

A scenic landscape photograph of a lake in Maine. The lake is calm, reflecting the sky and the surrounding mountains. In the foreground, there are large, grey rocks and some small bushes with autumn-colored leaves. The background features a range of mountains under a blue sky with light clouds. The overall scene is peaceful and natural.

Cycles, not trends: a new measure of recovery from acidic deposition?

Steve Kahl
Director of Environmental Sciences
JW Sewall Company
Old Town, Maine

EPA LTM meeting at UNH
June 6, 2011

EPA LTM/TIME Timeline in New England

1983: 6 lakes of the Tunk Mtn Watershed Study

1993: dropped one lake at TMWS

1993: added 11 LTM lakes w/ 1984 ELS data

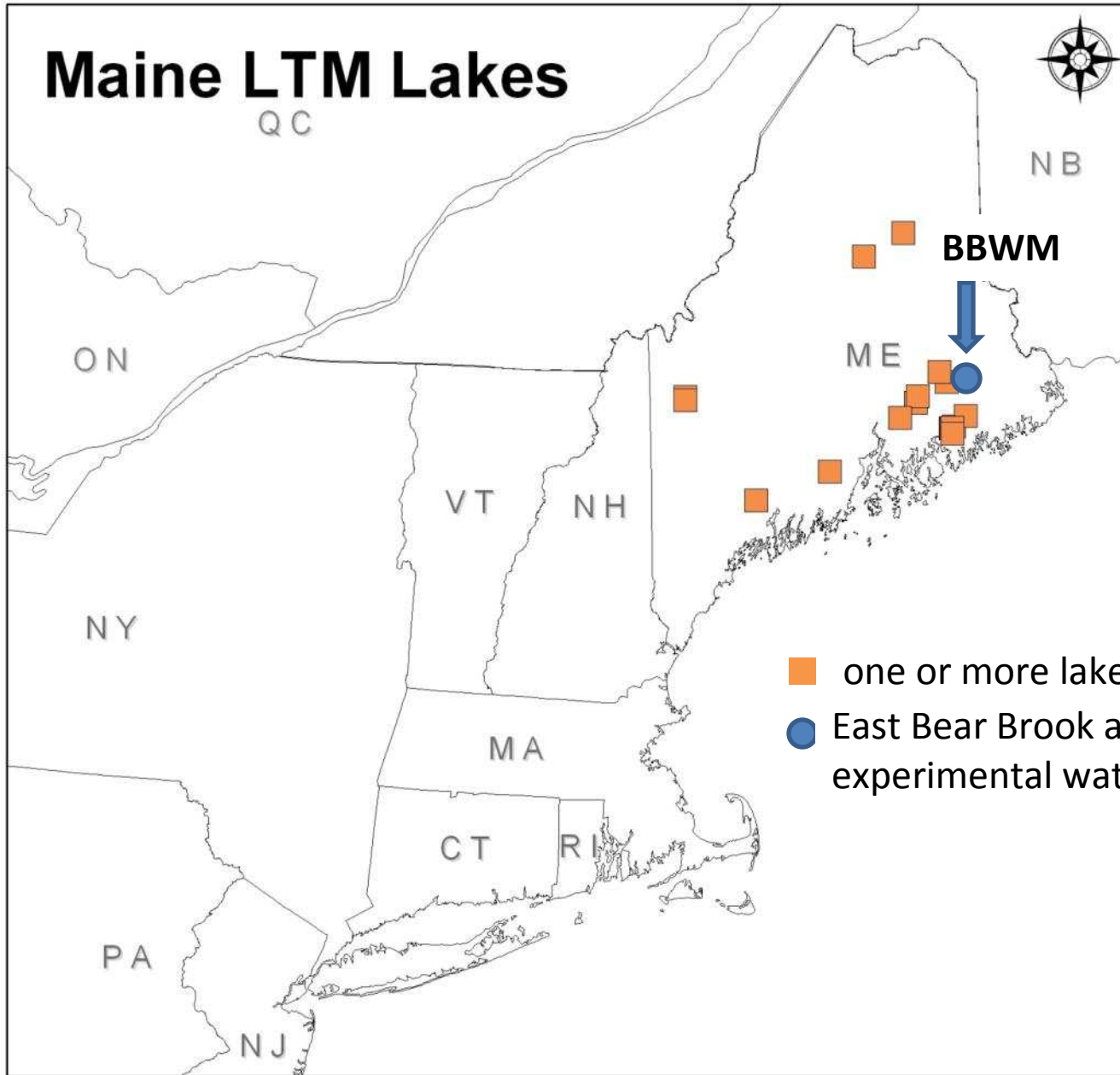
and new EPA TIME criteria:

drainage and seepage lakes
high and low DOC

high and low Ca
1993: 25 HELM lakes (of 90)

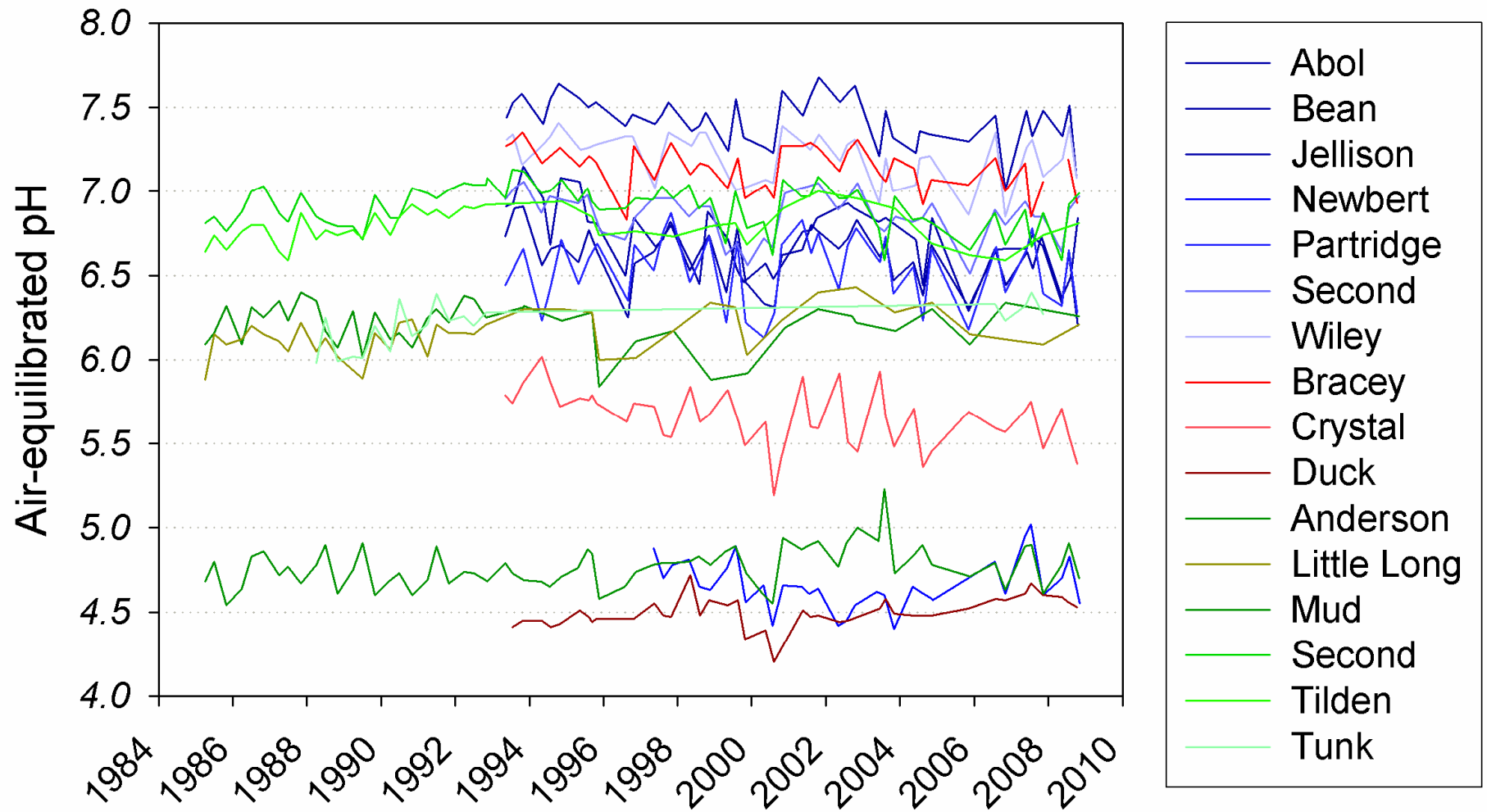
1993: BBWM ref. stream

Maine LTM Lakes

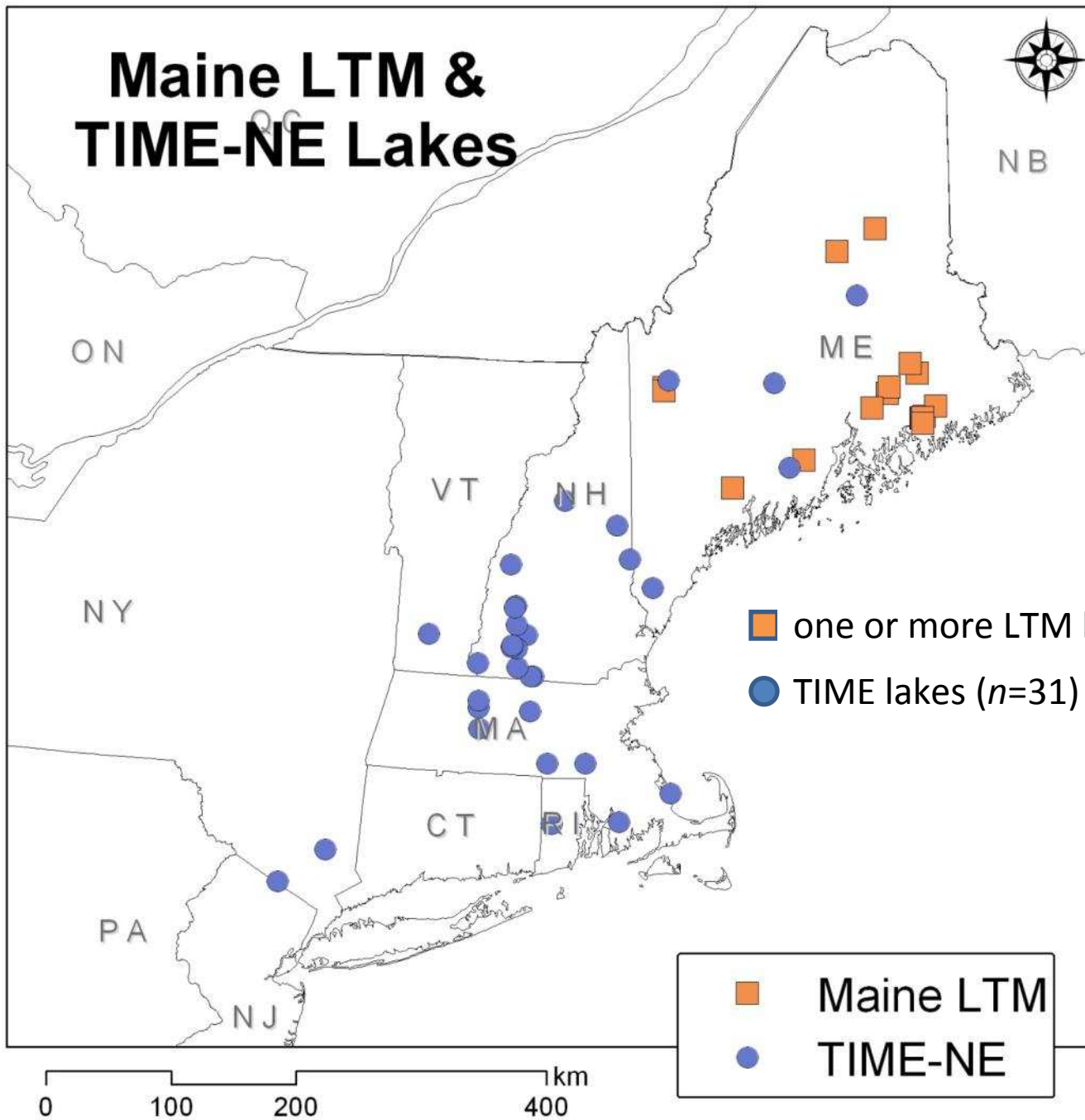


- one or more lakes ($n=16$)
- East Bear Brook at BBWM experimental watershed

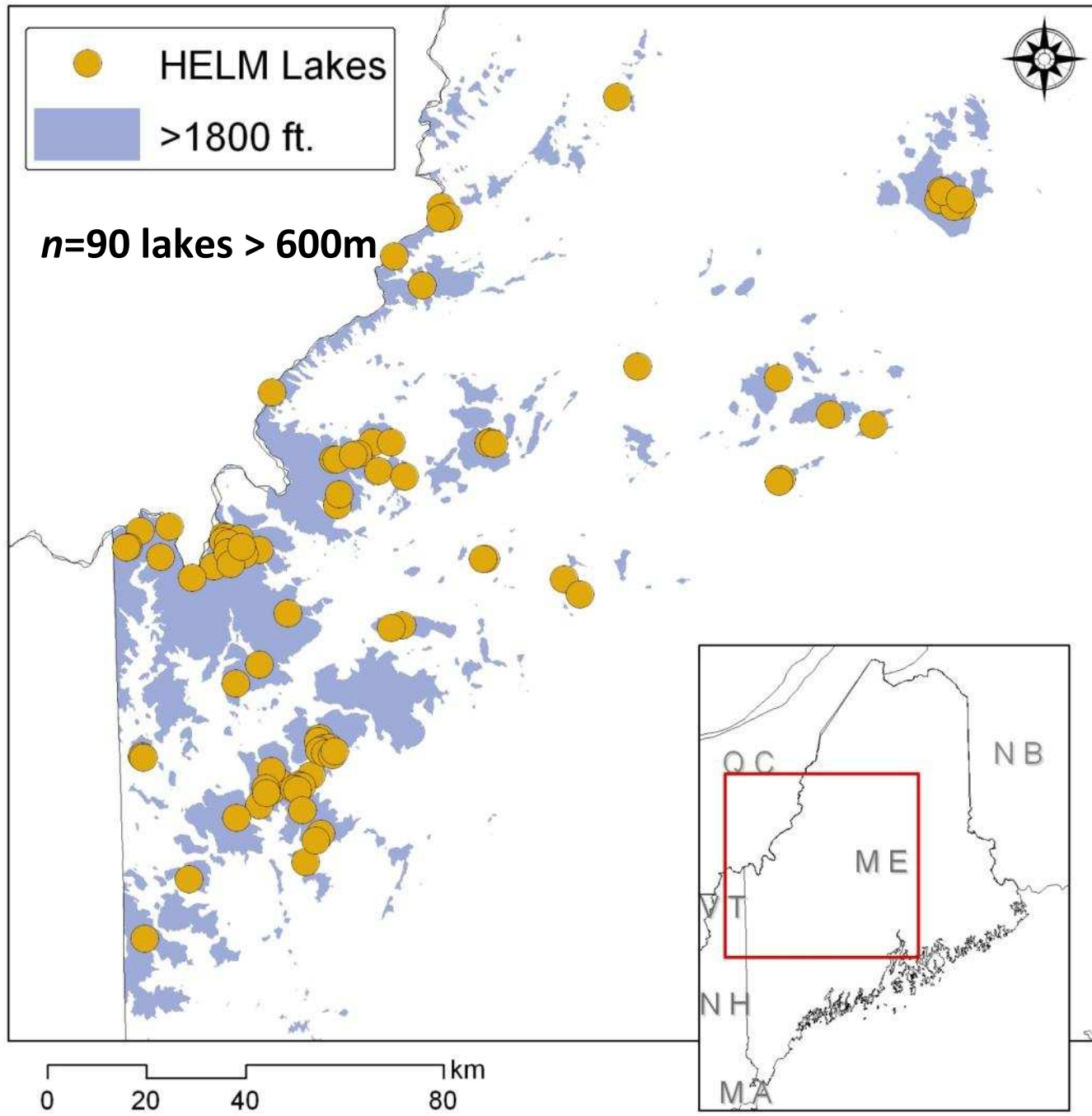
Standardized air-equilibrated pH – ME LTM



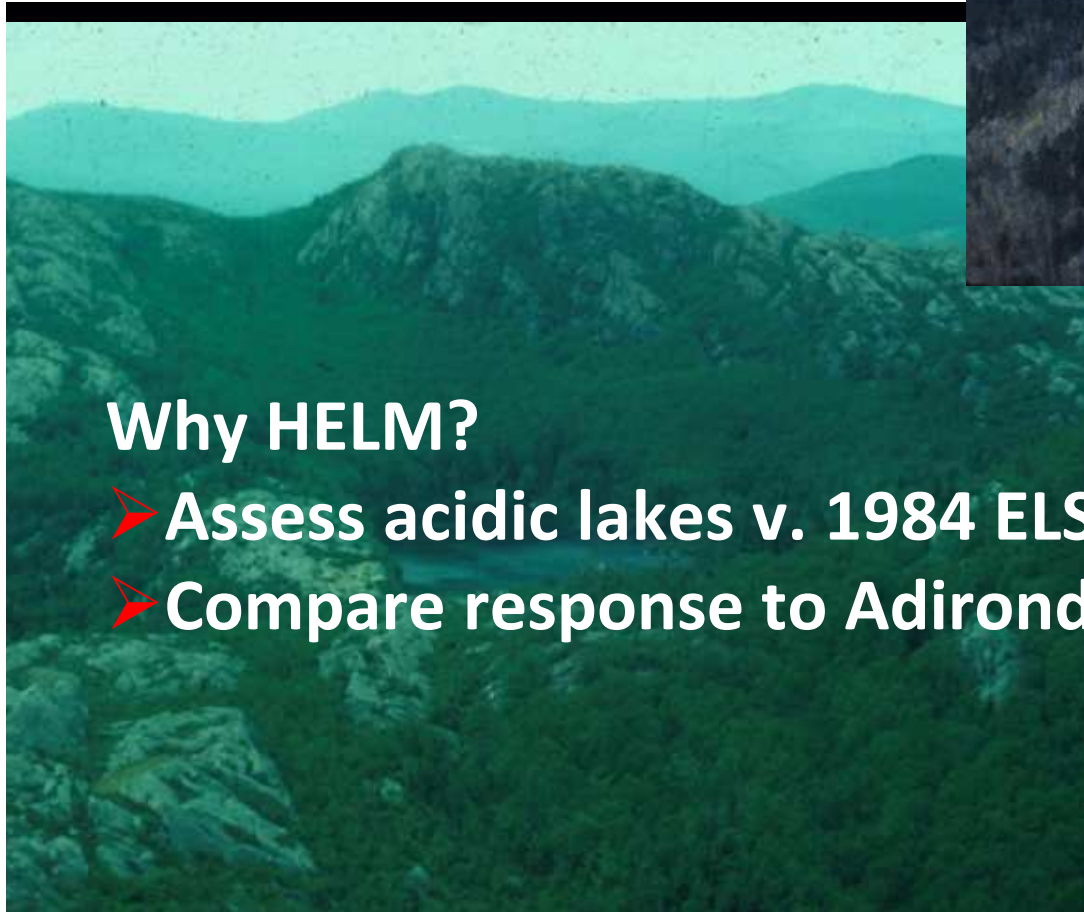
Maine LTM & TIME-NE Lakes



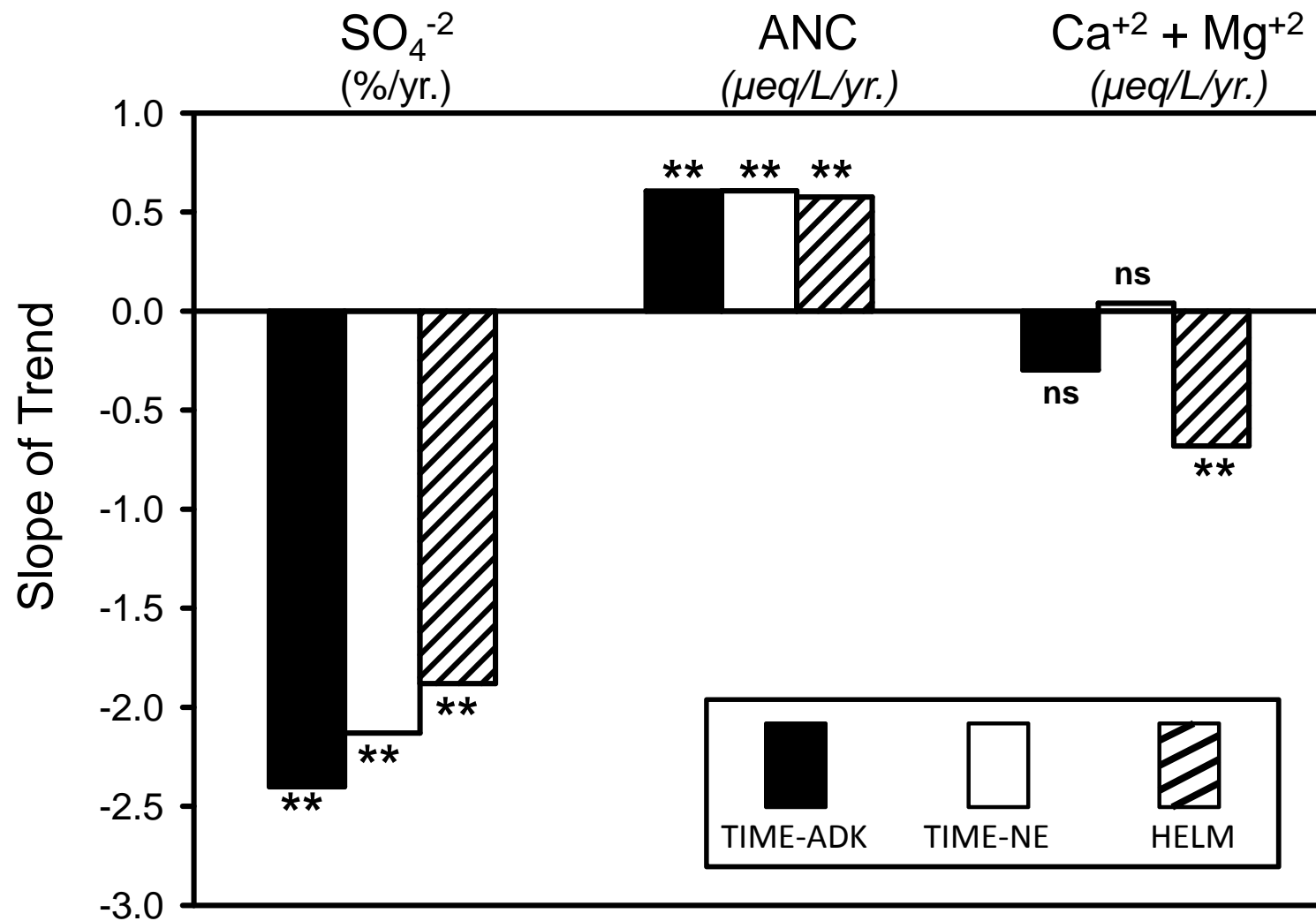
56 New Hampshire high elevation lakes
Investigated in 2007-09 (separate funding)



Maine high elevation lakes, 1986-present

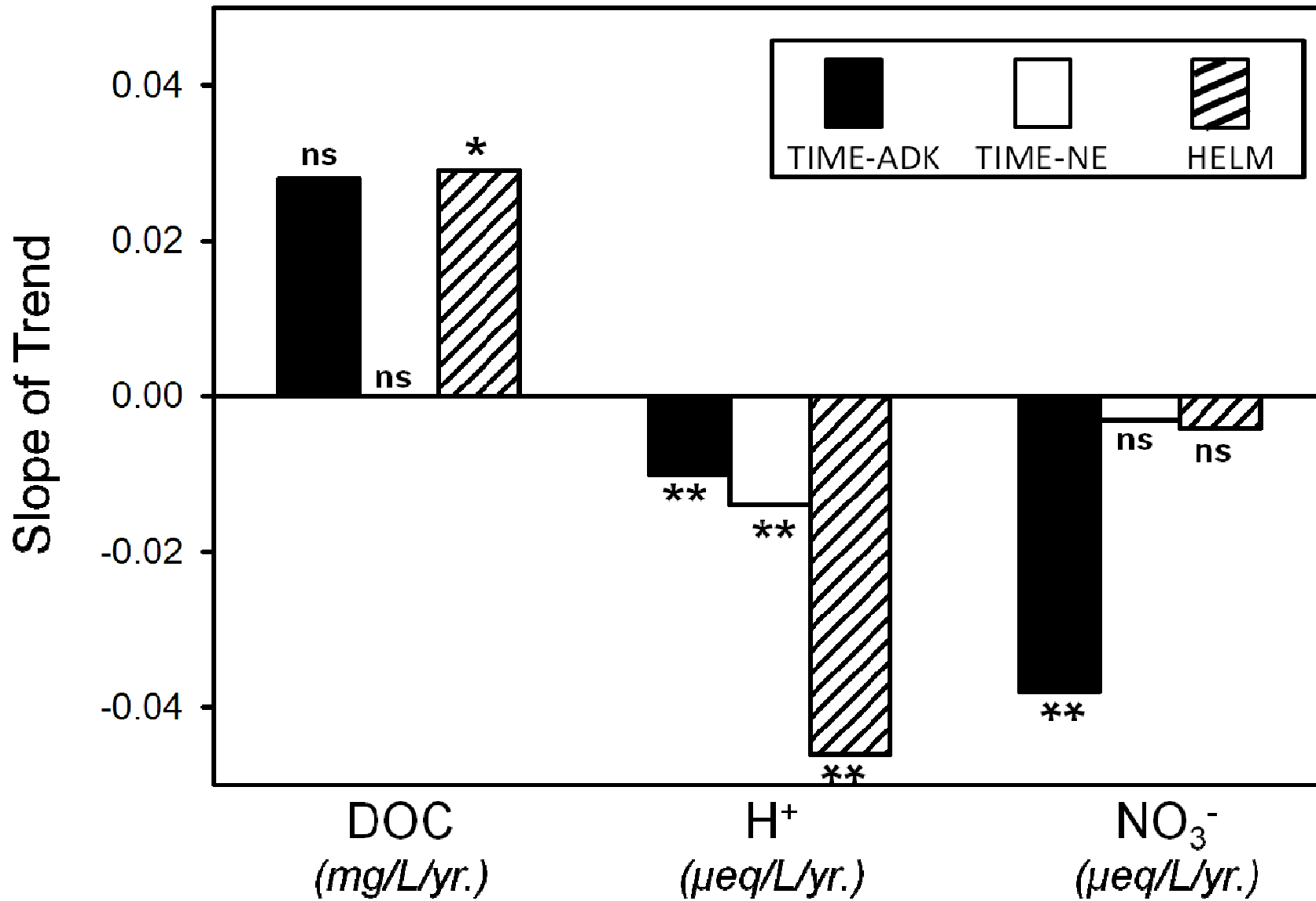


Regional population comparisons



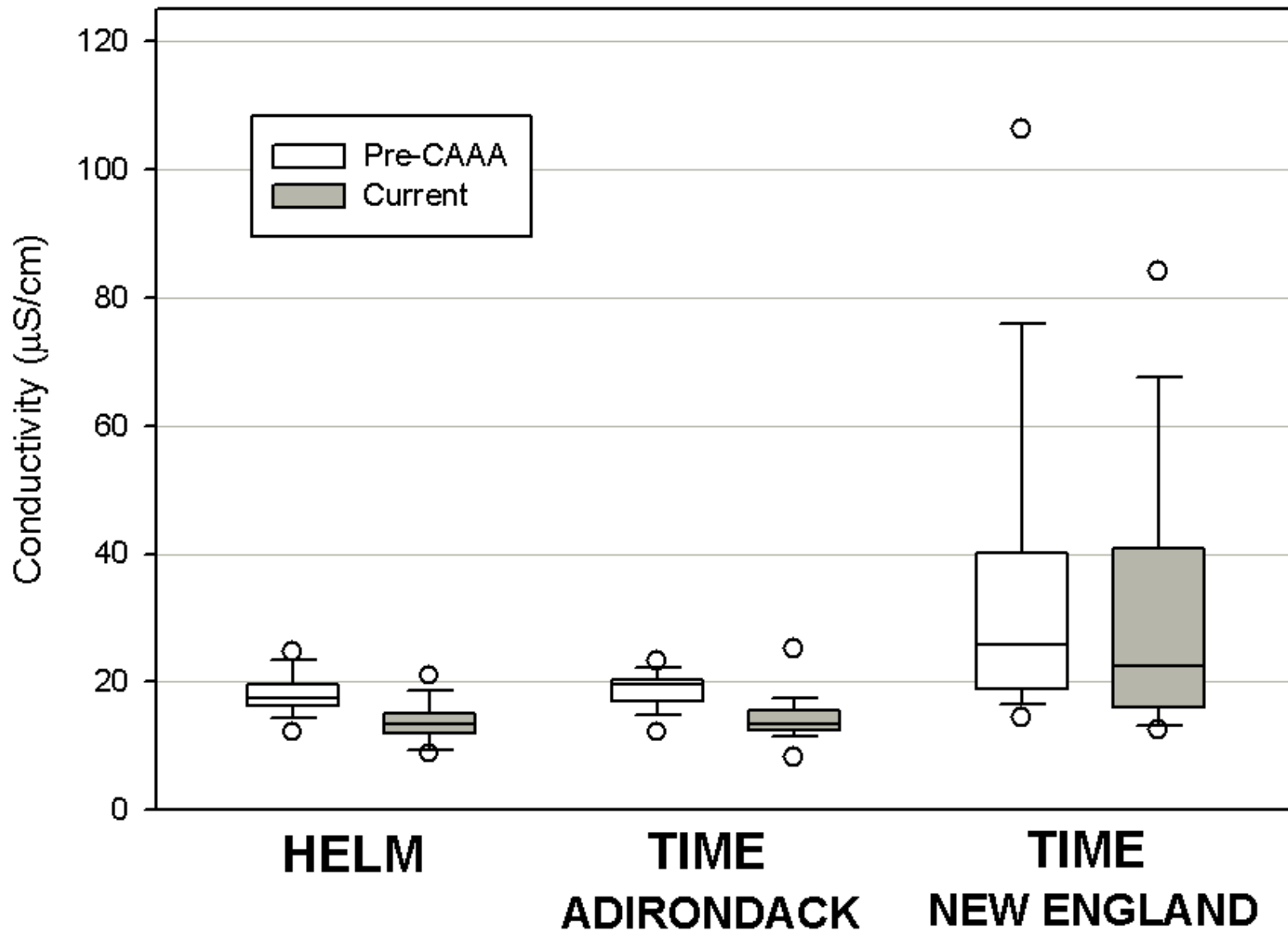
from Baumann, 2011

Regional population comparisons



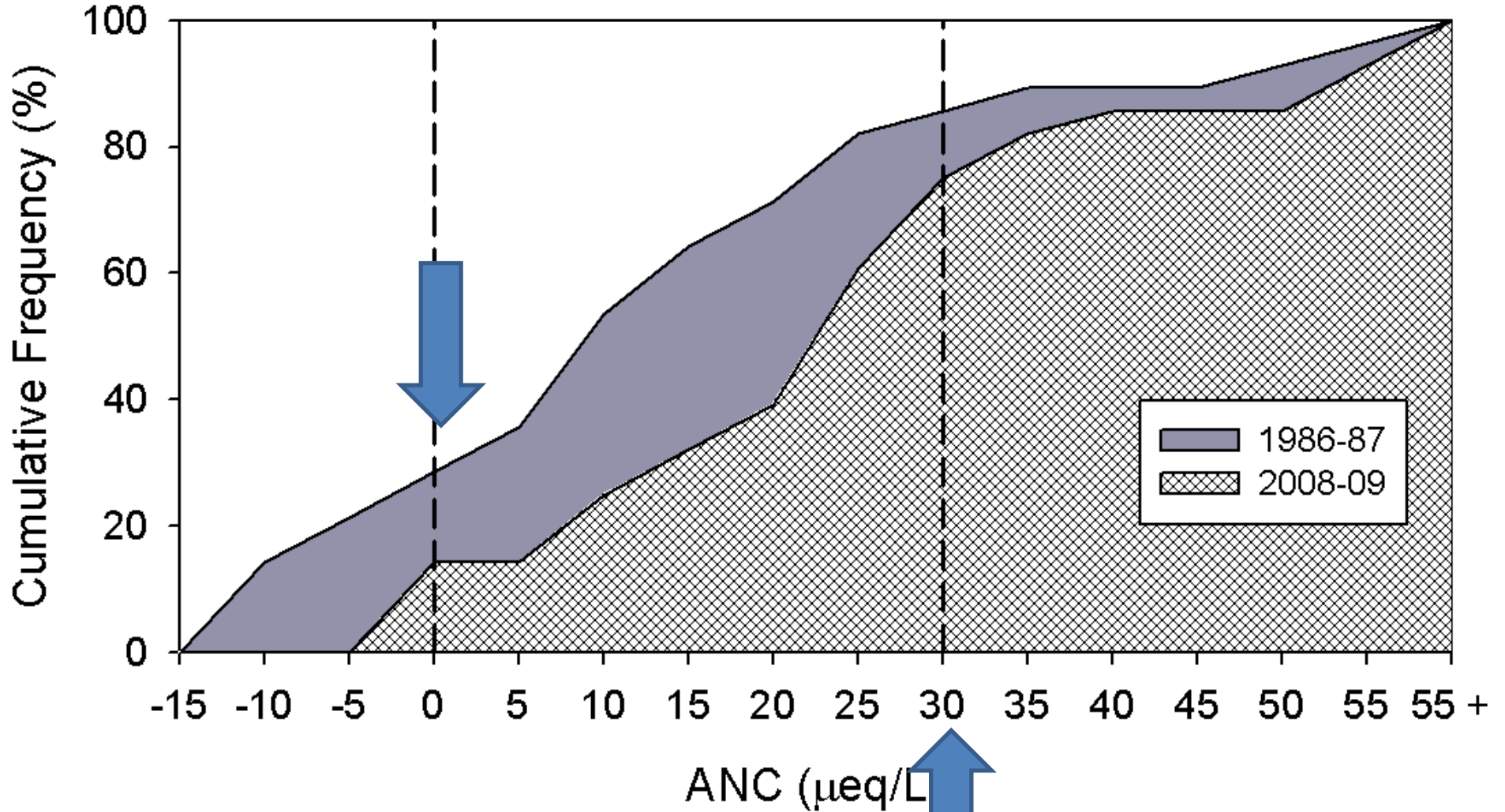
from Baumann, 2011

Regional population comparisons



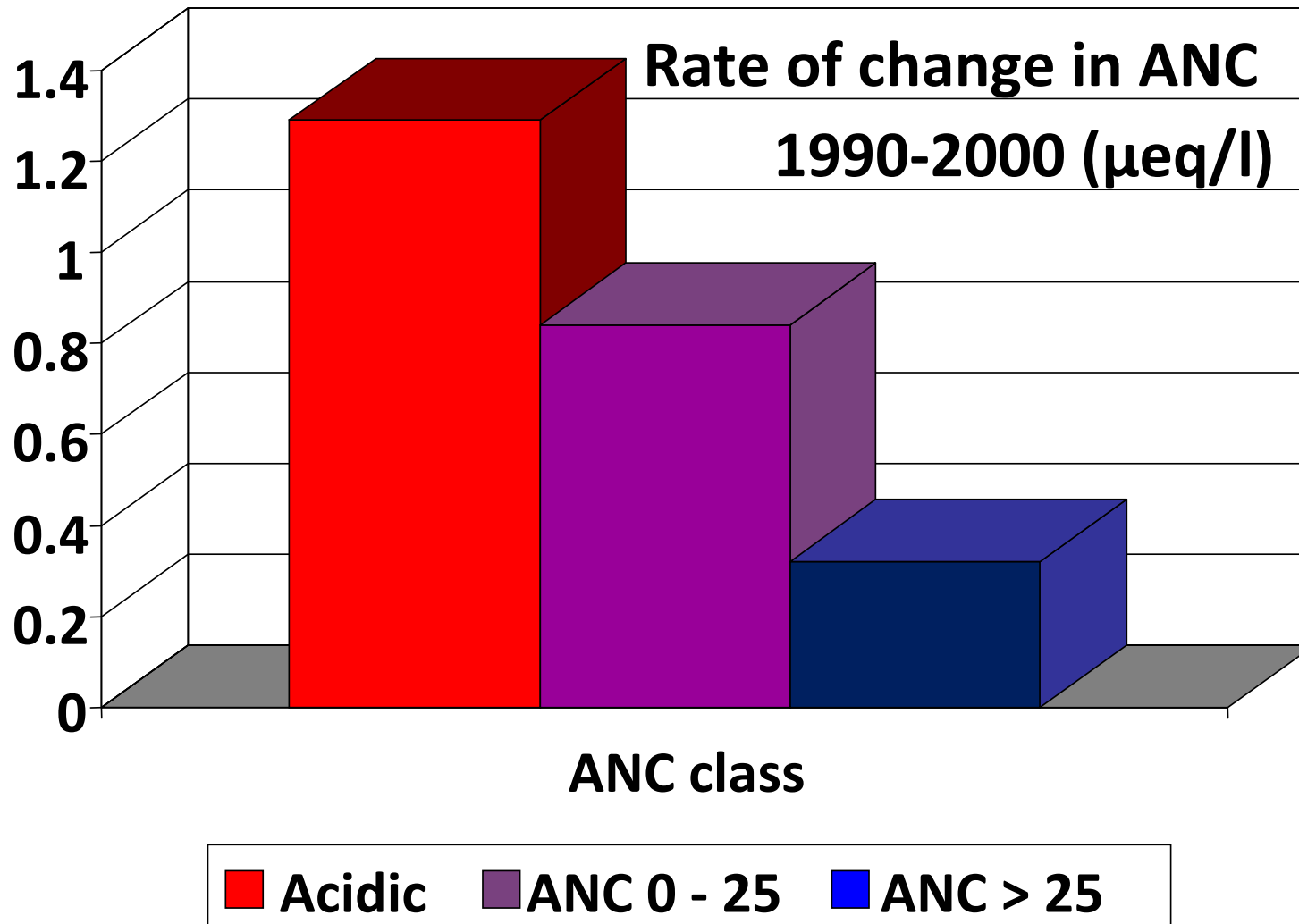
from Baumann, 2011

Change in HELM ANC, 1986 - 2009



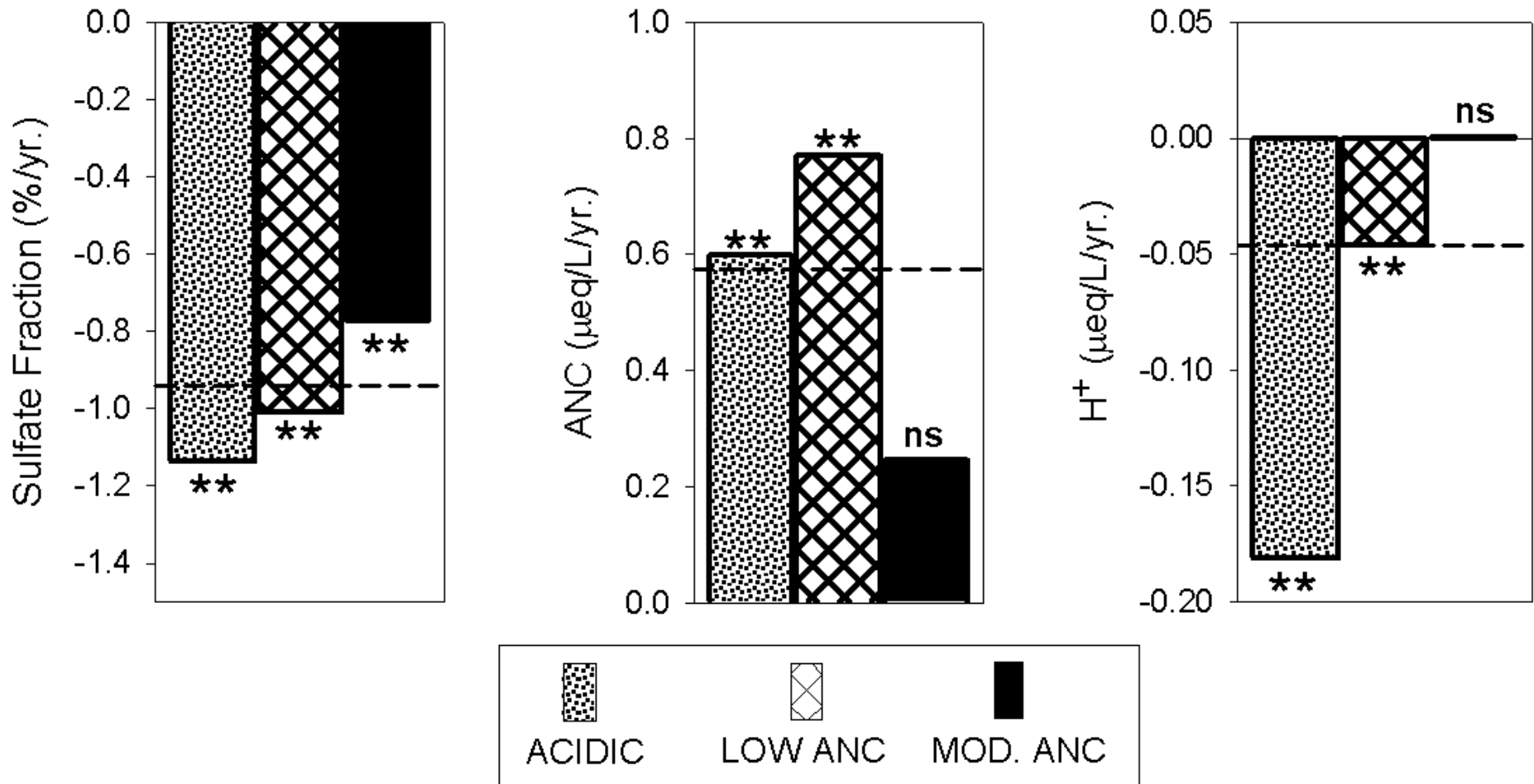
from Baumann, 2011

Change in ANC by ANC class



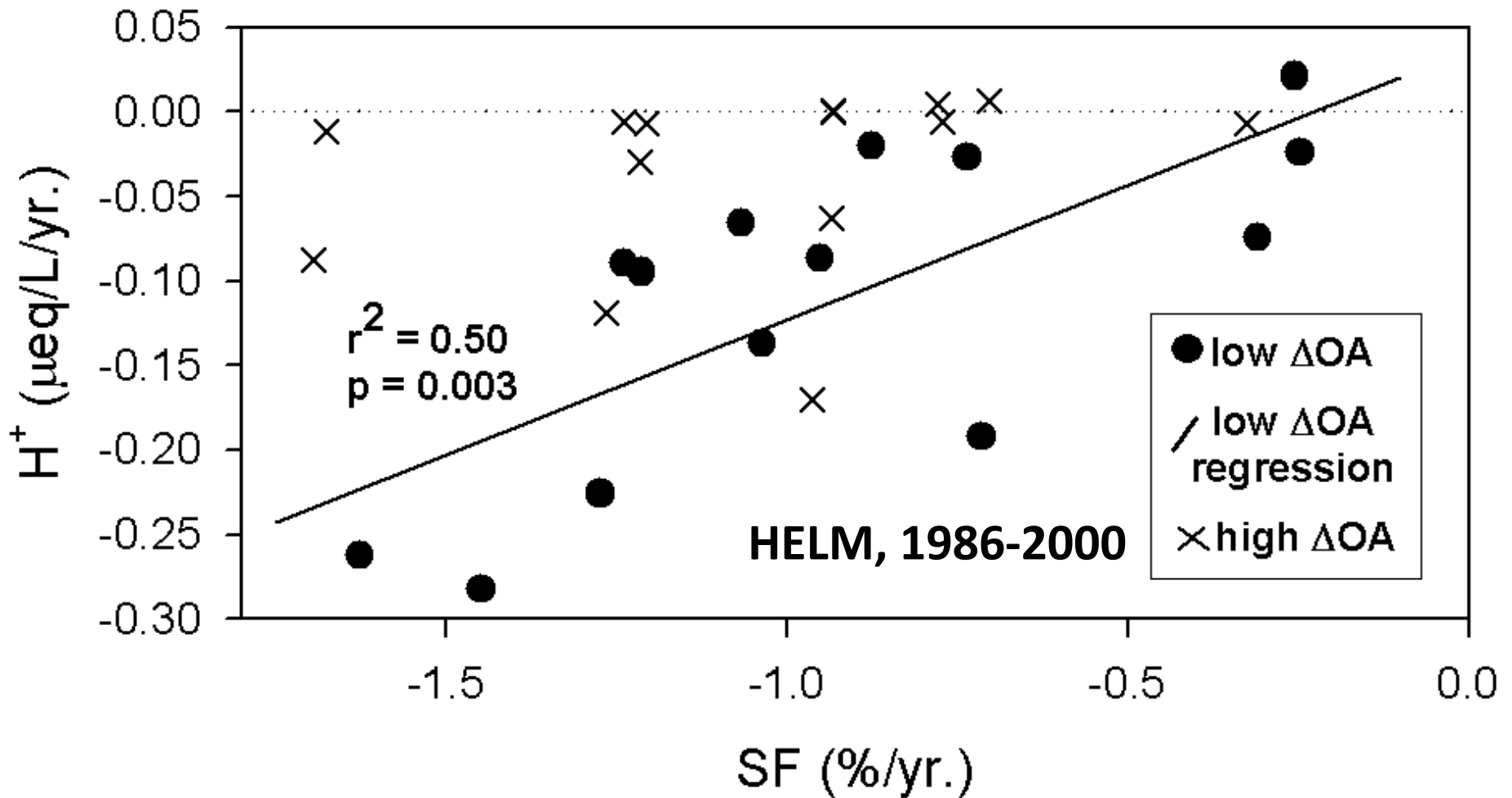
from Stoddard et al., 2003; Kahl et al., 2004

Change in HELM ANC by class, 1986 - 2009



from Baumann, 2011

Reduced influence of sulfate in controlling pH (as sulfate equivalent fraction)



from Baumann, 2011

Emphasis on wetland/DOC influence in New England TIME lakes

Bog Pond, TIME Maine

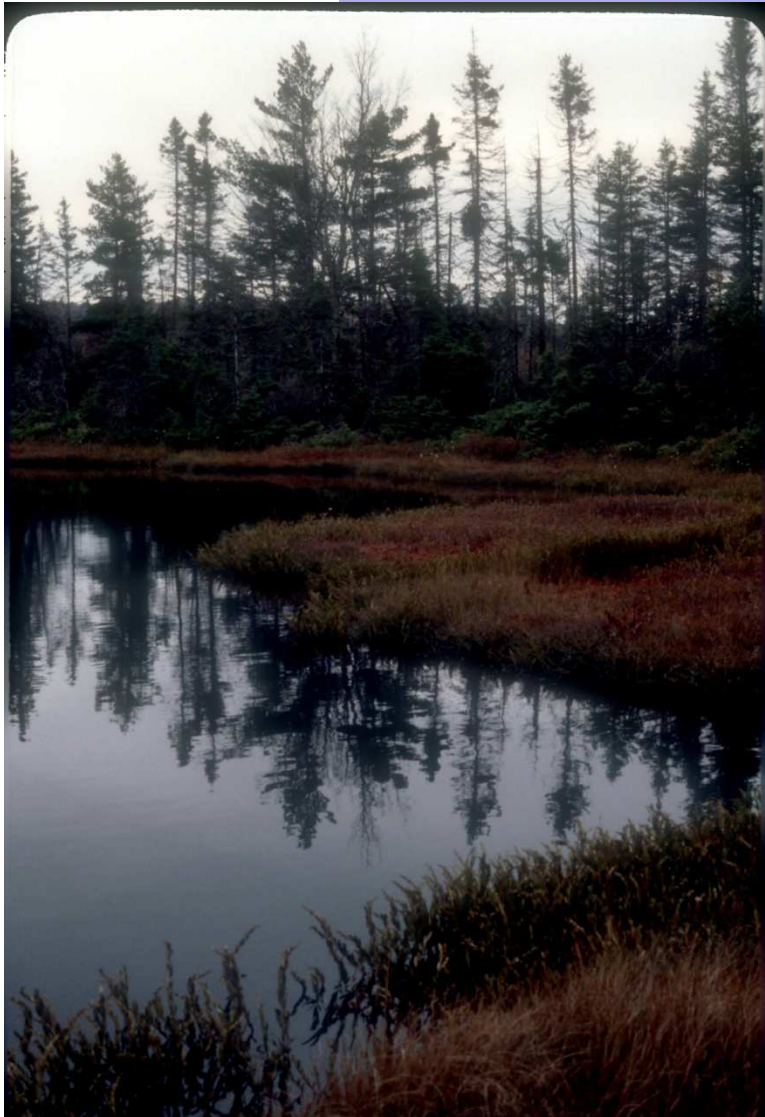


Image © 2009 Maine GeoLibrary

© 2009 Tele Atlas

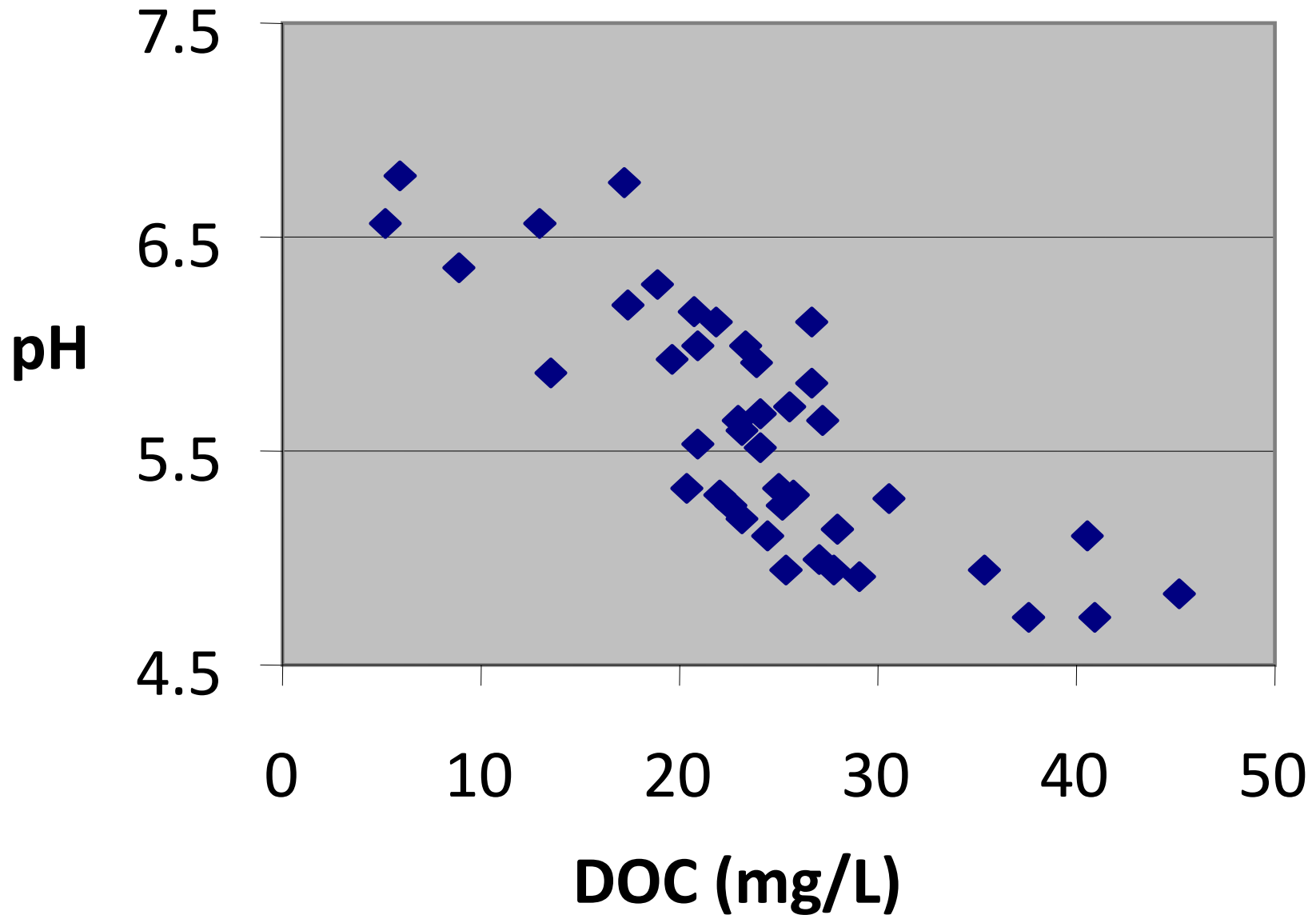
© 2009 Europa Technologies

Image USDA Farm Service Agency

2007 44°53'19.37" N 69°34'31.08" W elev 395 ft Eye alt 1466 ft

Google

Episodic acidification in the Denny's River (an Atlantic Salmon Restoration river)



Episodic acidification of Atlantic salmon rivers *(USFWS Endangered Species Act restoration plan)*

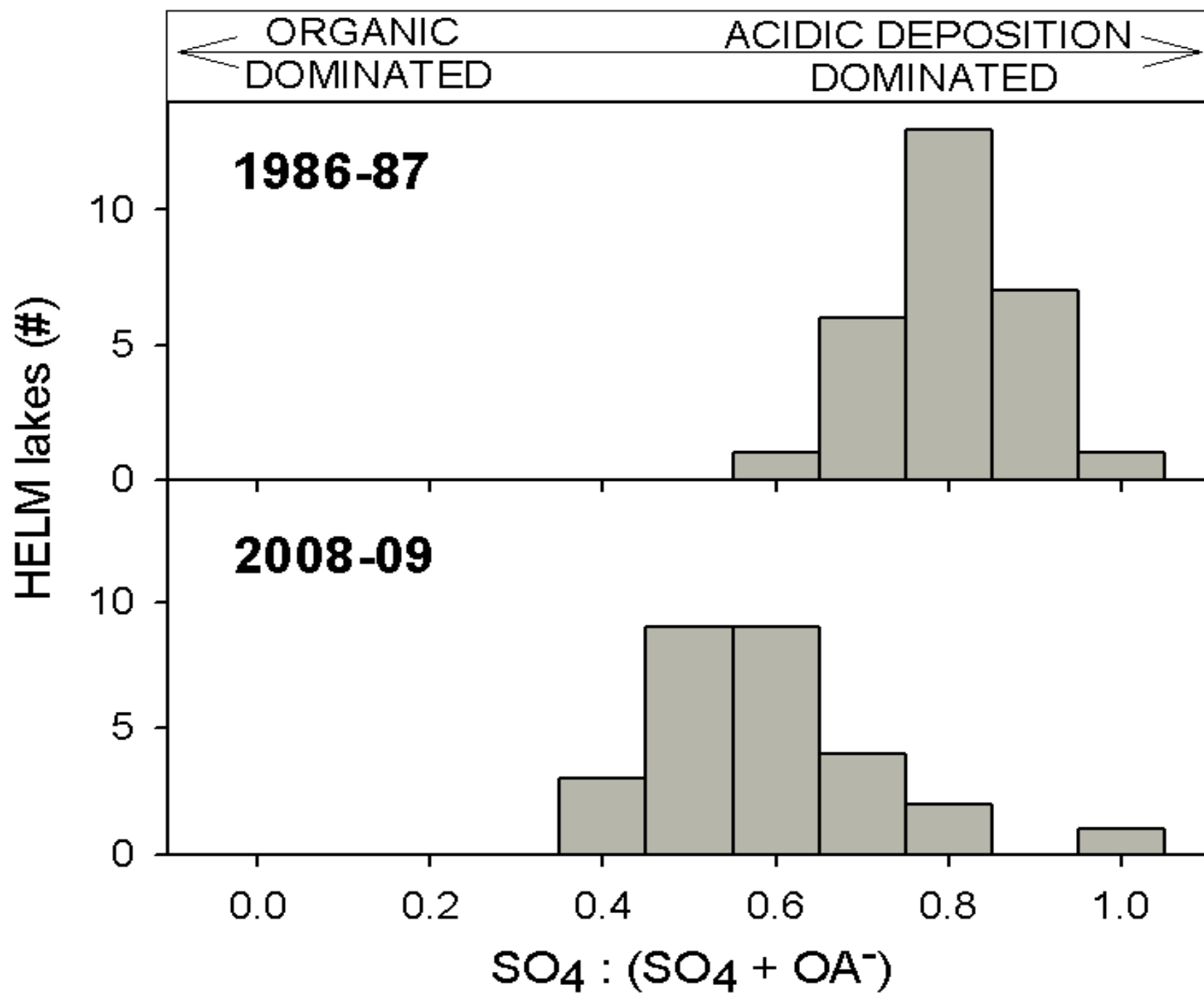
Causes of seasonal pH/ANC depressions:

$\text{pCO}_2 > \text{DOC} > \text{dilution}$

(sulfate and nitrate are irrelevant)

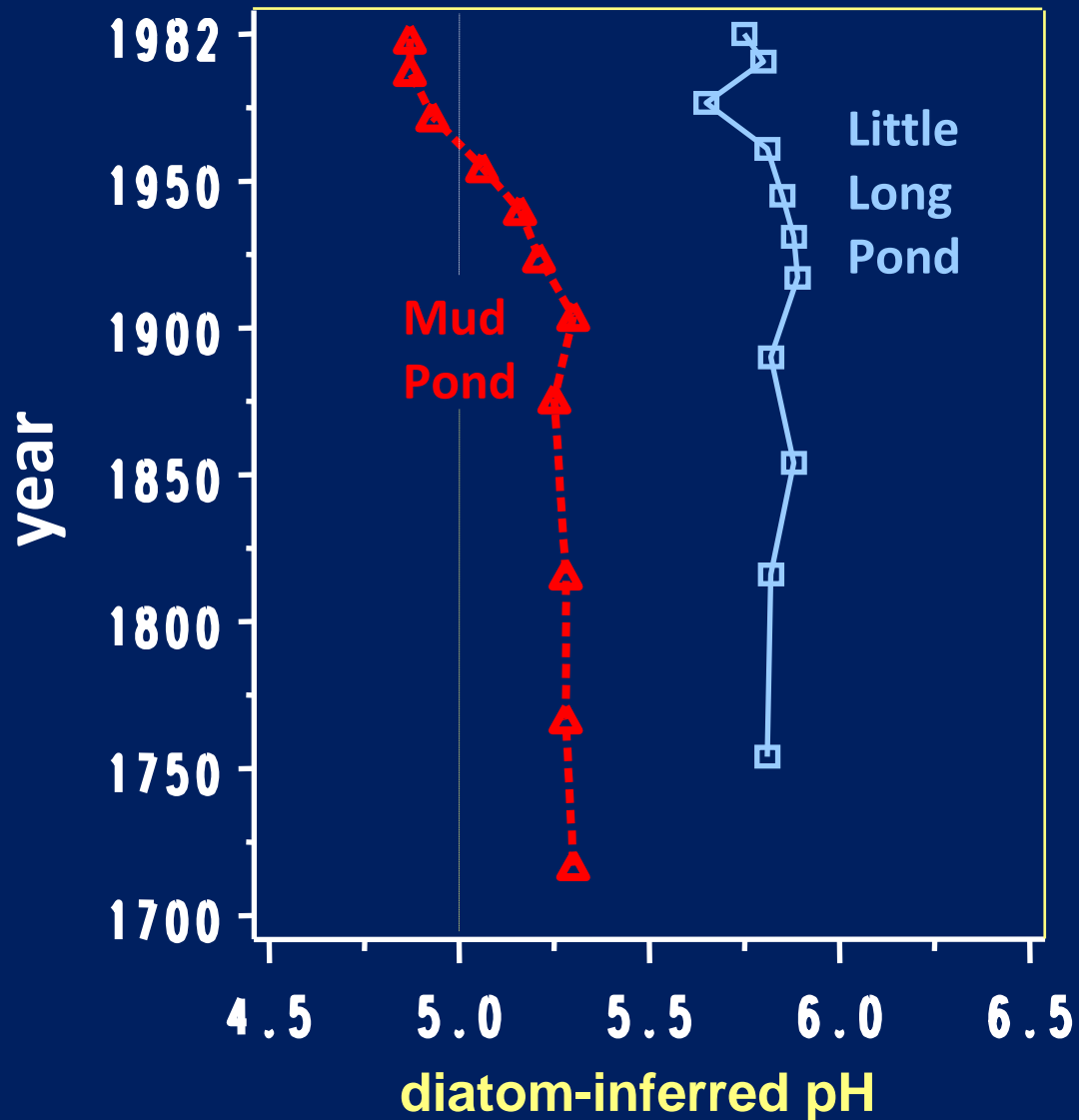
No evidence for base cation decline in these rivers

pH less than 5.0 requires $\text{DOC} > 5.0$



What should 'recovery' look like?

(Hint: today's acidic lakes were always at least marginally acidic).



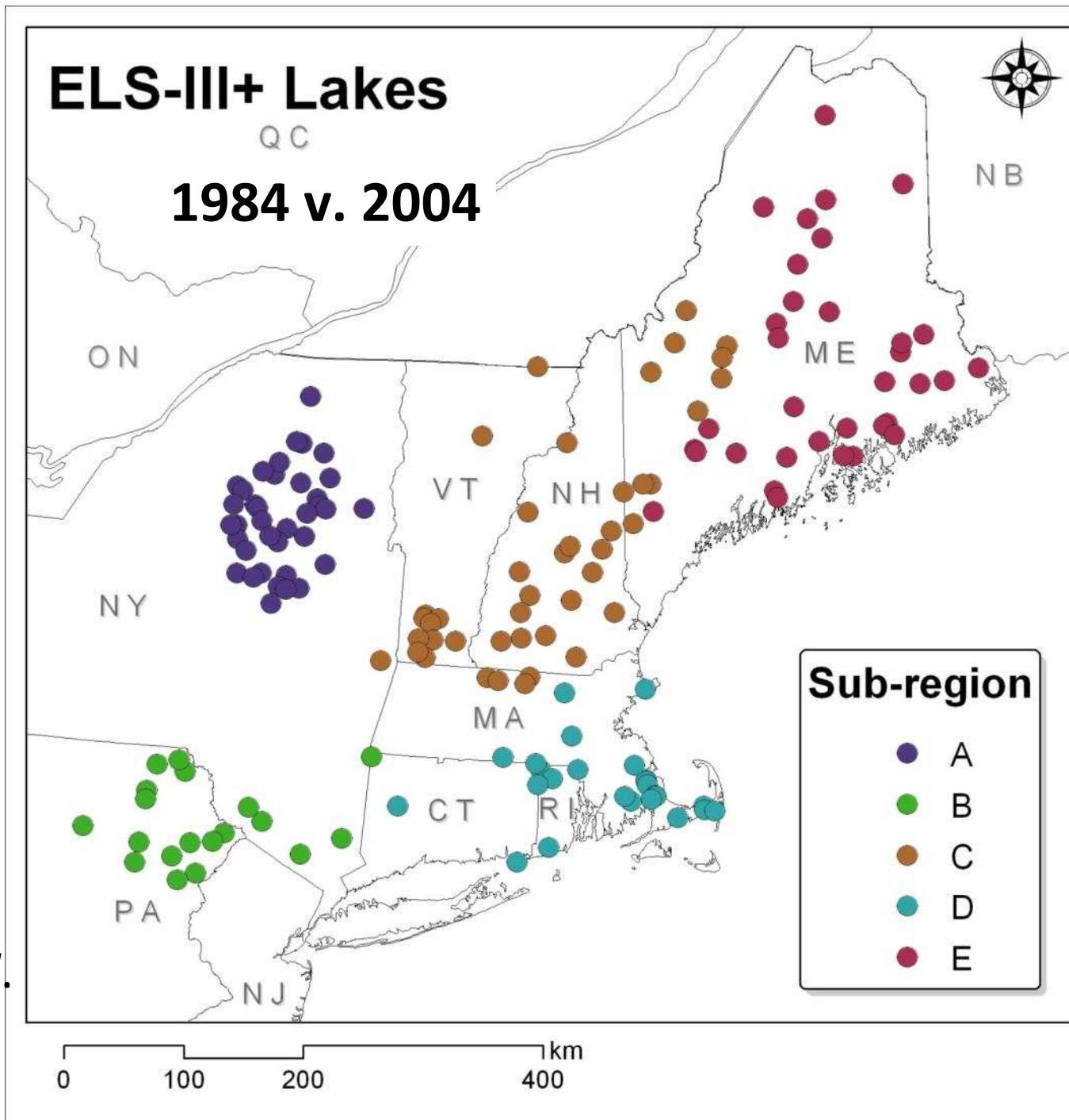
data from R.B. Davis, UMaine

- 20 year changes
- Regional statistical Hg survey
- ELS-II zooplankton comparison

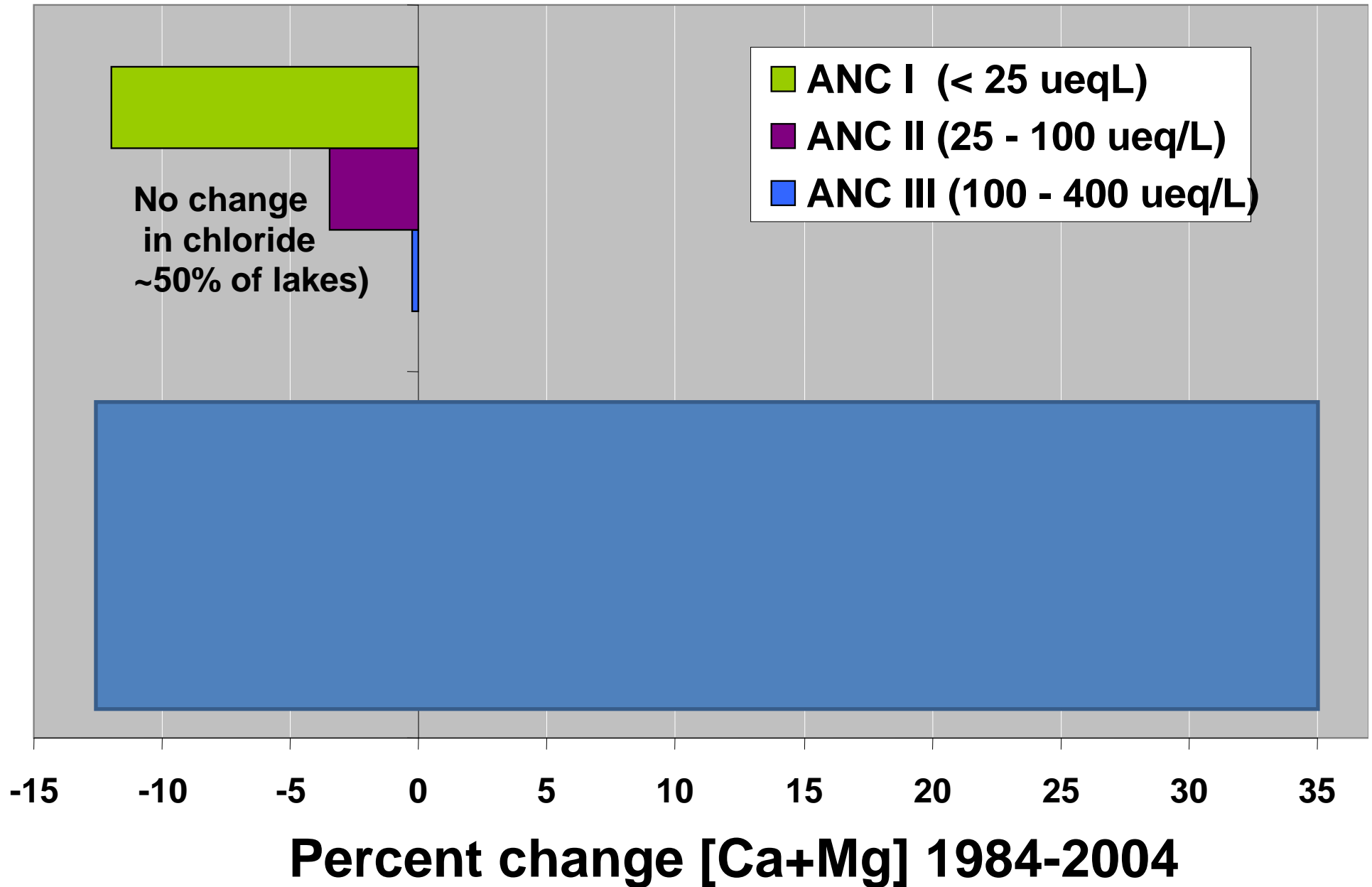
ELS-II/ELS-III populations:

n=145 lakes
N=3993 lakes

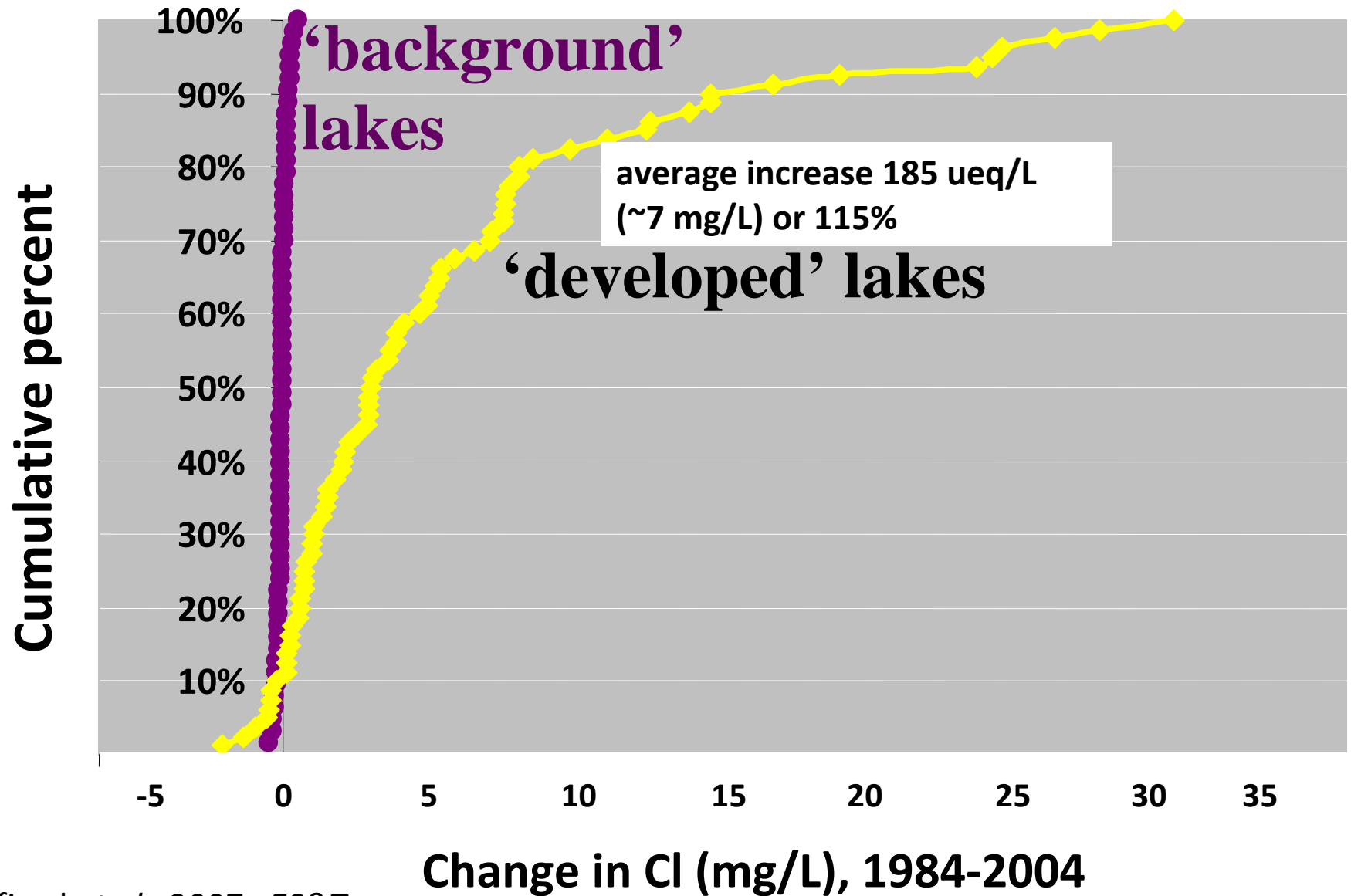
from Rosfjord *et al.*
 2007. ES&T



20 year response in [Ca+Mg]

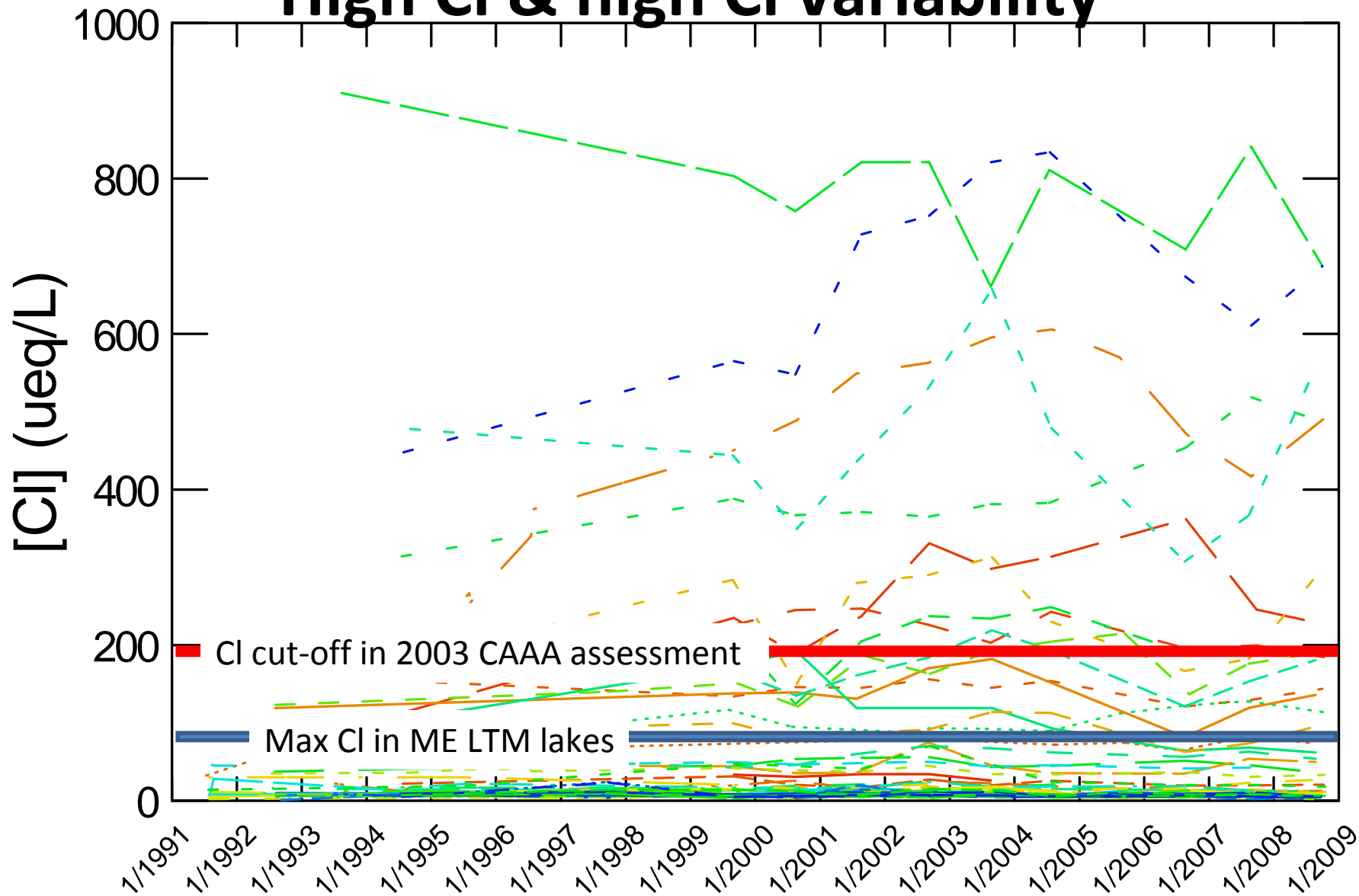


20 year changes in chloride, ELS-II lakes



Rosfjord *et al.*, 2007. ES&T

New England TIME lakes: High Cl & high Cl variability





Data access and sharing

[HTTP://PEARL.MAINE.EDU](http://PEARL.MAINE.EDU)



the source for environmental
information in maine



CAAA-relevant research leveraging

New England LTM/TIME:

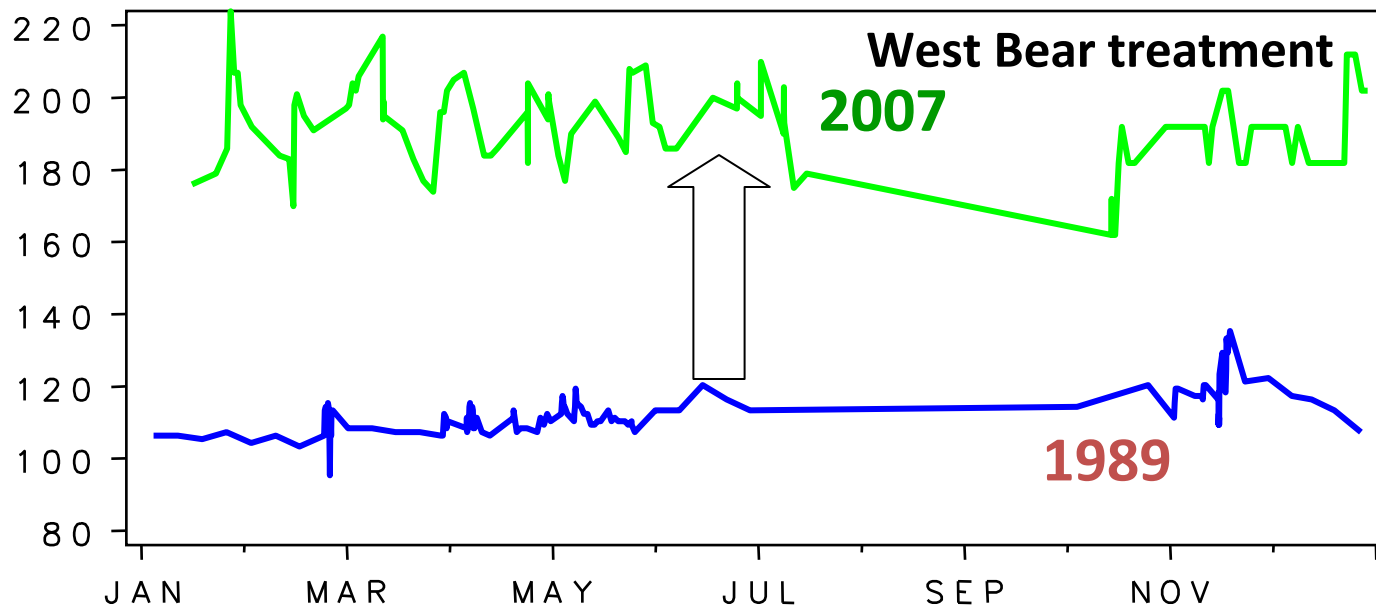
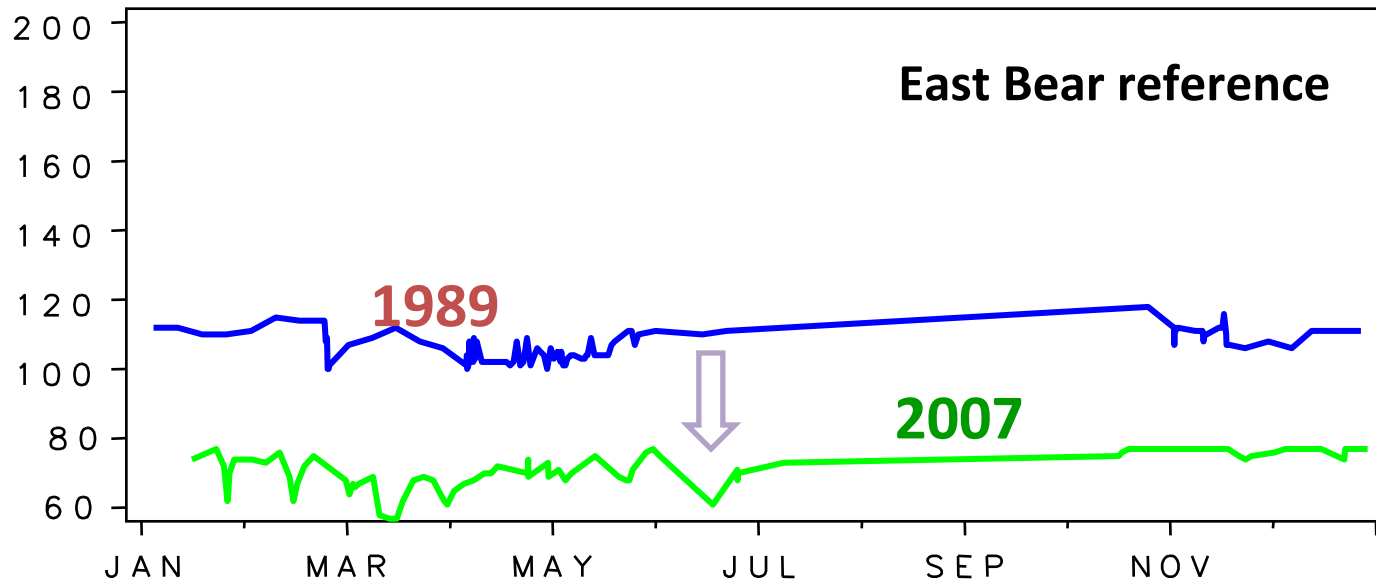
- 20 year chemical re-survey of ELS-II (NRSC)
- 20 year changes in ELS-II zooplankton (EPA and NSRC)
- Atlantic salmon ESA recovery assessment (USFWS)
- Bear Brook paired-watershed experiment (EPA, NSF)
- Acadia NP paired-watersheds (EPA, NPS, USGS)
- Acadia NP surface water status and trends (NPS)
- National Park Service AT monitoring plan (several)
- US-Canadian NEG-ECP critical loads
- ME and NH in high elevation indicator lakes (EPA, NSF, DEP)
- ME seepage indicator lakes (USGS)
- fishless lakes assessment
- Hg regional spatial relationships (EPA, USGS, NSF)



**LTM is a participant at the
Bear Brook Watershed (Maine)**

**23 year paired catchment
experimental treatment
for modelling S and N
(treatment includes
Isotopic labels)**

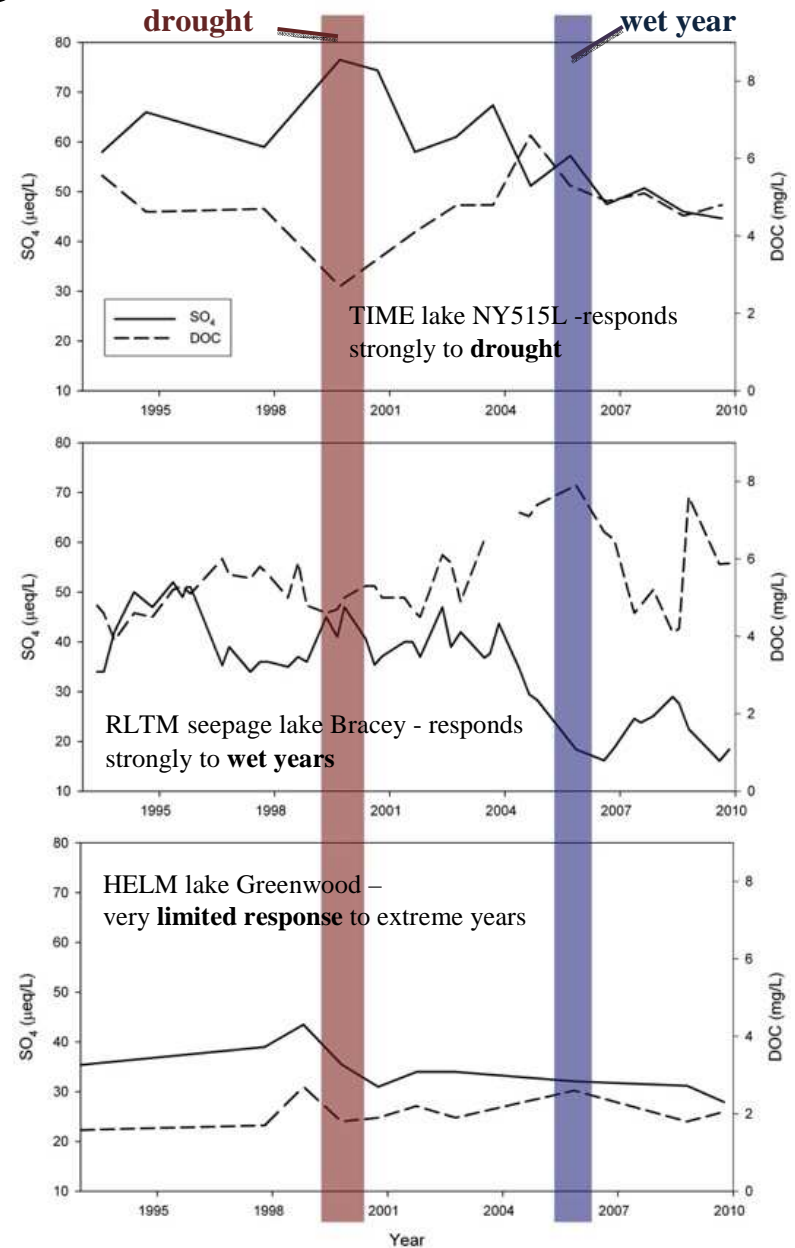
Sulfate concentrations in streamwater (ueq/l)



Climate focus – using long-term data

The importance of extreme climate events in altering the biogeochemical response of lakes in the northeast.

S. Nelson *et al.*



Indicators of return to 'pre-industrial chemical condition'

- 1) decrease in sulfate equivalent fraction
- 2) Increase in ANC and/or air-equilibrated pH
- 3) decrease in Al or Al-speciation (biol. rel. chem)
- 4) decrease in ionic strength (conductance)
- 5) decrease in base cations
- 6) increase in DOC/color
- 7) Pattern shift from 'response trend' to 'natural cycles' (a regional group proposal?)

