Squaw
G Lake
Bubb
North
Settlement
Wheeler, Limekiln, South
Dart, Rondaxe, Big Moose
Constable, Brook Trout
Windfall, Arbutus, Grass
Jockeybush, Queer, Mid Branch
Raquette, Moss
Sagamore, Cascade
Willys


Predicted Future ANC Recovery (1990-2050) - Base Scenario
Sample
Population
R—LTM
Cumulative Proportion of Lakes
1990—2050 Change in Acid Neutralizing Capacity (ueq/L)
1.0
0.8
0.6
0.4
0.2
0.0
—20
—10
0
10
20
30
40
Willys, Raquette
Arbutus
Cascade, Moss, Sagamore
Brook Trout, Grass, Jockeybush
Middle Branch
Constable, Big Moose, Settlement
South, Dart, Queer
Rondaxe, Wheeler
Windfall
Squash
Round, Limekiln
G Lake
North, Bubb
Long, Indian
Carry
West
Squaw
Helldiver
Willis

LINKAGE TO BIOLOGICAL RESPONSE



CONCLUSIONS

Future Change in ANC of Adirondack Lake Population in Response to Expected Emissions:

- Many higher ANC lakes continue increasing ANC
- Some lower ANC lakes reacidify
- Number of lakes having ANC $\leq$ 0 and $\leq$ 20 μeq/L will increase

Are ALTM/AEAP lakes representative of the Adirondack Lake population? No; only part:

- Current ANC less than about 125 μeq/L
- Those that have acidified the most in past
- Those expected to recover the most in future
- Generally about half of the population of lakes greater than 1 ha in area that have ANC less than 200 μeq/L, about one-third of all Adirondack lakes greater than 1 ha in area

Response to More Stringent Emissions Controls:

- Reacidification does not occur
- Chemical recovery continues
- Based on relationships between current ANC and zooplankton species richness, there will be limited change in zooplankton richness