

# Historical Changes in Water Quality of Horse Lake and Lotus Lake, Polk County, WI

***Joy Ramstack and Mark Edlund***

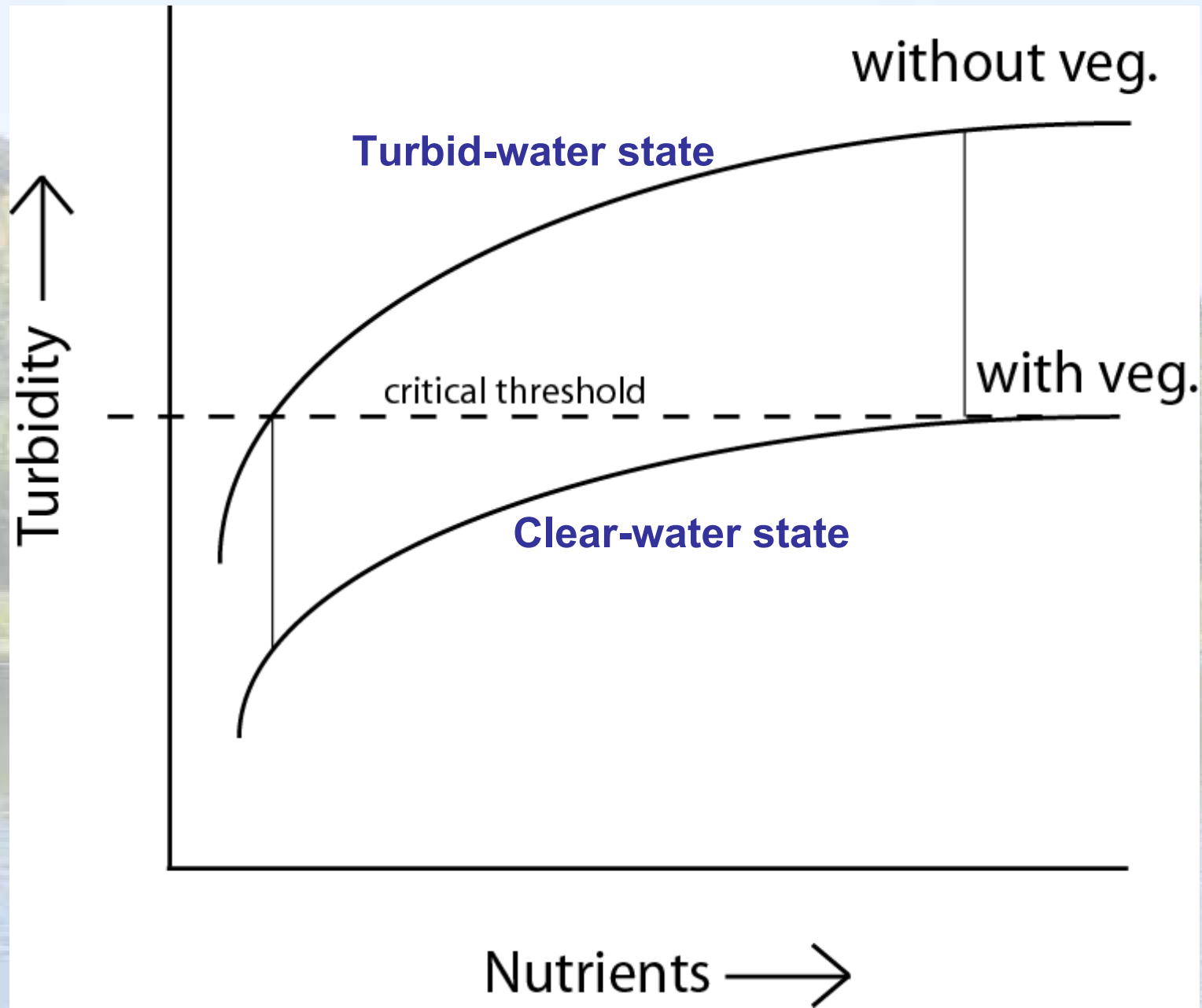
*St. Croix Watershed Research Station*

***Jeremy Williamson***

*Polk County Land and Water Resources*

# Outline

- Shallow Lakes
  - alternative stable states
  - drivers of change
- Paleolimnology of Horse and Lotus Lake
  - diatom community changes
  - nutrient reconstructions
- Directions for future research in shallow lakes



Adapted from Scheffer (1990)

# Alternative Stable States in Shallow Lakes

---



Courtesy of Mark Hanson, MNDNR

# Alternative Stable States

- Natural phenomenon? Or result of an altered landscape?
- What did these lakes look like before major human impacts?
  - did most shallow lakes exist in the clear water state before major landscape disturbance?

# Horse and Lotus Lakes

- 2 shallow lakes in the St. Croix River Basin - in Polk County, WI
- Primarily agricultural watersheds
- Increased development over the past 10-20 years
- Both highly eutrophic
- Carp in both lakes

# Paleolimnology of Horse and Lotus Lakes



- Sediment cores collected from both lakes
- Cores dated with lead-210
- Biological and geochemical markers examined to determine the history of both lakes
- Interested in changes since European settlement

# Paleolimnology of Horse and Lotus Lakes

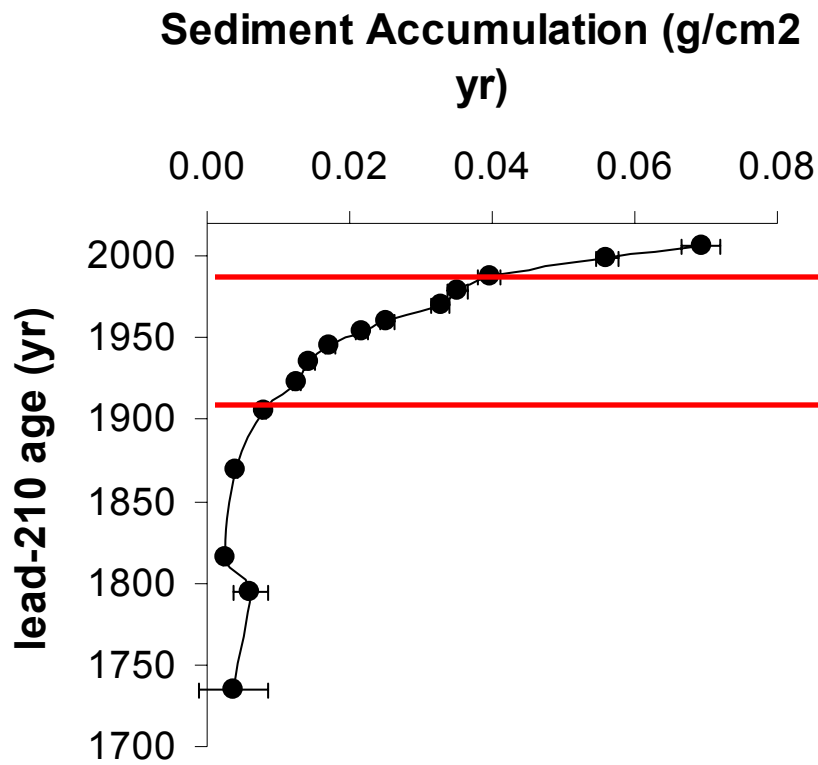


- What were these lakes like in the past?
- Can we find evidence of state changes in the paleo record?

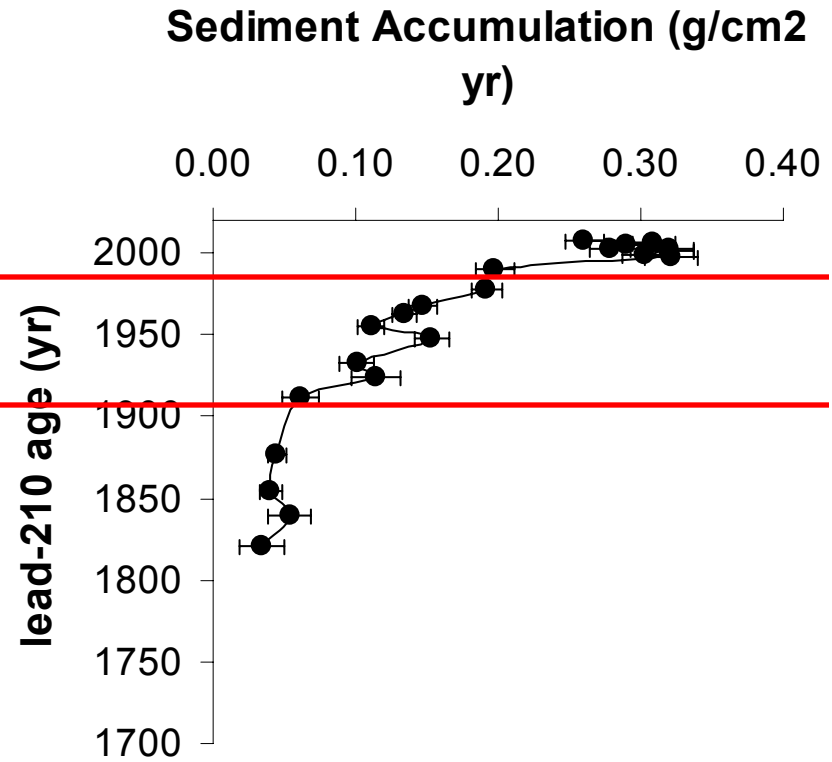


# Sediment Accumulation Rates

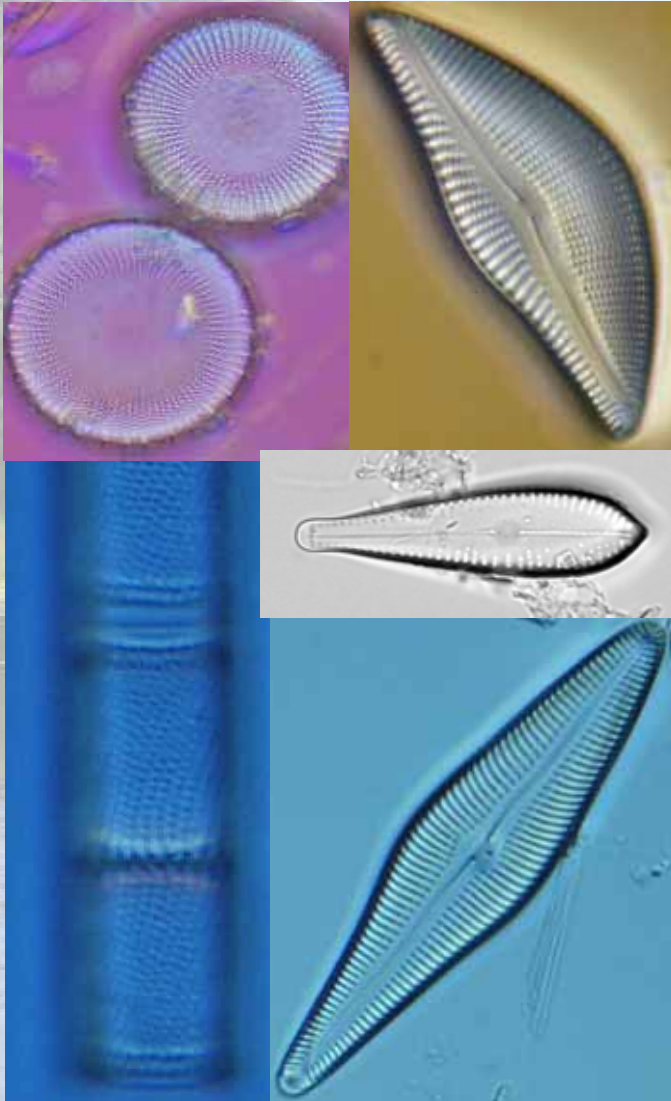
## Horse Lake



## Lotus Lake

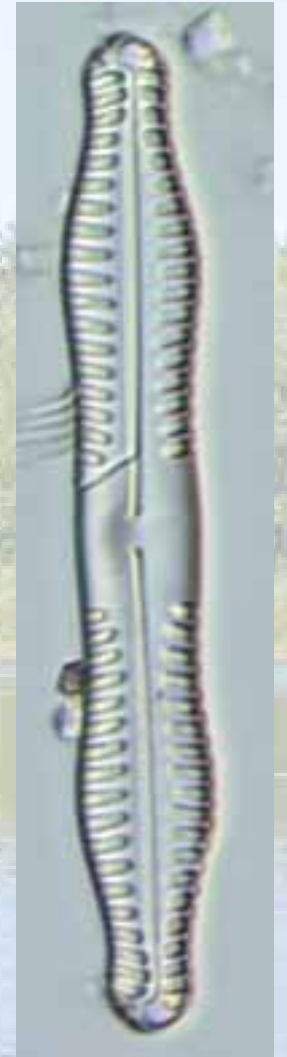
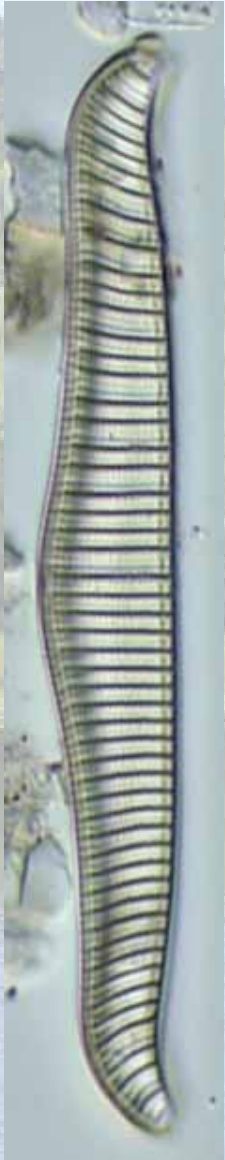
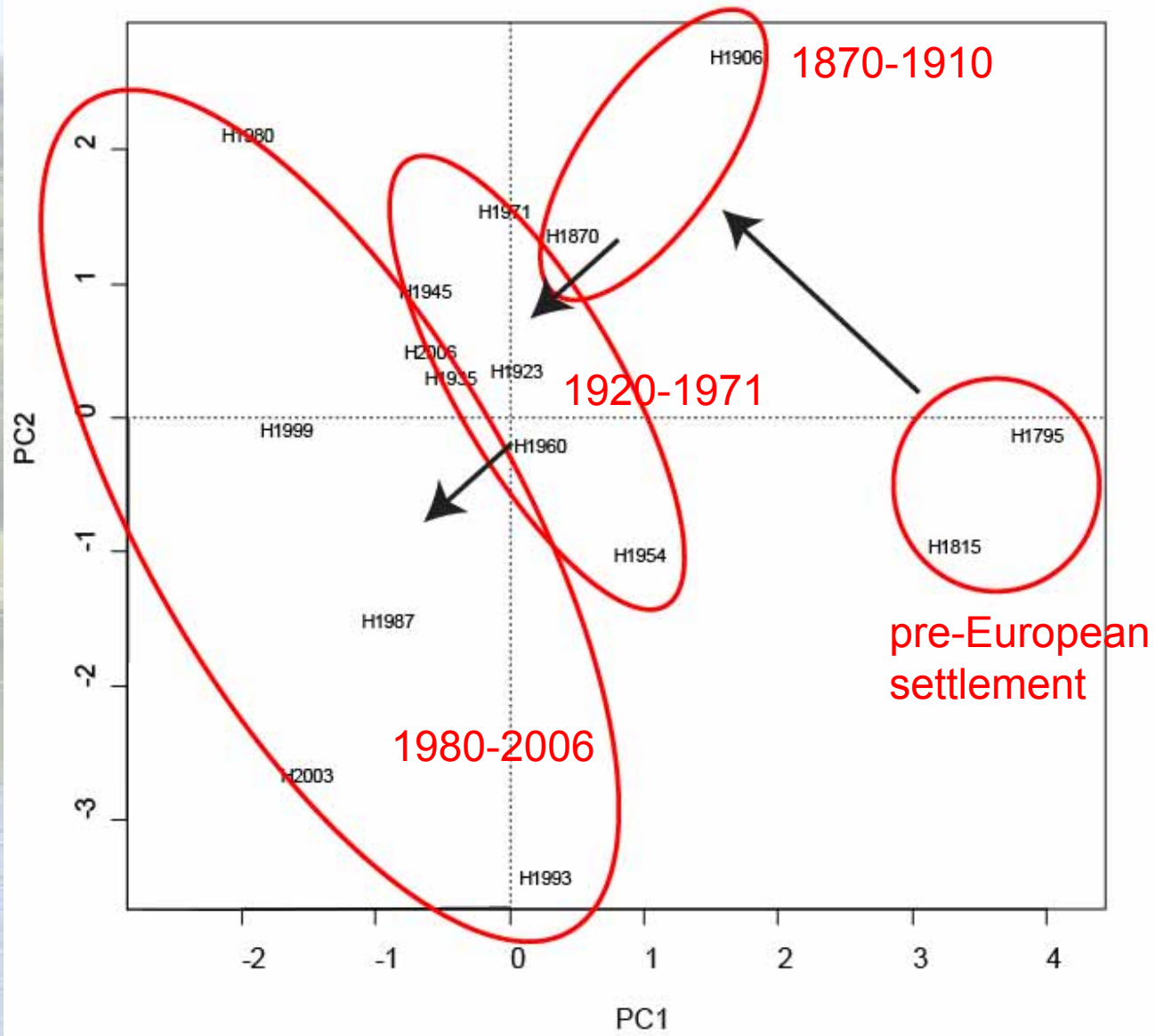


# Diatoms-a powerful tool

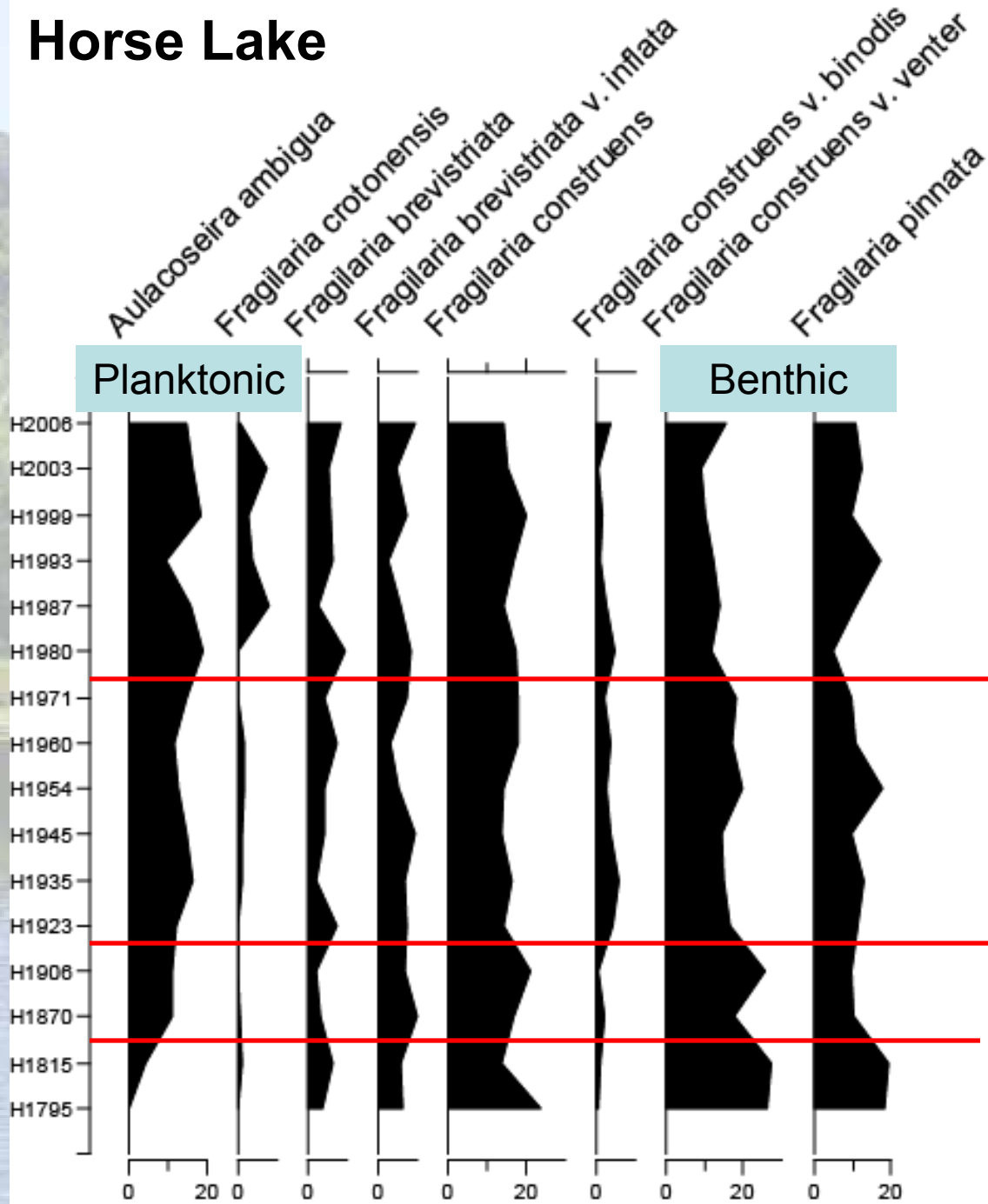


- Generally abundant and well preserved in lake sediments
- Respond rapidly to changes in their aquatic environment
- Multivariate statistical techniques
- Use relationships to determine past lake conditions from fossil assemblages

# Horse Lake



# Horse Lake



No plant fragments

1980-2006

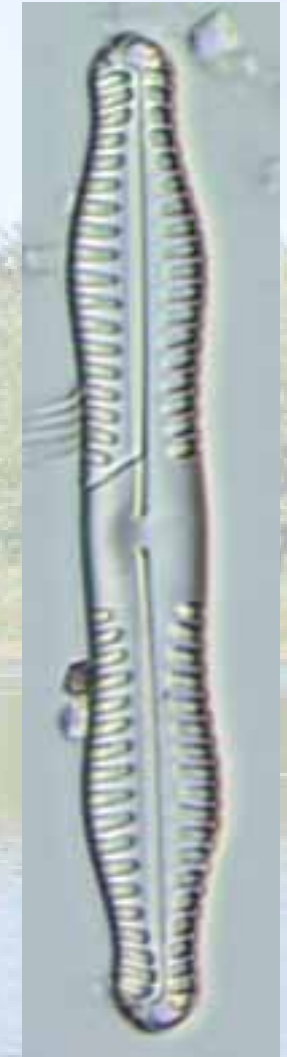
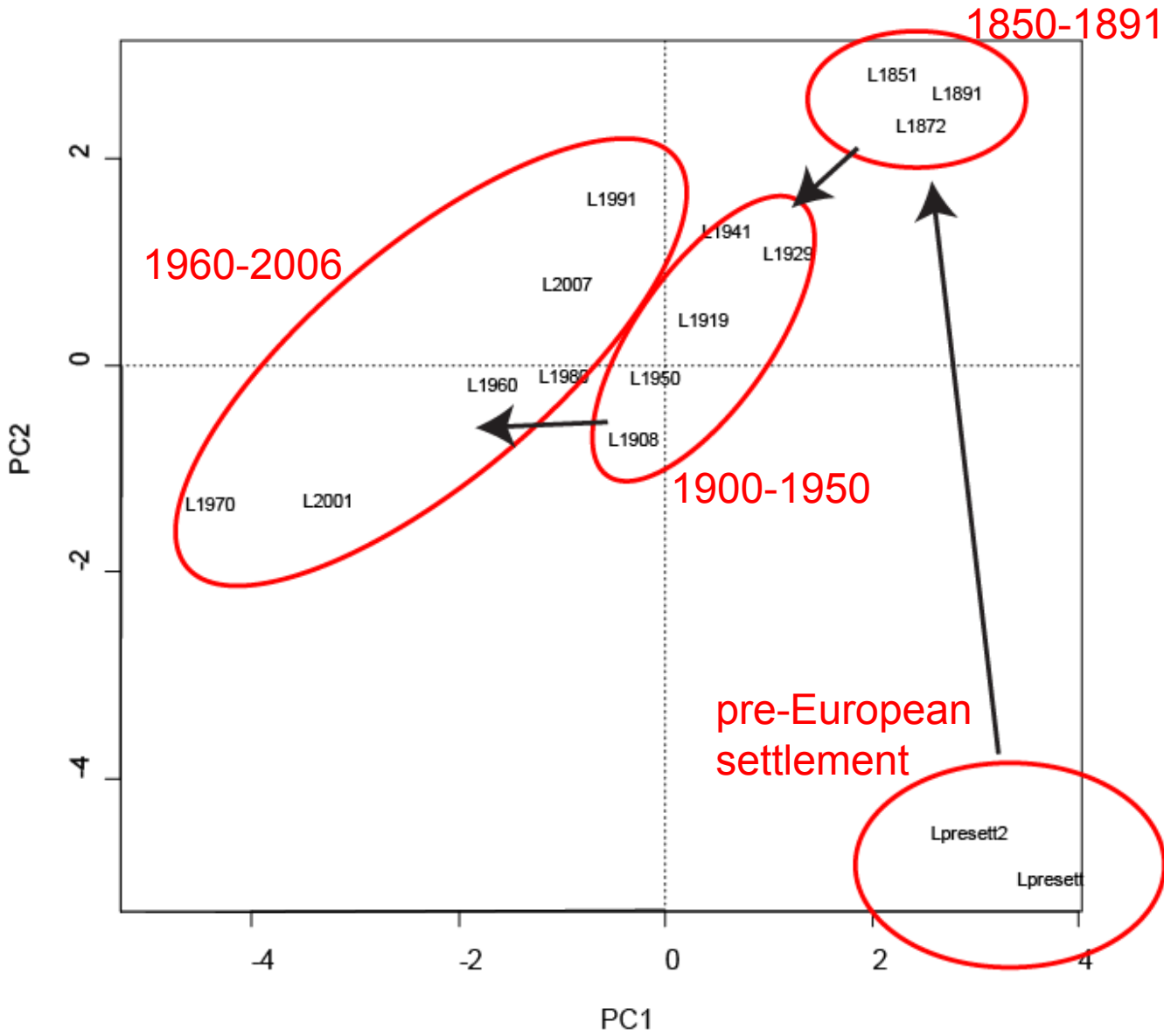
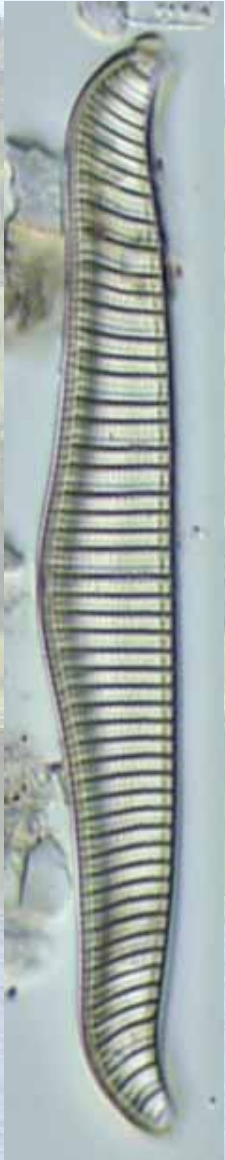
Increasing amount of  
plant fragments

1920-1971

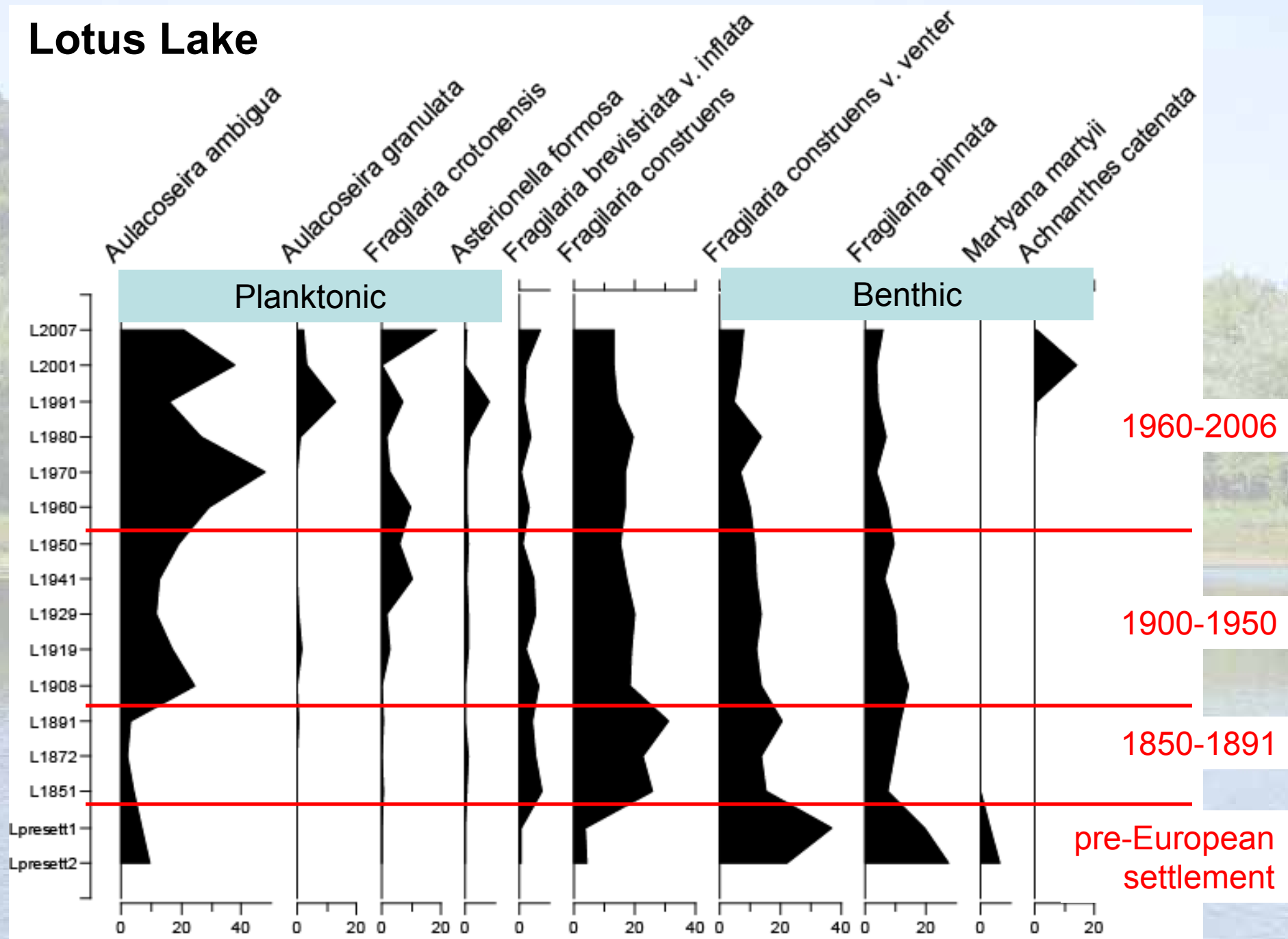
Abundant plant  
fragments

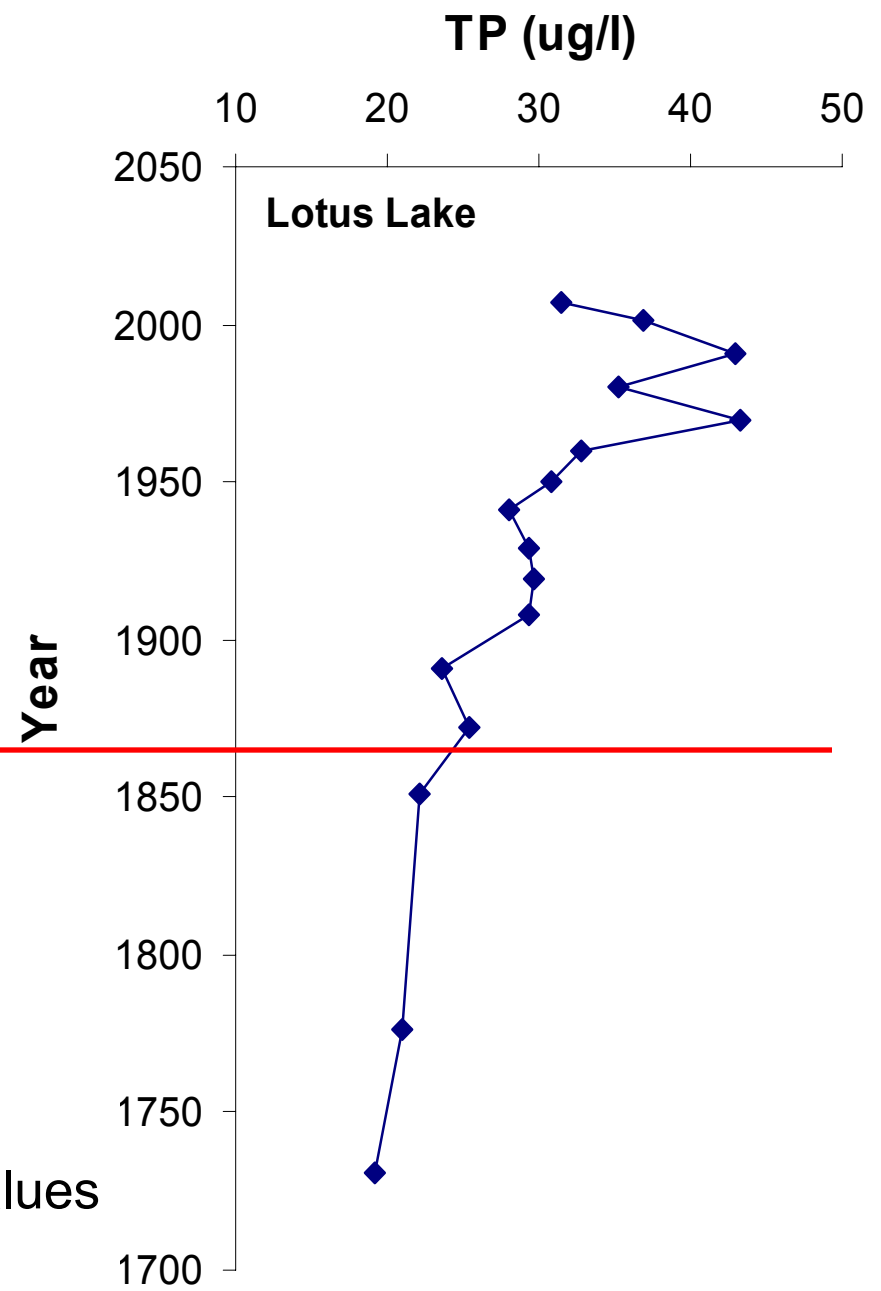
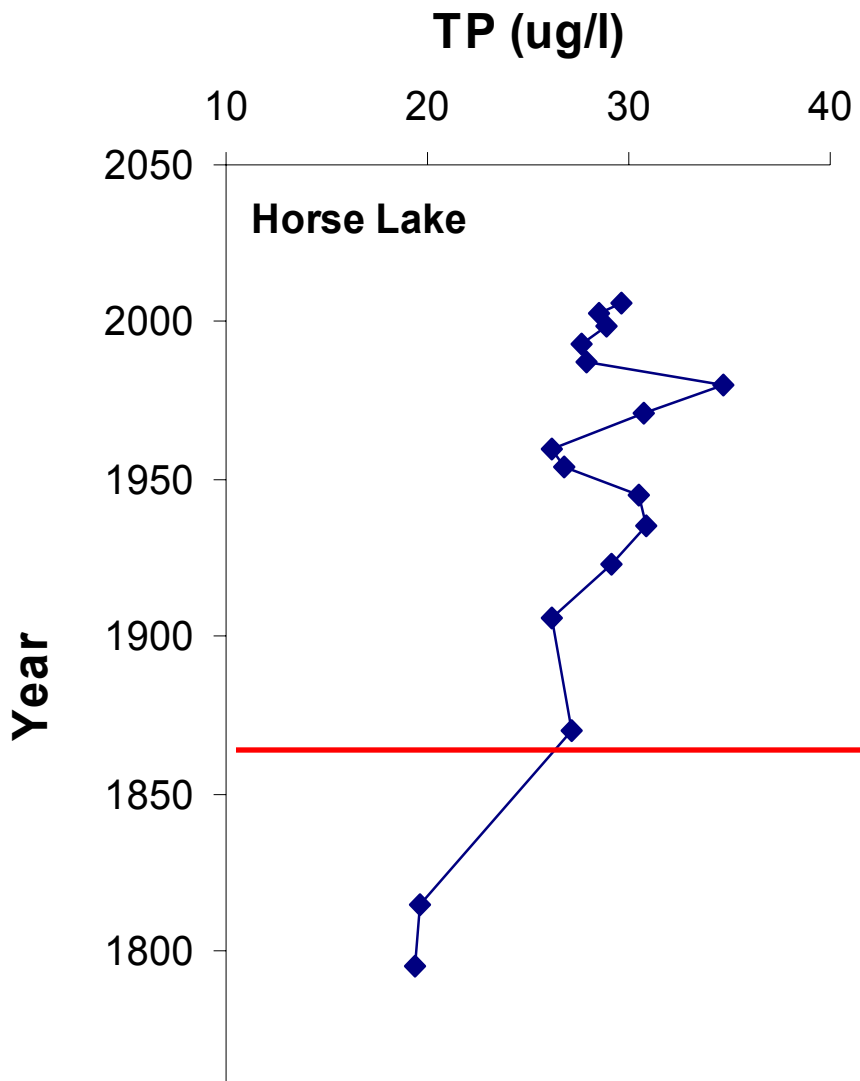
1870-1910  
pre-European  
settlement

# Lotus Lake



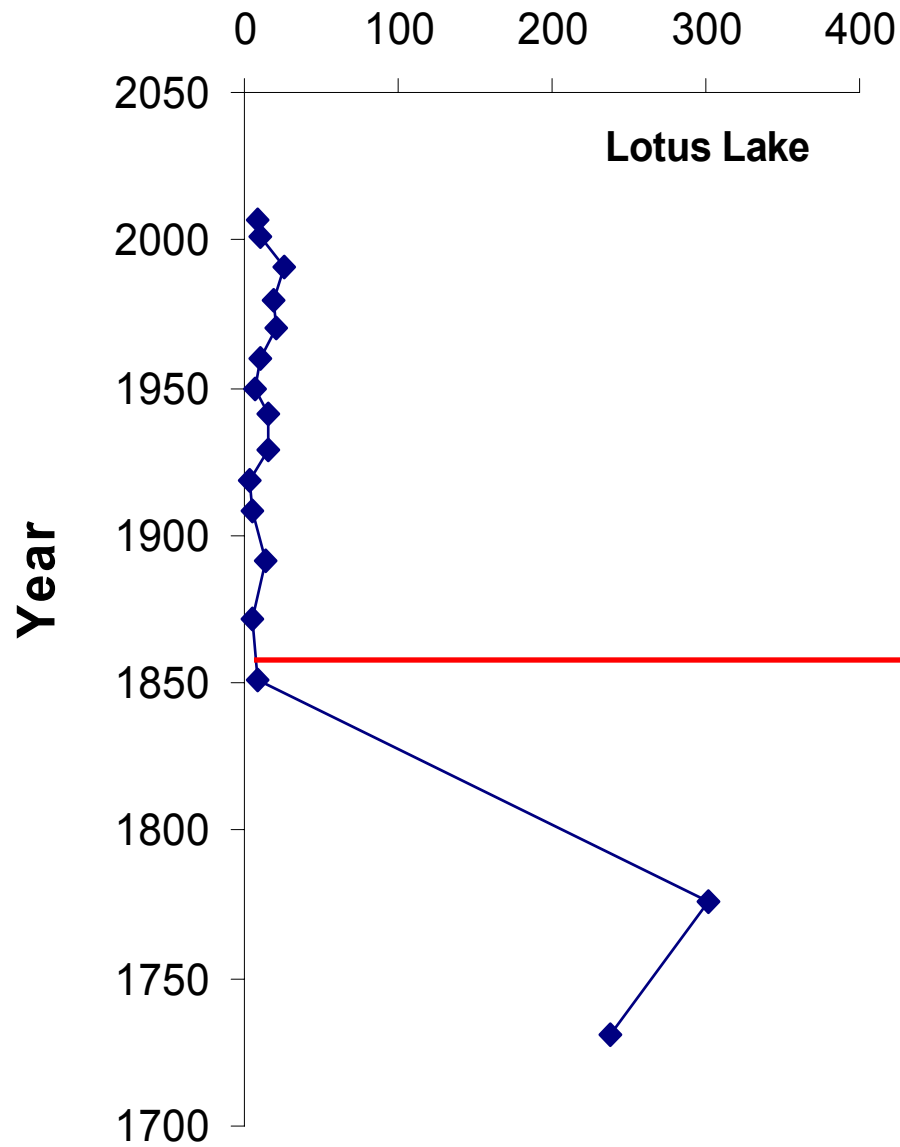
# Lotus Lake



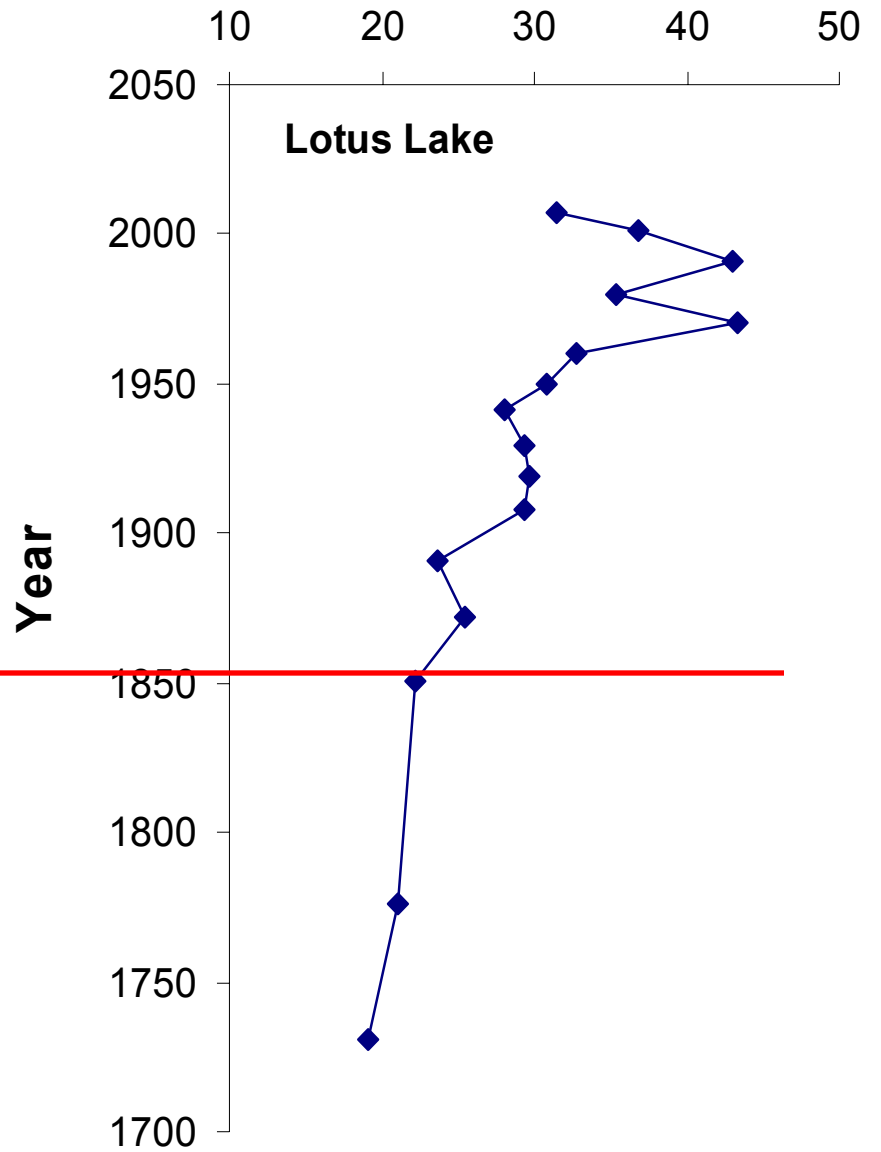


Trends are what we expect,  
but can't always reconstruct high TP values  
in shallow lakes

### Chrysophyte cysts per 400 diatom valves



### TP (ug/l)





# Horse and Lotus Lakes

- Similar changes in both systems
  - Increases in sedimentation rates (early 1900s and most recent 10-15 years)
  - Shifts in diatom communities (from benthic to planktonic assemblages)
    - Shifts are more subtle in Horse Lake, observations of plant remains corroborate timing of change seen in diatom data
    - In Lotus Lake, change in chrysophyte cysts corroborate diatom data
    - Shifts could indicate state changes
  - Increases in diatom-inferred TP
    - Difficulties in quantitative TP reconstructions in shallow lakes
    - TP isn't necessarily the primary driver of change!!

# Future work in shallow lakes – Multiple Proxies

- Macrophyte remains
  - quantify changes in the cores
- Zooplankton remains
  - changes in food webs/fish communities
- Measure TP
  - changes in TP flux, multiple cores
- Shallow Lakes Calibration set
  - more comprehensive dataset (fish, macrophytes, etc.)
  - include data on shallow lakes in clear-water state

# Acknowledgments

- Thanks to the WI DNR for funding for the Horse and Lotus Lake study
- Mark Hanson and Kyle Zimmer provided slides and shared their findings on shallow lake ecology
- Erin Mortenson and Dan Engstrom (SCWRS), for lead-210 dating
- Magnetic susceptibility logging and core imaging were performed at the LRC, University of MN–Twin Cities with the assistance of Amy Myrbo, Anders Noren, and Kristina Brady

# What regulates phytoplankton abundance in shallow lakes: ambient nutrients, fish communities, or watershed use?

Watershed use?  
(ag, grassland, etc)

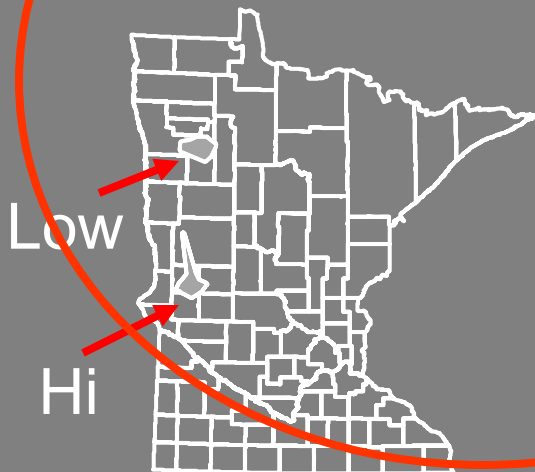


Algal Abundance



Courtesy of Mark Hanson, MNDNR

Ambient nutrient levels?



Fish community?  
(fishless, abundance, etc)

