Recovery Responses of Phytoplankton and Zooplankton Assemblages to Decreasing Acidic Deposition in Adirondack Lakes

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CLEAN AIR ACT AMENDMENTS (CAAA) 1990

- Significantly lowered SO4– emissions and marginally lowered NO3- emissions

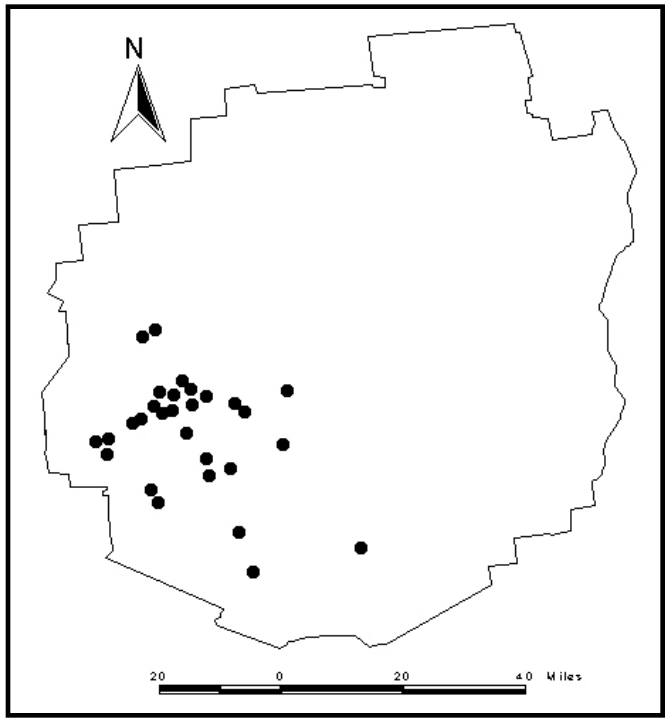
- Created a prospect of Acid Rain Abatement and potential recovery of acidified Adirondack lakes

Is there evidence in Adirondack lakes for:

- Chemical Recovery – Increasing lake pH
- Biological Recovery
  - Changes in phytoplankton and zooplankton with pH increases

Adirondack Effects Assessment Program (AEAP)

Study Sites



- 30 lakes and ponds
- Southwest Adirondacks
  - Highest acid deposition
  - Most acidic lakes

Possible Recovery Responses

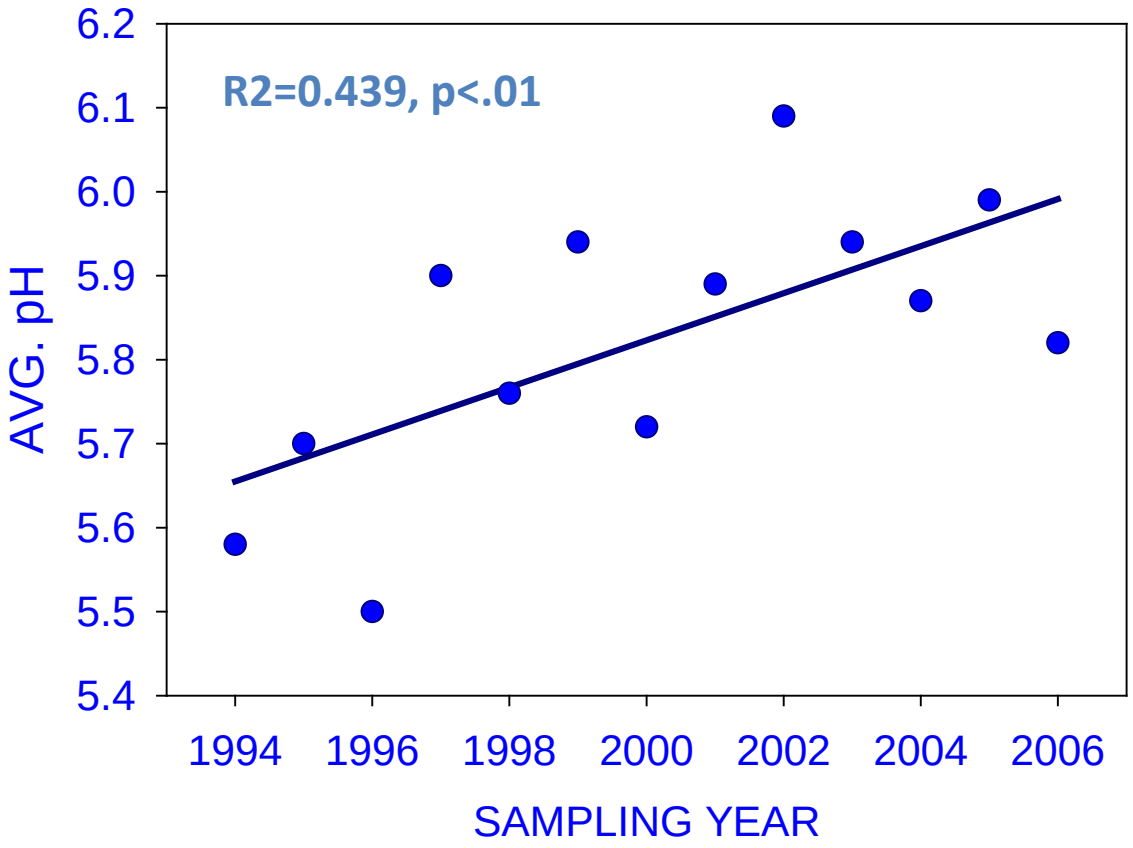
- Increased number of taxa
- Change in proportion of species groups
- Change in taxon abundance
- Increases in community variables:
  - Species Richness
  - Species Diversity (Shannon Weaver Index)
  - Community Evenness (Species distribution)

Plankton Samples

- Integrated sample (tube); surface to:
  - 1% light – phytoplankton
  - 1 PPM dissolved O2 - zooplankton
- Sampling:
  - 3 samples / yr. 1994-96 (June - July – Aug)
  - 2 samples / yr. 1997-2006 (July - Aug)
- 30 lakes (pH 4.5-6.8)

CHEMISTRY RESULTS:

AEAP 30 LAKES AVG. pH : Time Regression



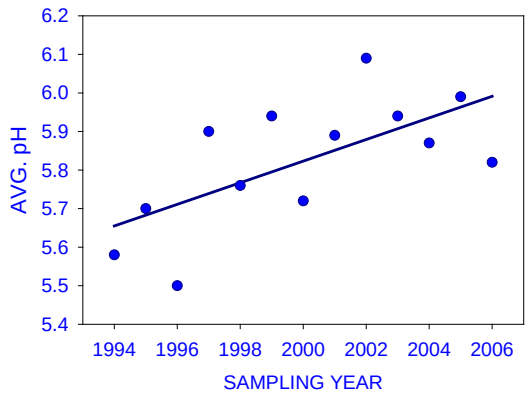
pH CHANGES IN INDIVIDUAL ACID LAKES

- Regression Analysis

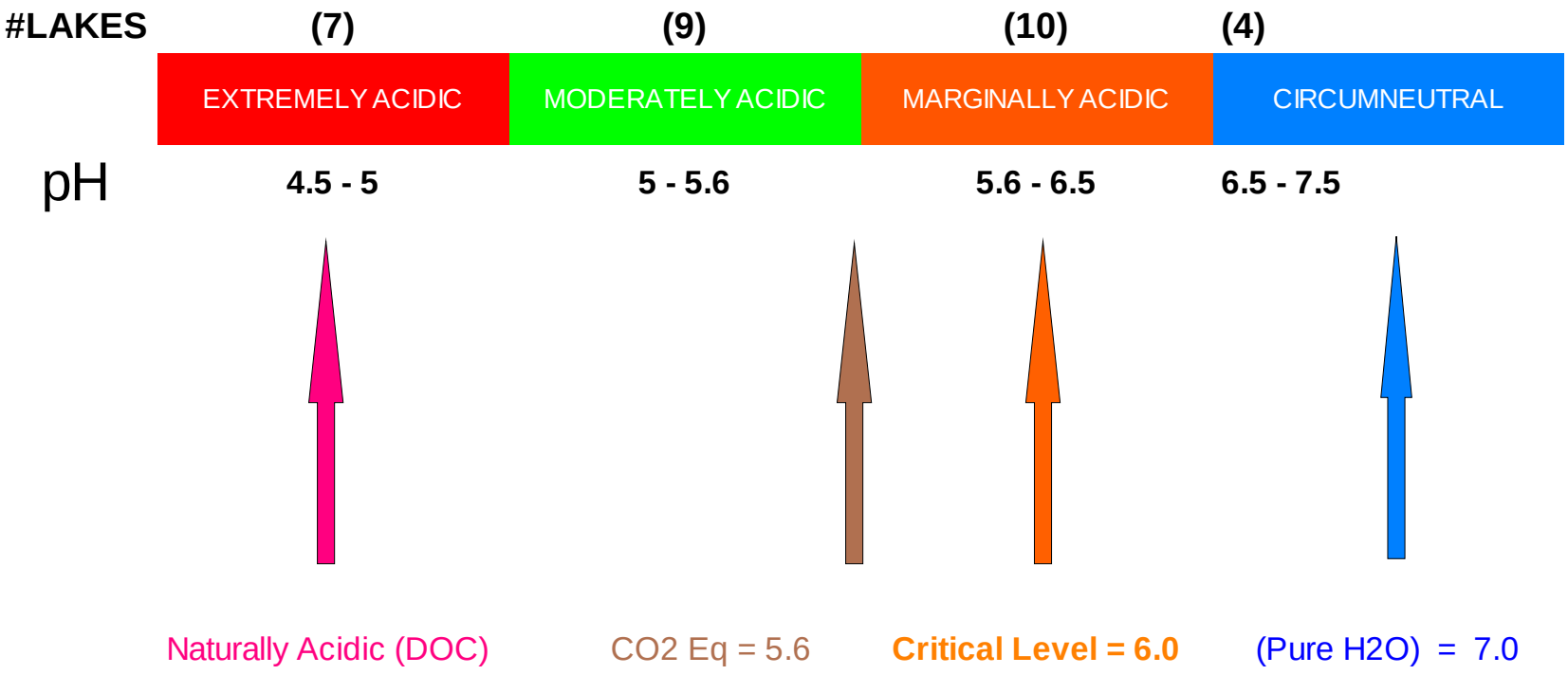
  pH vs. time per lake

  14 lakes showed significant increases (p=<.05)

- pH Difference between beginning & end
  - Avg. pH 1994-96 – Avg. pH 2004-06
  - Δ pH 0.3 ≈ Regr. Sig p<.05



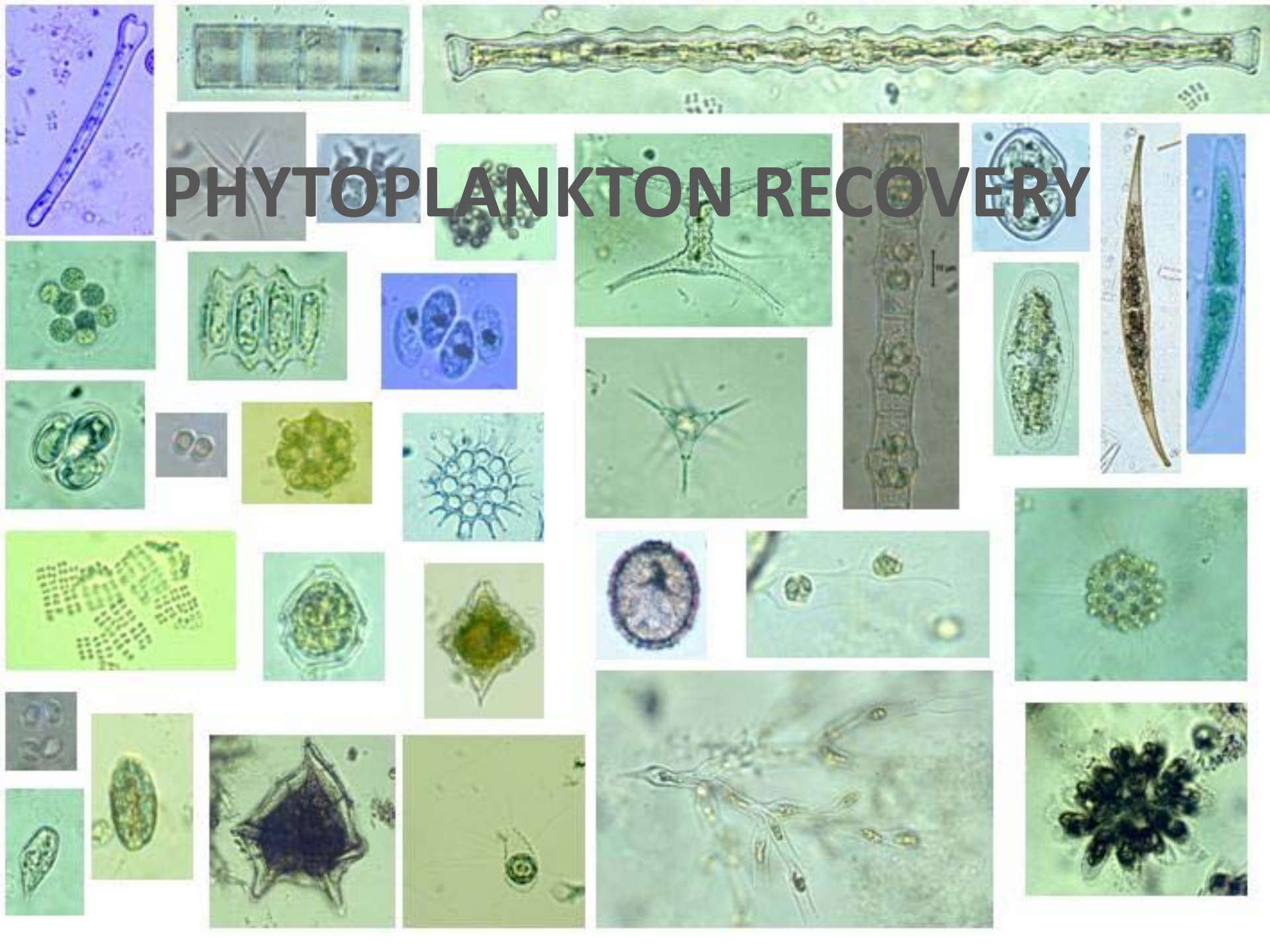
pH CATEGORIES OF AEAP LAKES



CHEMICAL RECOVERY ACCOUNTING pH CHANGE PER LAKE (13 YEARS)

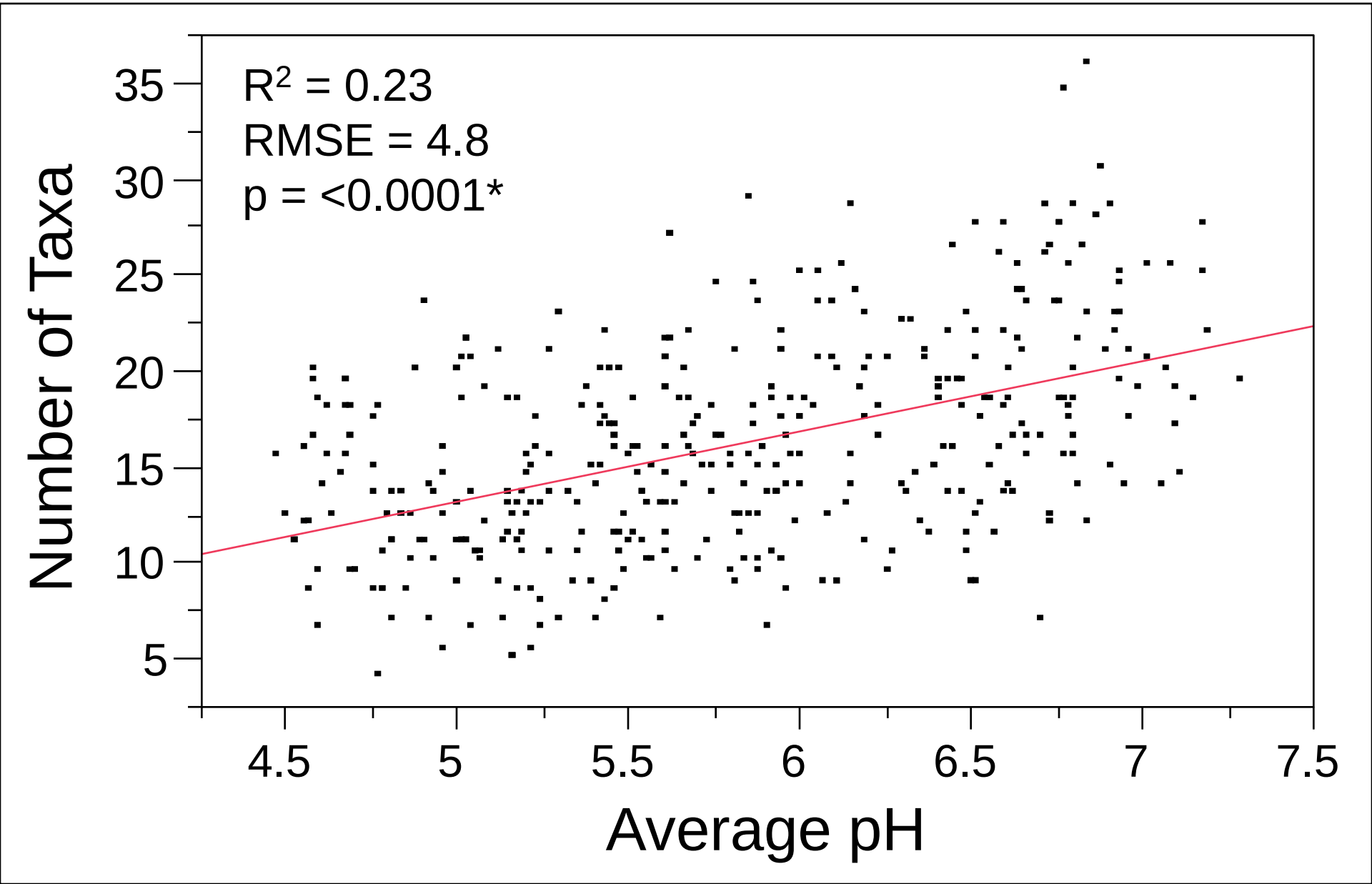
- CIRCUMNEUTRAL 4 (Initially > pH6.5)
- HIGH DOC 5 Unlikely to > pH5.6
- CO2 Eq. 4 → 5.6-5.9
- CRITICAL ZONE 2 → 6.0-6.25
- FINAL RECOVERY 6 → 6.5
- REMAINED ACIDIC 9 <pH 5.6

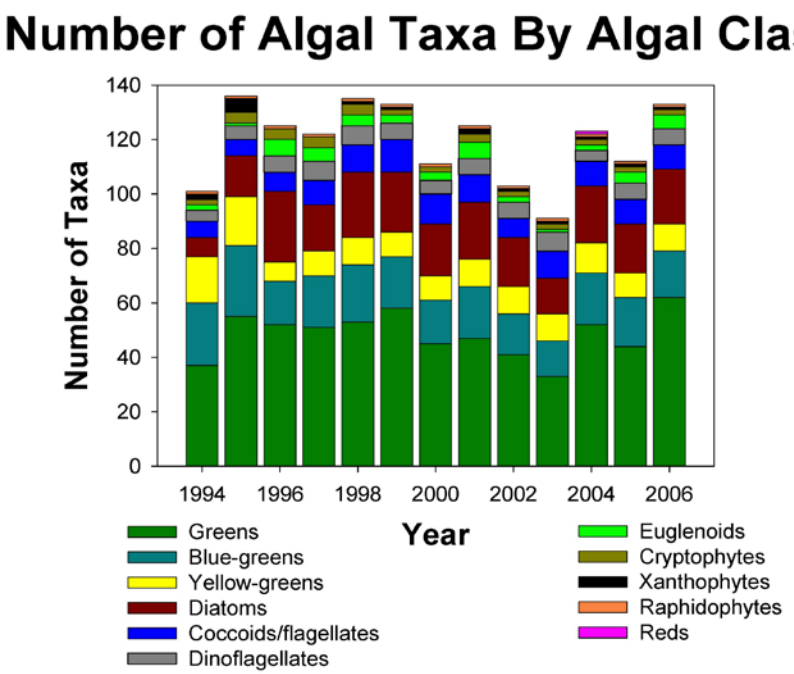
- **Evidence of Recovery in 12 /21 likely lakes**

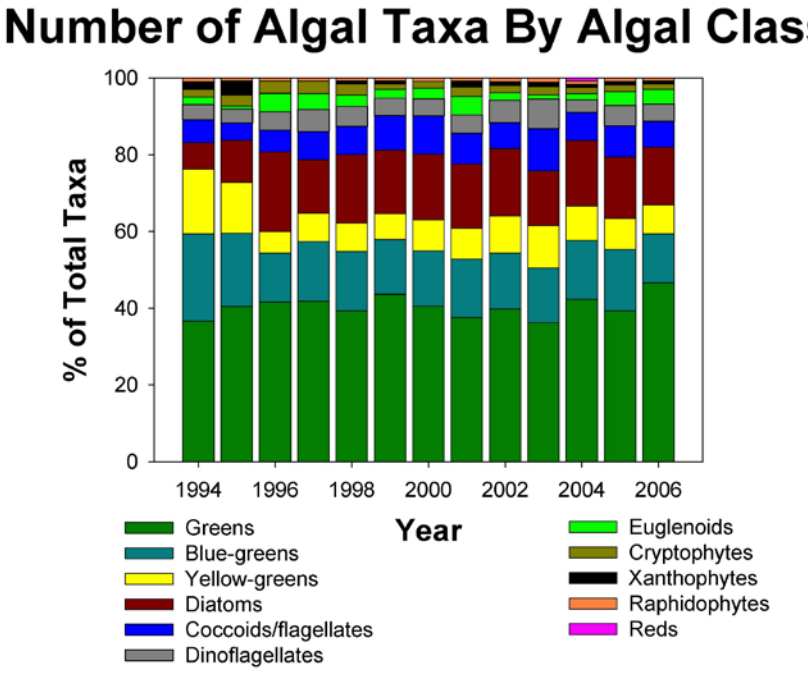

PHYTOPLANKTON RECOVERY

Number of Taxa / Sample vs. pH

30 lakes – 13 years – 750 samples

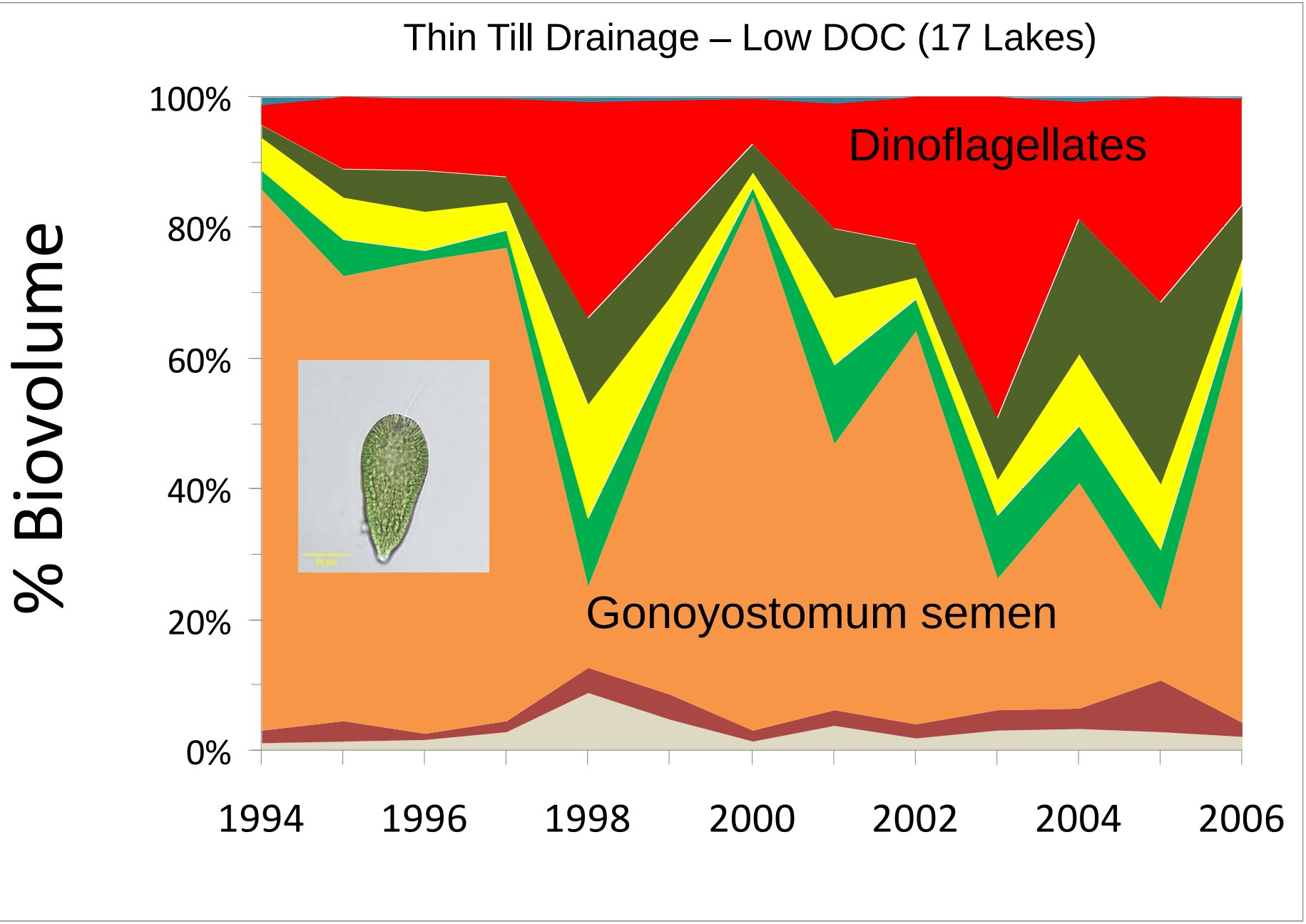






30 Study lakes – July and August

Biovolume of Algal Class vs. Year



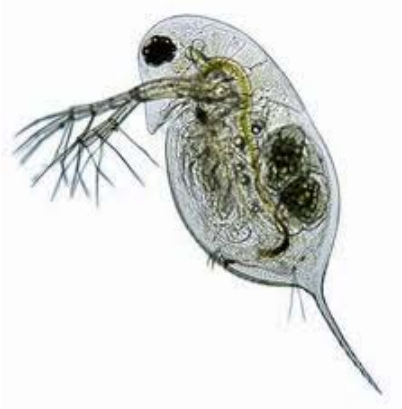
Drawing conclusions

- Increased number of taxa from 1994 to 2006 indicates limited biological recovery
- Proportions of taxa in algal classes and other groups change little
- Individual taxa increased with pH gain

ASSESSING ZOOPLANKTON RECOVERY

- Should expect increases in the following community variables:
  - Species Richness
  - Species Diversity (Shannon Weaver Index)
  - Community Evenness

- Community variables were assessed by regression analysis VS. pH for each lake



ASSESSMENT STRATEGY

- Crustaceans and Rotifers were assessed separately

- Lakes were divided into 2 groups
  - Marginally Impacted (Initial pH>5.7-6.4)
    - **Critical Level (pH 6.0)**
  - High-Moderate Impacted (Initial pH 4.5-5.6)
    - Includes extremely and moderately acidified lakes

CRUSTACEAN COMMUNITY IMPROVEMENTS IN ACIDIC LAKES

LAKE	1994-96 pH	2004-06 pH	▲ pH	SR p / r^2	SD p / r^2	EV p / r^2
14 ACIDIC LAKES WITH SIGNIFICANT pH CHANGE						
Grass	5.94	6.50	0.56	0.07 / .27		
Limekiln	6.13	6.54	0.41	0.06 / .29	0.05 / .18	
Rondaxe	6.37	6.84	0.47	0.02 / .39		
M branch	6.41	6.72	0.31	0.02 /.45	0.07 / .28	
Round	4.71	5.41	0.70			
South	5.27	5.80	0.53		0.02 / 0.4	0.03 / .38
Dart	5.50	6.05	0.55			
Carry	4.89	5.35	0.45	0.05 / .482		
Big moose	5.33	5.74	0.41			
M settlement	5.10	5.50	0.40			
Queer	5.55	5.91	0.36		0.02 / .41	0.03 / .35
Brooktrout	5.17	5.53	0.35			
West	5.23	5.54	0.31			
Jockeybush	5.26	5.58	0.32		0.04 / .33	.07 / .27
12 ACIDIC LAKES WITH NO SIGNIFICANT pH CHANGE						
Sagamore	6.10	6.57	0.47	0.04 / .33	0.03 / .38	
Wheeler	6.27	6.55	0.28			
Raquette	6.20	6.39	0.19			
Squaw	5.97	6.00	0.03			
'G'	5.68	5.97	0.28			
Constable	4.95	5.20	0.24			
Willy's	4.82	4.96	0.14			
Squash	4.49	4.61	0.12			
North	5.35	5.47	0.12			
Loon hollow	4.66	4.76	0.11		0.02 / .39	
Long	4.61	4.64	0.03			
Indian	5.19	5.02	-0.18			

ROTIFER COMMUNITY IMPROVEMENTS IN ACIDIC LAKES

LAKE	1994-96 pH	2004-06 pH	▲ pH	SR p / r^2	SD p / r^2	EV p / r^2
14 ACIDIC LAKES WITH SIGNIFICANT pH CHANGE						
Grass	5.94	6.50	0.56			
Limekiln	6.13	6.54	0.41	0.0003 / .70		
Rondaxe	6.37	6.84	0.47		0.05 / .30	
M branch	6.41	6.72	0.31			
Round	4.71	5.41	0.70	0.0005 / .68	0.009 / .48	
South	5.27	5.80	0.53	0.0003 / .70	0.04 / .35	
Dart	5.50	6.05	0.55			
Carry	4.89	5.35	0.45			
Big moose	5.33	5.74	0.41	0.004 / .53	0.0003 / .71	0.002 / .69
M settlement	5.10	5.50	0.40			
Queer	5.55	5.91	0.36	0.002 / .61	0.09 / .24	
Brooktrout	5.17	5.53	0.35		0.04 / .33	
West	5.23	5.54	0.31			
Jockeybush	5.26	5.58	0.32			
12 ACIDIC LAKES WITH NO SIGNIFICANT pH CHANGE						
Sagamore	6.10	6.57	0.47	0.001 / .60	0.09 / .24	
Wheeler	6.27	6.55	0.28			
Raquette	6.20	6.39	0.19			
Squaw	5.97	6.00	0.03			
'G'	5.68	5.97	0.28		0.035 / .35	
Constable	4.95	5.20	0.24			
Willy's	4.82	4.96	0.14			
Squash	4.49	4.61	0.12			
North	5.35	5.47	0.12		0.008 / .49	0.03 / .31
Loon hollow	4.66	4.76	0.11			
Long	4.61	4.64	0.03			
Indian	5.19	5.02	-0.18			

RESULTS SUMMARY

- Biotic improvements were generally limited to lakes with significant pH improvement.
  - SR - Crustaceans (6) & Rotifers (6)
  - SD & EV - Crustaceans (10) & Rotifers (11)

- Improvements in crustaceans were essentially limited to marginally impacted lakes and were weak compared to rotifers.

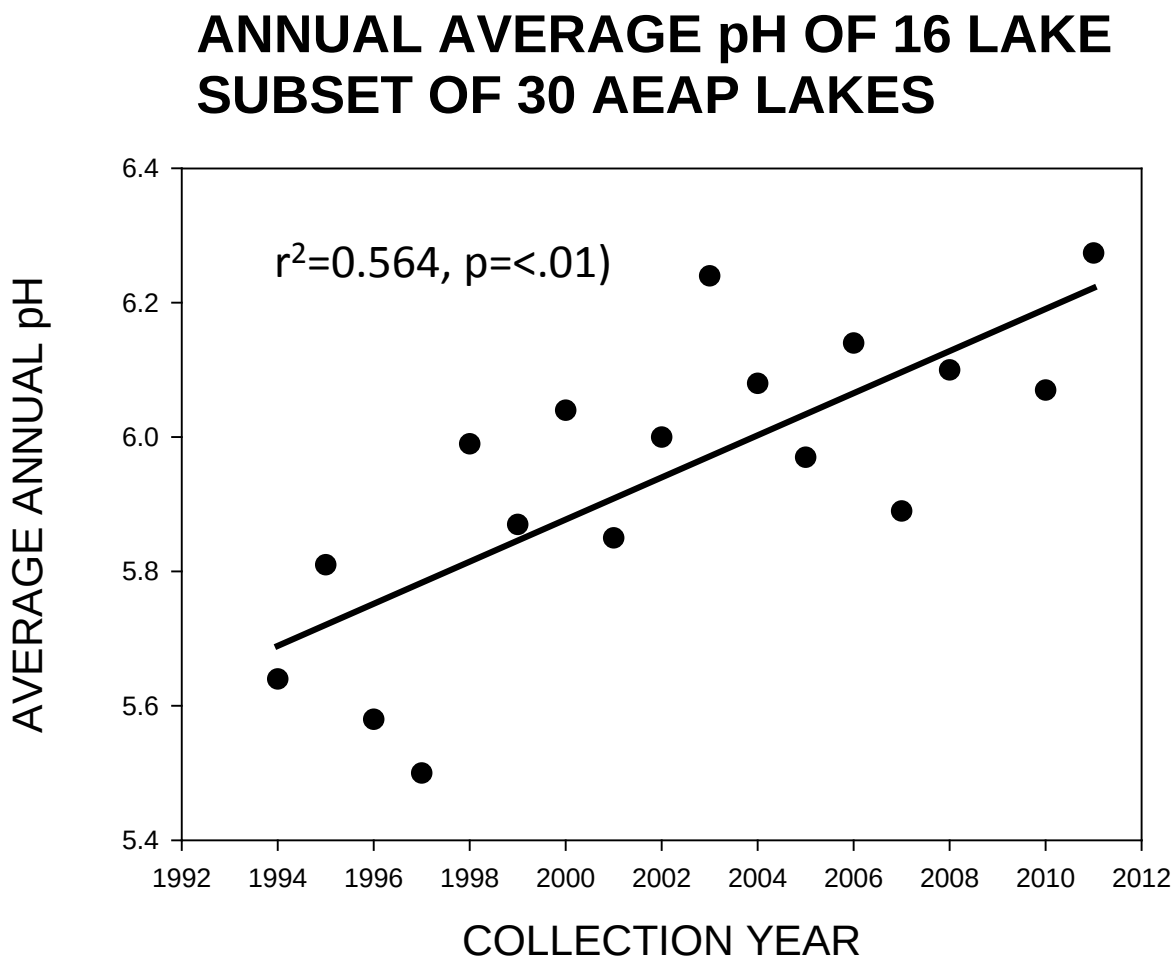
- Improvements in rotifers occurred mostly in the acidic lakes and were stronger than that of crustaceans

- Recovery in the rotifer community probably precedes that of the crustacean community.

CONCLUSIONS

- Chemical recovery was limited
  - Only 1 initially acidic lakes exceeded pH 6.0 at end
  - 9 of 21 initially acidic lakes remained <pH 5.6
- Biotic recovery was incomplete
  - Phytoplankton show taxa increase over time, but community variables as yet unknown
  - initially acidic lakes (< pH 5.6) with pH improvement
    - species richness increases for rotifers in 3/10 lakes
    - and only 1/10 for crustaceans

NYSERDA EXTENSION



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