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Analysis of Sediment Reveals an Ecological “Regime Change” in Lake Hilary

Toni Gohman, Emily Kiolbasa, *advisor* D. Gordon Brown

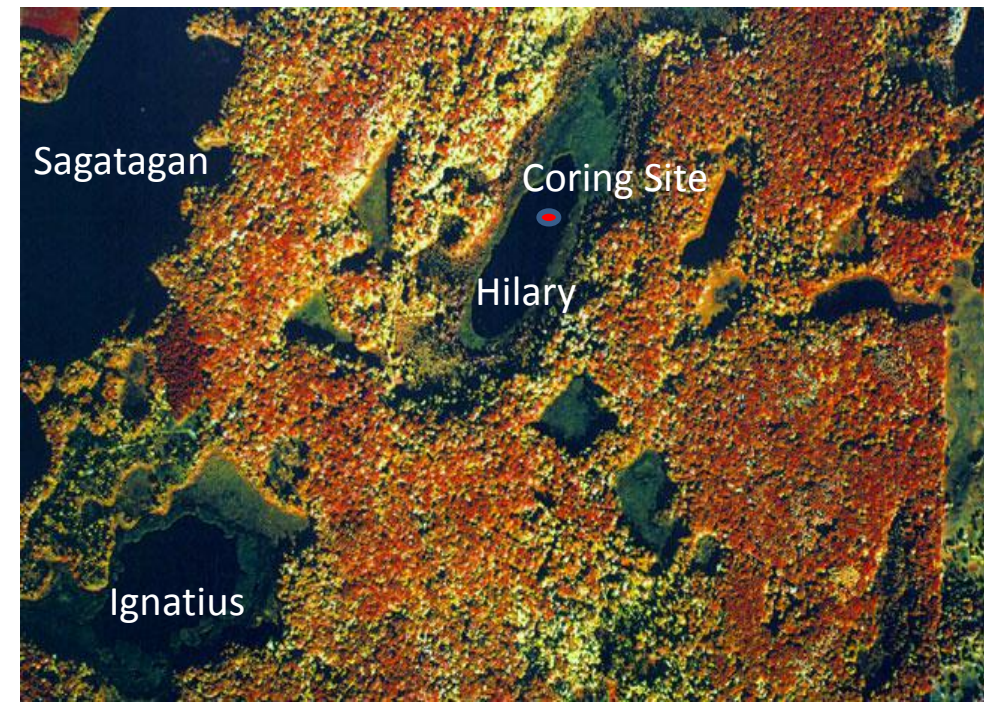
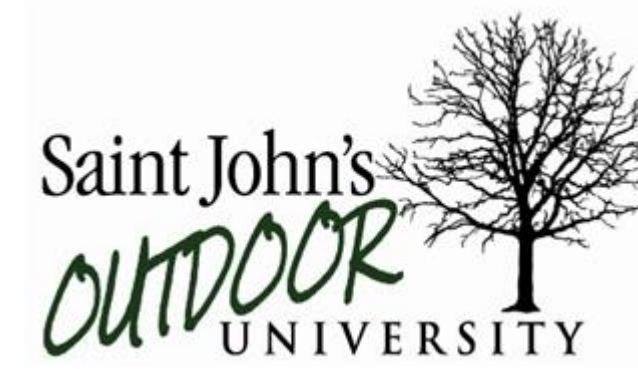
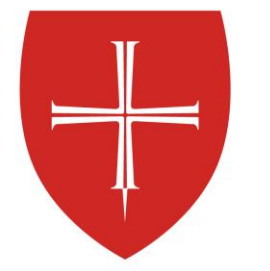


Figure 1. Aerial view of Saint John's Abbey Arboretum showing the coring site in Lake Hilary.

Background & Purpose:

Lake sediments contain excellent records of both fossils and component minerals that can be used to reconstruct regional ecological history. To complement ongoing studies of Lake Hilary's pollen and macrofossils, we constructed a high-resolution record of the organic matter, carbonate, and non-carbonate mineral fractions of the lake's sediment. The organic fraction is a proxy for the biological productivity of the pelagic, littoral, and shoreline of the lake. Non-carbonate minerals can evince erosion and subsequent aerial or fluvial deposition. Carbonate deposition can be related to lake productivity and chemical weathering in the surrounding watershed. We sought to compare our sediment record to existing records for pollen and charcoal from Lake Hilary and find evidence for linkages between vegetation change and sediment composition.

Methods:

1. A 15.75 m sediment core was extracted from Lake Hilary in 2002 and kept refrigerated at 4°.
2. We collected sediment samples (1 ml) at approximately 5 cm intervals.
3. We heated these samples for at least 24 hours to 105°C, 500°C, 900°C and determined their mass after each temperature.
4. We used these mass measurements to estimate the sediment's bulk density, and its organic, carbonate, and mineral fractions.
5. We used compared our sediment record to pollen and charcoal records that had been produced by Dr. Brown and many student researchers (including EKK).

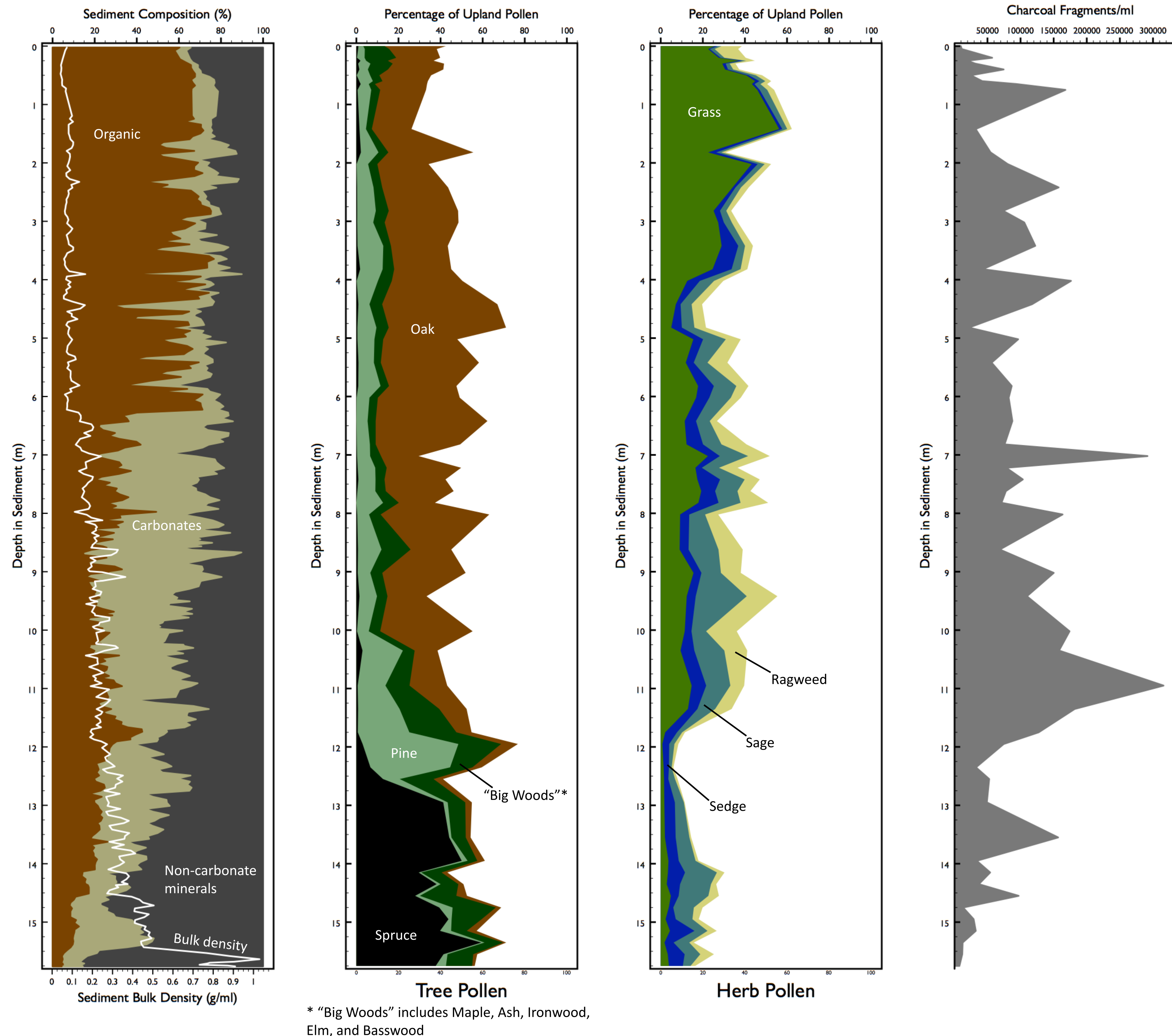


Figure 2. Sedimentary and microfossil record of Lake Hilary (Stearns County, MN USA). *Left to right:* Sediment characteristics, tree pollen and herb pollen percentages, and charcoal concentration.

Acknowledgements

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Major Results:

1. Non-carbonate minerals dominate the sediment below 11 m, carbonates do so between 11 and 6.5 m, and organics dominate above 6.5 m.
2. Sediment bulk density is highest when non-carbonate minerals are abundant and drops dramatically as organic and carbonate fraction increase.
3. Carbonate-dominated sediments predominate during much of the period with a high relative abundance of forbs. This period is preceded by a marked rise in charcoal concentration,
4. A “regime change” occurs in the lake above 6.5 m as evinced by the abrupt and sustained rise in the organic sediment fraction.
5. There do not appear to be any major changes in the pollen and charcoal records that coincide with the dramatic change in Lake Hilary's sediments.

Discussion:

- At the beginning of the Lake Hilary's lifespan, probably close to 14,000 y BP, it was deep and cold; silt and clay derived from glacial meltwater settled at its bottom, producing sediment with relatively high bulk density.
- As the climate warmed, terrestrial vegetation covered developing soils more completely, reducing transport of non-carbonate minerals into the lake.
- Increased vegetative biomass and warmer temperatures may have hastened chemical weathering of developing soils, producing more deposition of carbonates.
- Warming temperatures and gradual shallowing likely enhanced algal production, resulting in slowly increasing organic matter content of the sediment. Much of the sediment between 14.5 m and 6.5 m is ooze and copropel, which evince phytoplankton productivity and zooplankton grazing.
- The increase in carbonate content above 11 m is associated with high relative abundance of herb pollen. This may represent a very warm period with high phytoplankton production that was associated with the production of marl. This interval is preceded by a large spike in charcoal concentration, suggesting a transition from a more wooded to a more open, prairie-savanna landscape.
- Above 6.5 m depth the sediment rapidly switched to being dominated by fragmented granular peat. This suggests that the lake had shallowed to the point that extensive littoral or wetland zones now contributed the bulk of the sediment organic matter. Above 6.5 m, entire or fragmented mollusk shells commonly appear in the sediment, also evincing a shallower lake system.
- Short-term increases in the carbonate fraction above 6.5 m are open to a number of interpretations. When carbonates expand at the expense of both organic and non-carbonate mineral fractions, this may indicate a period of lake level rise, enhancing pelagic production while reducing the relative input from littoral portions of the lake.