Unearthing the effects of European-American settlement on a northeast Ohio kettle lake through diatom stratigraphy

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ABSTRACT

Recently, wetland conservation has highlighted the necessity for assessing limnological changes following European-American settlement. A prior study at Brown's Lake (northeast Ohio) identified a stratigraphic sequence that shows an abrupt transition from organic-rich muds to several centimeters of a bright loess layer, then a recovery to organic-rich sediments near the top. Based on 210Pb dates, the loess deposition occurred before 1846 CE, when a growing population cleared trees and farmed intensively. Likewise, organics had recovered after 1950 CE, when people abandoned farmland and practiced conservation tillage. However, the effects of settlement on limnology are poorly known. Diatoms (microscopic algae; class Bacillariophyceae) respond to modifications in water quality and habitat parameters, and siliceous cell walls enable preservation in sediments as fossils. Therefore, a diatom stratigraphy can record the lake's limnological history. A 1-m sediment core was extracted using a modified-Livingstone sampler and dated using AMS radiocarbon dating. A total of 380 cells from the core were analyzed. The data reveal shifting relative abundances that coincide with settlement activities. Before 880 CE, *Thalassiosira* sp., a non-motile genus, is dominant, making up 22.1% of diatoms. Between 880 CE and 1950 CE, *Achnanthidium* sp., a motile genus, is abundant, making up 25.0% of diatoms. It has been noted that the replacement of planktonic genera by diatoms capable of moving through fine sediments suggests a time of excess siltation. From 1950 CE to the present-day, *Cyclotella* sp., a non-motile genus, is dominant, making up 30% of diatoms. Despite these associations, the data cannot provide evidence of a cause-and-effect relationship due to confounding variables (e.g., climate, habitat availability, and structures), errors, and limitations. This study offers the first catalog of historical and modern diatom assemblages at Brown's Lake to support conservation initiatives.

LOCATION

Brown's Lake Bog (BLB) is a peat-filled kettle hole situated 4.2 km west of Shreve in Wayne County, Ohio. The Nature Conservancy, the current site manager, acquired the kettle hole in 1966 CE. In 1968 CE, the Ohio Department of Natural Resources designated BLB a Natural Landmark and State Nature Preserve for its distinctive plant assemblage. Today, the site contains a lake and a bog.

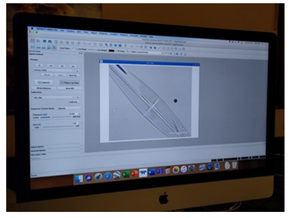
FIELD COLLECTION

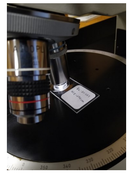
In the field, we extracted a 1-m sediment core near the lakefront using a modified-Livingstone sampler. The core contains diatoms, mostly from pre-settlement and post-settlement times. We also sampled the lake's sediment-water interface using a probing instrument to collect modern diatoms.

We sent sections of the core to a lab for AMS radiocarbon dating. Radiocarbon ages, given in Cal yr. BCE/CE, were calibrated using INTCAL20 and estimated with 2 σ calibration. Conventional ages, reported in BP (before present, 1950 CE), corrected for fractionation using the $\delta^{13}C$.

We isolated diatoms from sediments by mixing the core sections with DI water and allowing the resulting suspension to settle. We removed all organic material obscuring identification using high-temperature 30% hydrogen peroxide and hydrochloric acid. We mounted the diatoms onto slides and identified 380 of them using a photomicroscope. The diatoms are classified as modern, post-settlement, and pre-settlement based on their core and sediment-water interface location.

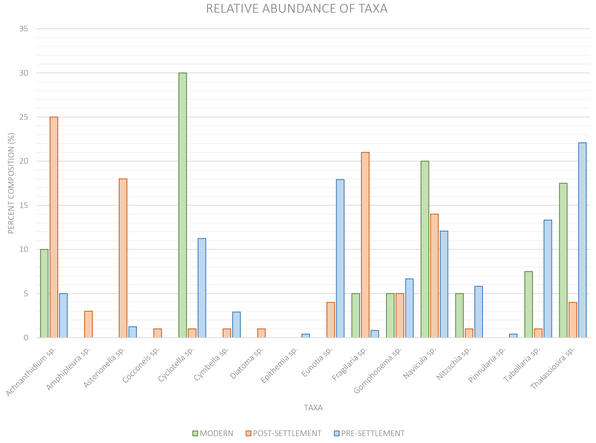
Top: Livingstone sampler
Bottom: Probing instrument

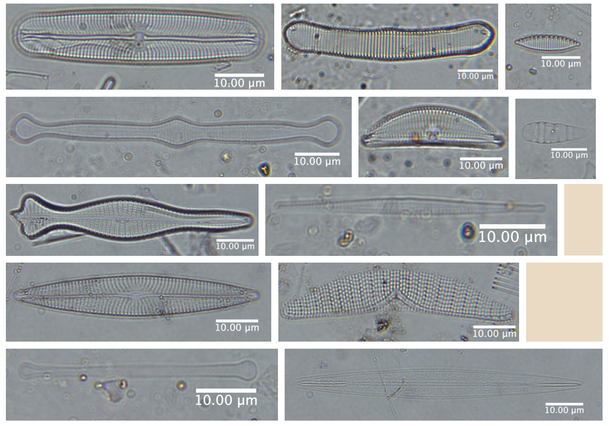




Top-left: Sediment suspension
Top-middle: 30% H_2O_2 and HCl
Top-right: Photomicroscope
Bottom-left: Box of permanent slides
Bottom-middle: 40X objective

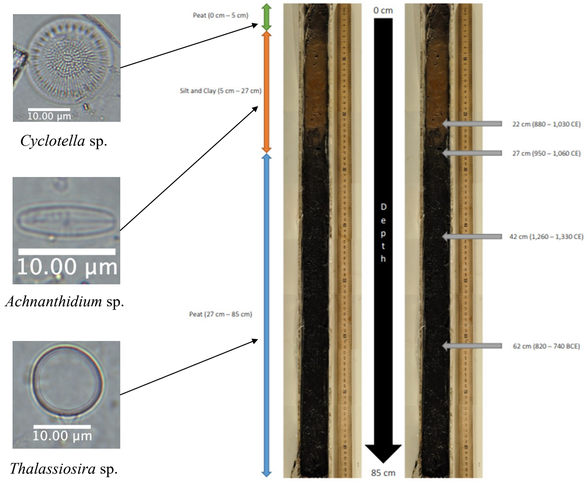
LAB ANALYSIS





Left-to-right and top-to-bottom: *Pinnularia* sp., *Eunotia* sp., *Nitzschia* sp., *Tabellaria* sp., *Cymbella* sp., *Diatoma* sp., *Gomphonema* sp., *Fragilaria* sp., *Navicula* sp., *Epithemia* sp., *Tabellaria* sp., and *Amphipleura* sp.

STRATIGRAPHY



CONCLUSIONS

Despite these associations, the diatom stratigraphy cannot provide evidence of a cause-and-effect relationship. Confounding variables, such as climate and habitat availability and structures, can change a lake's diatom distribution and limnology

One should consider the errors and limitations of radiometric dating and diatom analysis, depending on a project's objectives, budget, and indicator metrics.

To conclude, this study requires further work in identifying the water quality and habitat parameters for identified taxa through literature review and experimentation. Consequently, it can deepen understanding of the link between human settlement and limnological changes and help people conserve wetlands.

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