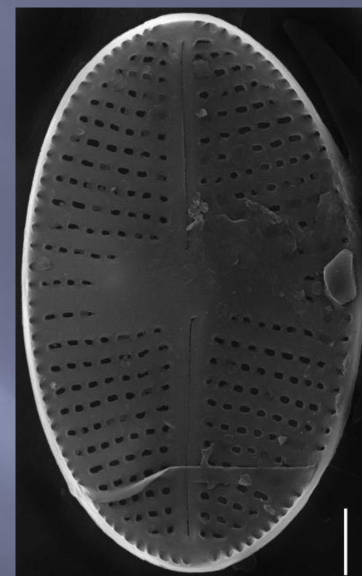
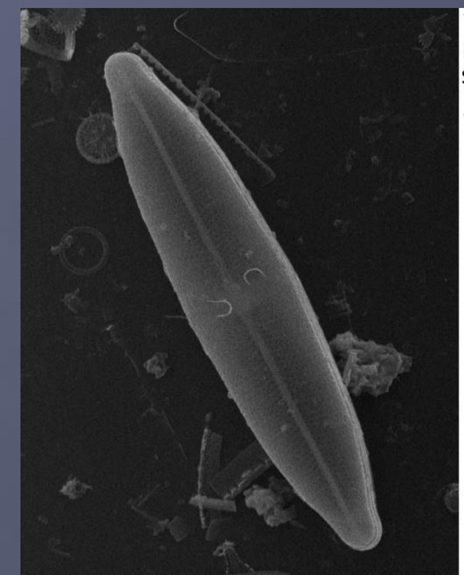
Changes in Diatom Taxa in Sierra Nevada Lakes during the 20th Century: Implications for Critical Loads Development

Moat Lake in winter



Psammothidium subatomoides



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Goals of Today's Talk

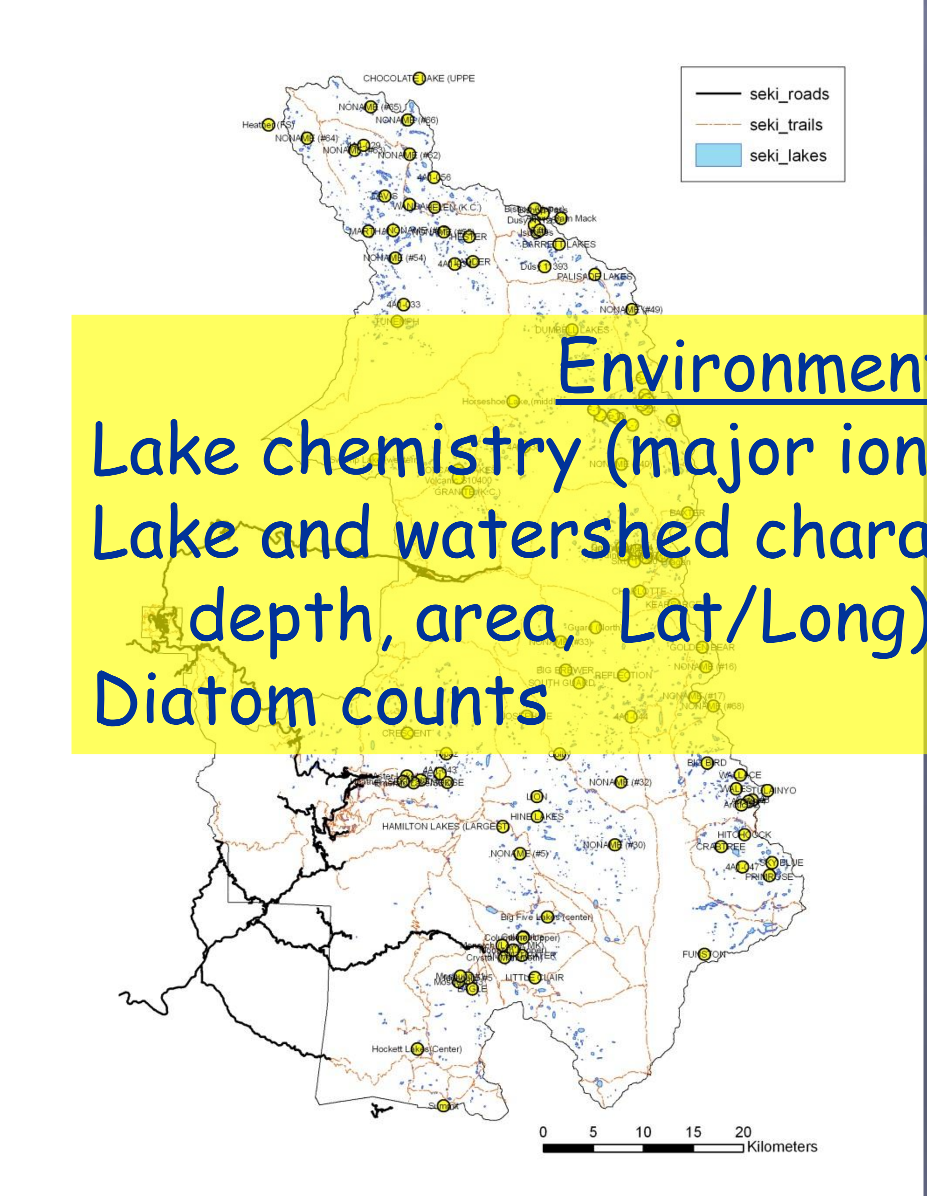
- Paleolimnology research in Sierra Nevada:
  - Determine water quality parameters that most strongly affect diatom communities
  - Develop diatom-chemistry inference models
  - Develop diatom stratigraphy and apply models to sediments cores
- If changes are detected, determine if they are related to increased atmospheric deposition of acids and nutrients or something else…?

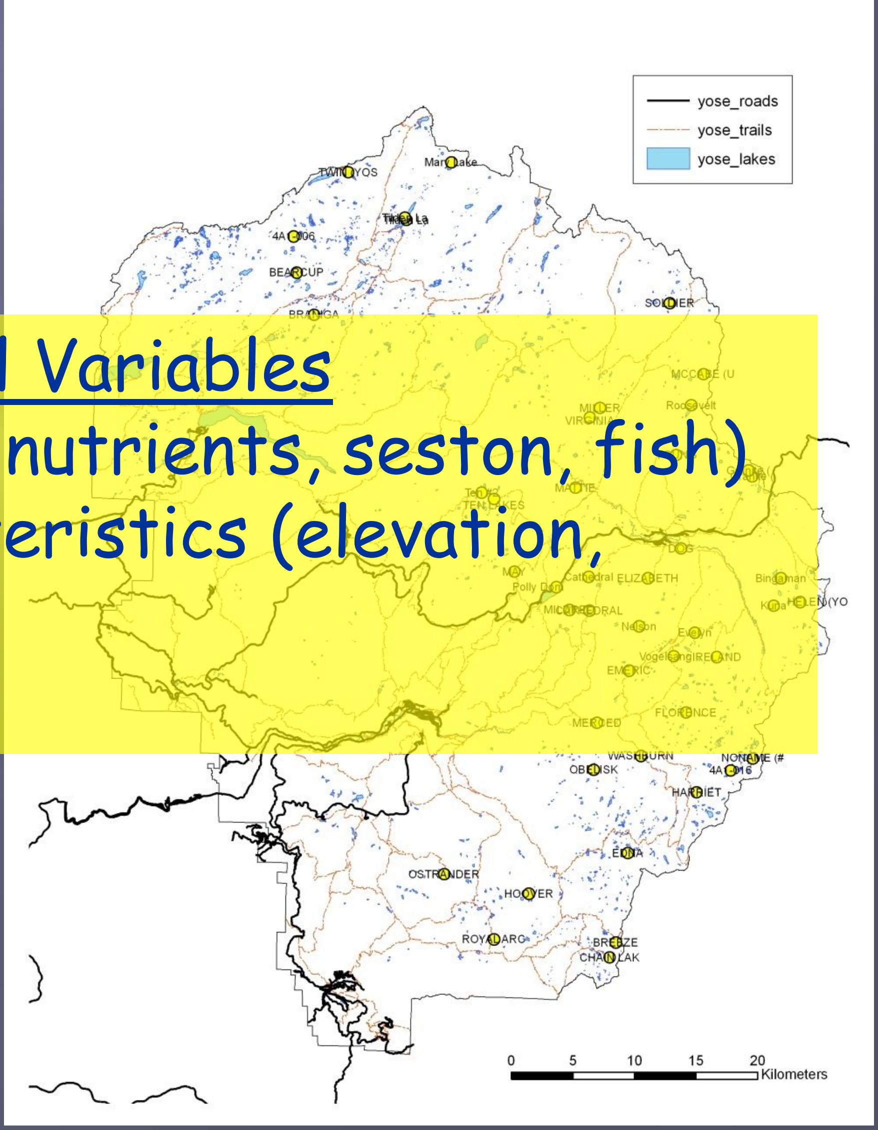
Study Design

Methods

1. Sample 50 lakes for chemistry and diatoms
2. Perform PCA and CCA to identify most important water quality parameters
3. Develop transfer functions between diatoms and chemistry
4. Develop diatom stratigraphy
5. Apply the functions to stratigraphy to reconstruct past water quality

Step 1: Calibration Survey (50 lakes)





Environmental Variables

Lake chemistry (major ions, nutrients, seston, fish)

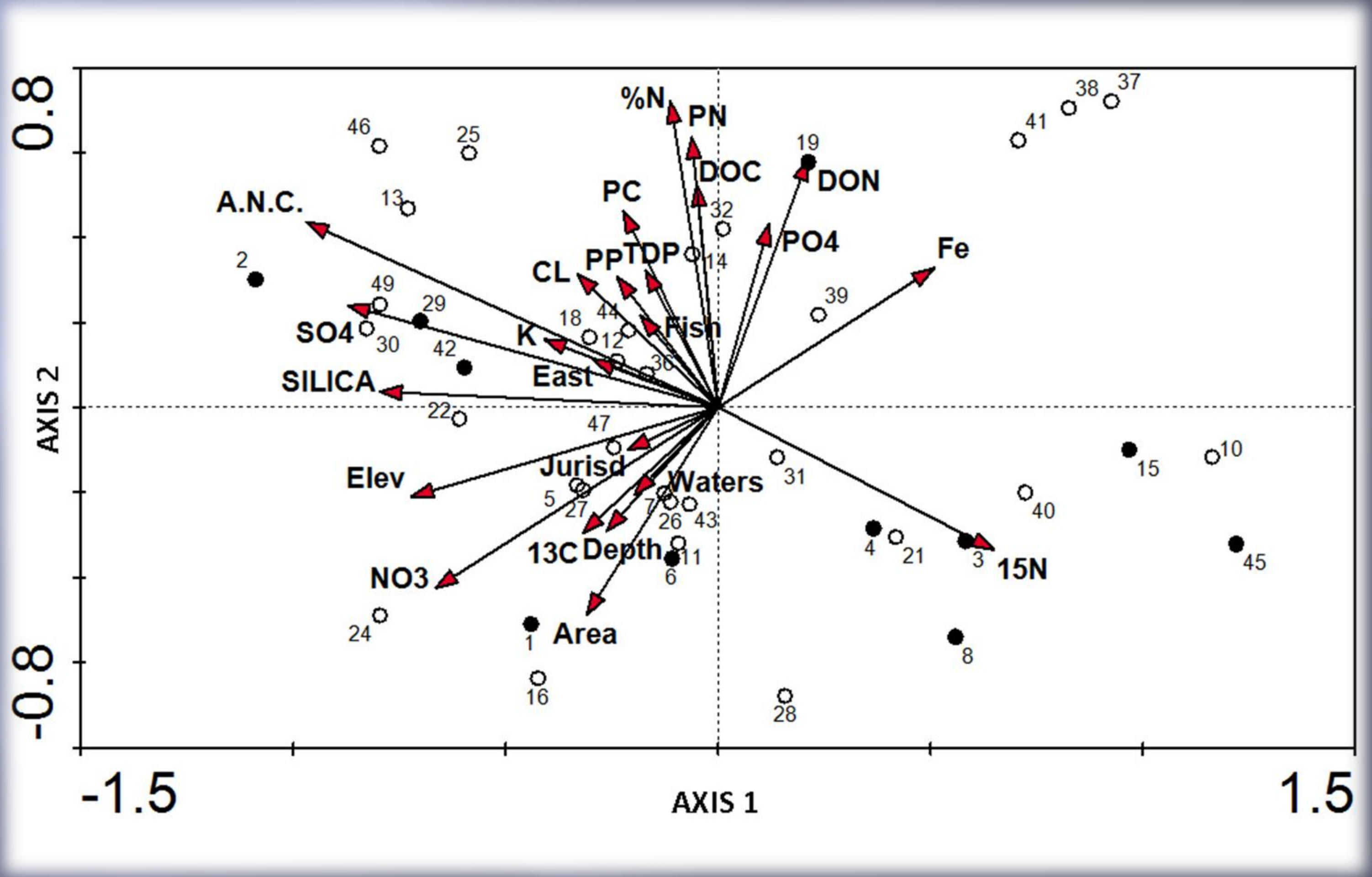
Lake and watershed characteristics (elevation, depth, area, Lat/Long)

Diatom counts

Courtesy of Roland Knapp

Step 2:

Principal Components and Canonical Correspondence Analysis

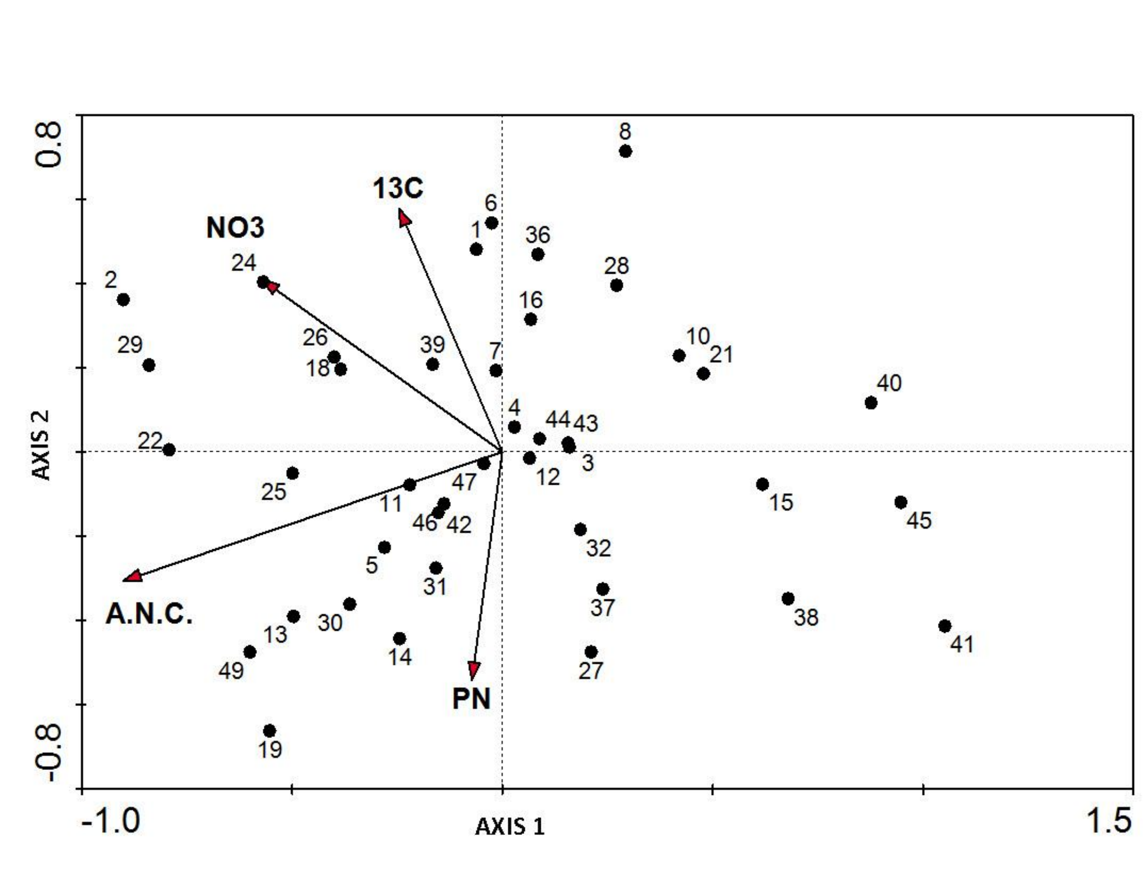


Results from PCA and CCA (1)

- Data mining revealed that diatom assemblages in Sierra Nevada lakes are affected by:
  - Indices of mineral weathering - (ANC, SO_4, Silica)
  - Indices of nitrogen availability in water column (NO_3, PN) and in sediments (%N, $\delta^{15}N$)
  - Indices of carbon availability and source (DOC, $\delta^{13}C$)

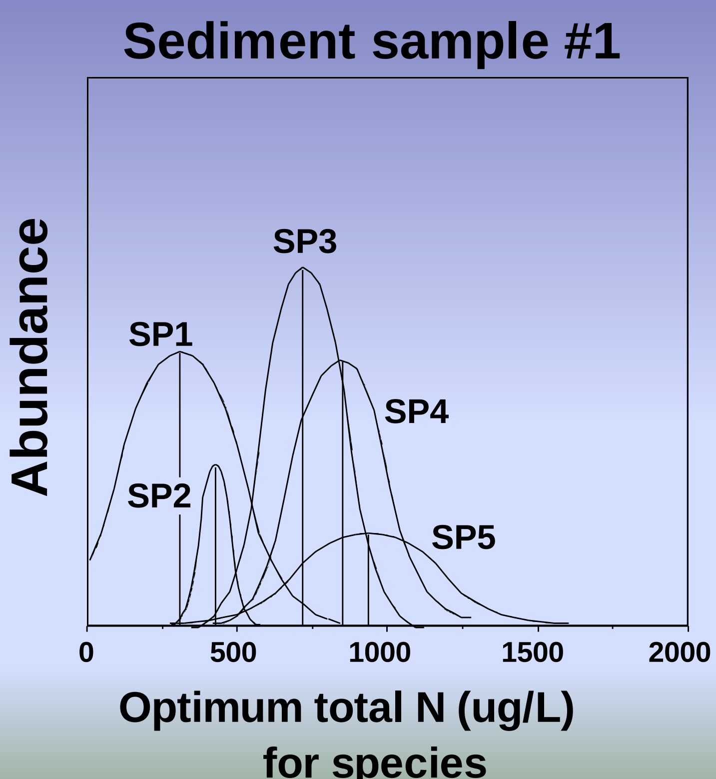
Results from PCA and CCA (2)

- Final set of variables to model:
  - ANC
  - NO_3
  - $\delta^{13}C$ or PN



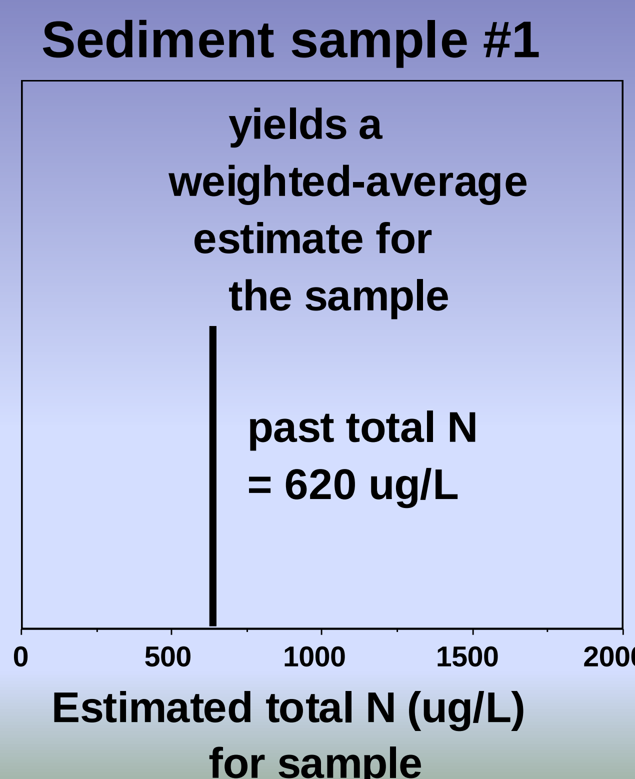
Step 3: Develop Transfer Models Between Diatoms and ANC, NO_3 and $\delta^{13}C$

Reconstruct water chemistry of the lakes using sediment diatoms and weighted-average approach

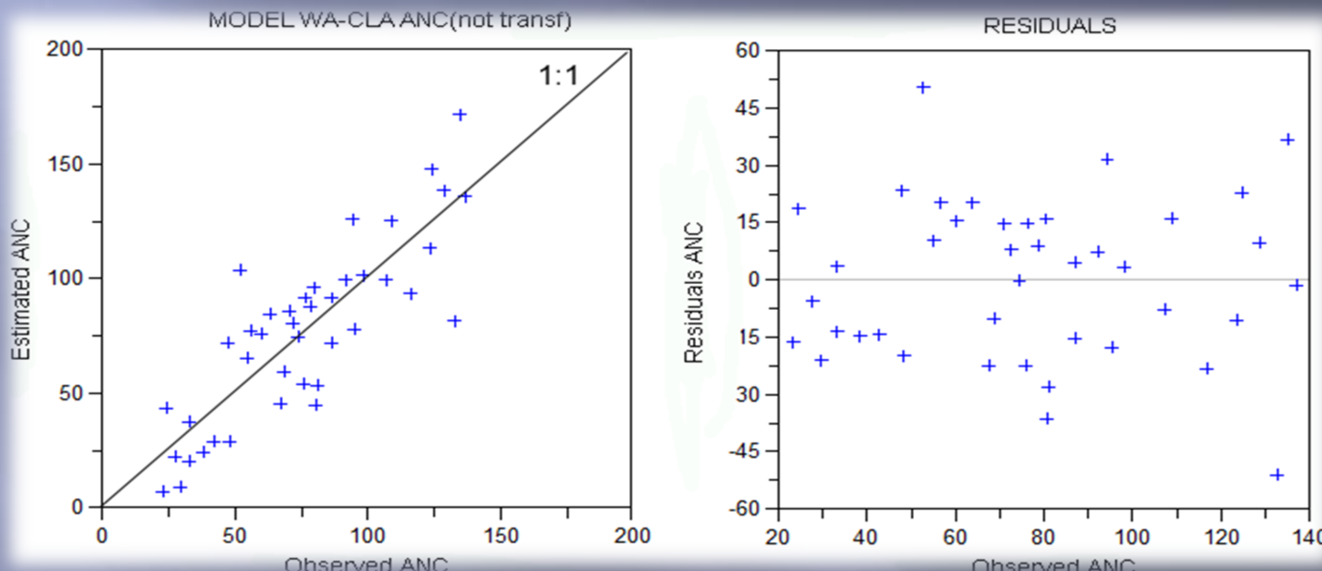


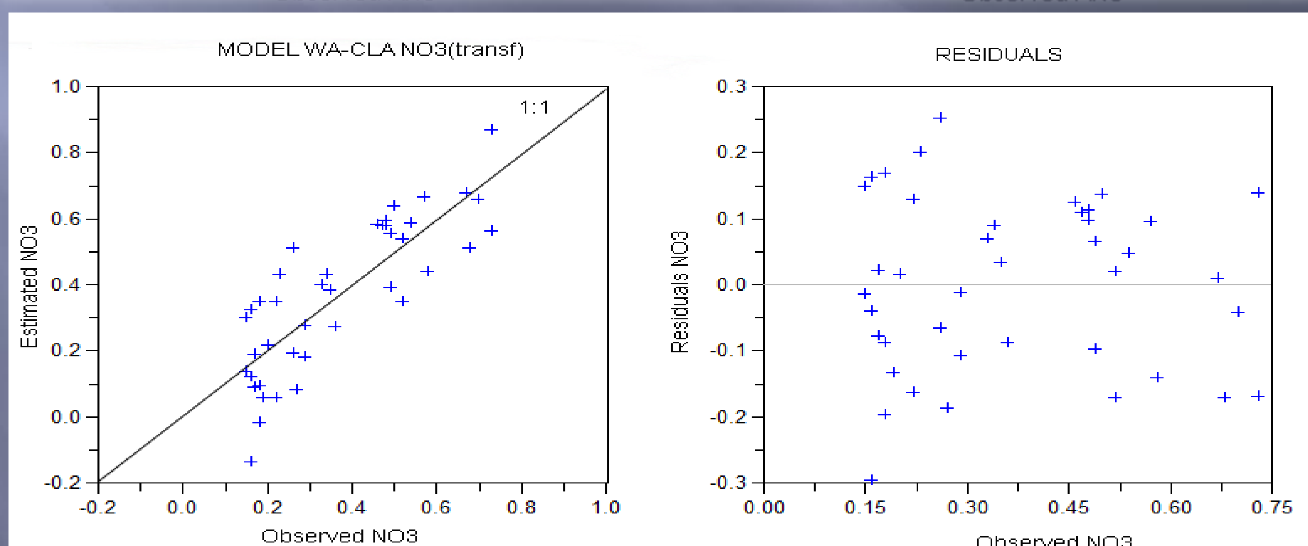
Past water quality?

calculated as the average of the species' optima weighted by each species' abundance

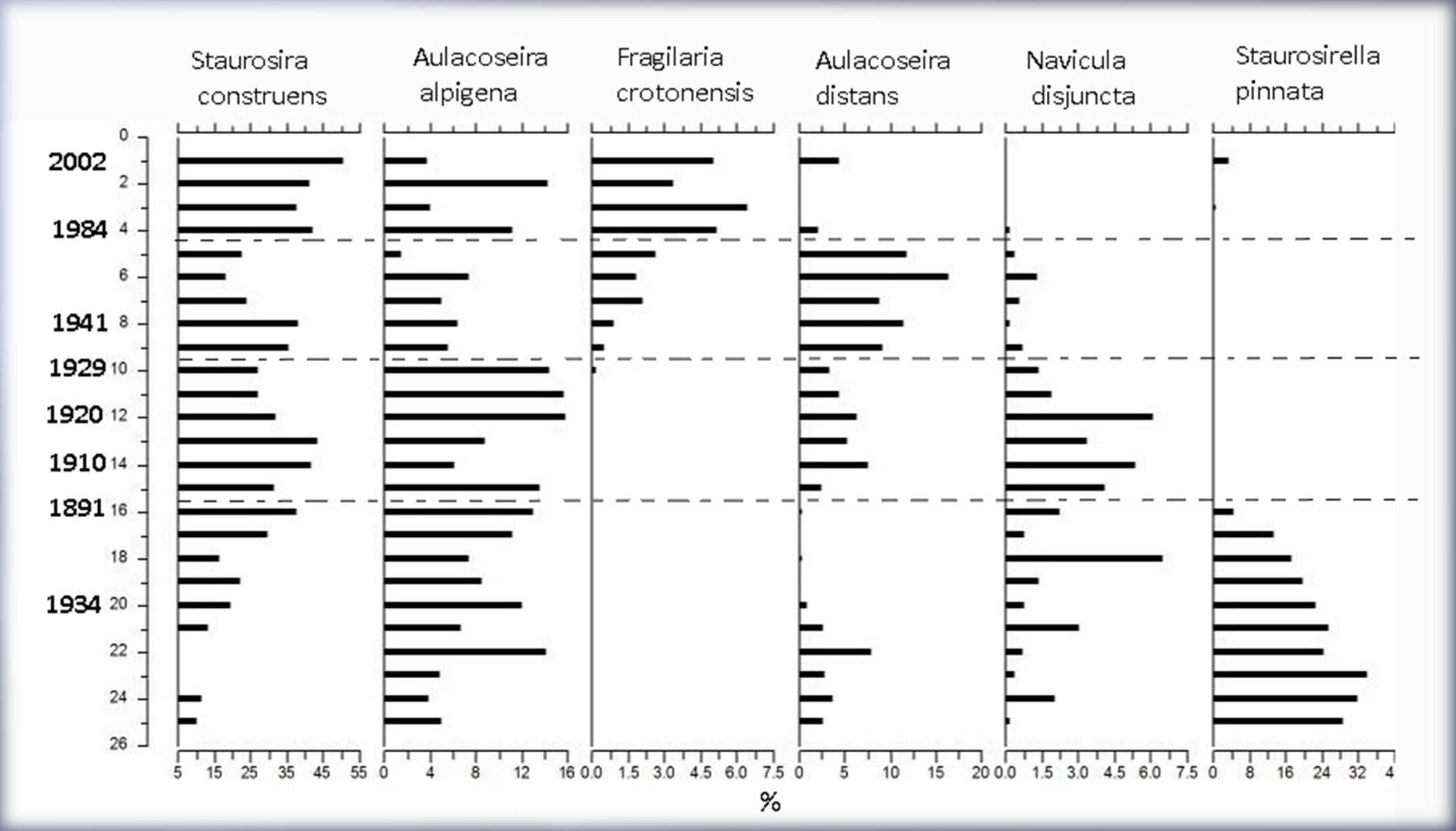


The Models

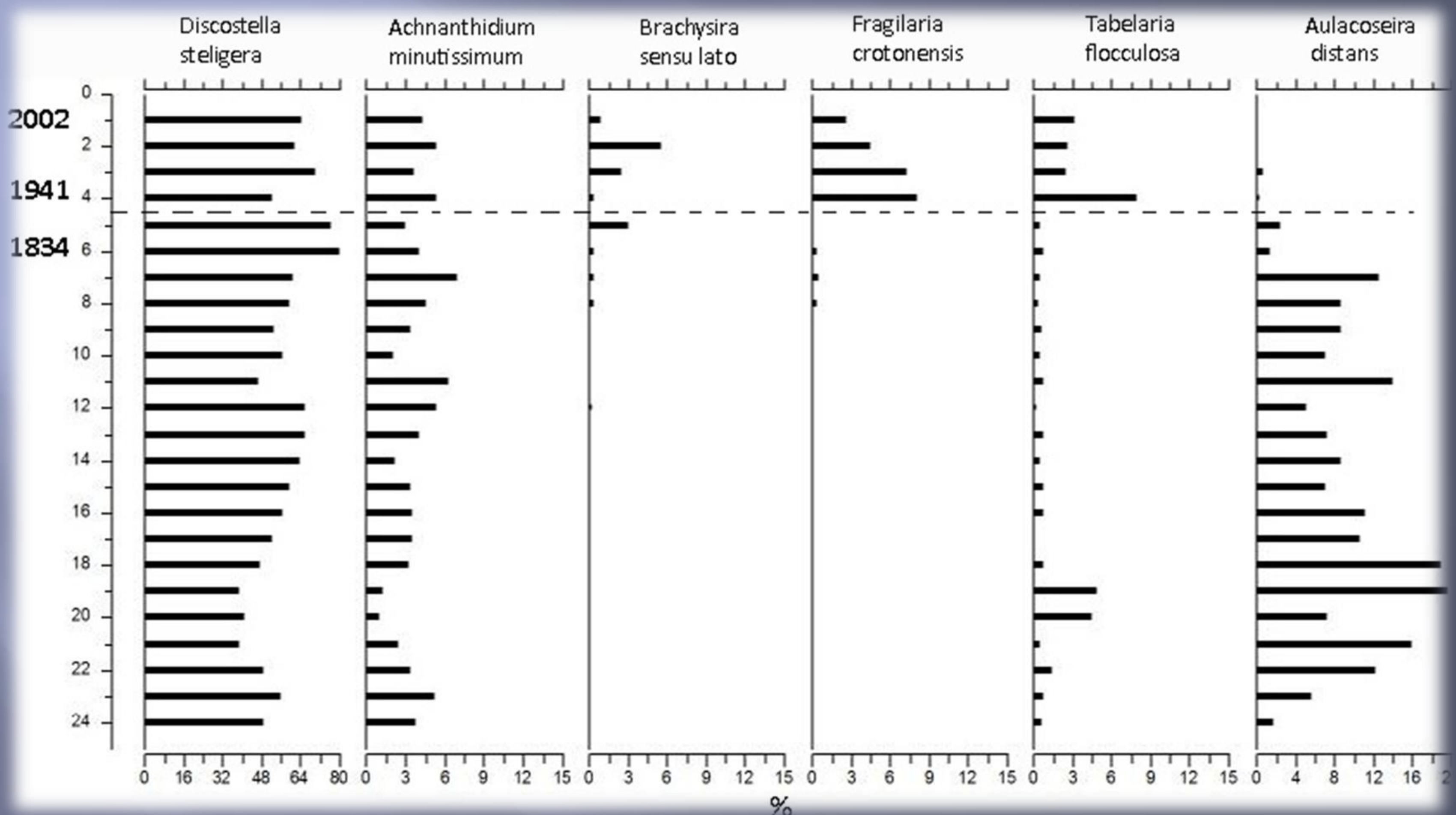

MODEL WA-CLA ANC(not transf)
1:1
Estimated ANC
Observed ANC
RESIDUALS
Residuals ANC
Observed ANC


MODEL WA-CLA NO3(transf)
1:1
Estimated NO3
Observed NO3
RESIDUALS
Residuals NO3
Observed NO3

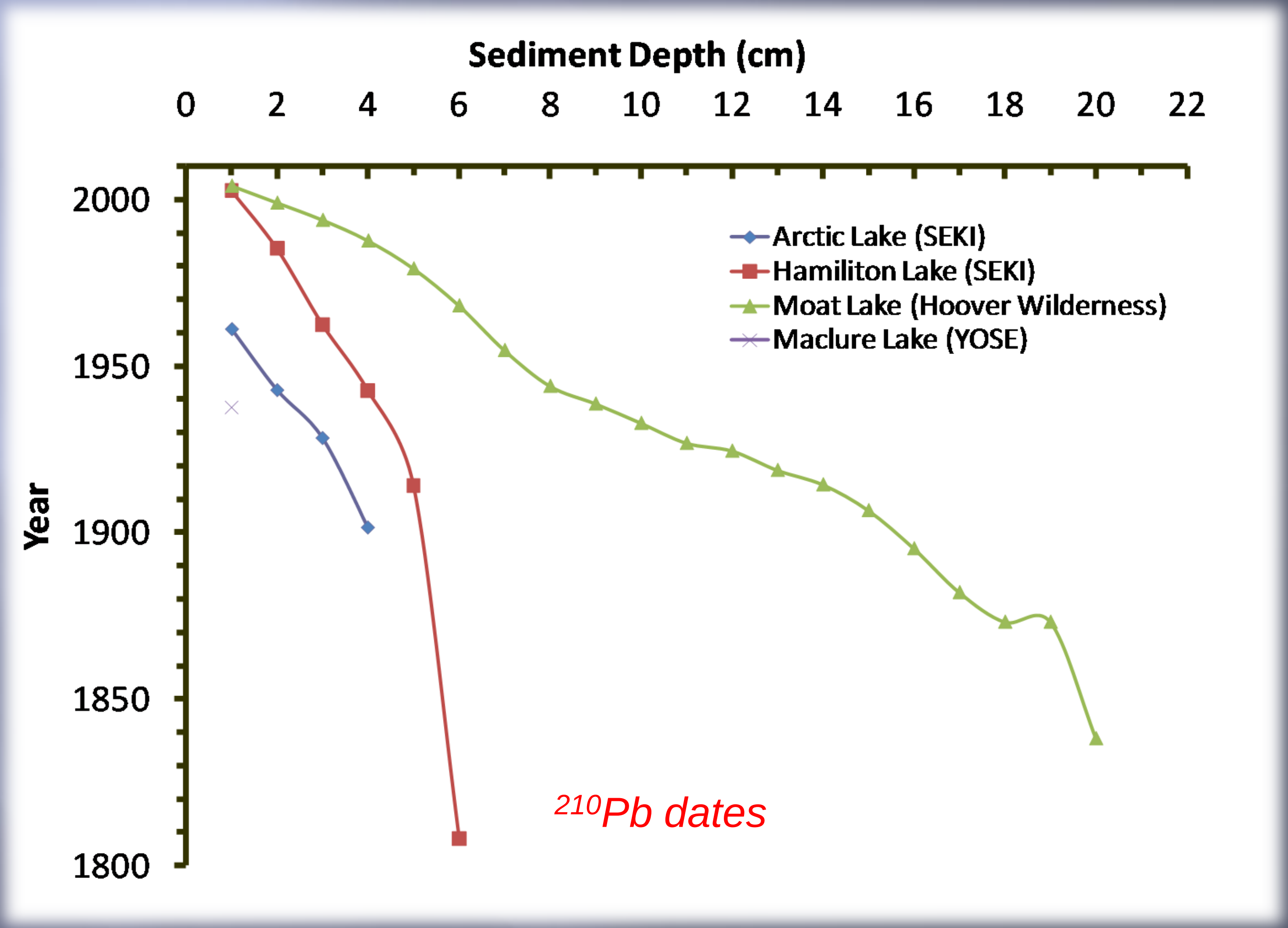
Step 4: Diatom Stratigraphy
Moat Lake (currently N-limited)



Diatom Stratigraphy
Hamilton Lake (currently P-limited)



Step 5: Apply Models to Long Cores



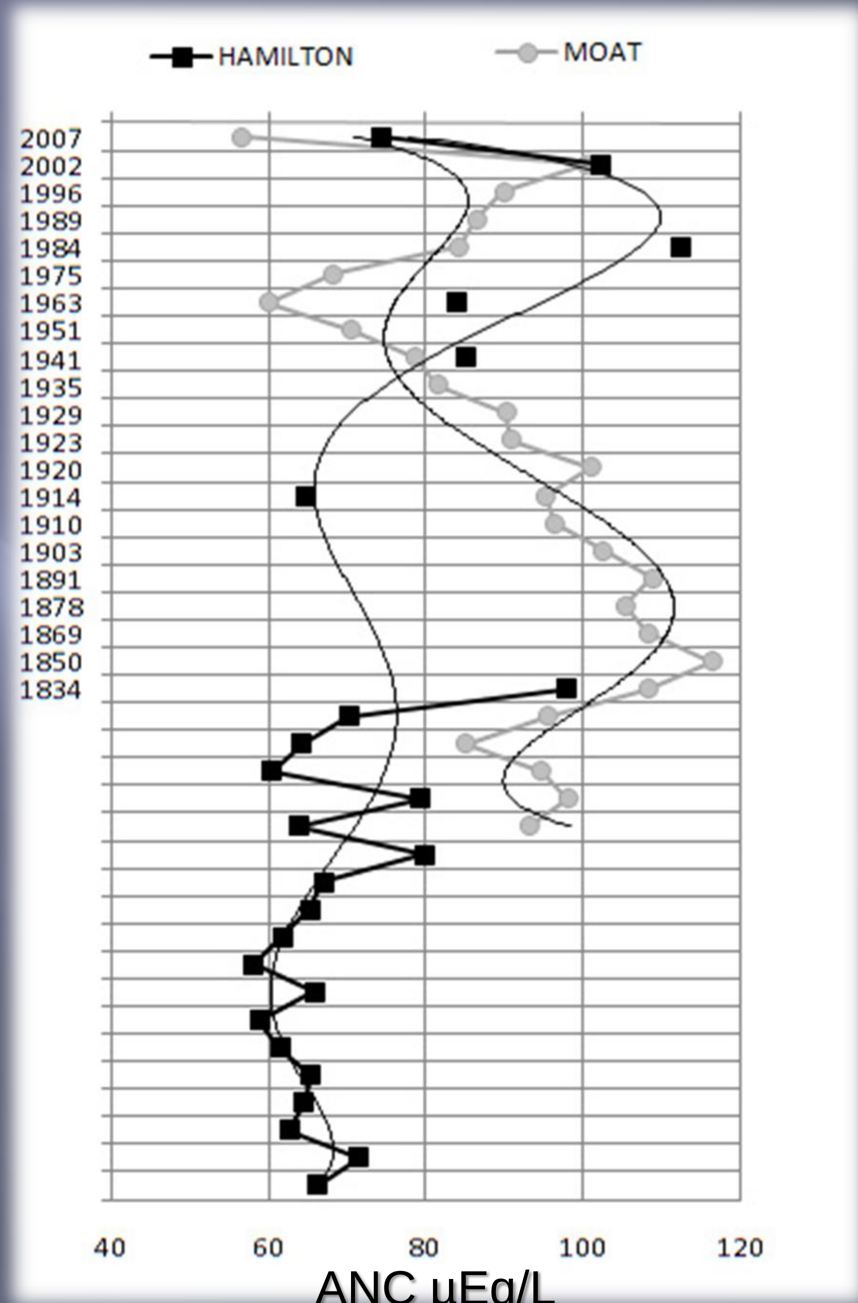
ANC Reconstructions

Moat:

a. Increase near end of Little Ice Age
b. Steady decrease from 1860's to 1960's
c. Steady increase from 1960's to 2000

Hamilton:

a. Increase near end of Little Ice Age then return to trend
b. Steady increase from 1960's to 1990's then decrease



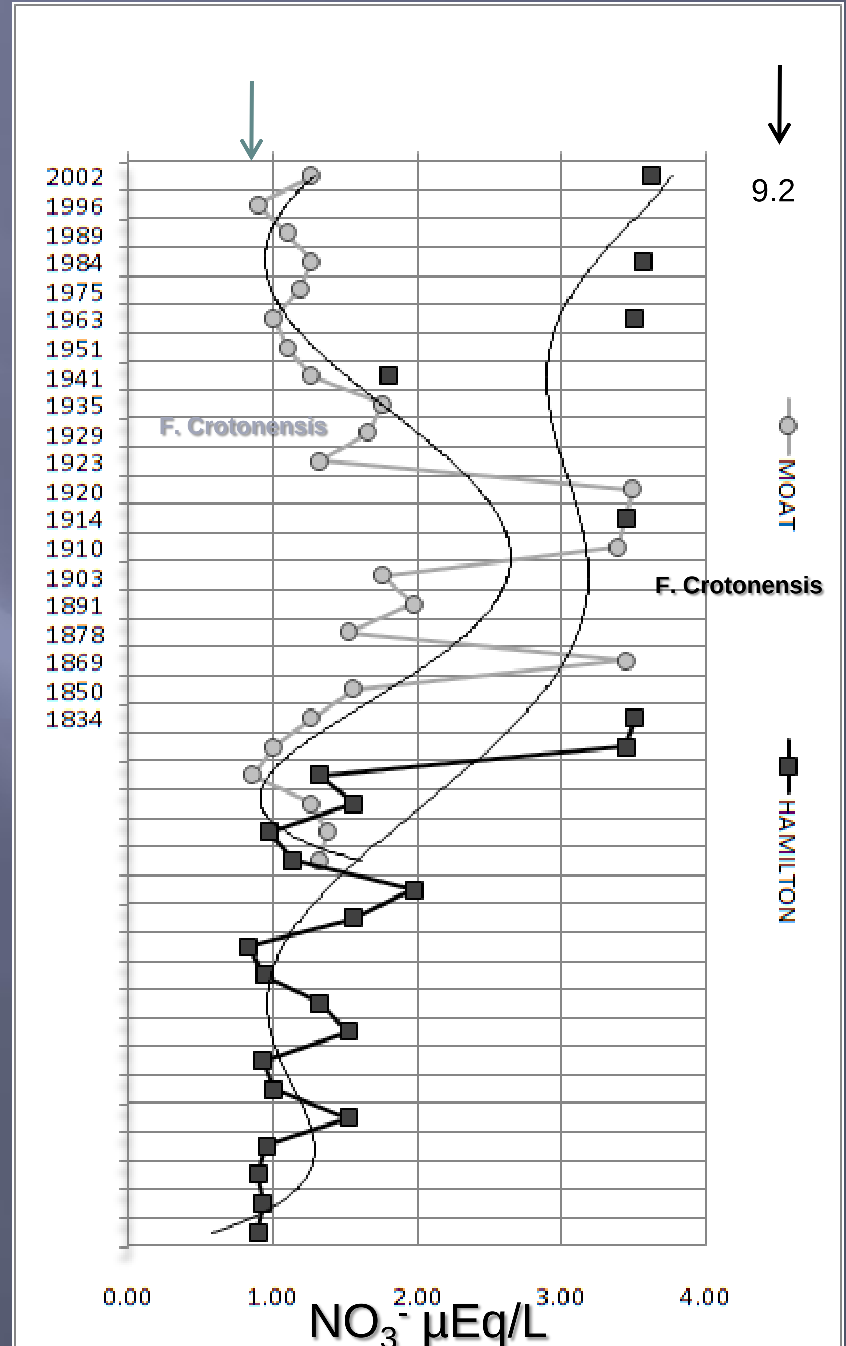
NO_3 Reconstructions

Moat:

a. Periods of increase during late 1800's and during years before and during Dustbowl
b. Slight decrease or no change from 1930's to present
c. F. Crotononesis appears ~1930

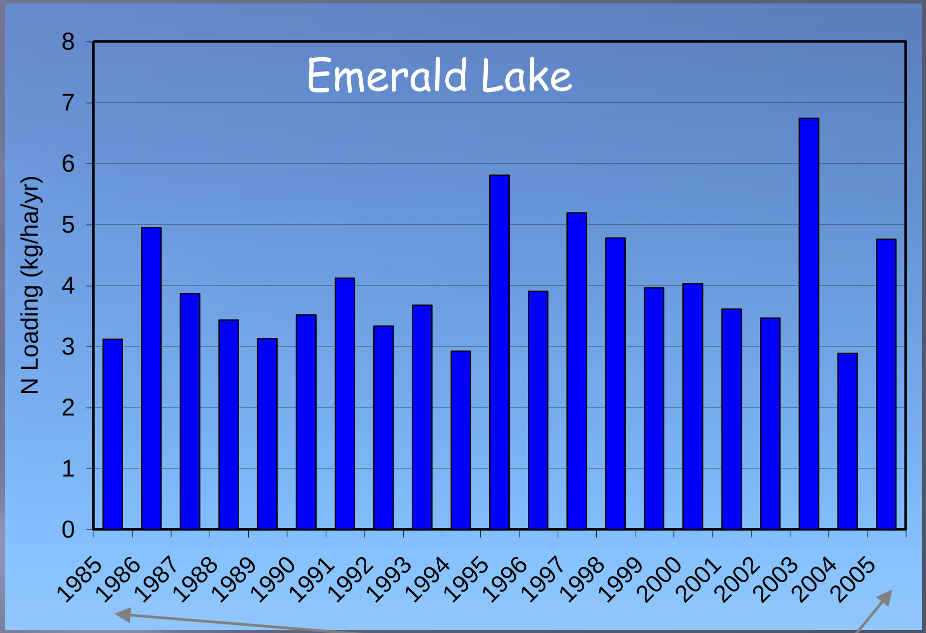
Hamilton:

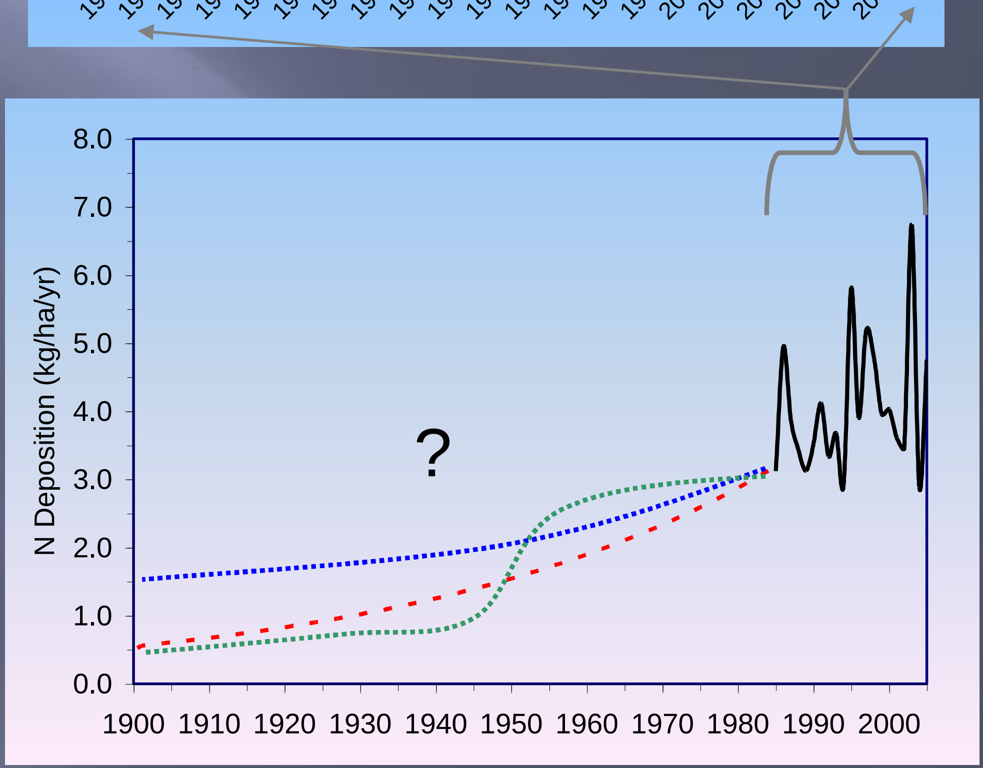
a. Abrupt increase near end of Little Ice Age then steady
b. F. Crotononesis appears ~1900

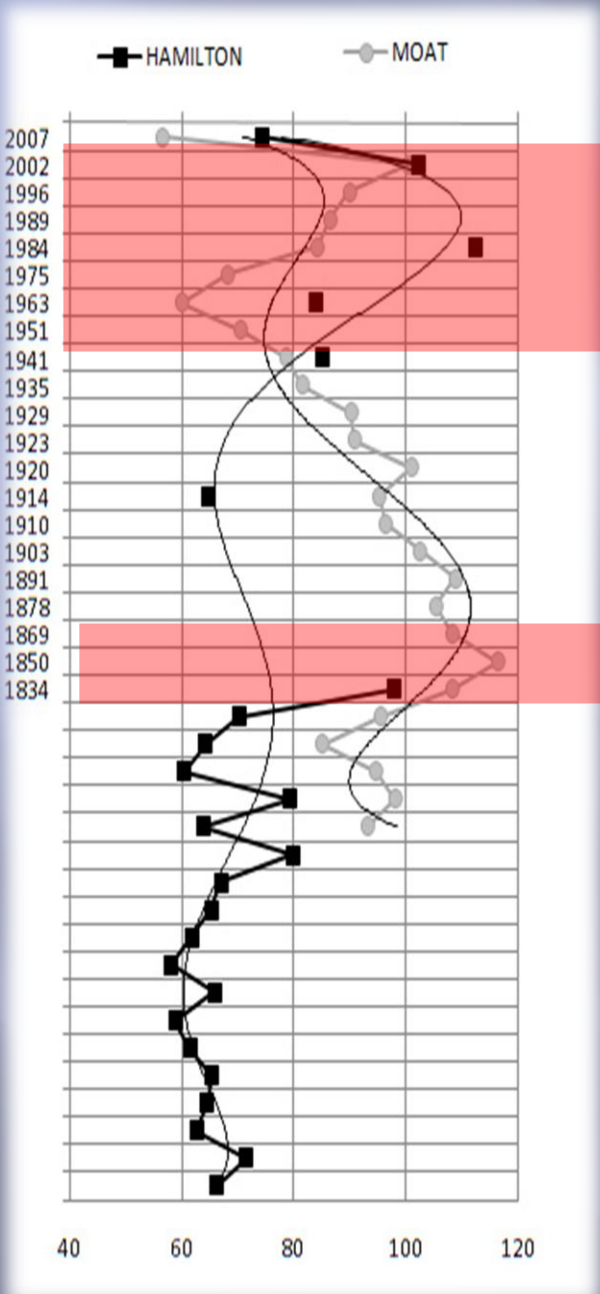


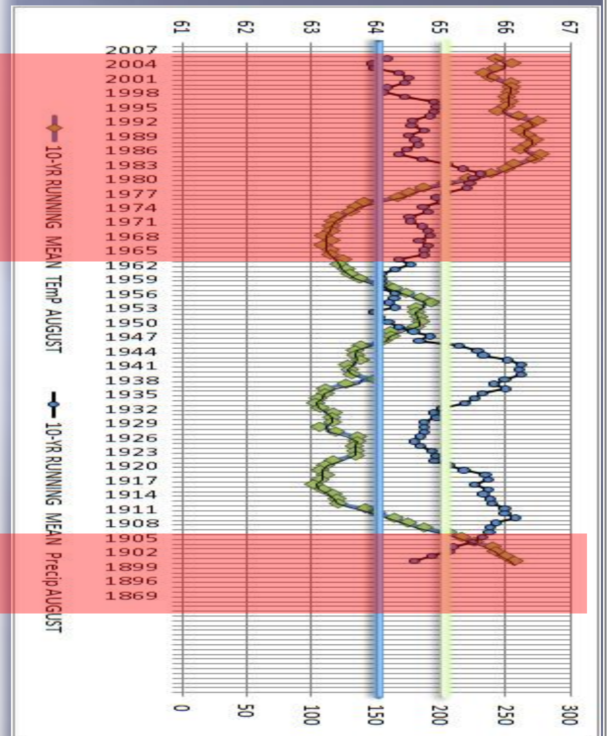
Implications for N and H+ Critical Loads Analysis

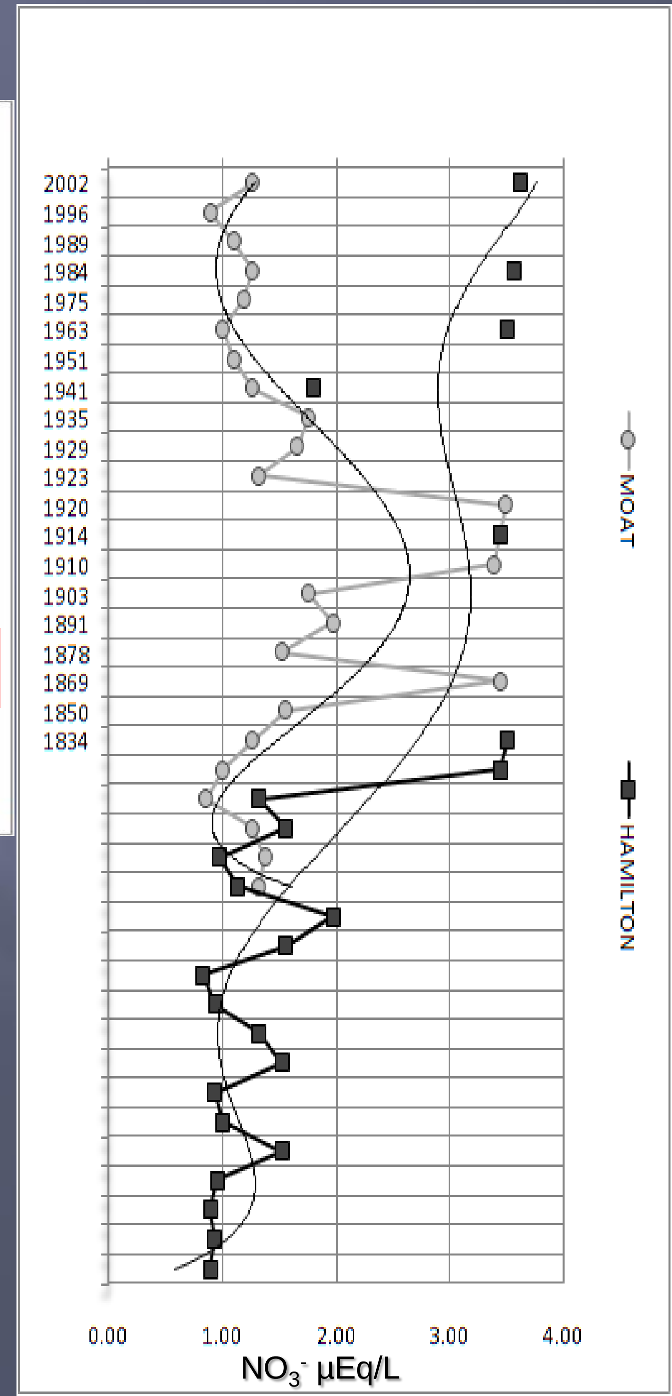
- Shifts in subdominant diatom species are observed in both lakes
- Shifts occur at multiple points – strongest changes related to NO_3 and F. Crotonensis may occur too early to be deposition driven →
- ANC patterns could be attributed to increasing acid deposition over most of 20th Century with decrease in late 20th due to regulation but what about climate..





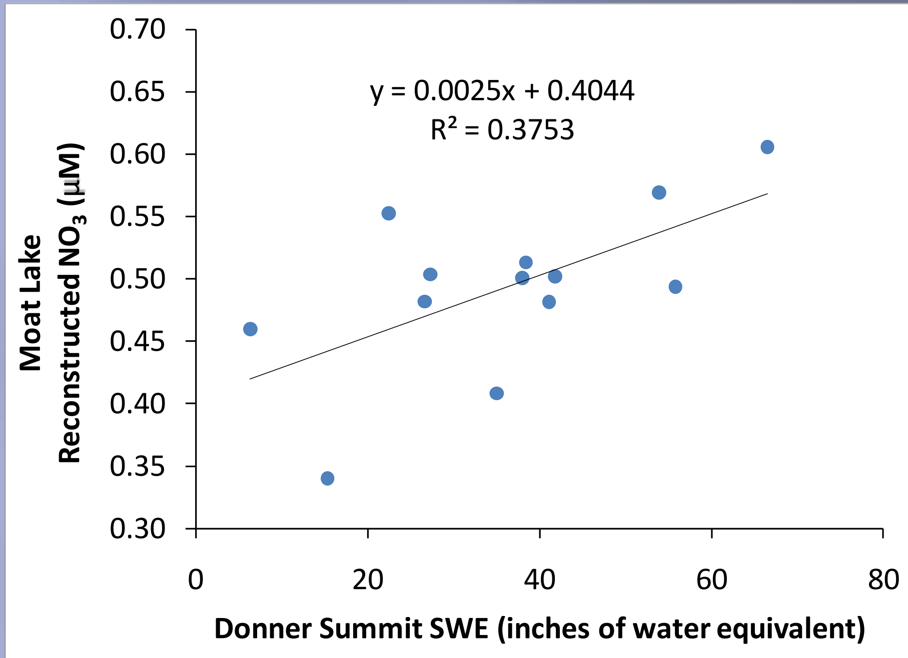


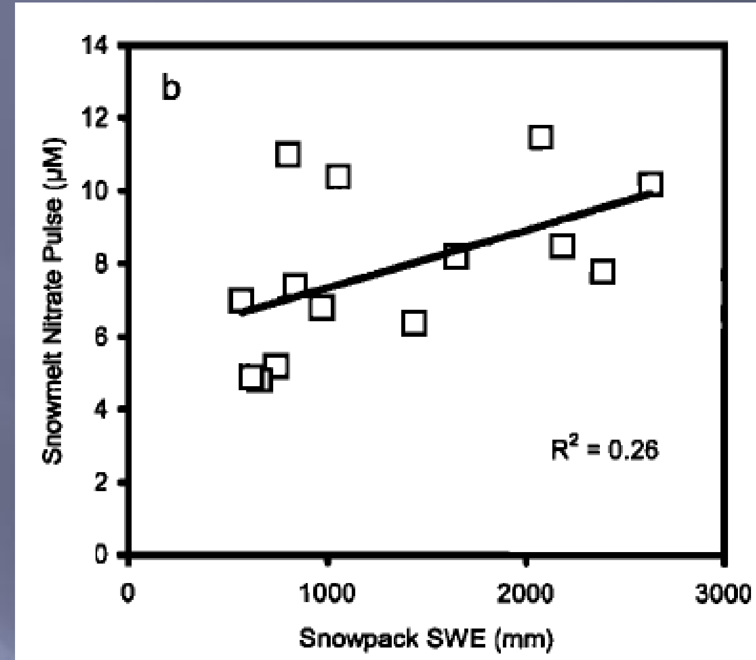




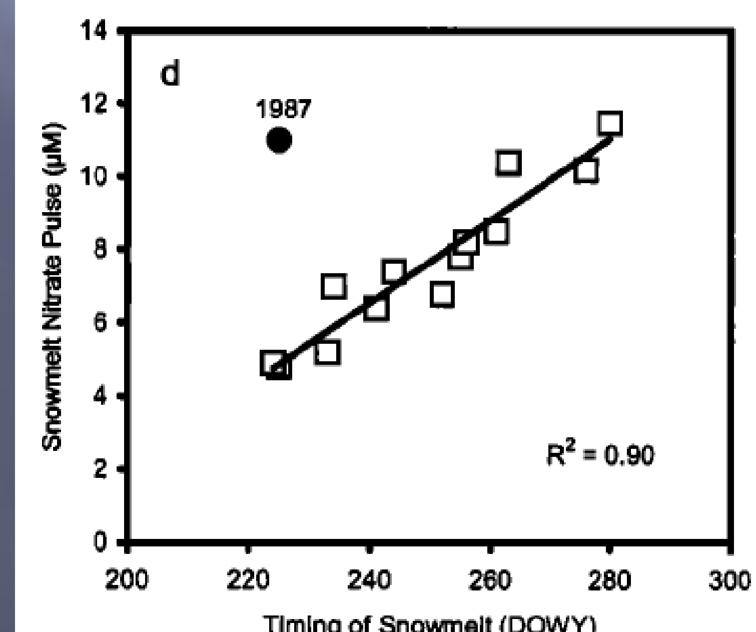
Climate Signals?

°C↑ ANC↑





Emerald Lake



Climate Signals?

Snowfall↑

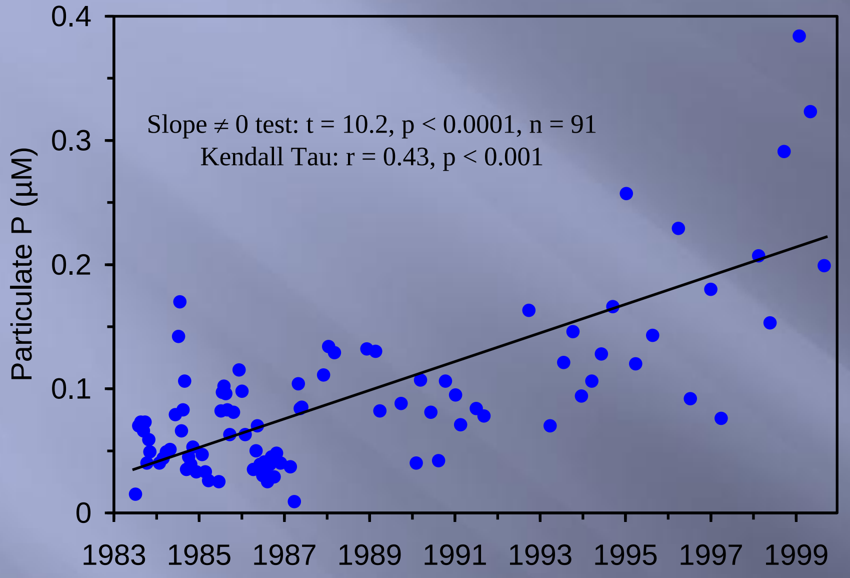
Snow duration↑

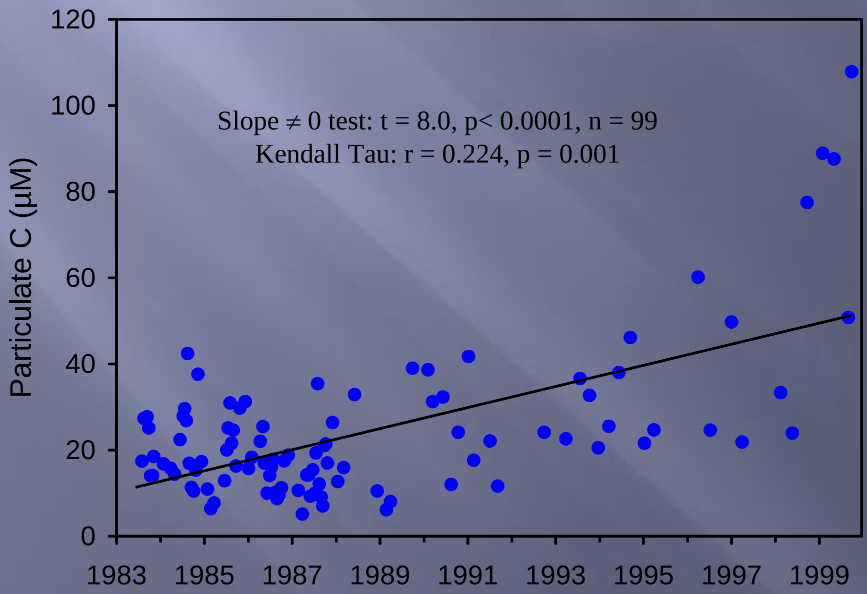
NO_3 ↑

Conclusions

- Our work suggests that diatom communities respond strongly to water quality indices for weathering and nitrogen availability
- Our work demonstrates that diatom communities and lake chemistry have changed over the past 200 years
- However, whether atmospheric deposition of acids and nutrients are the strongest determinants of water quality and are driving diatom shifts in the SN is still an open question
- The timing of F. Crotonensis appearance is very early in 20th Century and does not coincide with increasing NO_3 concentrations…

Can Diatom Shifts Occur Without Changes in Lake Chemistry?





Trends detected at Emerald Lake:

- ❖PP increase
- ❖ Increased phytoplankton biomass

Both trends suggest increased loading of P, BUT they occurred without any increase in PO_4 or TDP

Perhaps N deposition did increase at Moat and drive F. Crotonensis shift without NO_3 increase


QUESTIONS?
Funding provided by the National Park Service,
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