Dynamic Critical Loads for Adirondack Lake Watersheds

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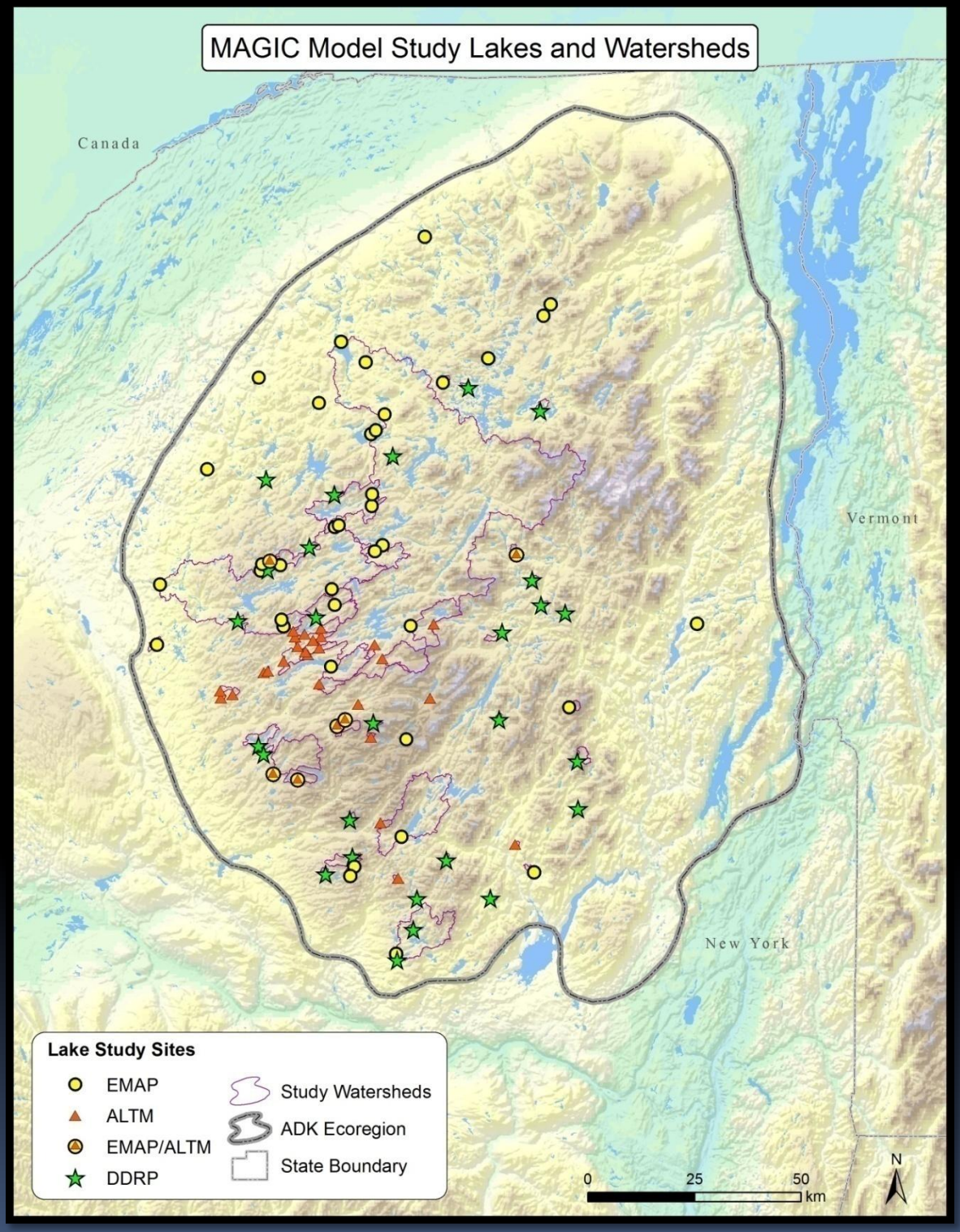
Project Support:

New York State Energy Research and Development Authority (NYSERDA)

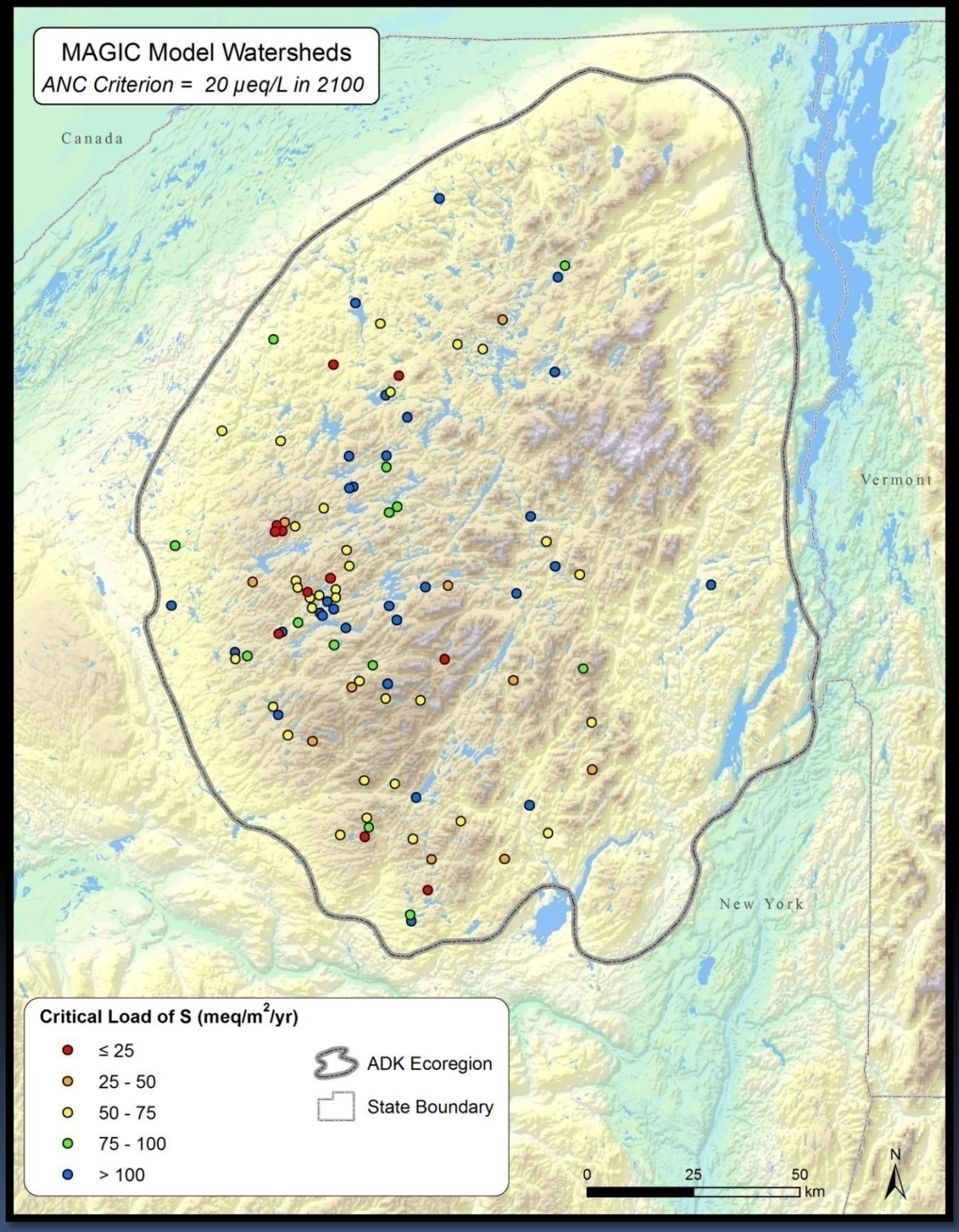
Project Components:

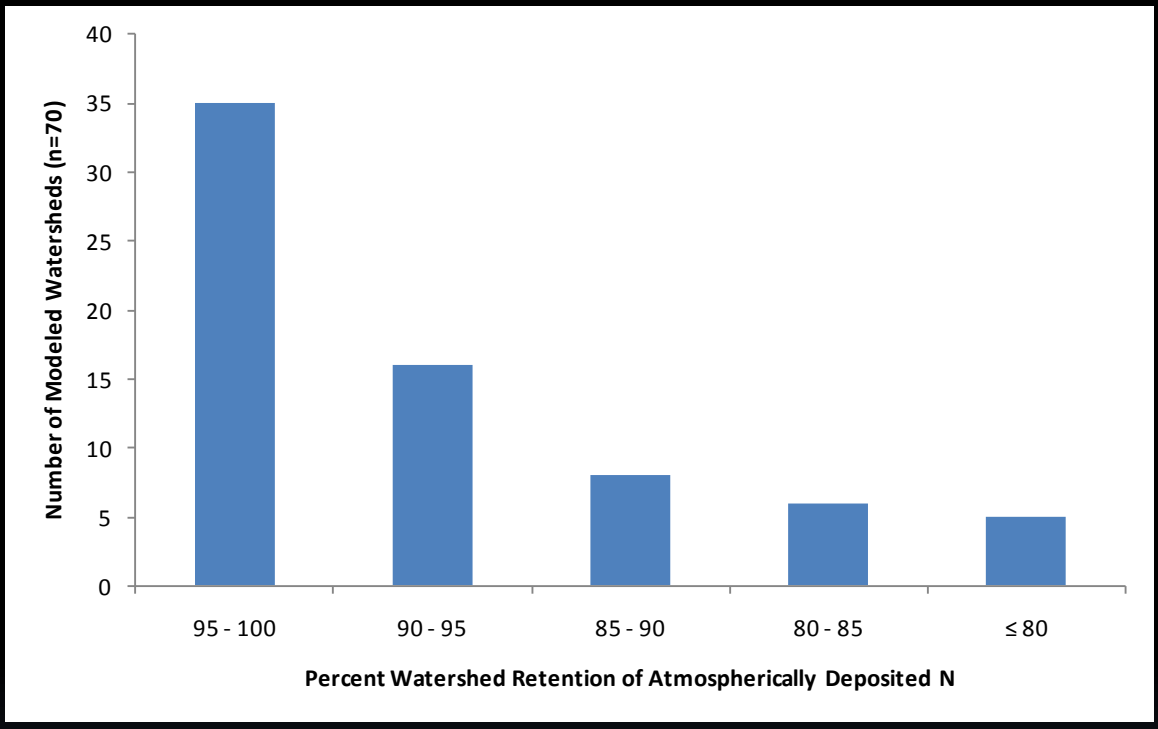
1. **MAGIC modeling**
2. PnET-BGC modeling
3. **Regional extrapolation**
4. Process investigations
5. Dose-response relationships

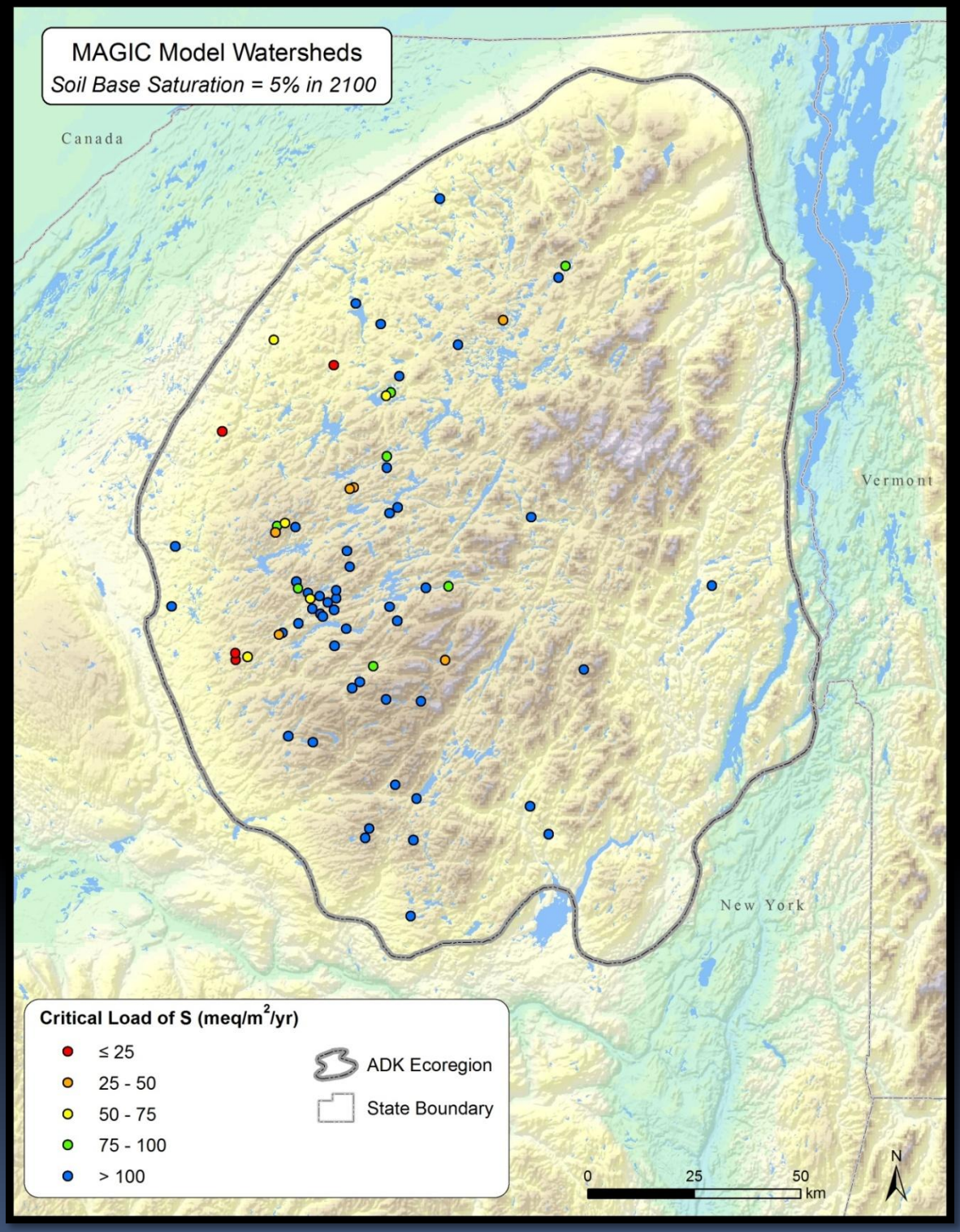

MAGIC Model Study Lakes and Watersheds
Canada
Vermont
New York
Lake Study Sites
EMAP
ALTM
EMAP/ALTM
DDRP
Study Watersheds
ADK Ecoregion
State Boundary
0
25
50
km
N

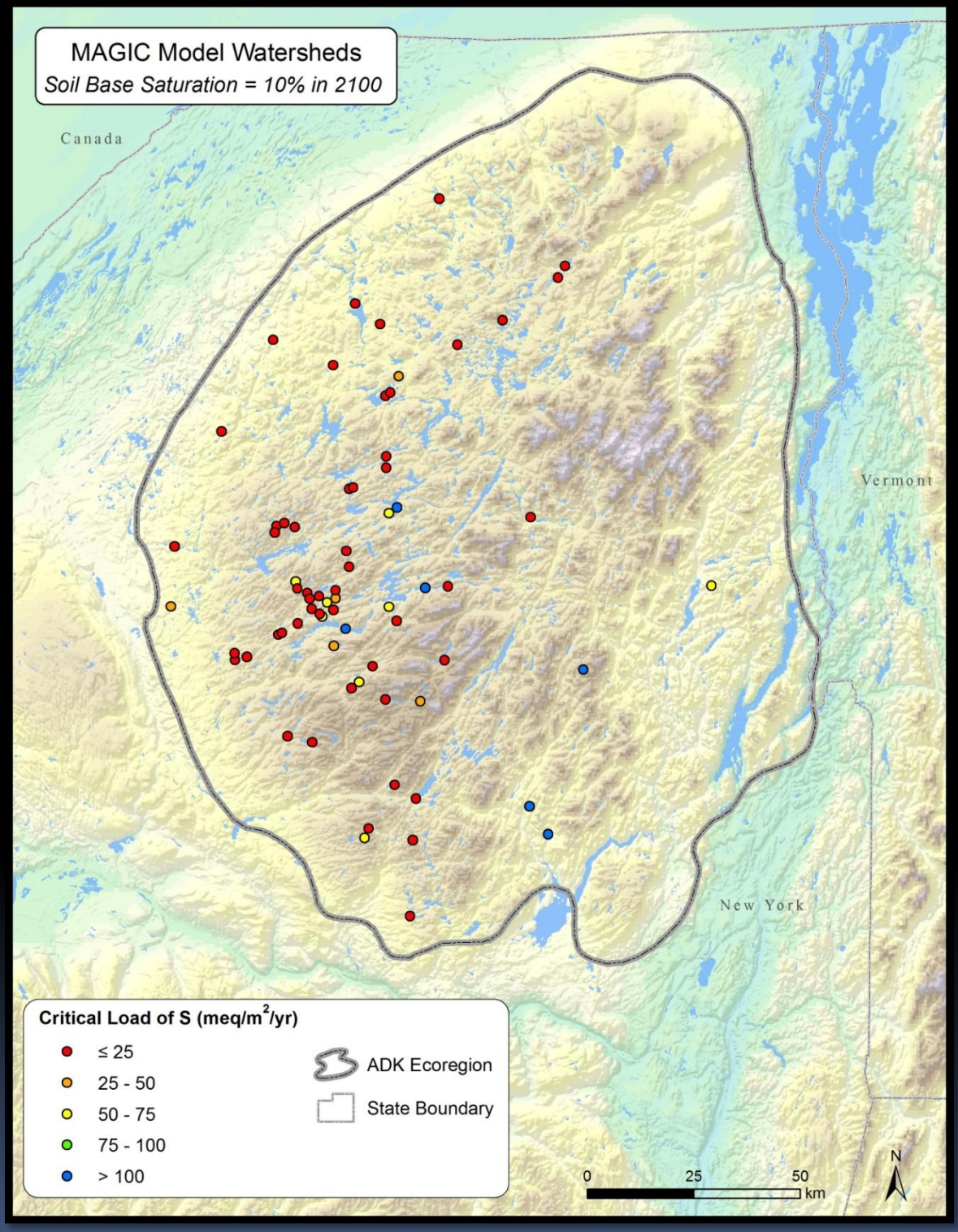
Indicators, critical levels, and timeframes investigated for MAGIC critical loads modeling

Pollu-tants	Ecosystem Stress	Sensitive Receptor	Indicator	Critical Level	Timeframe
S, N	Acidification	Lake	ANC	0, 20, 50 µeq/L	2020, 2050, 2100
	Eutrophication	Lake	NO_3^-	10, 20 µeq/L	2020, 2050, 2100
	Acidification	Soil	BS	5, 10,	2020, 2050, 2100
	Acidification	Soil Sol.	Ca:Al	15%	2020, 2050, 2100
	Acidification	Soil Sol.	Bc:Al	1, 10	2020, 2050, 2100
				1, 10	


MAGIC Model Watersheds
ANC Criterion = 20 µeq/L in 2100
Canada
Vermont
New York
Critical Load of S (meq/m2/yr)
≤ 25
25 - 50
50 - 75
75 - 100
> 100
ADK Ecoregion
State Boundary
0
25
50
km
N


Number of Modeled Watersheds (n=70)
40
35
30
25
20
15
10
5
0
95 - 100
90 - 95
85 - 90
80 - 85
≤ 80
Percent Watershed Retention of Atmospherically Deposited N

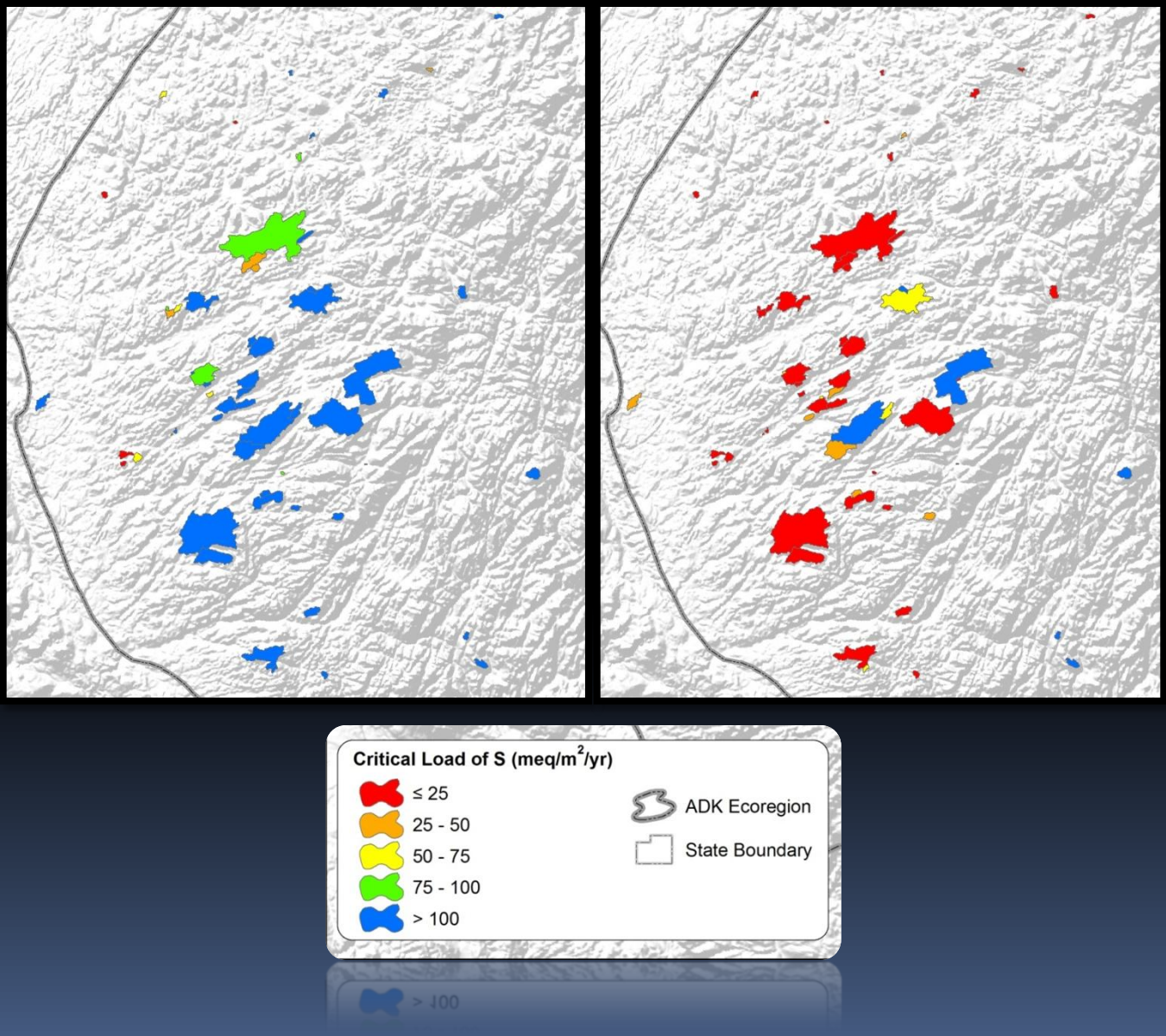

MAGIC Model Watersheds
Soil Base Saturation = 5% in 2100
Canada
Vermont
New York
Critical Load of S (meq/m2/yr)
≤ 25
25 - 50
50 - 75
75 - 100
> 100
ADK Ecoregion
State Boundary
0
25
50
km
N

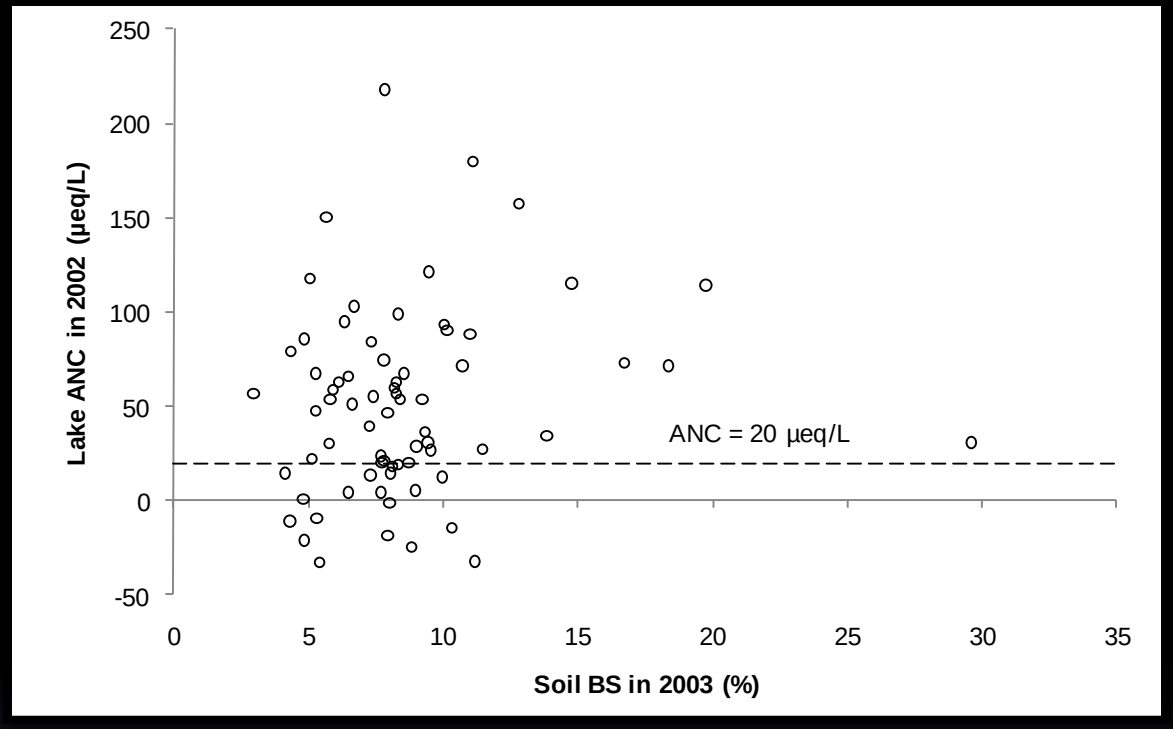

MAGIC Model Watersheds
Soil Base Saturation = 10% in 2100
Canada
Vermont
New York
Critical Load of S (meq/m2/yr)
≤ 25
25 - 50
50 - 75
75 - 100
> 100
ADK Ecoregion
State Boundary
0
25
50
km
N

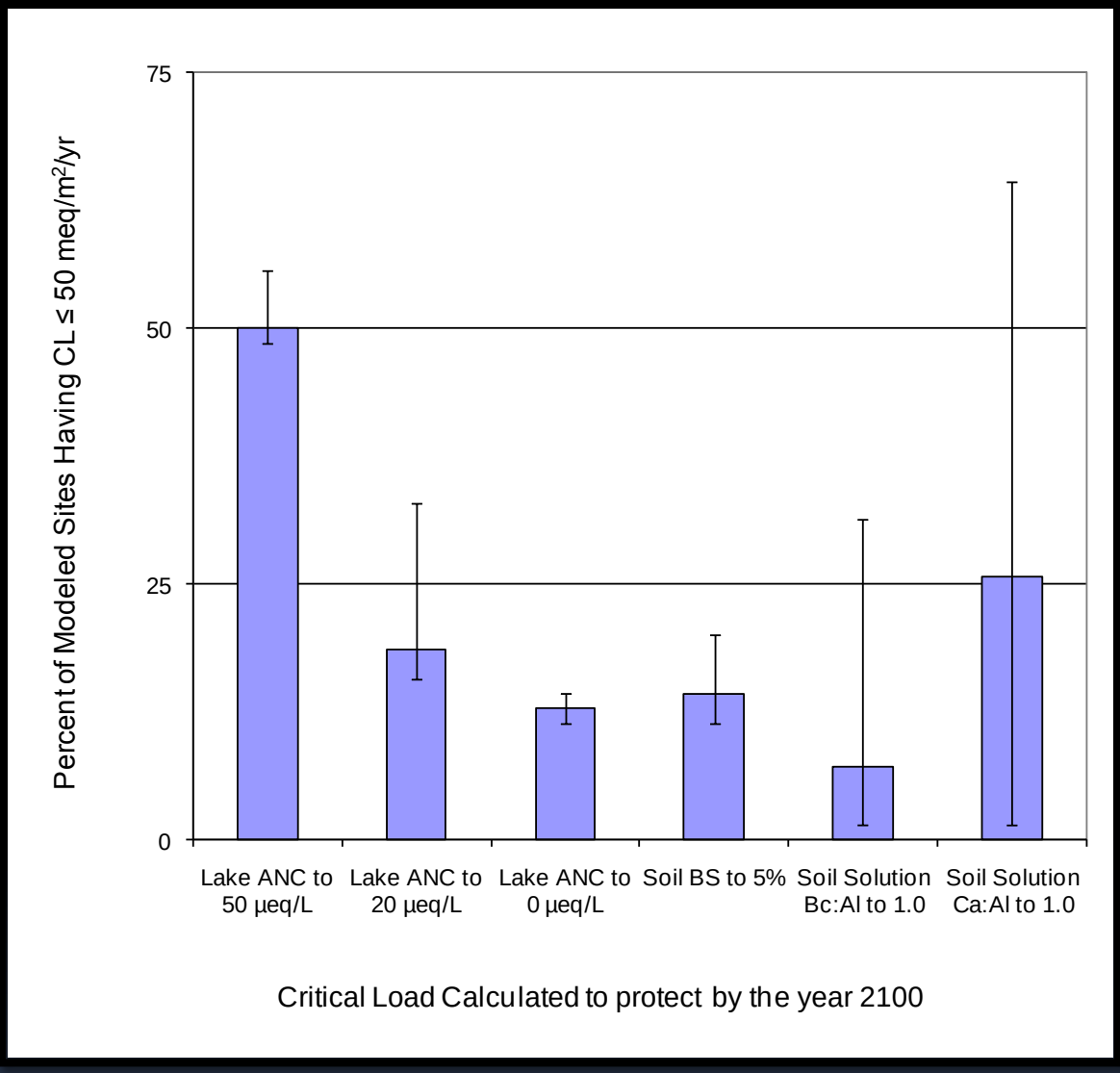
MAGIC Model Watersheds

Soil Base Saturation: 5% in 2100

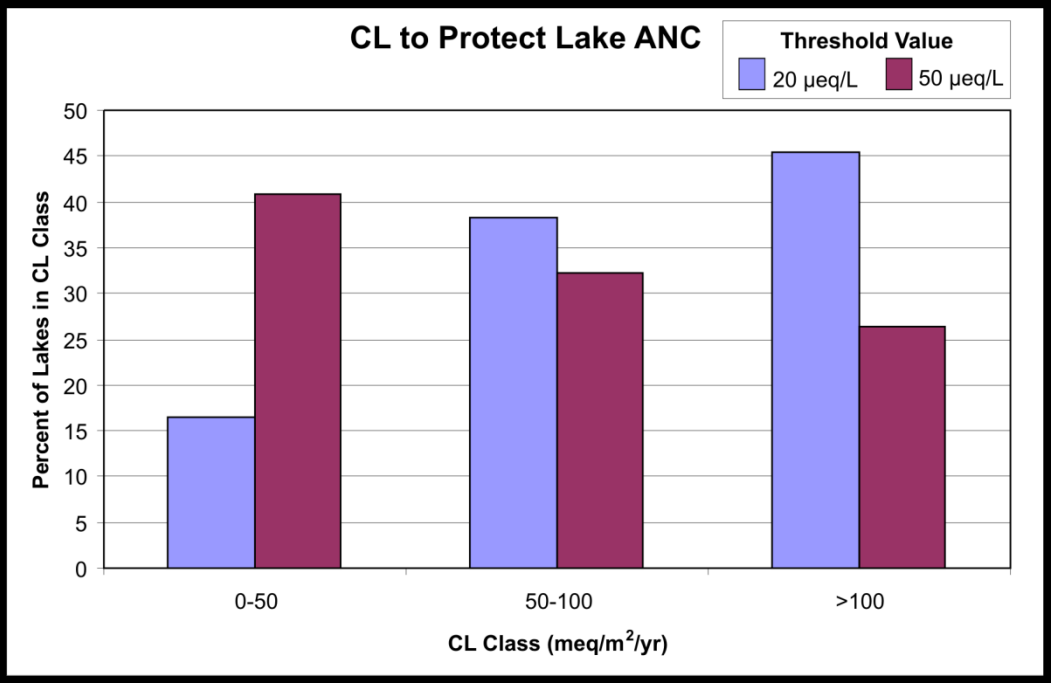
Soil Base Saturation: 10% in 2100

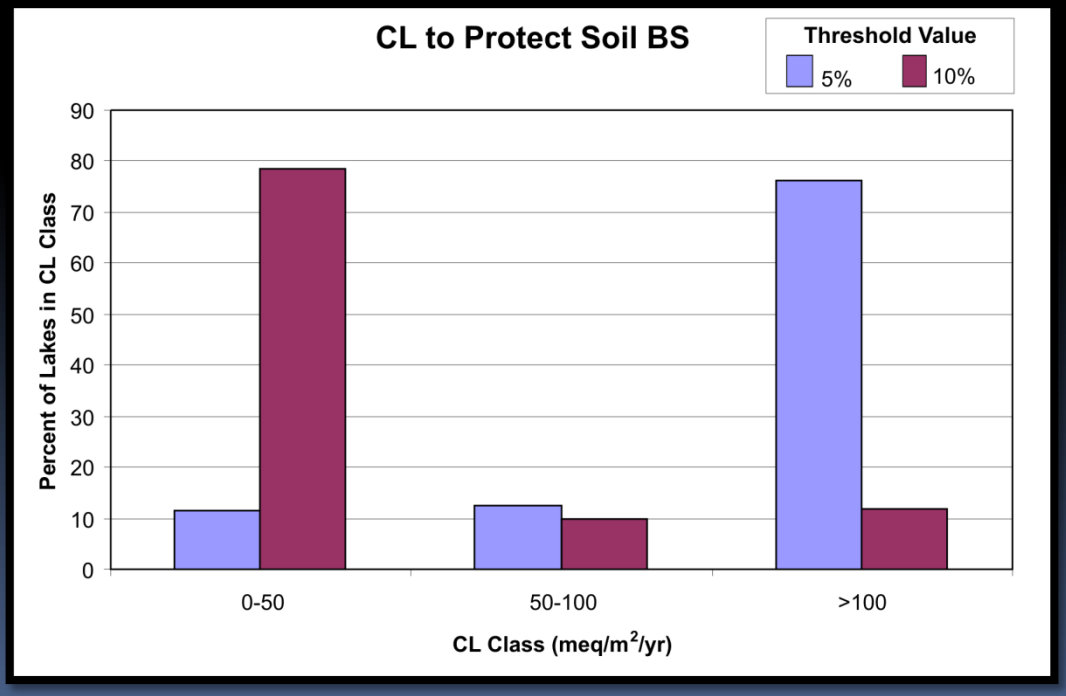



250
200
150
100
50
0
-50
Lake ANC in 2002 (µeq/L)
ANC = 20 µeq/L
0
5
10
15
20
25
30
35
Soil BS in 2003 (%)

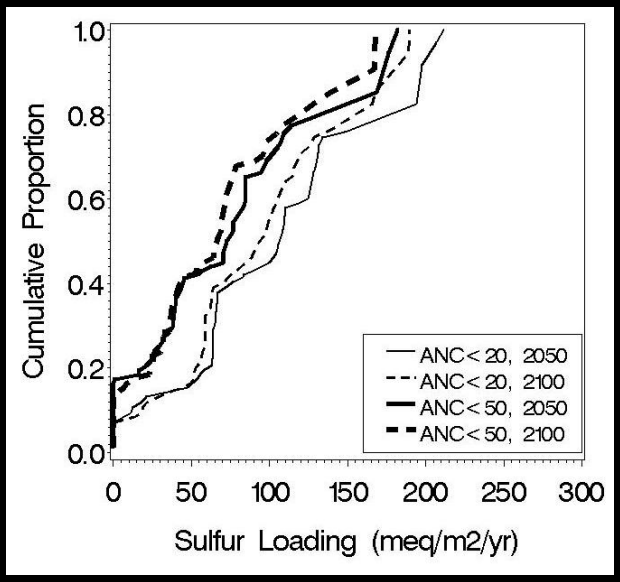

Percent of Modeled Sites Having CL ≤ 50 meq/m²/yr
75
50
25
0
Lake ANC to 50 µeq/L
Lake ANC to 20 µeq/L
Lake ANC to 0 µeq/L
Soil BS to 5%
Soil Solution Bc:Al to 1.0
Soil Solution Ca:Al to 1.0
Critical Load Calculated to protect by the year 2100

Numeric extrapolation of S CL results for the year 2100 to 1320 low-ANC Adirondack lakes

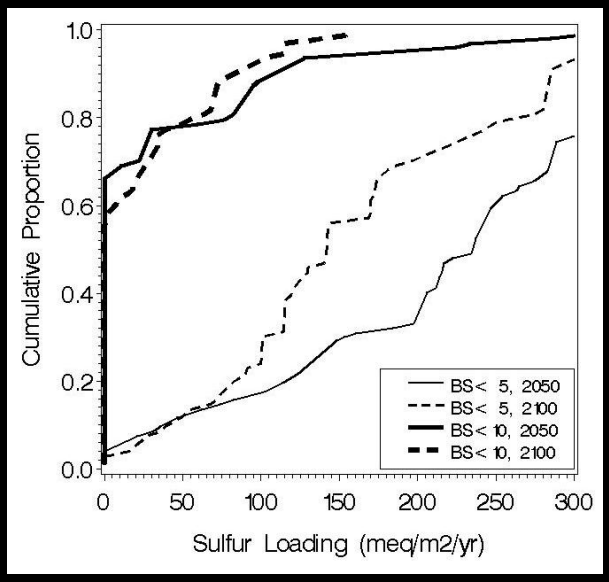




Critical load for protecting Lake ANC



Critical load for protecting Soil Base Saturation



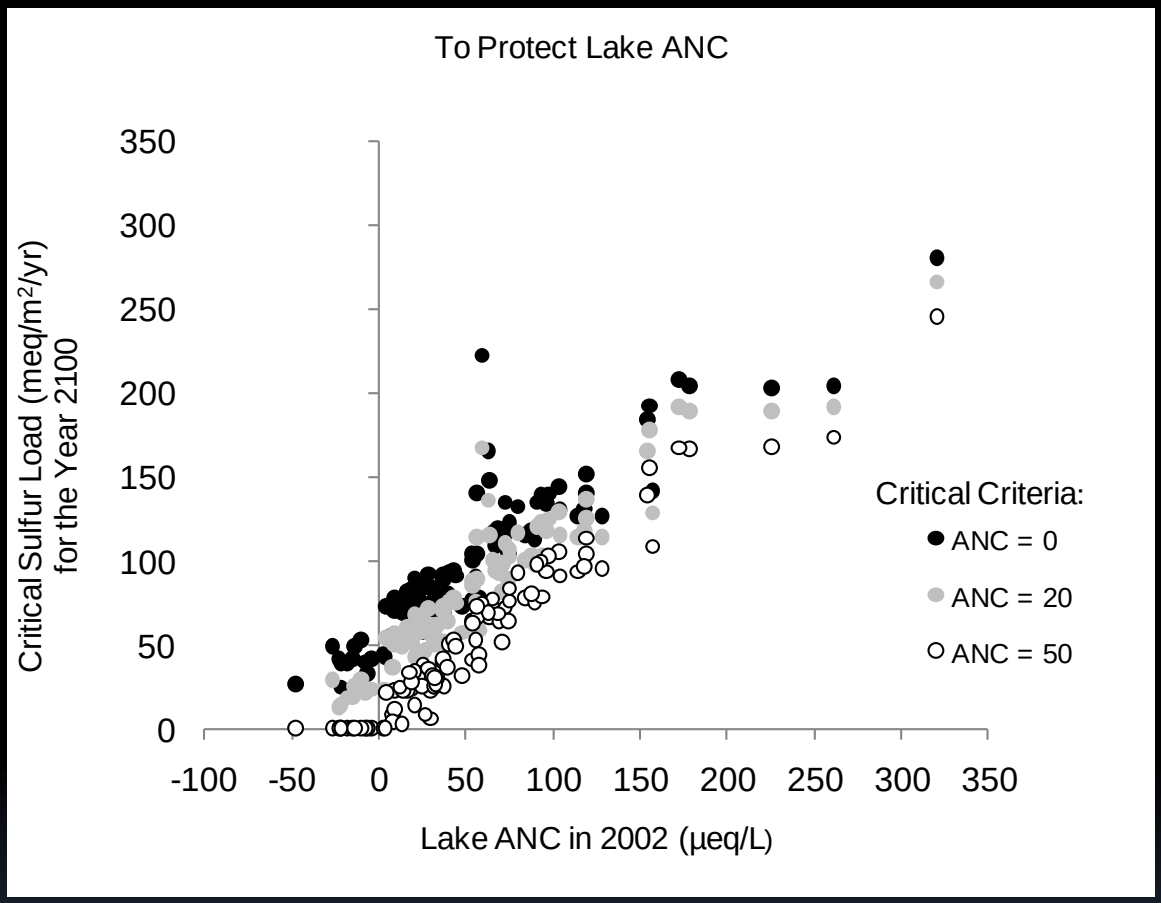
Candidate variables for extrapolating critical load

Landscape Characteristics

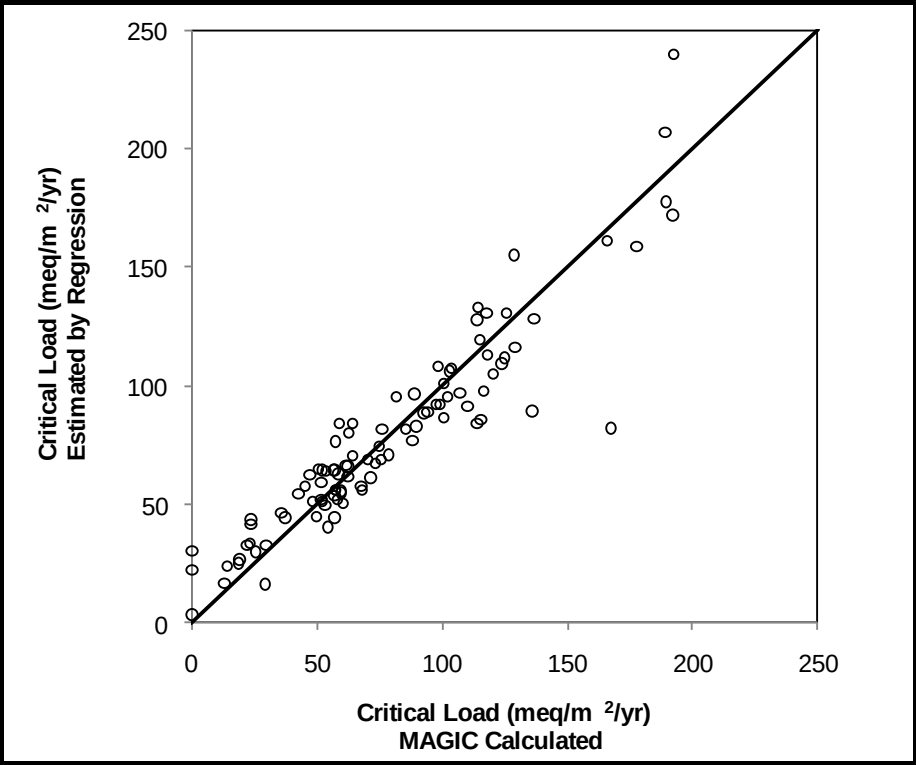
- Watershed area
- WA:SA
- Elevation
- Slope
- % clay in soil
- Soil pH
- Soil depth to restricting layer

Water Chemistry

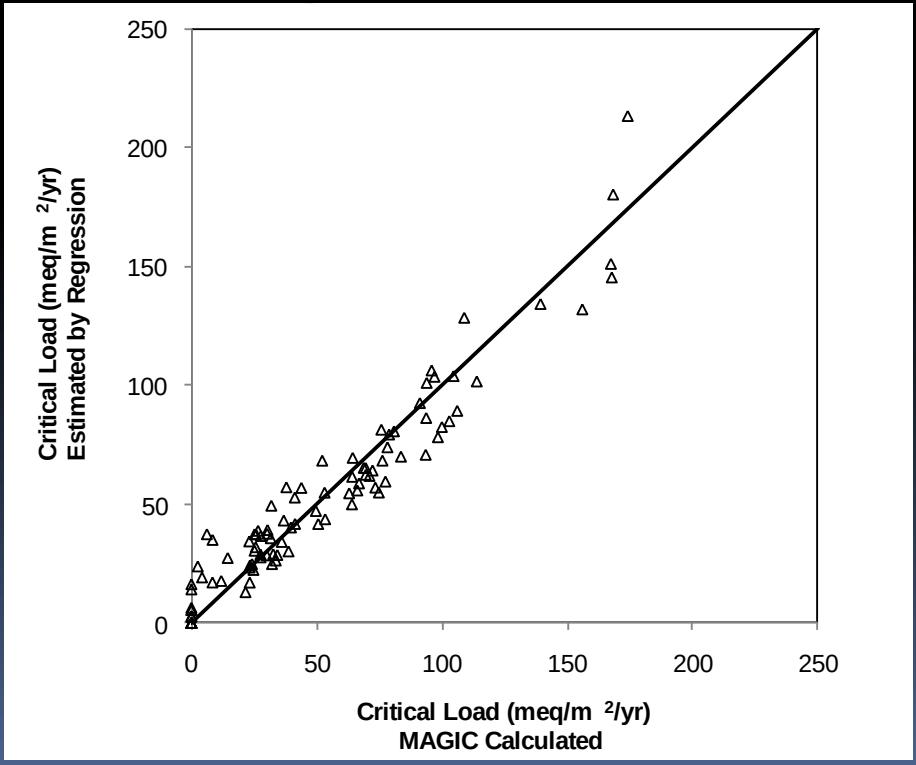
- ANC
- pH
- Sum of base cations
- Sum of base cations – chloride
- Sulfate
- Nitrate

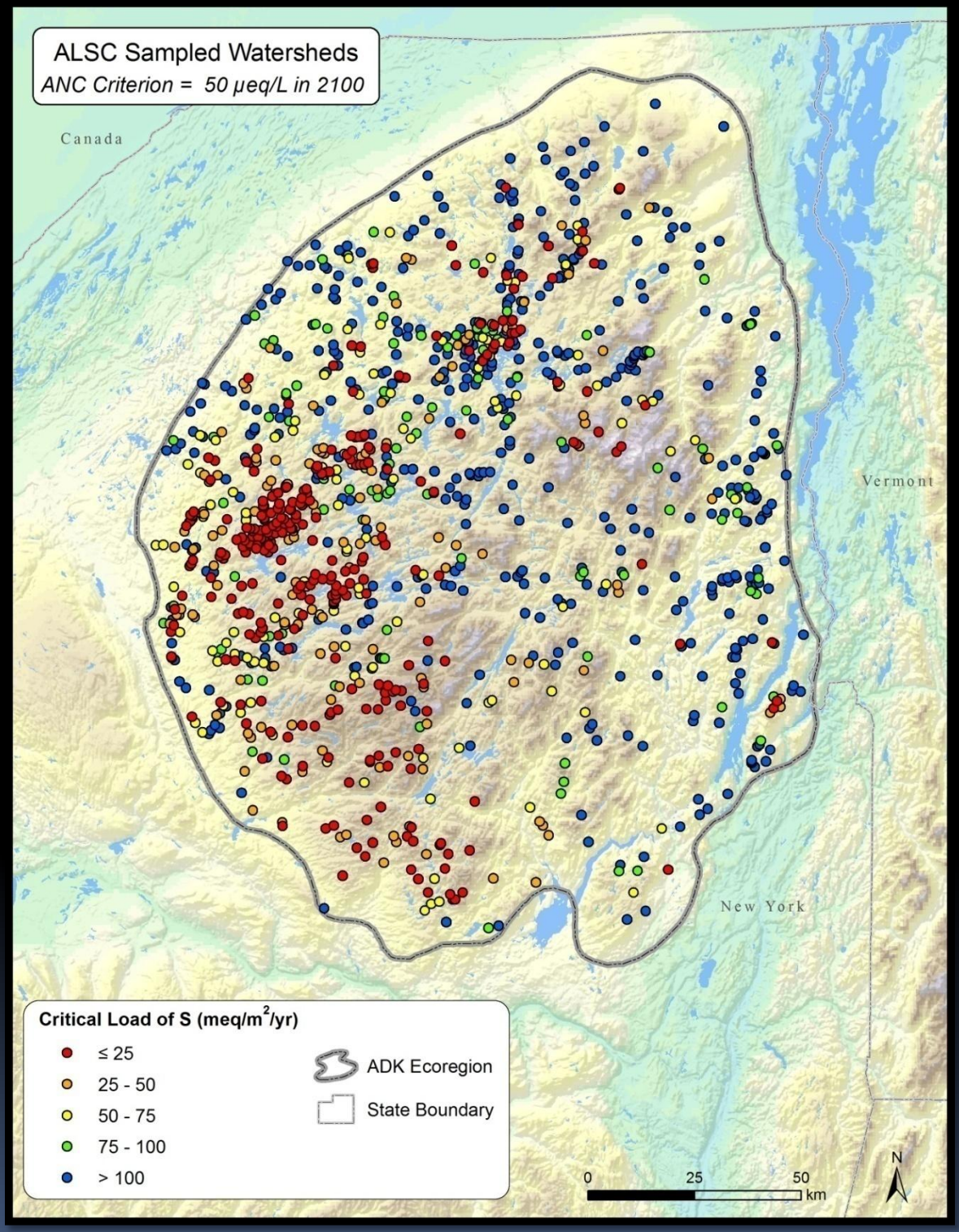

To Protect Lake ANC
Critical Sulfur Load (meq/m²/yr) for the Year 2100
350
300
250
200
150
100
50
0
-100
-50
0
50
100
150
200
250
300
350
Lake ANC in 2002 (µeq/L)
Critical Criteria:
ANC = 0
ANC = 20
ANC = 50

ANC = 20 µeq/L. Year 2100

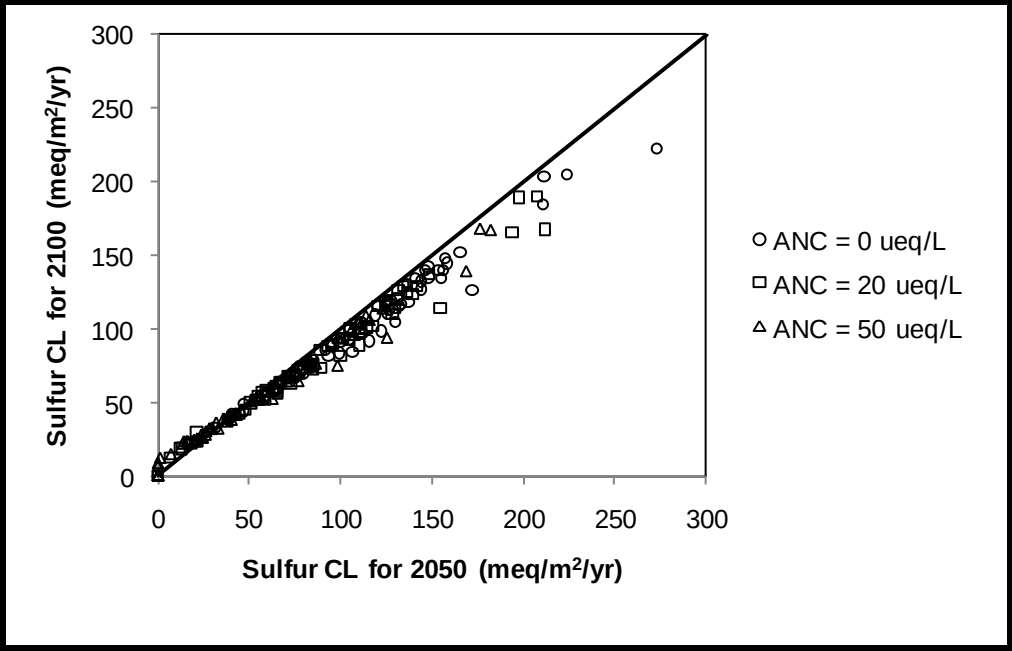


ANC = 50 µeq/L. Year 2100

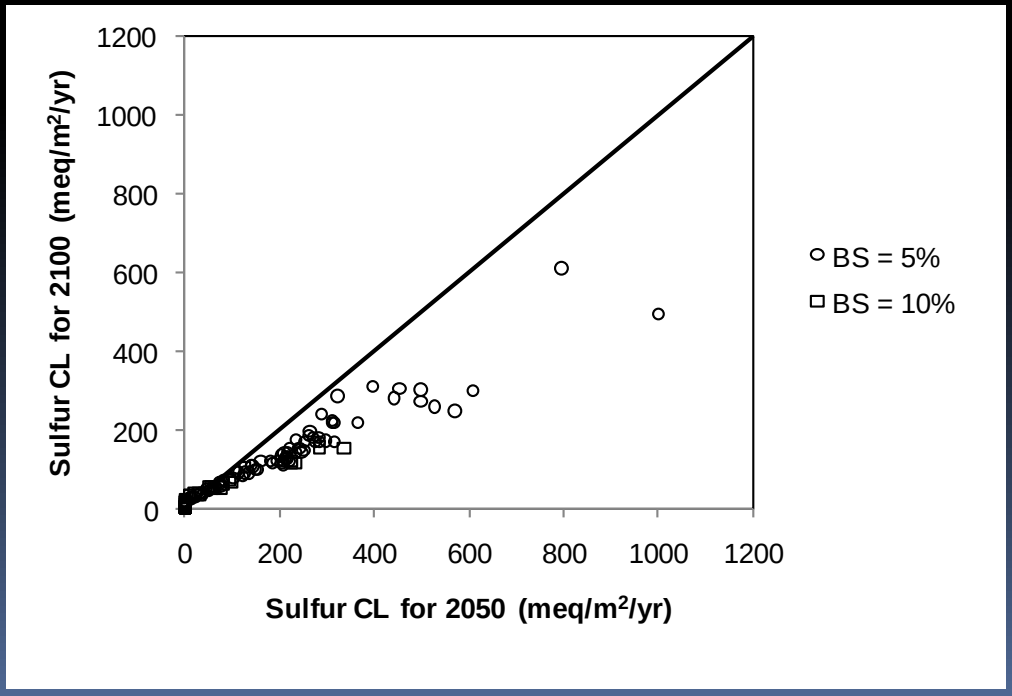



ALSC Sampled Watersheds
ANC Criterion = 50 µeq/L in 2100
Canada
Vermont
New York
Critical Load of S (meq/m2/yr)
≤ 25
25 - 50
50 - 75
75 - 100
> 100
ADK Ecoregion
State Boundary
0
25
50
km
N

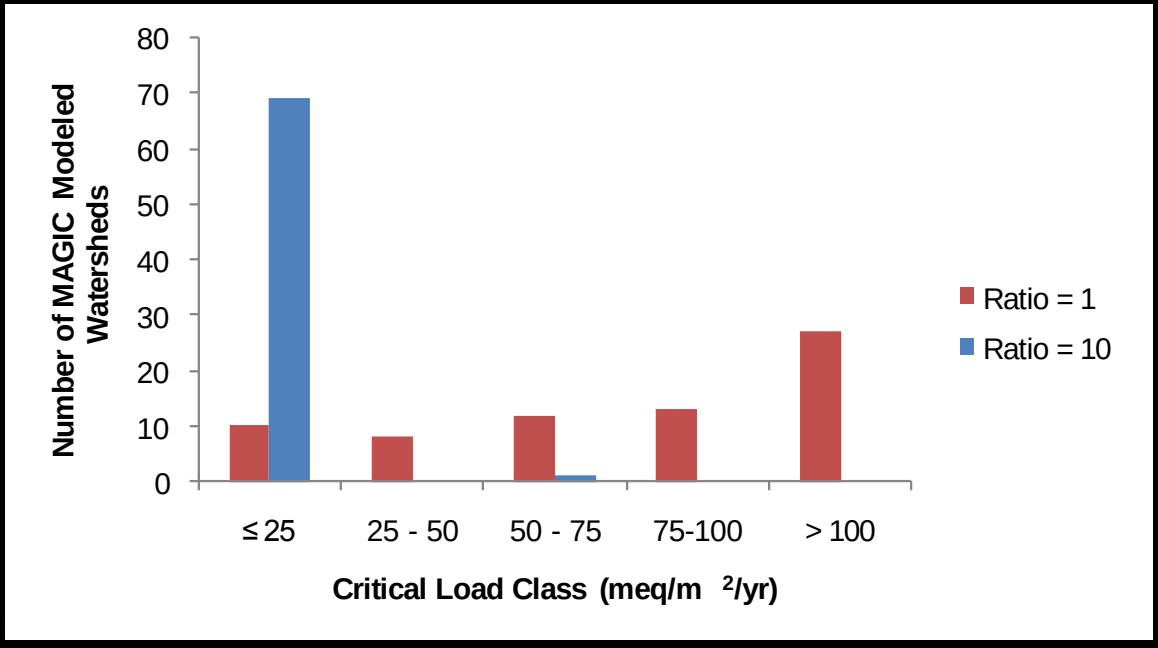
Critical sulfur load to protect Lake ANC

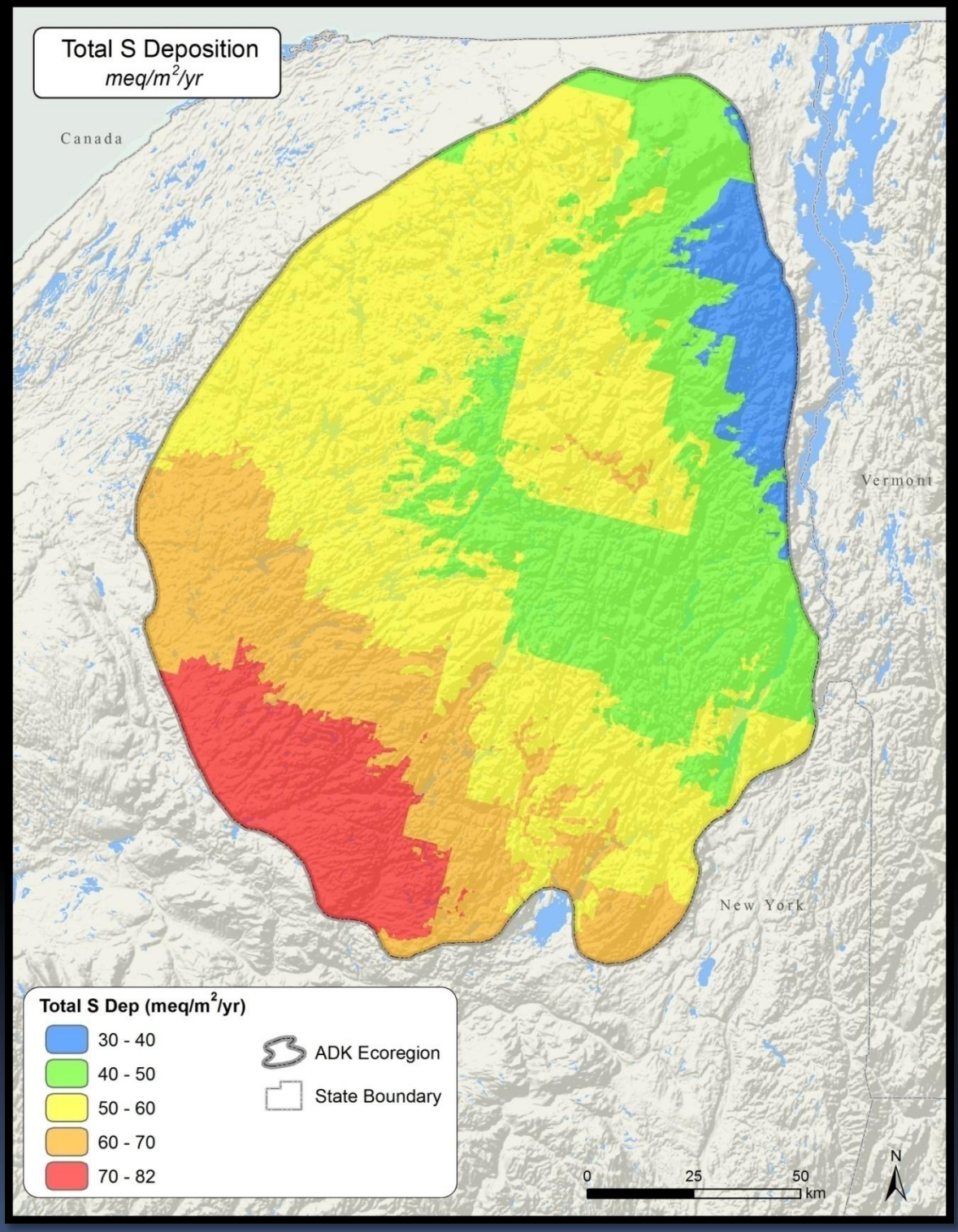


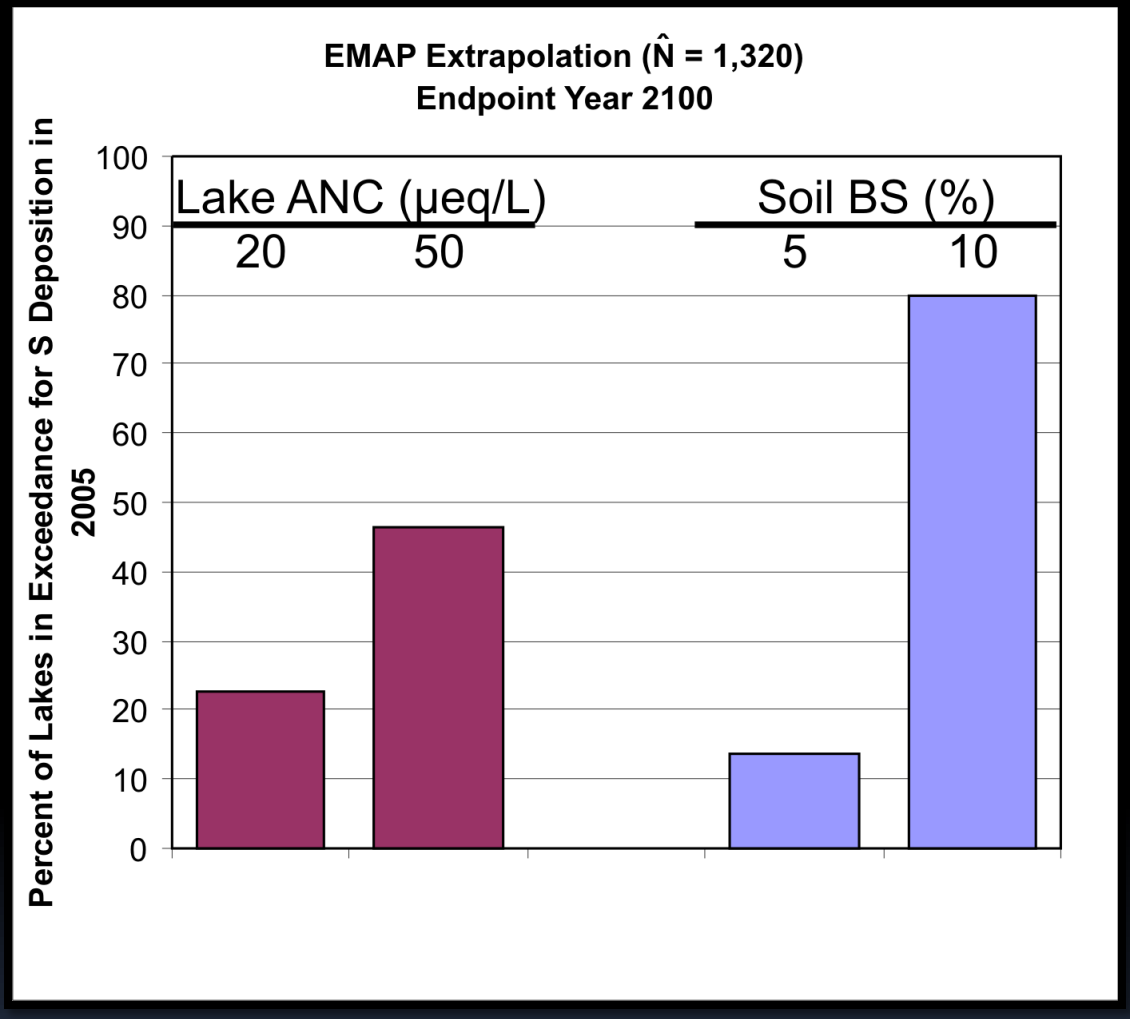
Critical sulfur load to protect Soil Base Saturation

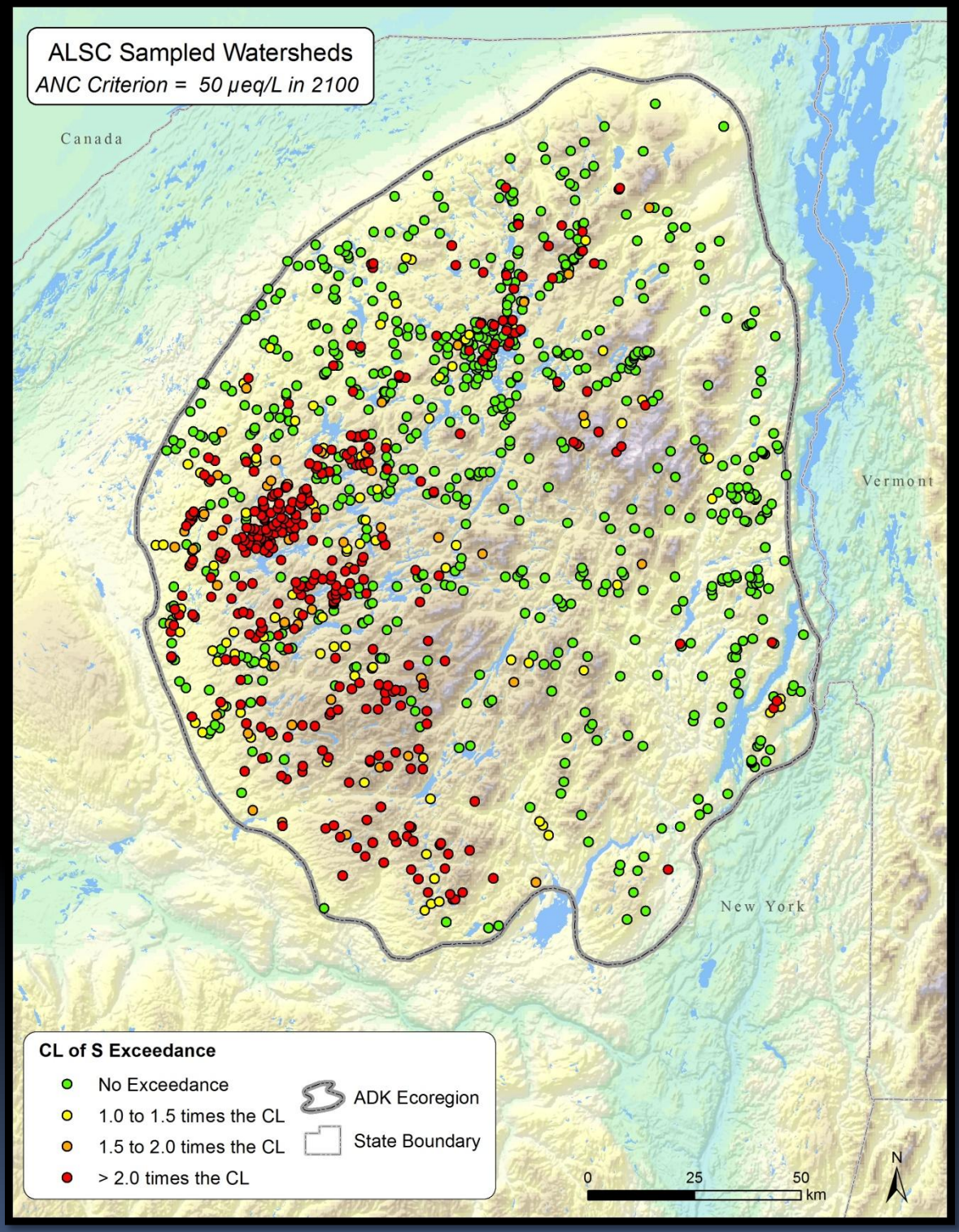


CL of S for Ca/Al ratio criterion for the year 2100




Total S Deposition
meq/m2/yr
Canada
Vermont
New York
Total S Dep (meq/m2/yr)
30 - 40
40 - 50
50 - 60
60 - 70
70 - 82
ADK Ecoregion
State Boundary
0
25
50
km
N


EMAP Extrapolation (N̂ = 1,320)
Endpoint Year 2100
Percent of Lakes in Exceedance for S Deposition in 2005
100
90
80
70
60
50
40
30
20
10
0
Lake ANC (µeq/L)
20
50
Soil BS (%)
5
10


ALSC Sampled Watersheds
ANC Criterion = 50 µeq/L in 2100
Canada
Vermont
New York
CL of S Exceedance
No Exceedance
1.0 to 1.5 times the CL
1.5 to 2.0 times the CL
> 2.0 times the CL
ADK Ecoregion
State Boundary
0
25
50
km
N