LINKAGES AMONG ACIDIC AND MERCURY DEPOSITION AND CLIMATE CHANGE IN ADIRONDACK ECOSYSTEMS

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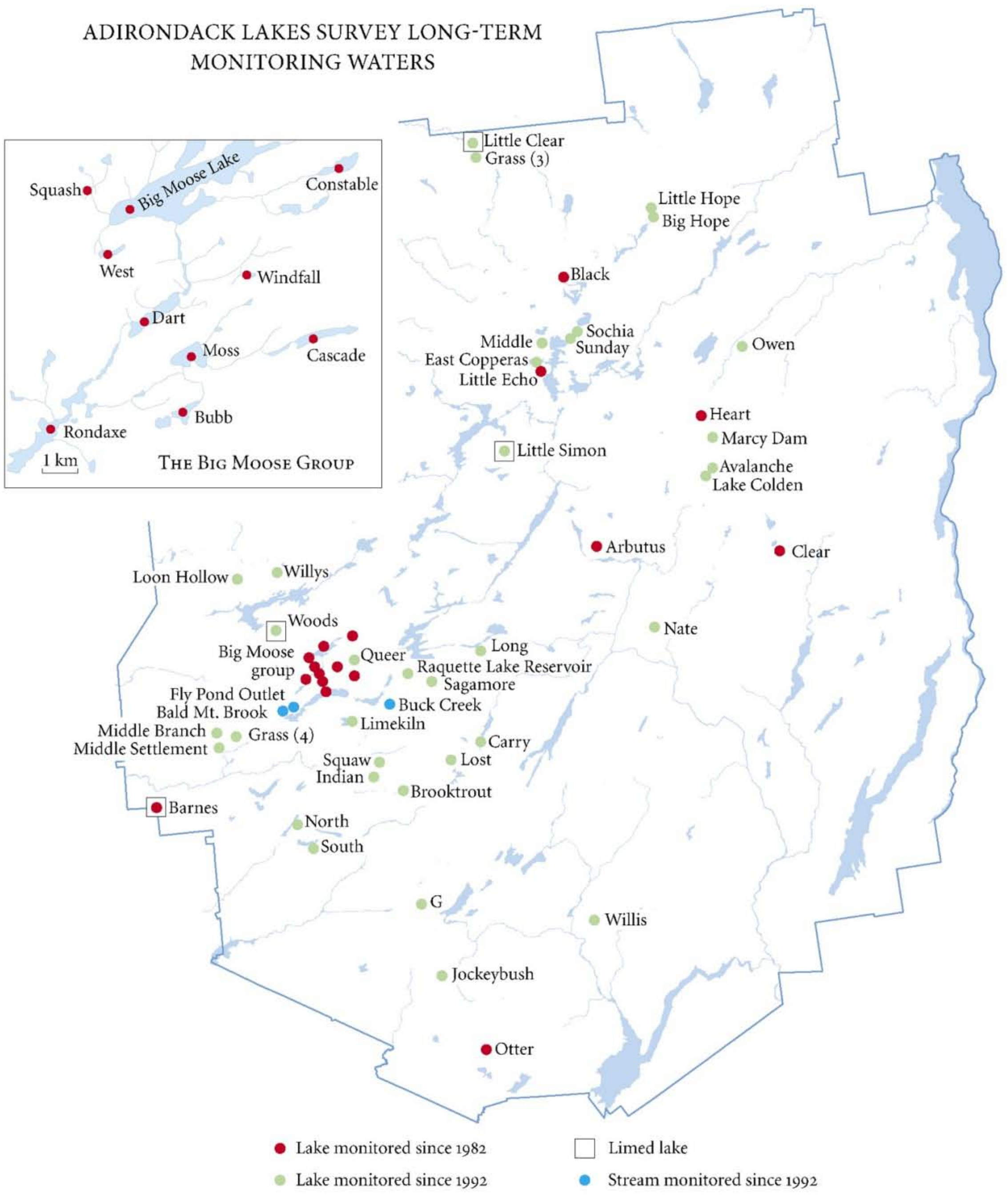
Outline

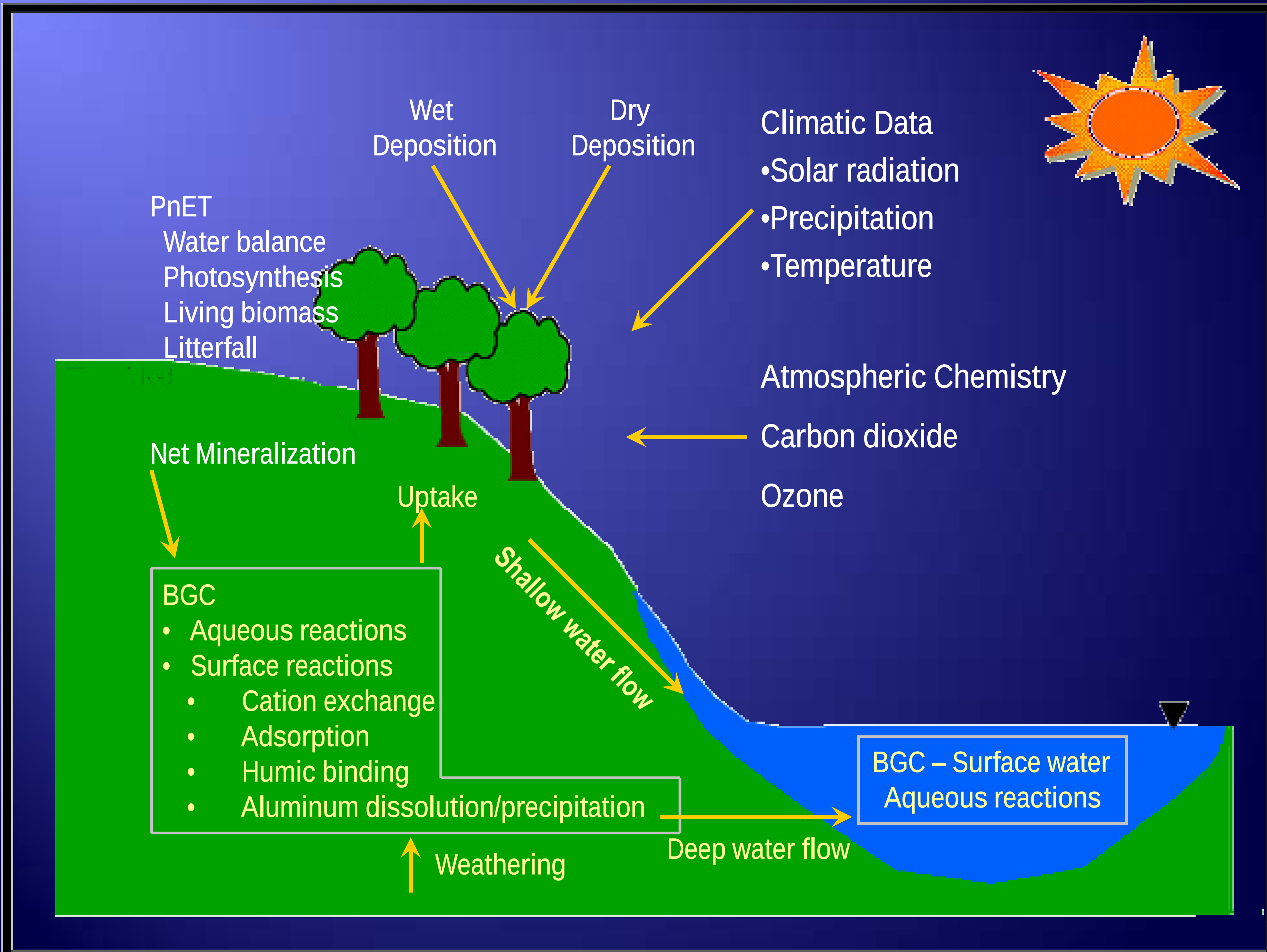
- Approach and pollutant interactions
- Recent trends in Adirondack deposition and lake chemistry
- Linkages with mercury
- Linkages with climate change
- Final thoughts



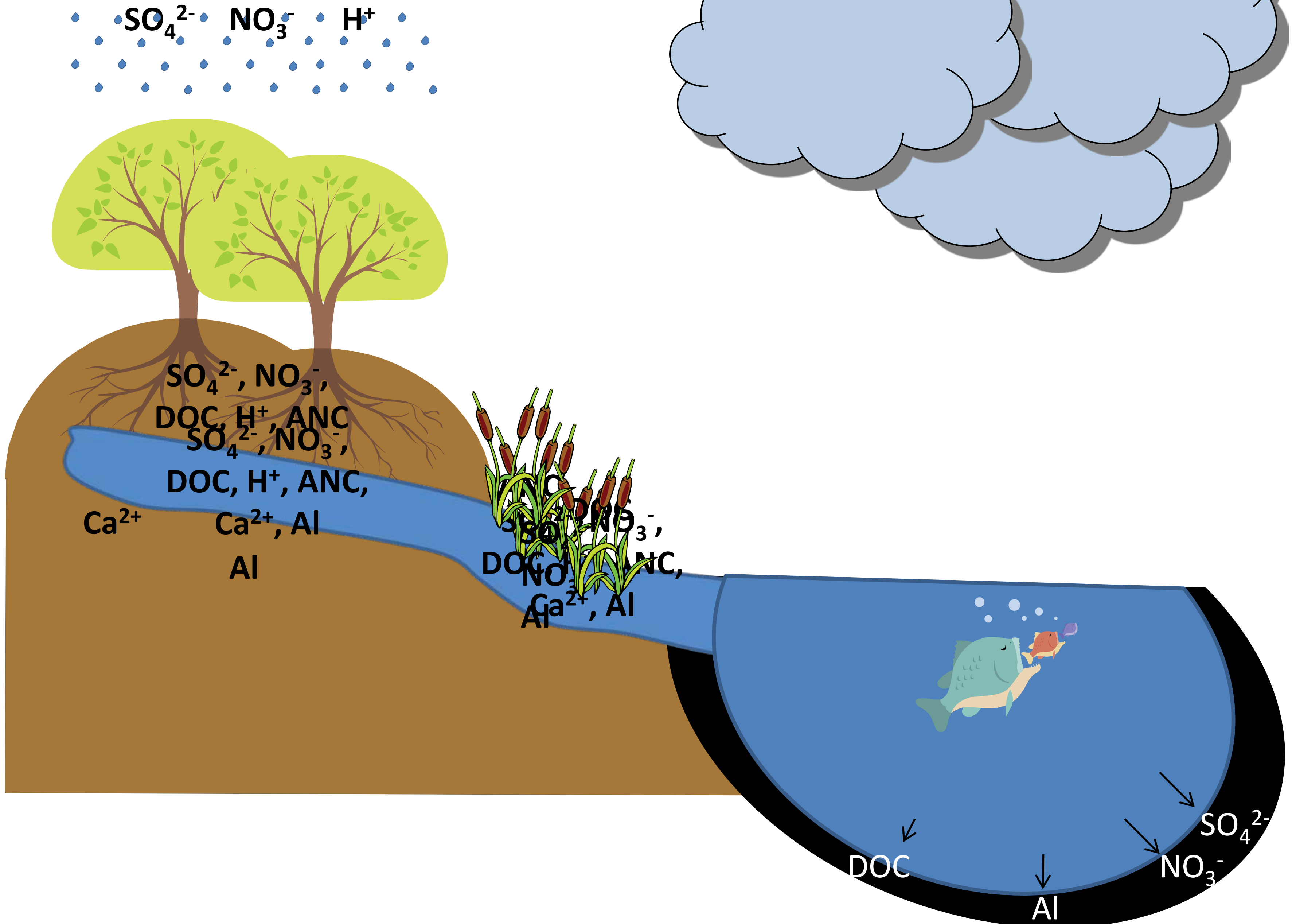
Lake Classes

- Seepage
- Drainage
  - Thin till
  - Medium till
  - Thick till
  - Carbonate

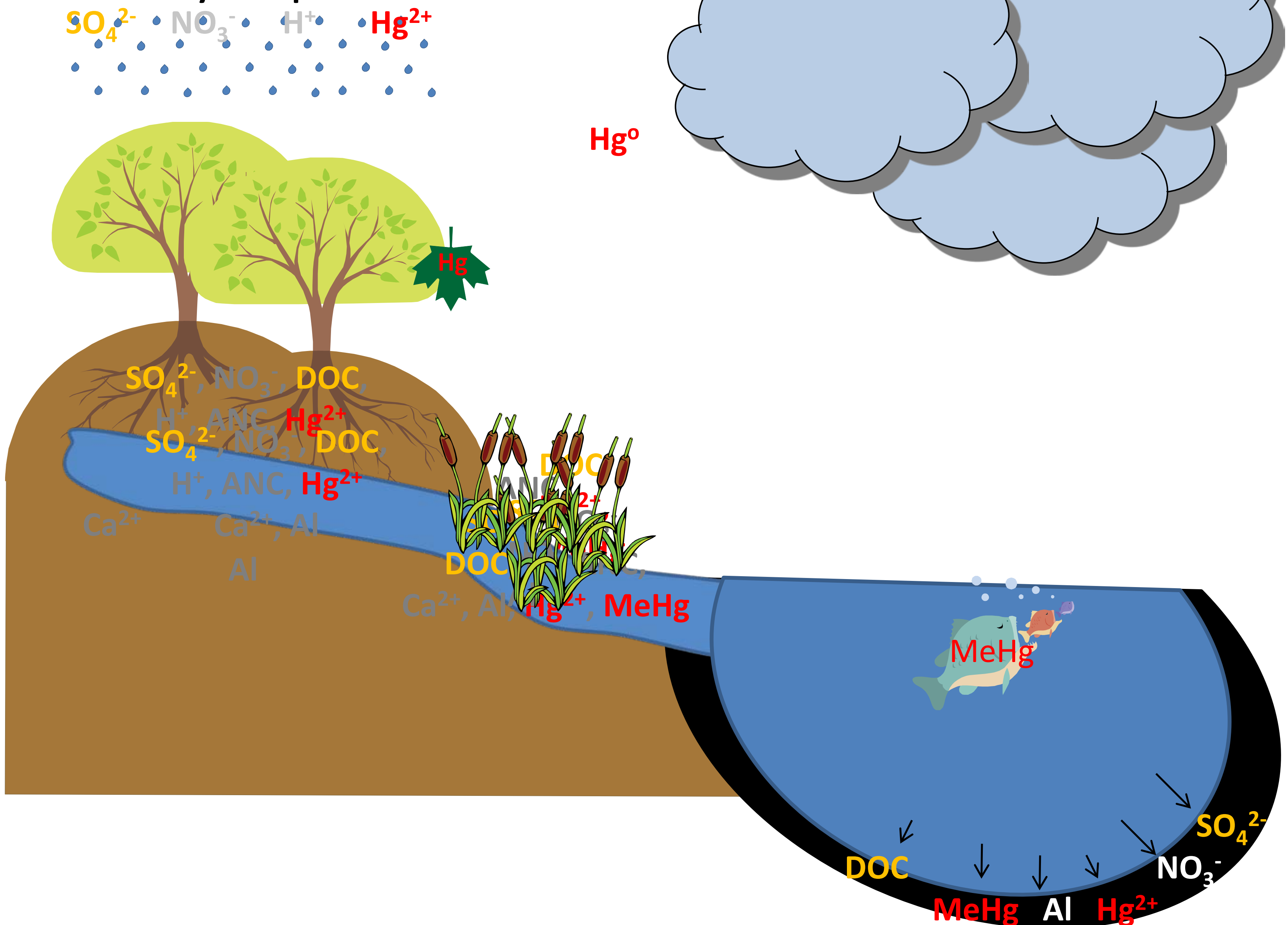
Arbutus Lake – 48.2 ha


Wet Deposition
Dry Deposition
Climatic Data
•Solar radiation
•Precipitation
•Temperature
PnET
Water balance
Photosynthesis
Living biomass
Litterfall
Atmospheric Chemistry
Carbon dioxide
Ozone
Net Mineralization
Uptake
Shallow water flow
BGC
• Aqueous reactions
• Surface reactions
• Cation exchange
• Adsorption
• Humic binding
• Aluminum dissolution/precipitation
BGC – Surface water
Aqueous reactions
Deep water flow
Weathering

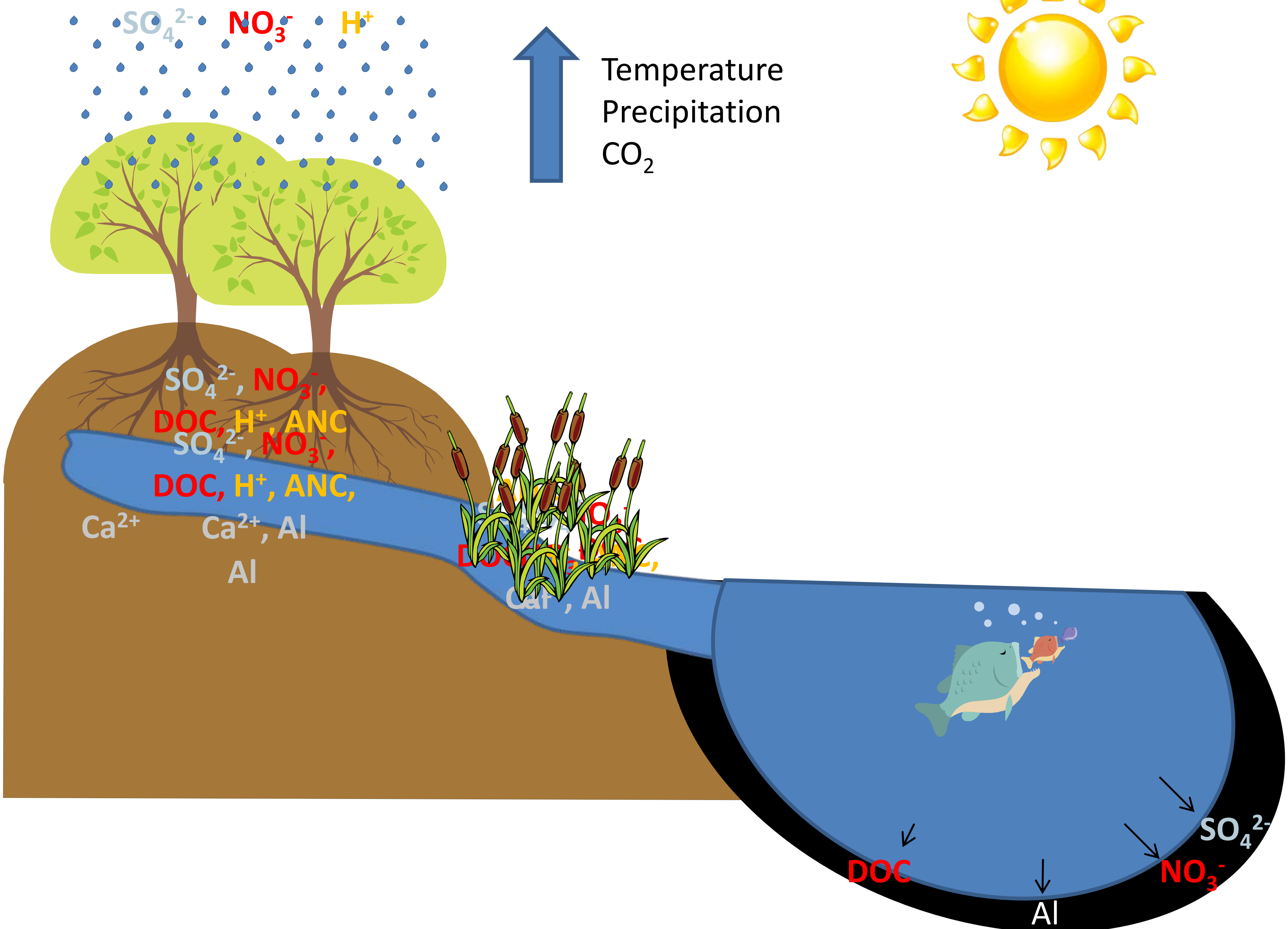
Acid Deposition

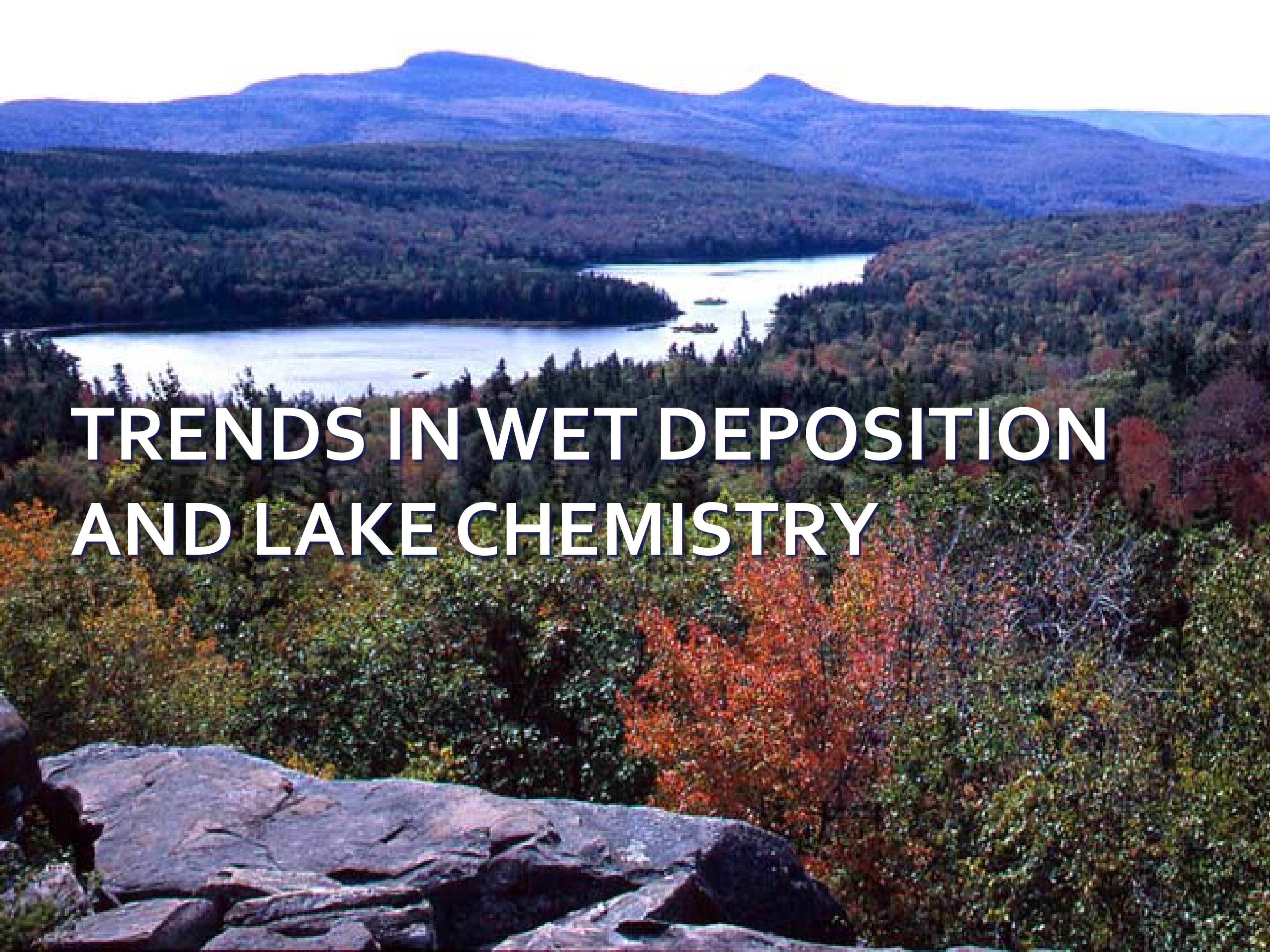


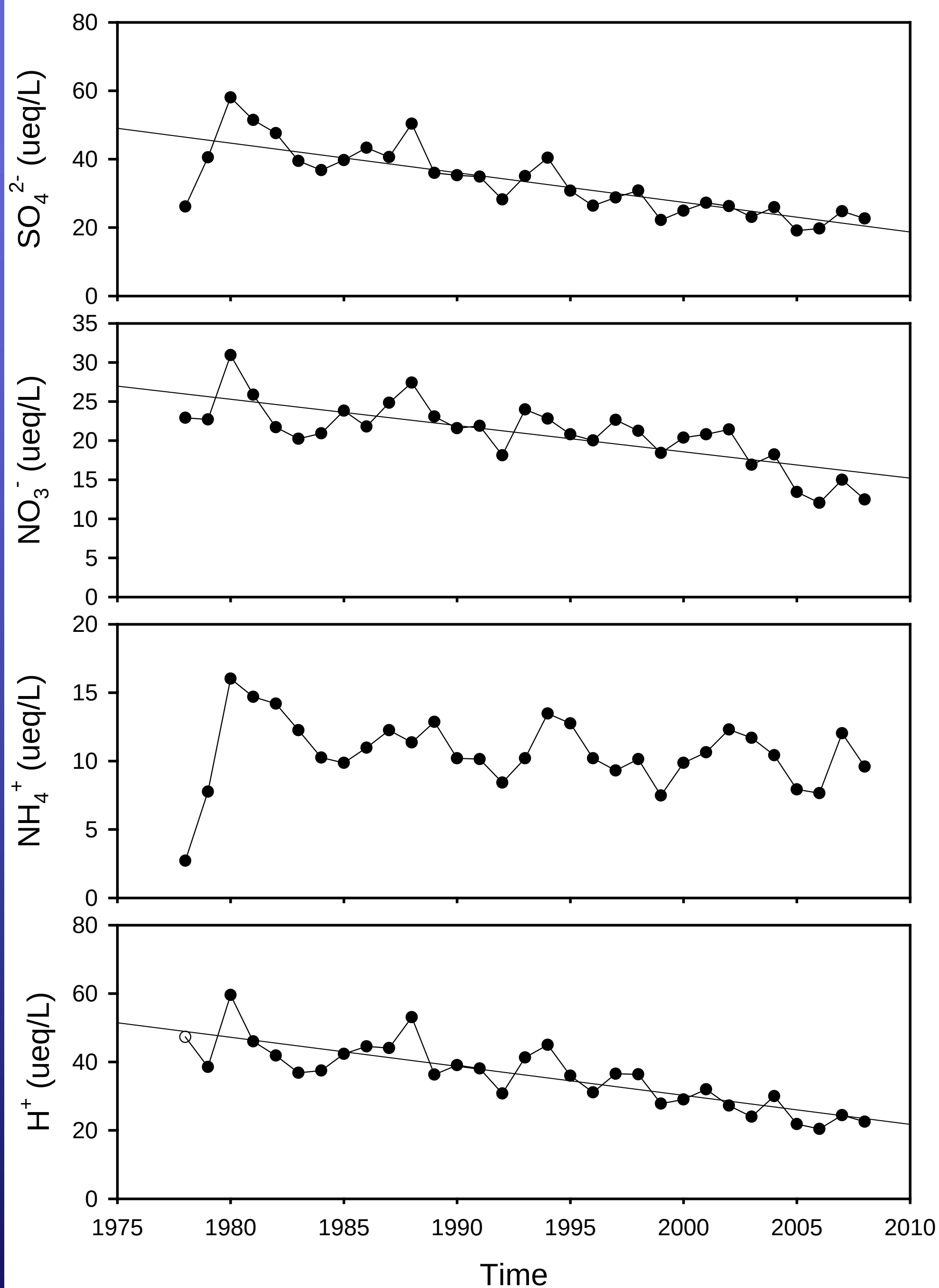
Mercury Deposition



Climate Drivers

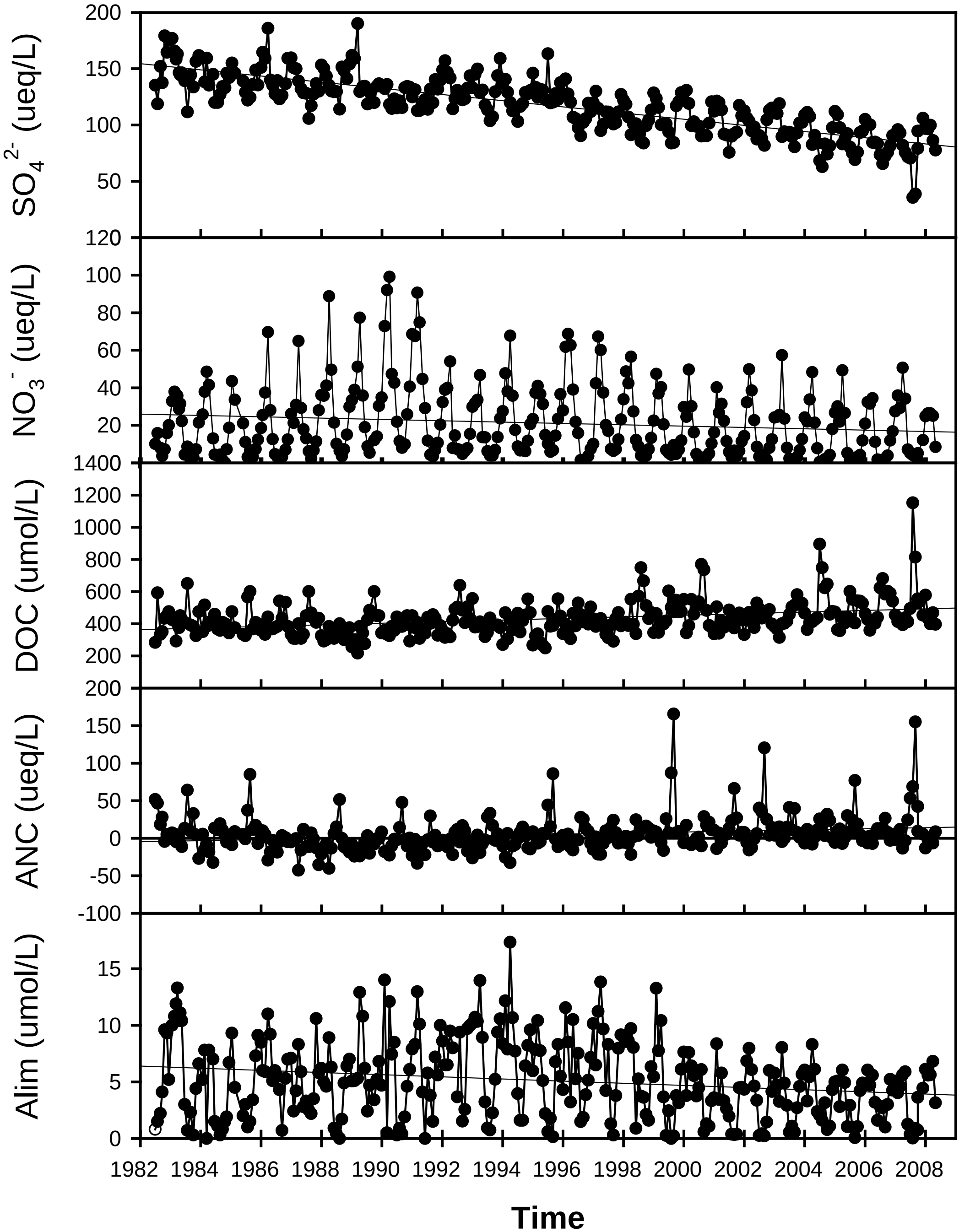



TRENDS IN WET DEPOSITION
AND LAKE CHEMISTRY

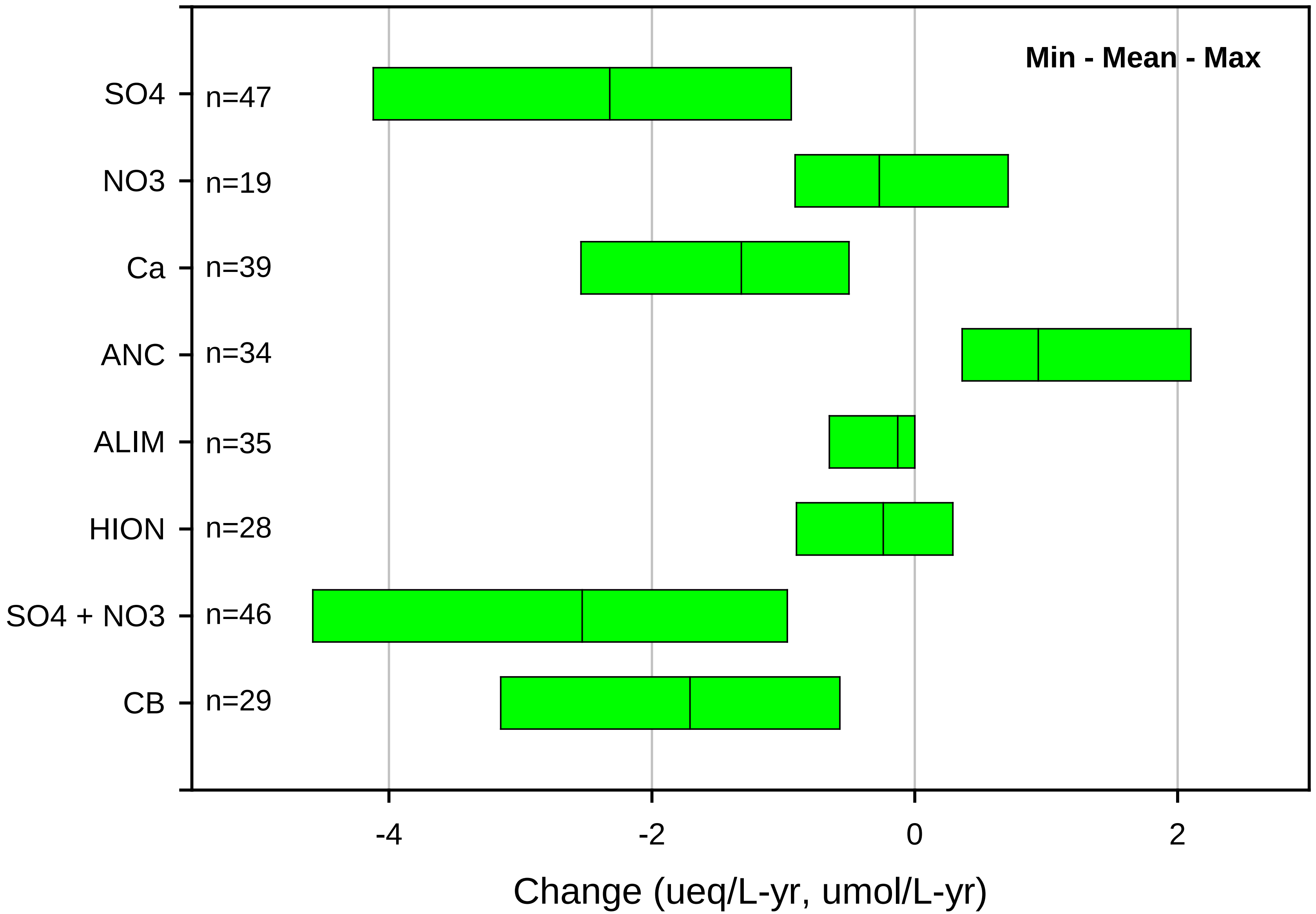


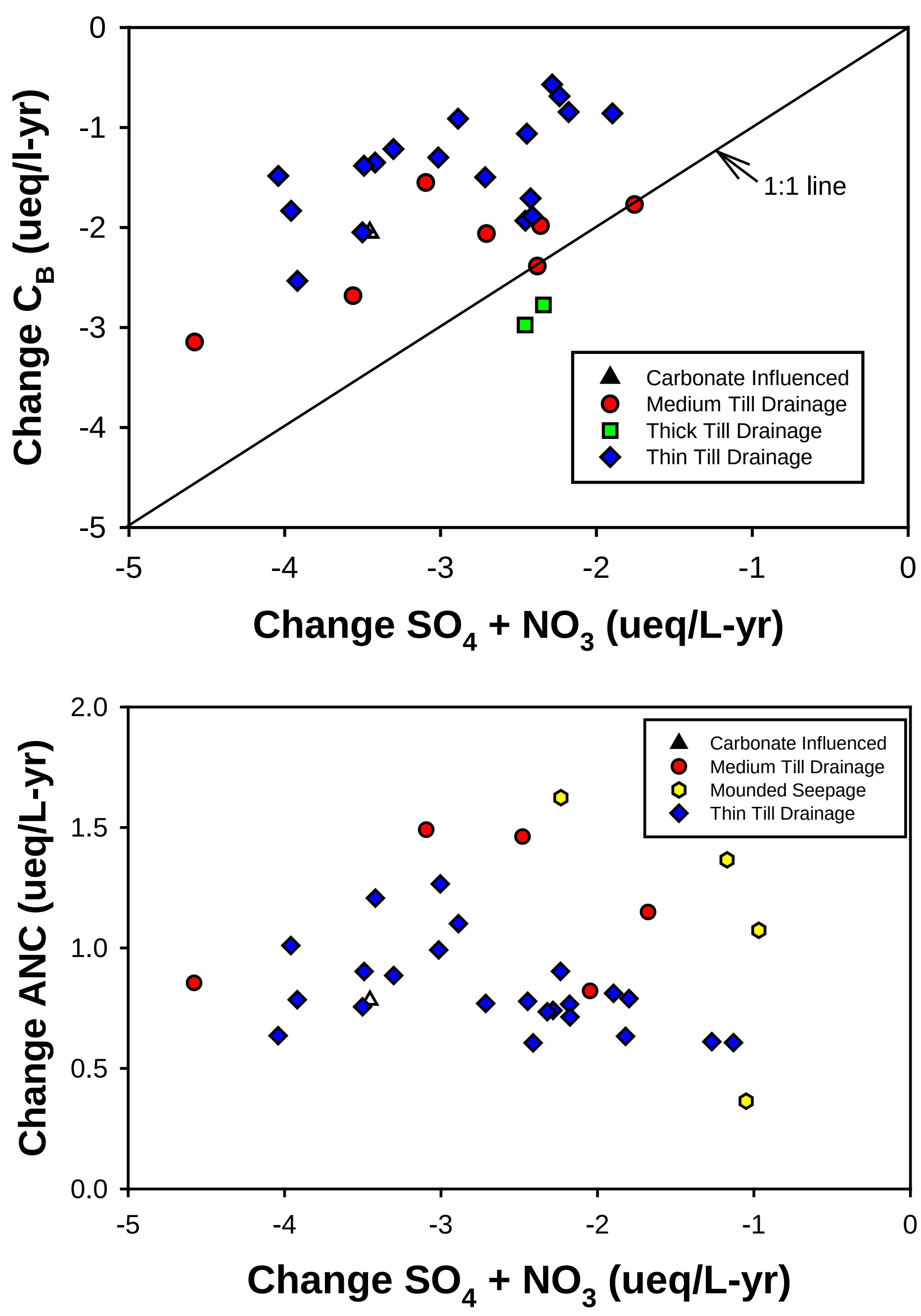
SO_4^{2-} (ueq/L)
80
60
40
20
0
35
30
25
20
15
10
5
0
NO_3^- (ueq/L)
20
15
10
5
0
NH_4^+ (ueq/L)
80
60
40
20
0
H^+ (ueq/L)
1975
1980
1985
1990
1995
2000
2005
2010
Time

Constable Pond

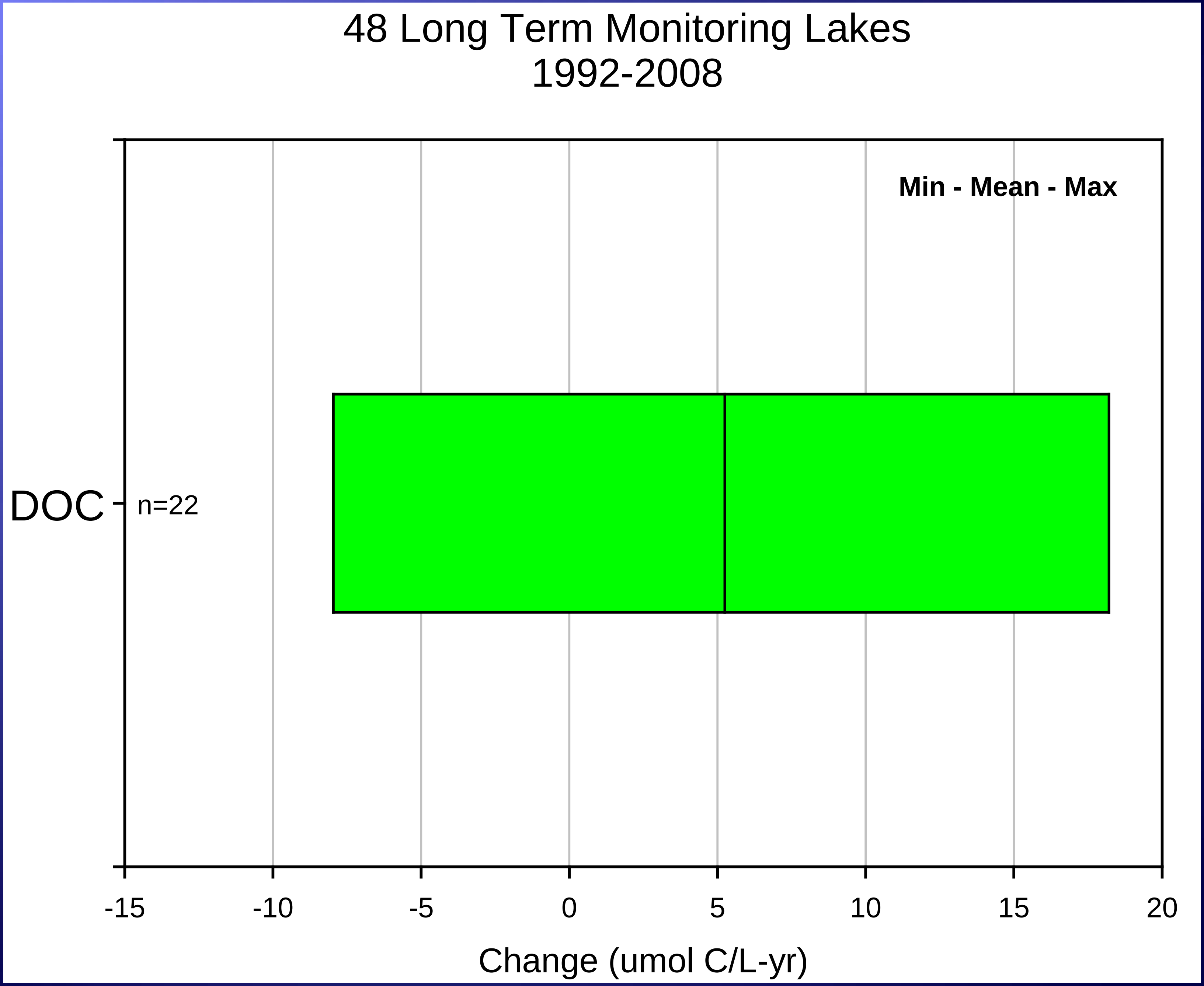


48 Long Term Monitoring Lakes
1992-2008

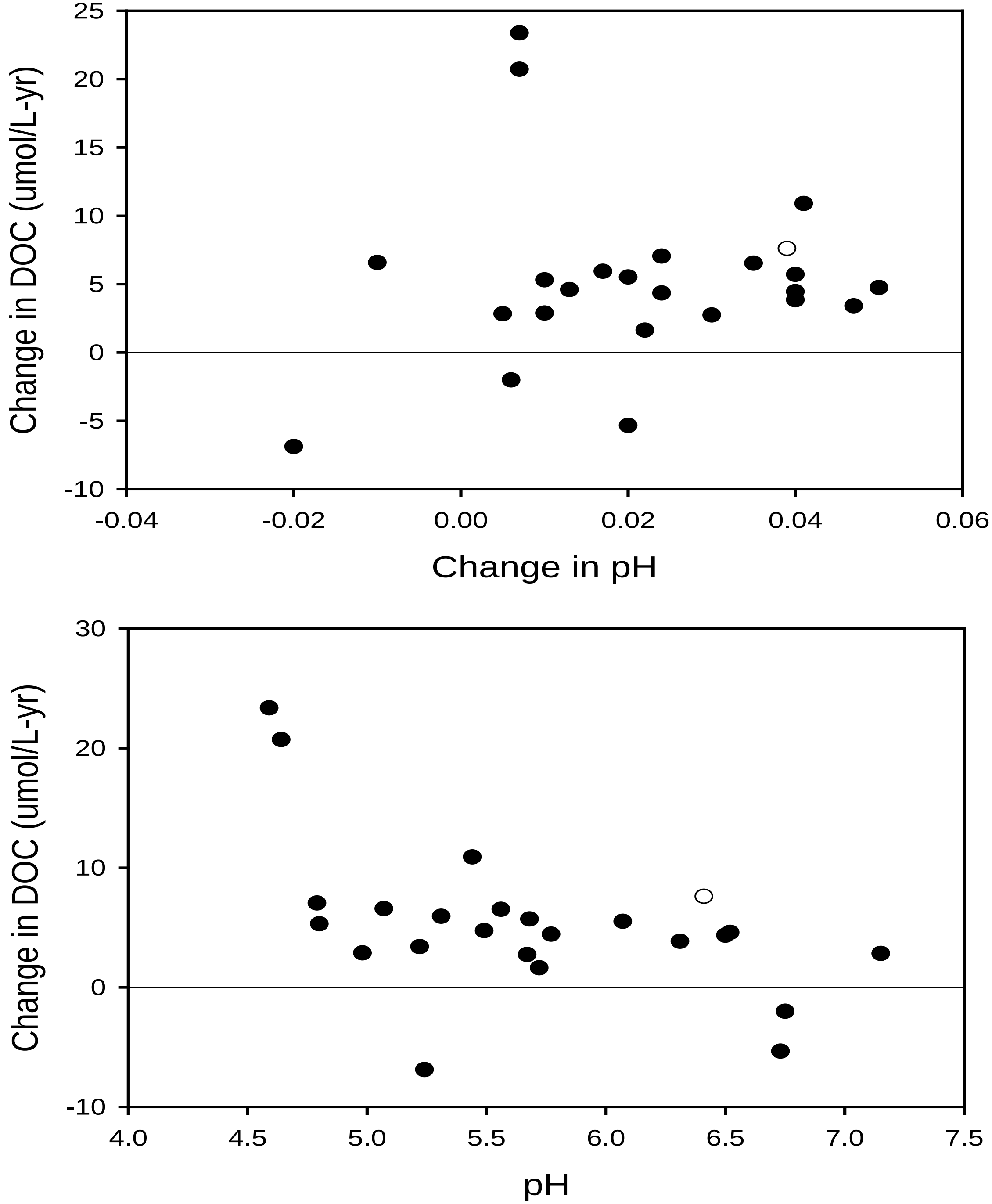




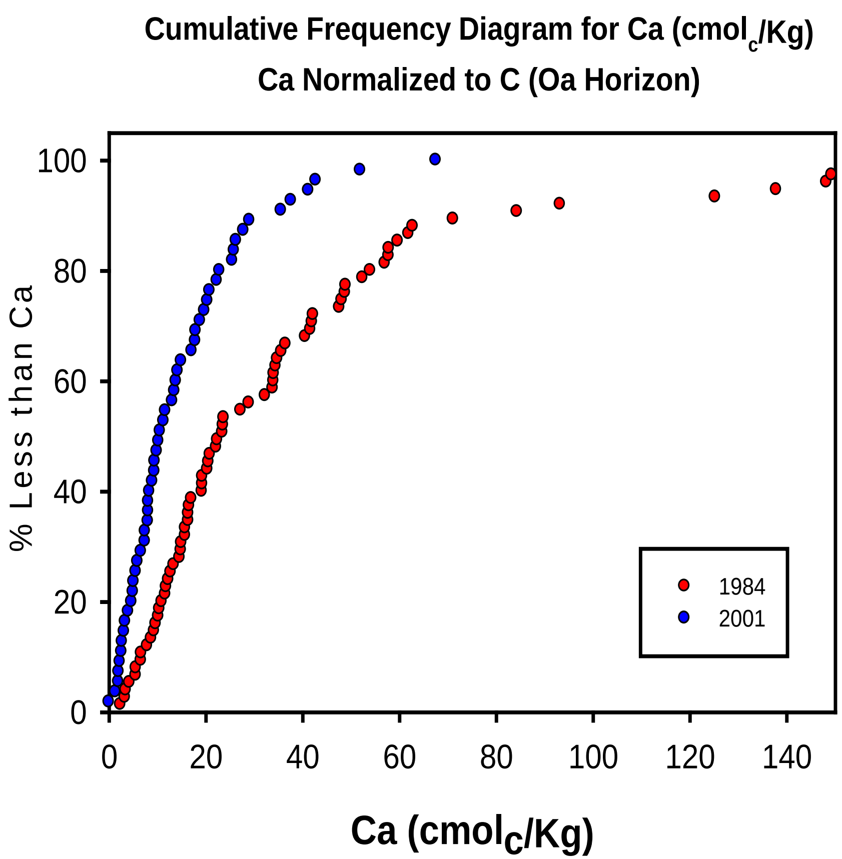
0
-1
-2
-3
-4
-5
Change C_B (ueq/l-yr)
1:1 line
Carbonate Influenced
Medium Till Drainage
Thick Till Drainage
Thin Till Drainage
-5
-4
-3
-2
-1
0
Change $SO_4 + NO_3$ (ueq/L-yr)
2.0
1.5
1.0
0.5
0.0
Change ANC (ueq/L-yr)
Carbonate Influenced
Medium Till Drainage
Mounded Seepage
Thin Till Drainage
-5
-4
-3
-2
-1
0
Change $SO_4 + NO_3$ (ueq/L-yr)



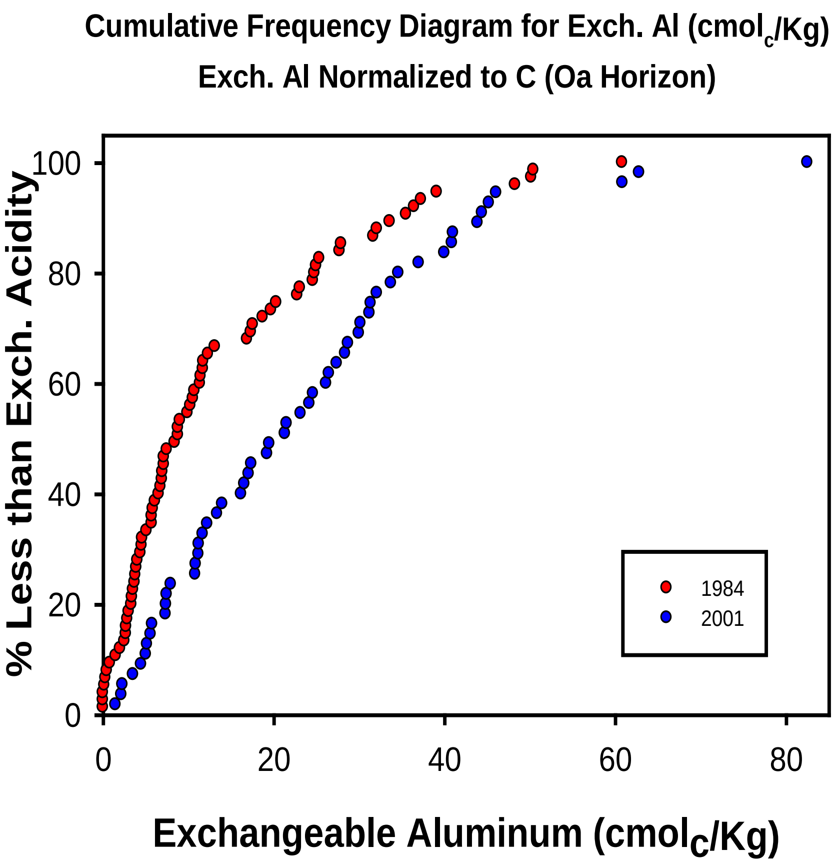
48 Long Term Monitoring Lakes
1992-2008
Min - Mean - Max
DOC
n=22
-15
-10
-5
0
5
10
15
20
Change (umol C/L-yr)



25
20
15
10
5
0
-5
-10
-0.04
-0.02
0.00
0.02
0.04
0.06
Change in DOC (umol/L-yr)
Change in pH
30
20
10
0
-10
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
Change in DOC (umol/L-yr)
pH

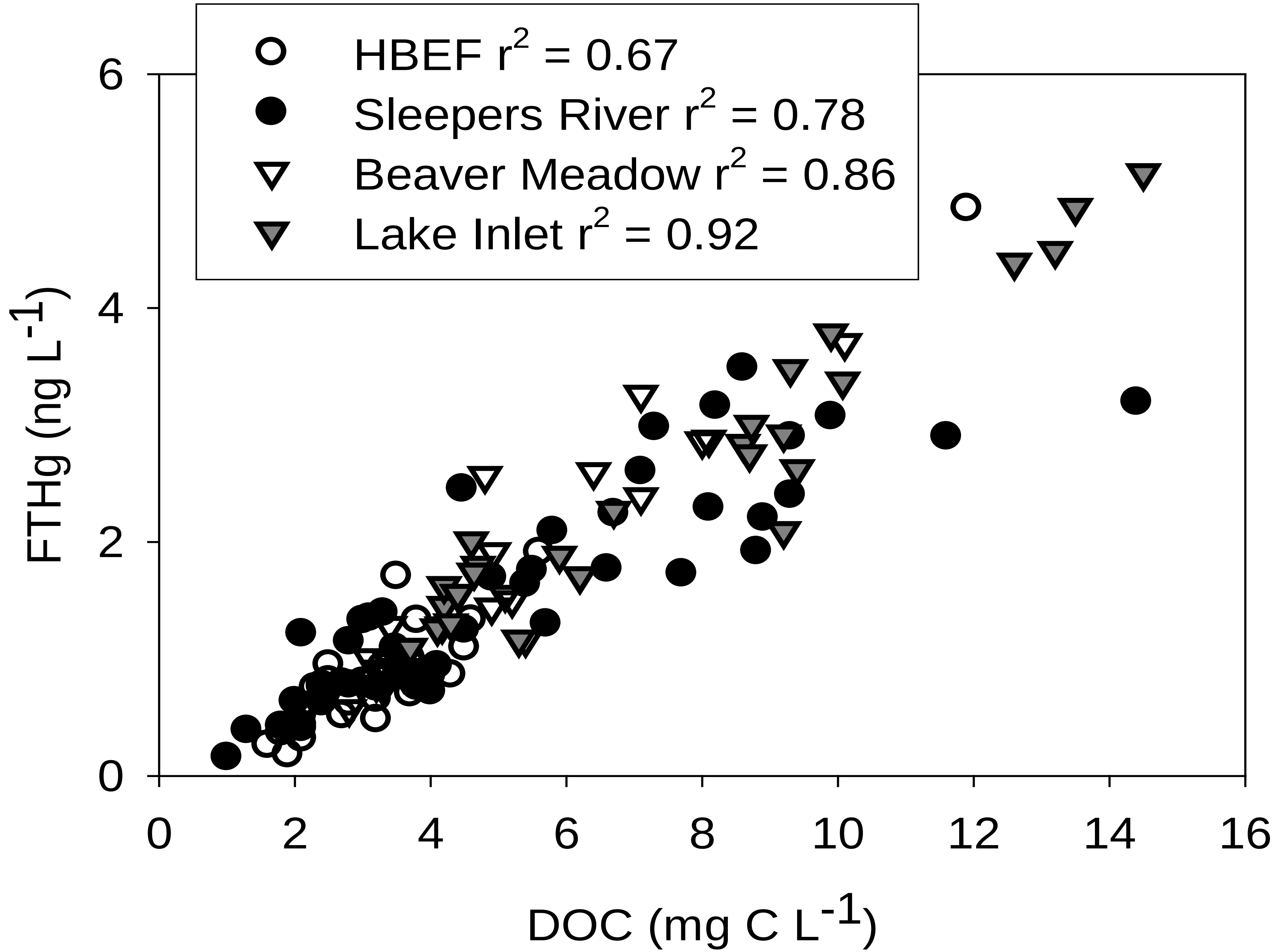


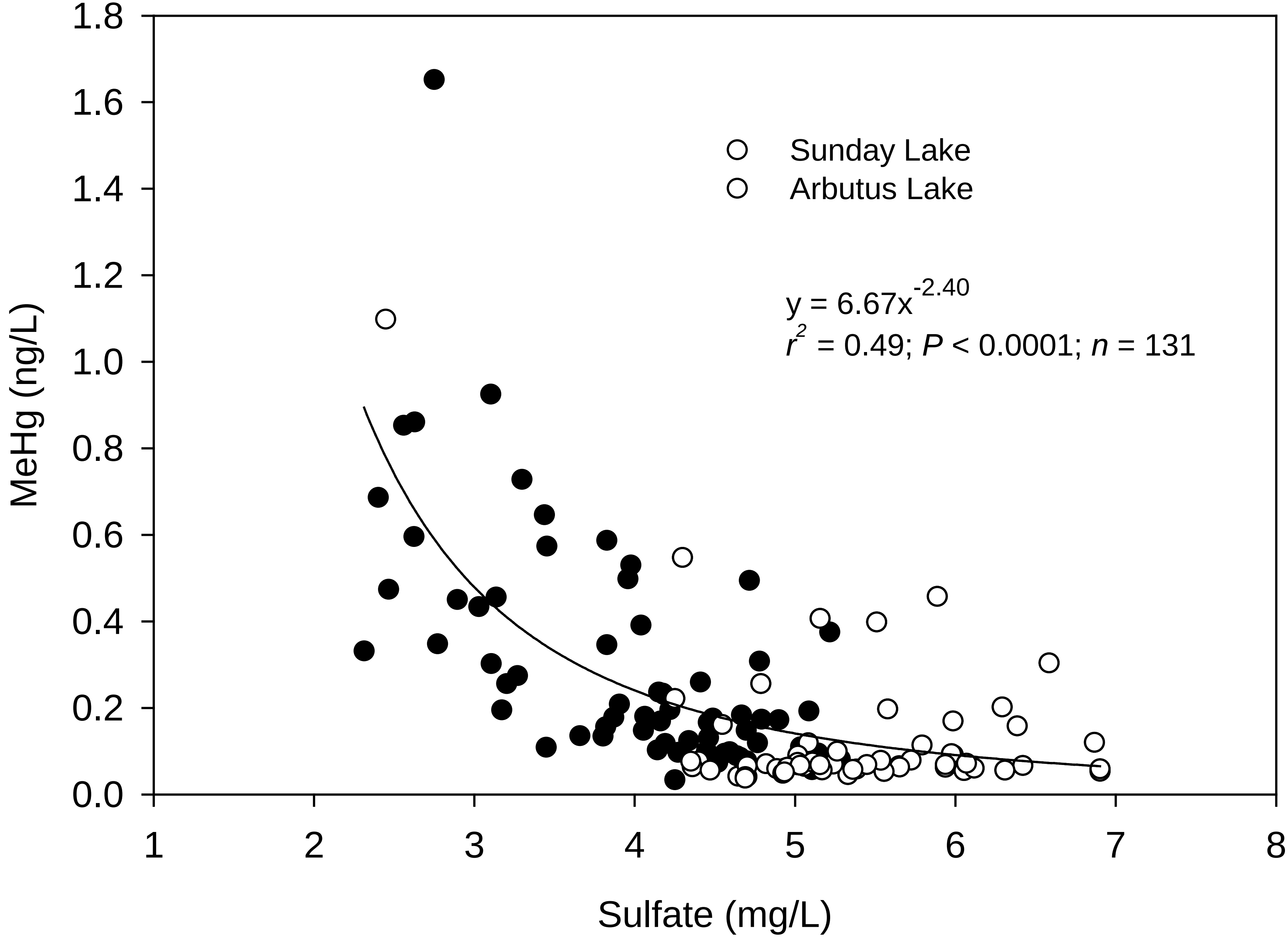
Cumulative Frequency Diagram for Ca (cmolc/Kg)
Ca Normalized to C (Oa Horizon)
% Less than Ca
0
20
40
60
80
100
0
20
40
60
80
100
120
140
Ca (cmolC/Kg)
1984
2001



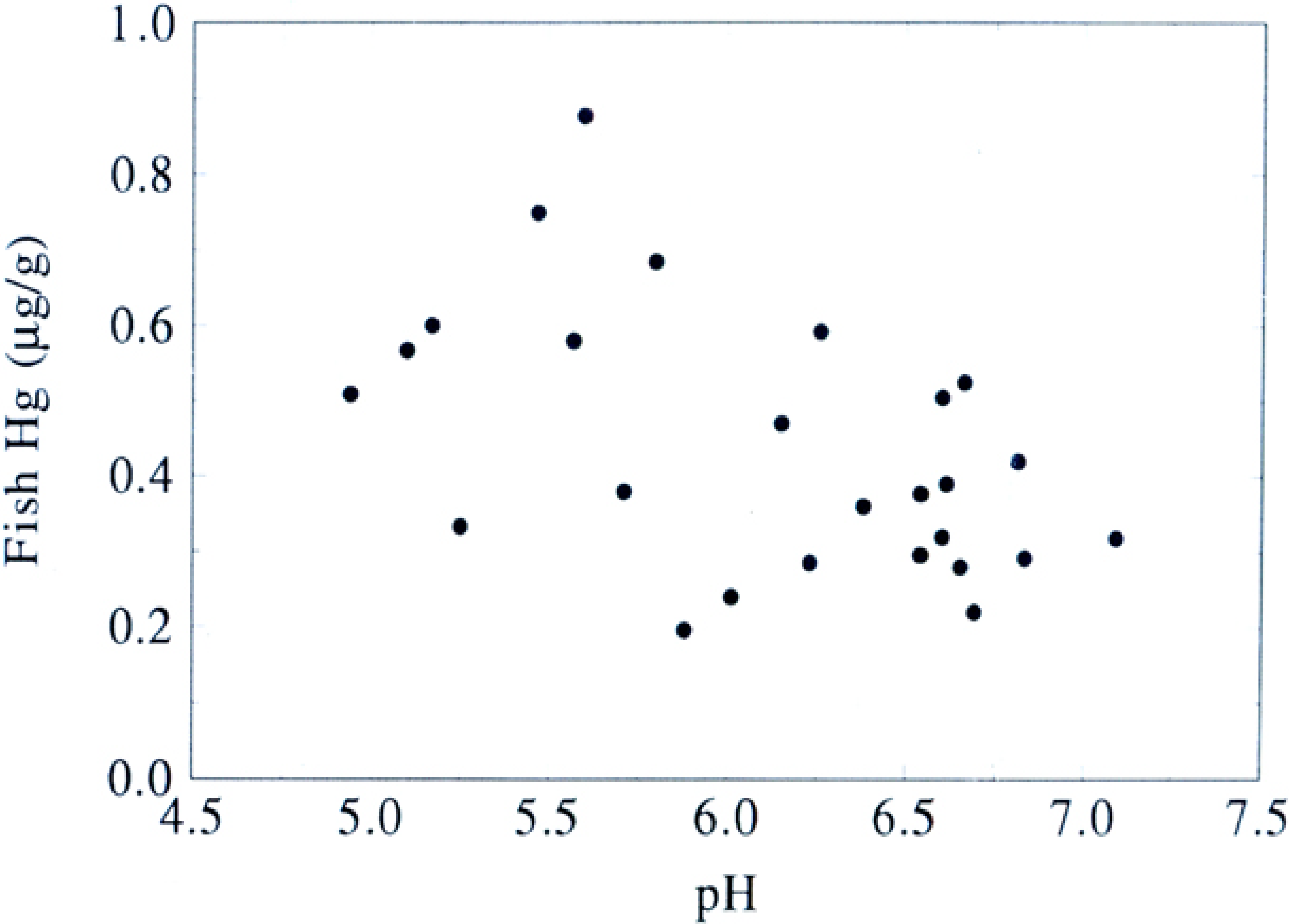
Cumulative Frequency Diagram for Exch. Al (cmolc/Kg)
Exch. Al Normalized to C (Oa Horizon)
% Less than Exch. Acidity
0
20
40
60
80
100
0
20
40
60
80
Exchangeable Aluminum (cmolC/Kg)
1984
2001

LINKAGES WITH MERCURY DEPOSITION

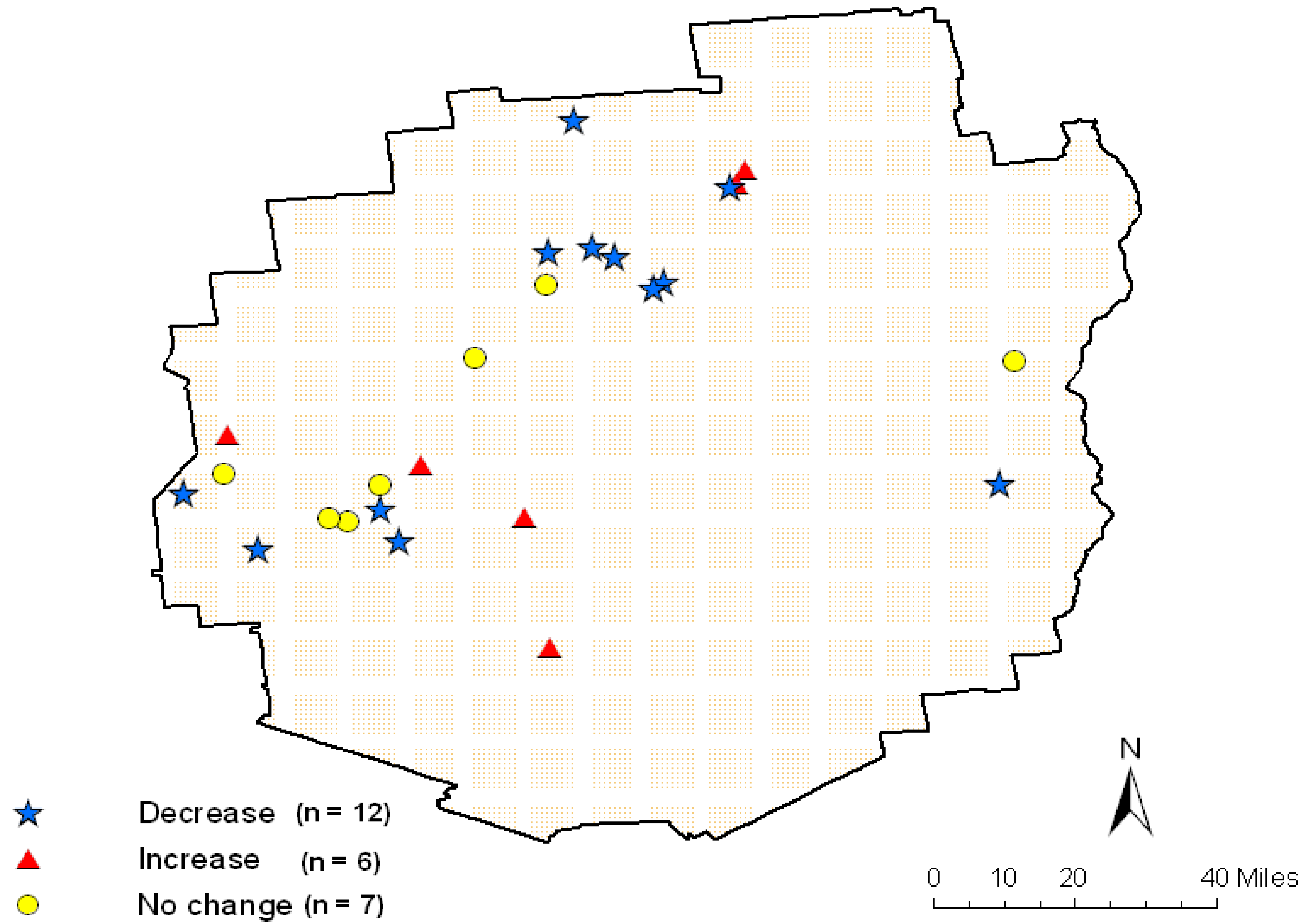

HBEF r^2 = 0.67
Sleepers River r^2 = 0.78
Beaver Meadow r^2 = 0.86
Lake Inlet r^2 = 0.92
FTHg (ng L^{-1})
0
2
4
6
0
2
4
6
8
10
12
14
16
DOC (mg C L^{-1})



Sunday Lake
Arbutus Lake
y = 6.67x^-2.40
r^2 = 0.49; P < 0.0001; n = 131
MeHg (ng/L)
Sulfate (mg/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
1
2
3
4
5
6
7
8



Fish Hg (μg/g)
1.0
0.8
0.6
0.4
0.2
0.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
pH



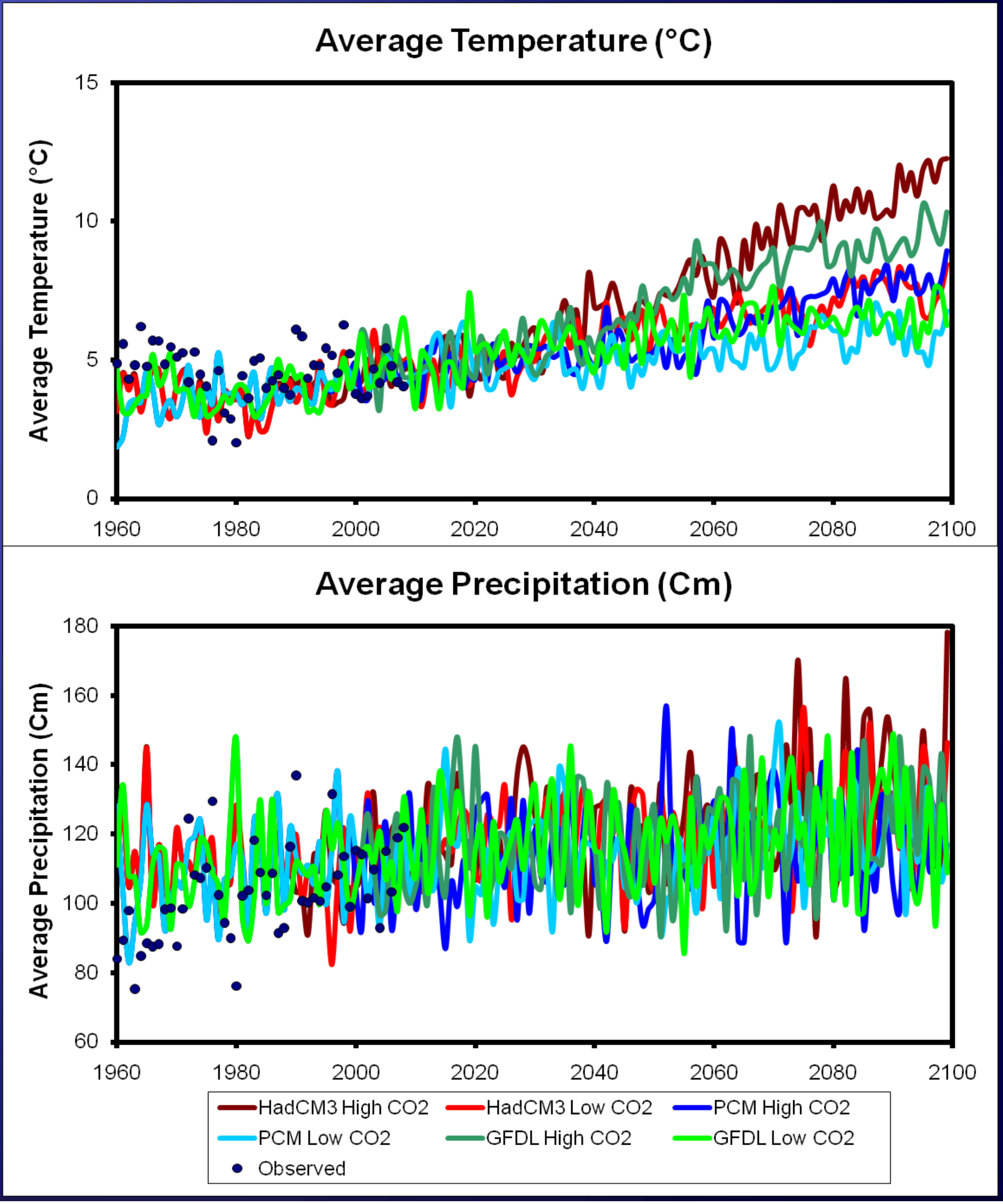
Decrease (n = 12)
Increase (n = 6)
No change (n = 7)
N
0 10 20 40 Miles

LINKAGES WITH CLIMATE CHANGE

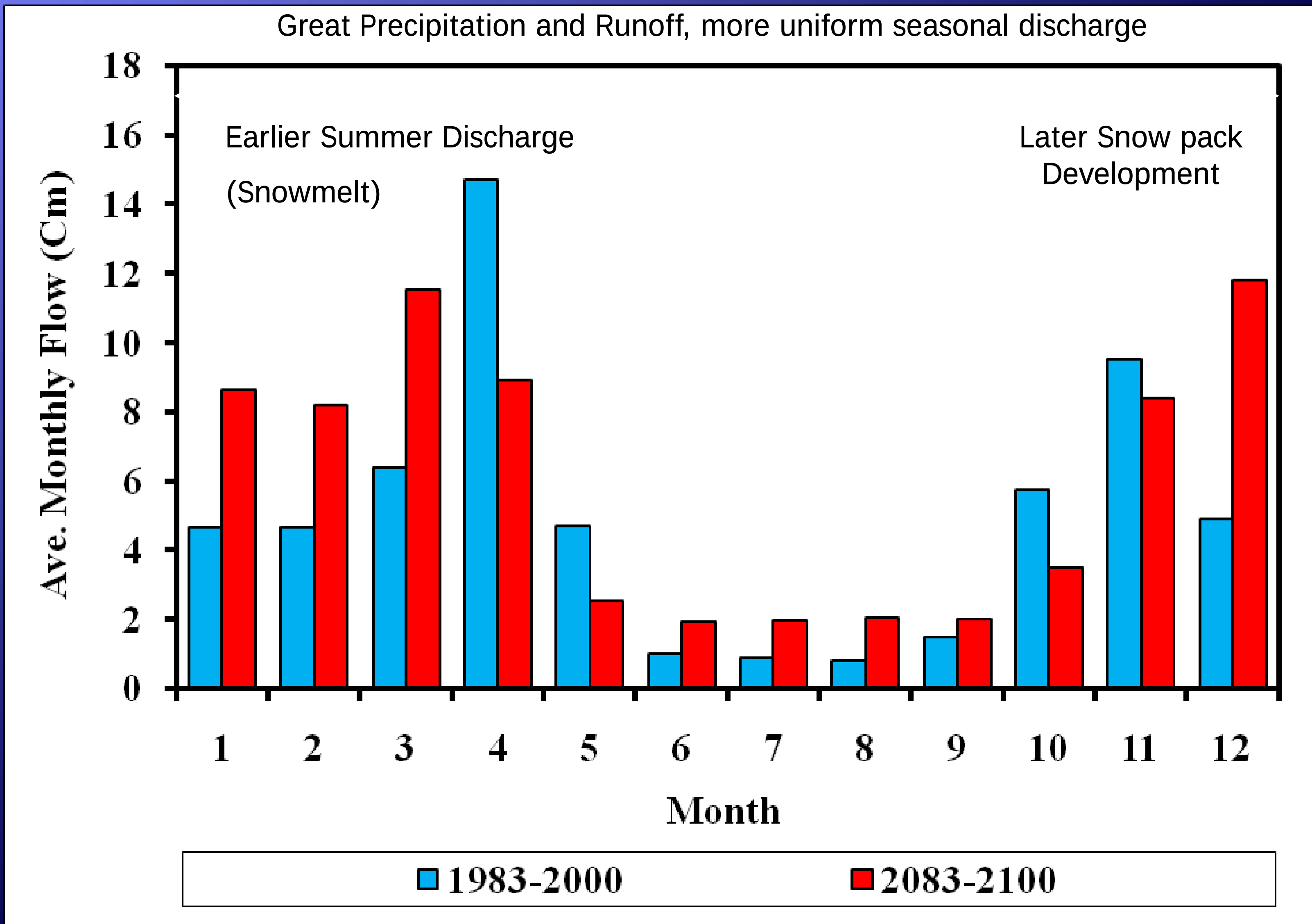
AOGCM Temperature Projections

AOGCM
- Hadley (high sensitivity)
- GFDL (mid sensitivity)
- PCM (low sensitivity)

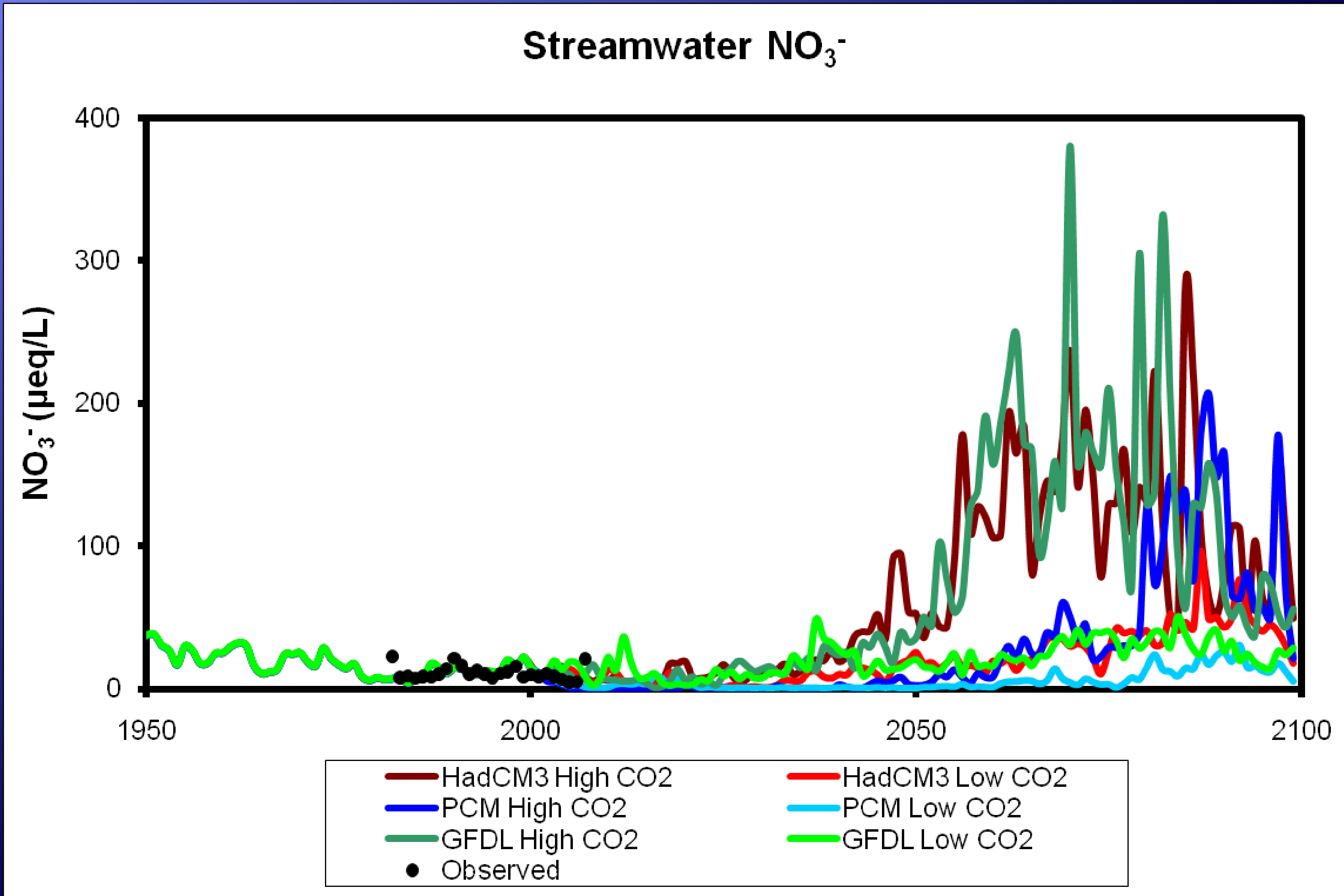
Low CO_2 = 550 ppm
High CO_2 = 970 ppm
at 2100



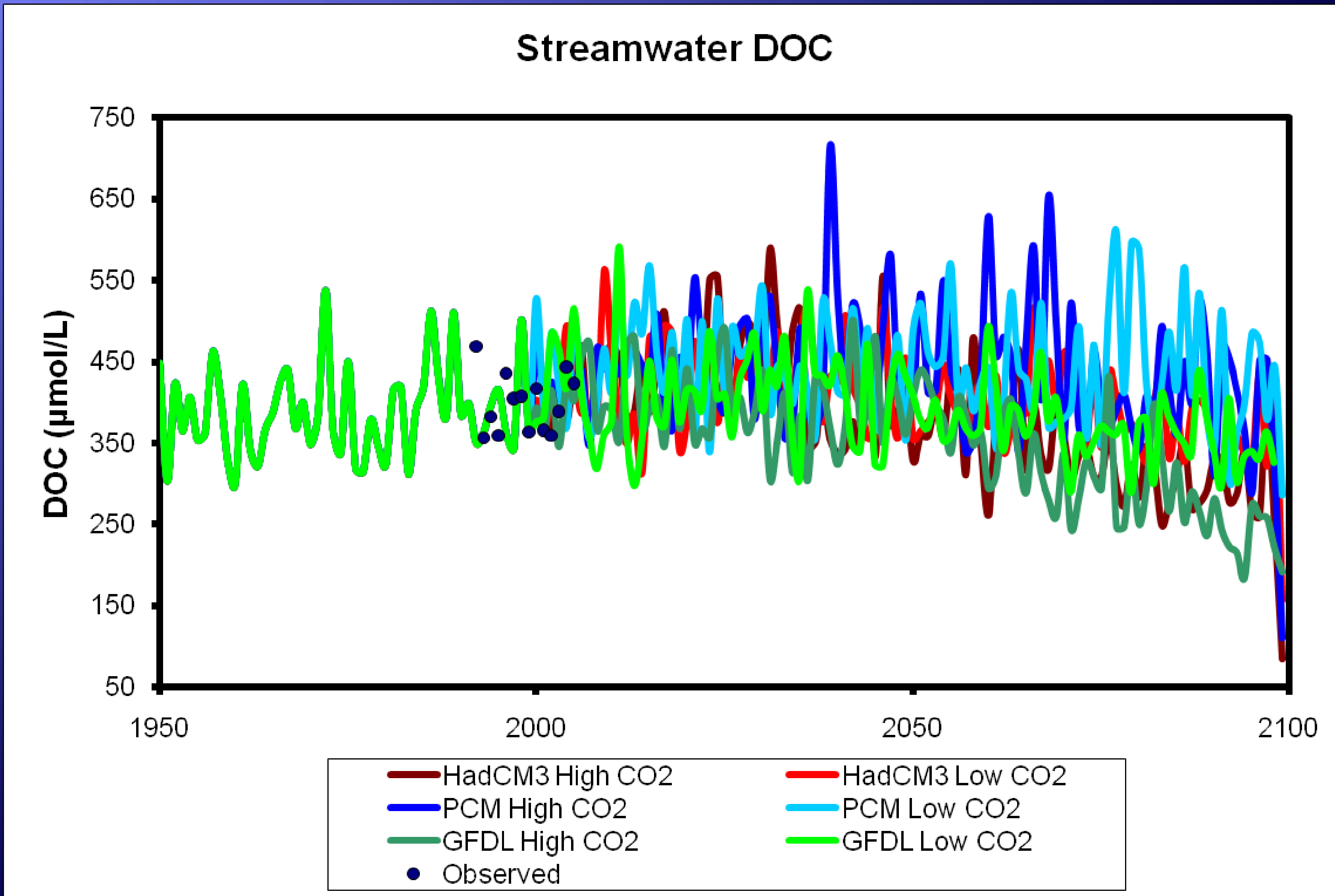
Stream Flow (HF-HadCM3)



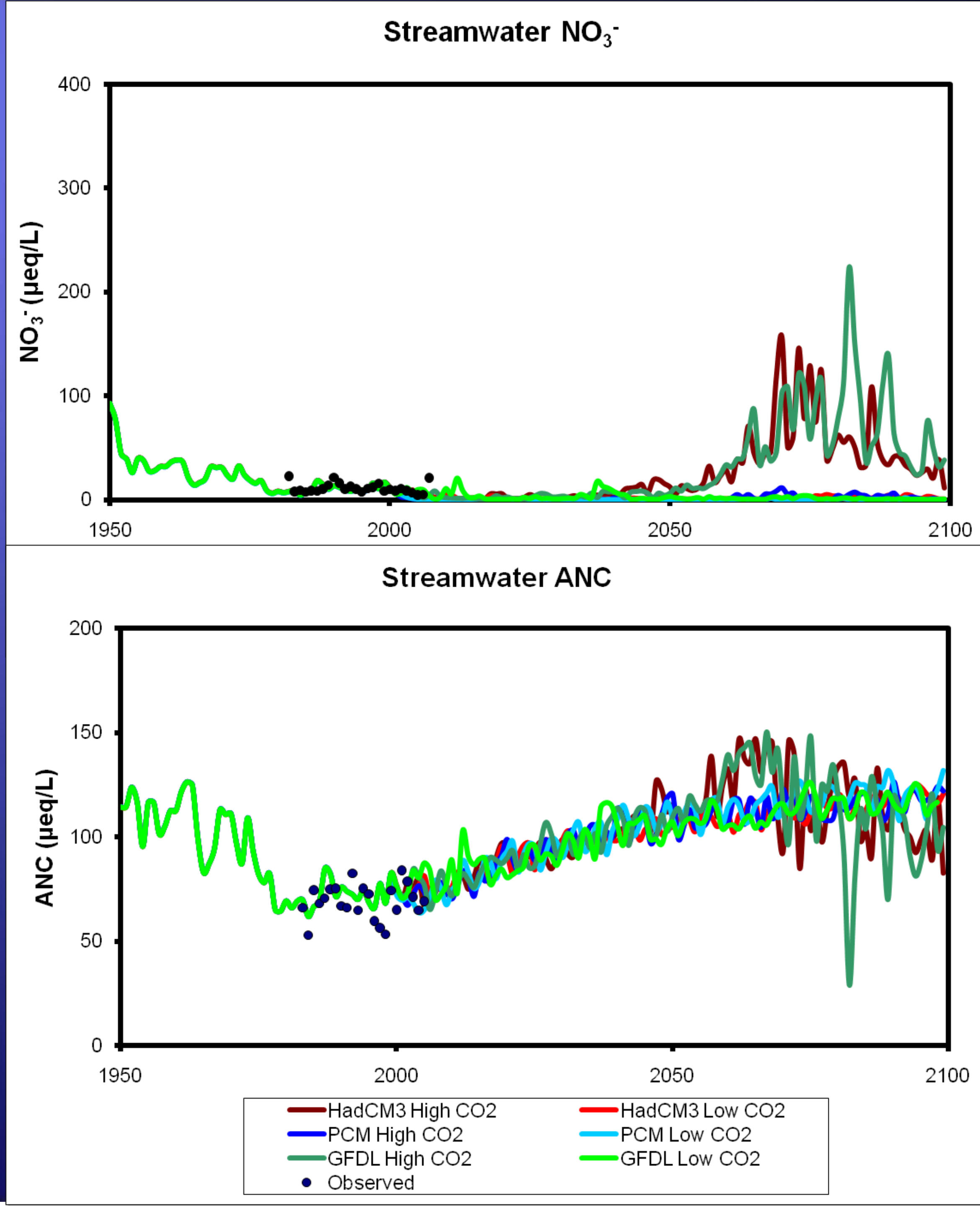
Streamwater NO3-



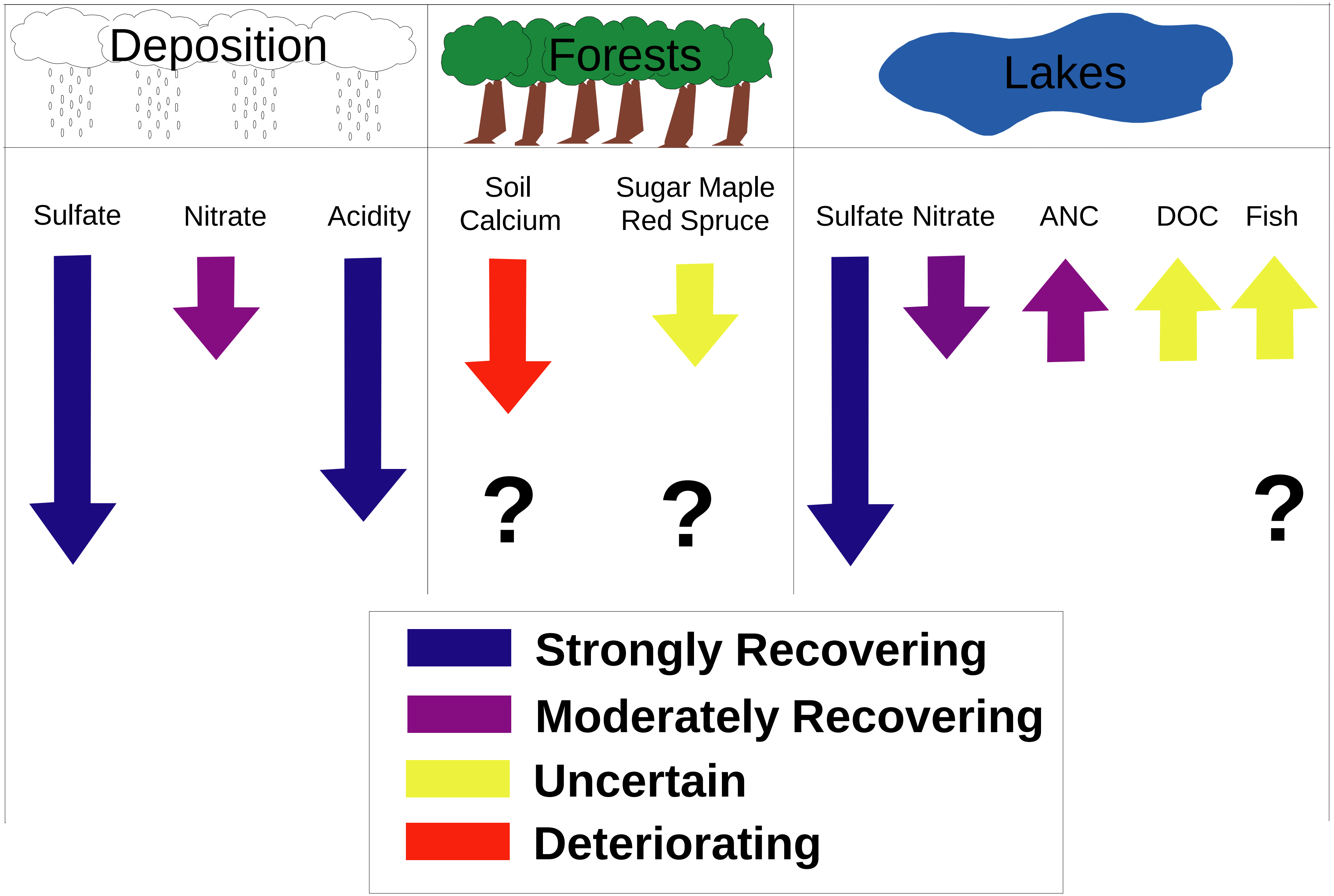
Streamwater DOC



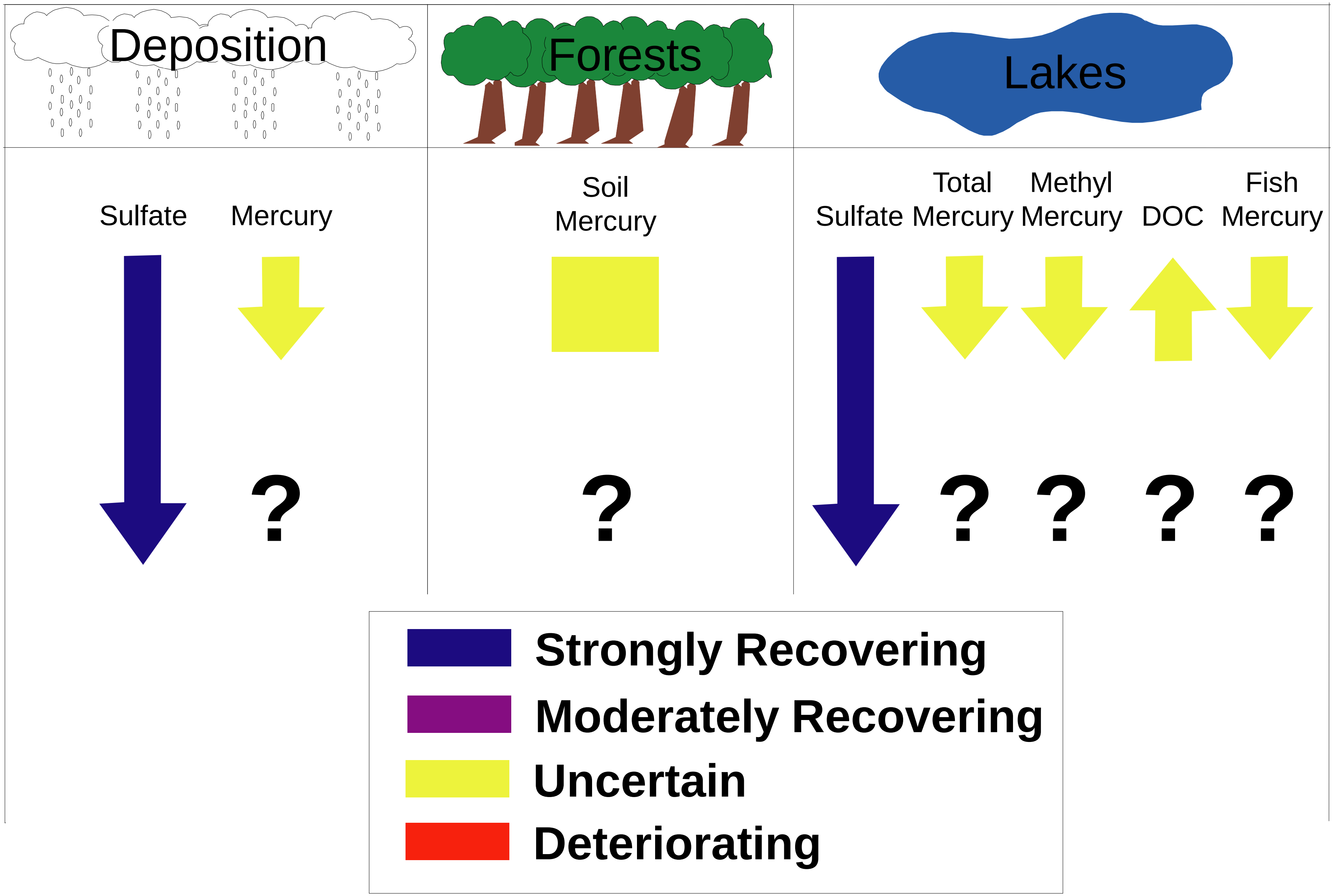
With CO_2 Fertilization



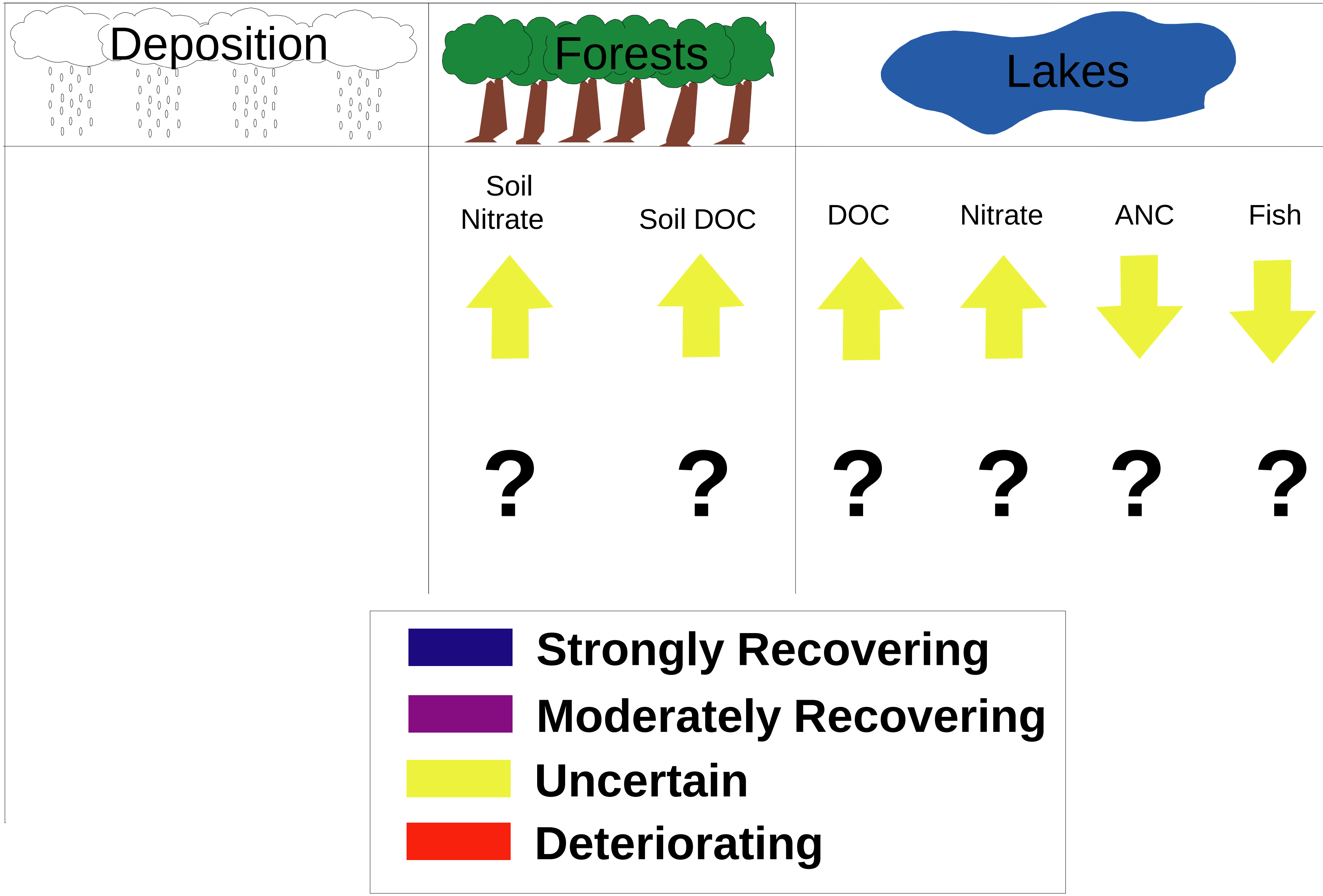
Acidification Recovery



Mercury Interactions



Climate Interactions



Final Thoughts

- NADP can play a critical role in assessing interactions among acidic and mercury deposition and climate change.
- Long-term meteorological, deposition and watershed data are essential for hypothesis generation and testing models.
- A key research need moving forward is evaluating the linkages between atmospheric and watershed models.

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- National Science Foundation (NSF); and
- USDA Forest Service - NSRC

Climate Projections (HWF)

	1970-1999	Mean Change 2070-2099					
		PCM B1	PCM A1	Had B1	Had A1	GFDL B1	GFDL A1
Temperature (°C)	**4.4**	**+1.4**	**+3.2**	**+2. 9**	**+6.3**	**+2.1**	**+4.7**
Annual Precipitation (cm)	**101**	**+21.2**	**+15.4**	**+25.2**	**+30.4**	**+20.3**	**+21.8**
PAR (mmol m^{-2} s^{-1})	**618**	**+21.0**	**-18.3**	**+13.1**	**-4.9**	**-22.5**	**+18.8**

Low CO_2 = 550 ppm by 2100

High CO_2 = 970 ppm by 2100

Current CO_2 = 370 ppm

In 1800 CO_2 = 280 ppm

Streamwater SO_4^{2-}