

Effects of early Mdewakanton Dakota settlement patterns on the ecology of Lake Calhoun

Grant Two Bulls (2014-15)

Question

A significant question of interest is how to enable Native peoples to embrace their rich cultural history while managing the 20% of the nation's natural resources and 27% of the freshwater resources over which they have sovereignty (Geoscience Alliance). This study will show that geoscience methods using lacustrine coring may serve as accessible tools for Native communities to understand their history while managing freshwater resources.

Proposal

Previous studies have used lacustrine core sampling to look at effects of settlement patterns on lake ecology:

- Frisch et al. (2014) used lacustrine core sampling to reveal key differences in *daphnids (*freshwater crustaceans that are a staple food source for many fish) that correlated directly with urbanization and human impact around the lake studied.
- Ekdahl et al. (2004) used lacustrine core sampling to study siliciclastic diatoms (a major group of freshwater algae) in core samples from Crawford Lake, Canada, showing that a prehistorical Iroquois village significantly increased diatoms concentrations in the lake.
- Myrbo (2008) investigated sedimentary records in lacustrine core samples to determine effects of settlement patterns on eutrophication (a process by which a body of water becomes enriched with dissolved nutrients such as phosphates) in an east-central Minnesota lake over the course of the 20th century, showing that settlement patterns correlated with spikes in eutrophication of the lake.

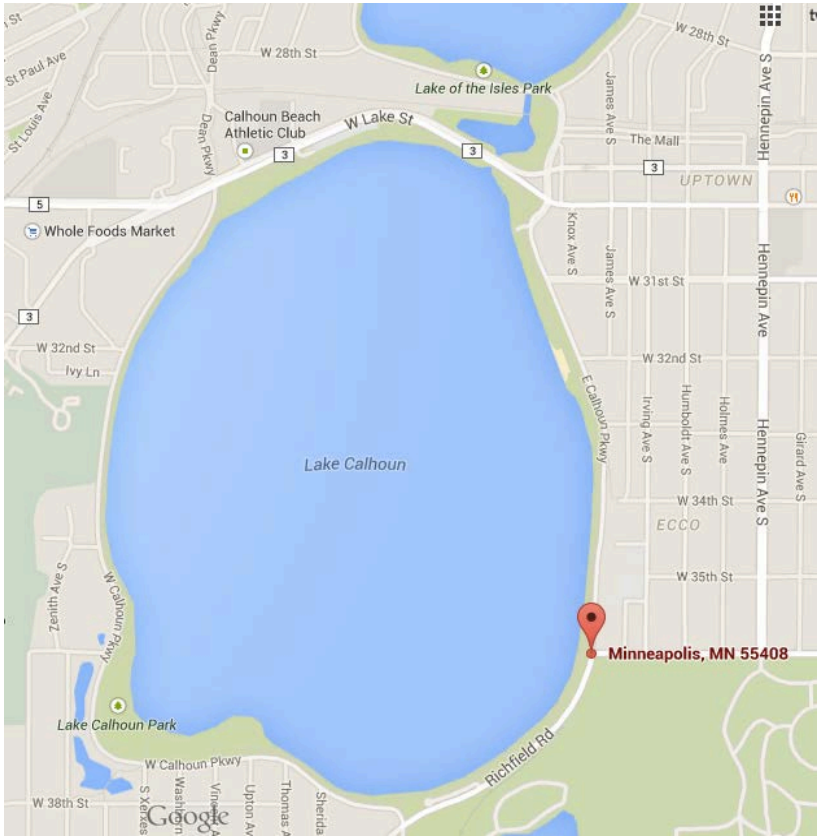
Hypothesis

- Based on these previous studies, I hypothesized that lacustrine core sampling could be used to examine pollen remains from *Mde Maka Ska* (called Lake Calhoun today) to determine the impacts of Eatonville, an early 19th century Mdewakanton Dakota agricultural settlement, on the ecology of the Lake Calhoun in Minneapolis, MN.

Research: Historical Context of Study Site

I began by researching the historical context of the Dakota settlement on Lake Calhoun.

- Prior to Eatonville, there were no settlements on Lake Calhoun.
- The Dakota were nomadic, using Lake Calhoun only as a seasonal encampment.
- Encroaching white settlement forced the government to find a way for the Dakota and white settlers to coexist.
- Lawrence Taliaferro, an Indian agent at Fort Snelling, suggested the idea of a sedentary, Dakota agricultural village.
- With key assistance and leadership from Cloud Man, Eatonville was established in 1828.
- By the mid 1830s, 300 Dakota people were living in Eatonville, producing more than 1000 bushels of corn each year.
- A feud between the Eatonville Dakota and local Ojibwe forced the settlers out of the indefensible village.
- By 1839, Eatonville was abandoned.



Location of Eatonville, named after John H. Eaton, the then United States Secretary of War. (Google Maps)

Source material: Imboden T, Phillips CI. Uptown Minneapolis. *Images of America*. Arcadia Publishing, MN. 2004.
Lanegran DA, Sandeen ER. The lake district of Minneapolis: A history of the Calhoun-Isles community. *Living Historical Museum*. St. Paul, MN. 1979.
Shirley D. Lake Calhoun. http://www.waterlaws.com/venture/calhoun.html. Published 1997. accessed June 20, 2014.

Research: Lacustrine coring

After contacting LacCore at the University of Minnesota for training and help with lacustrine core sampling, I worked with the LacCore team to extract cores at:

Core 1:

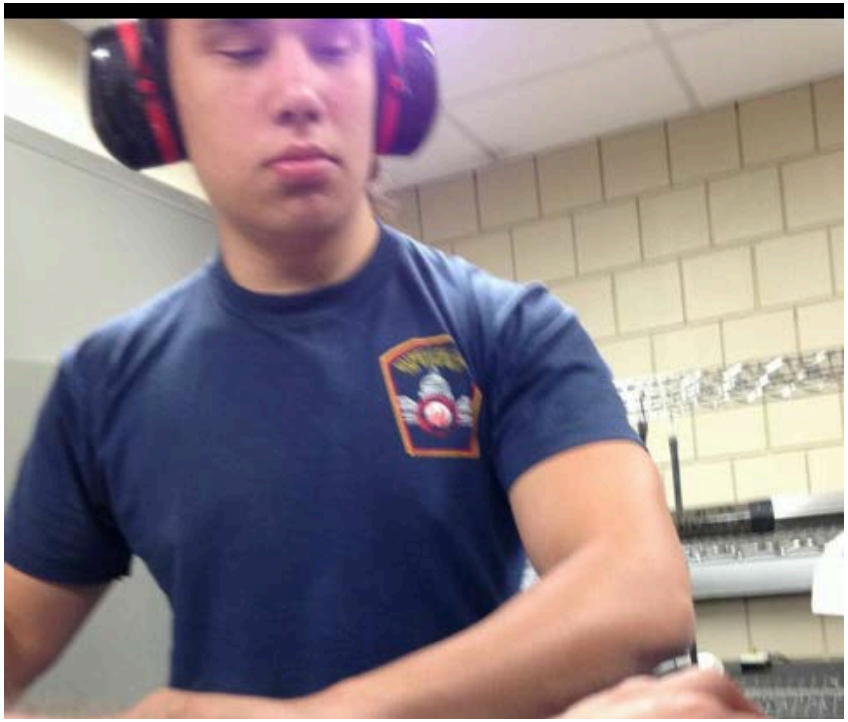
44.94362 latitude and -93.31303 longitude

Core 2:

44.94192 latitude and -93.31292 longitude (core 2).

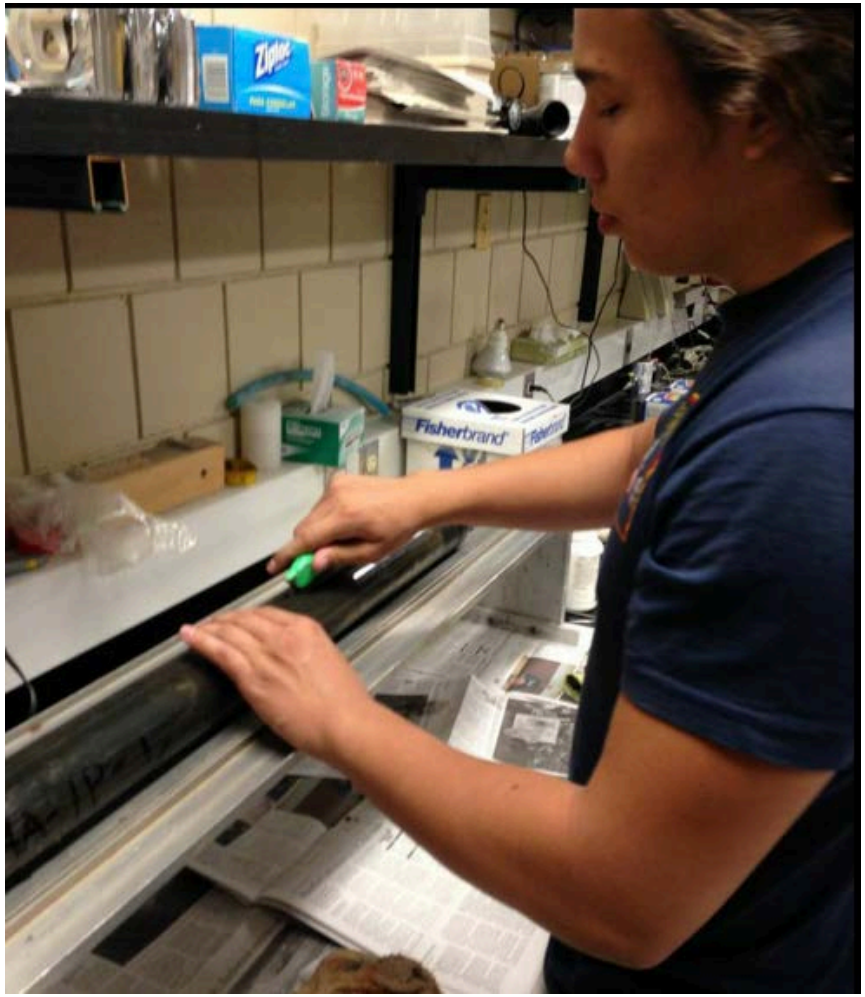
Photos of author driving a coring

Research: Processing the cores

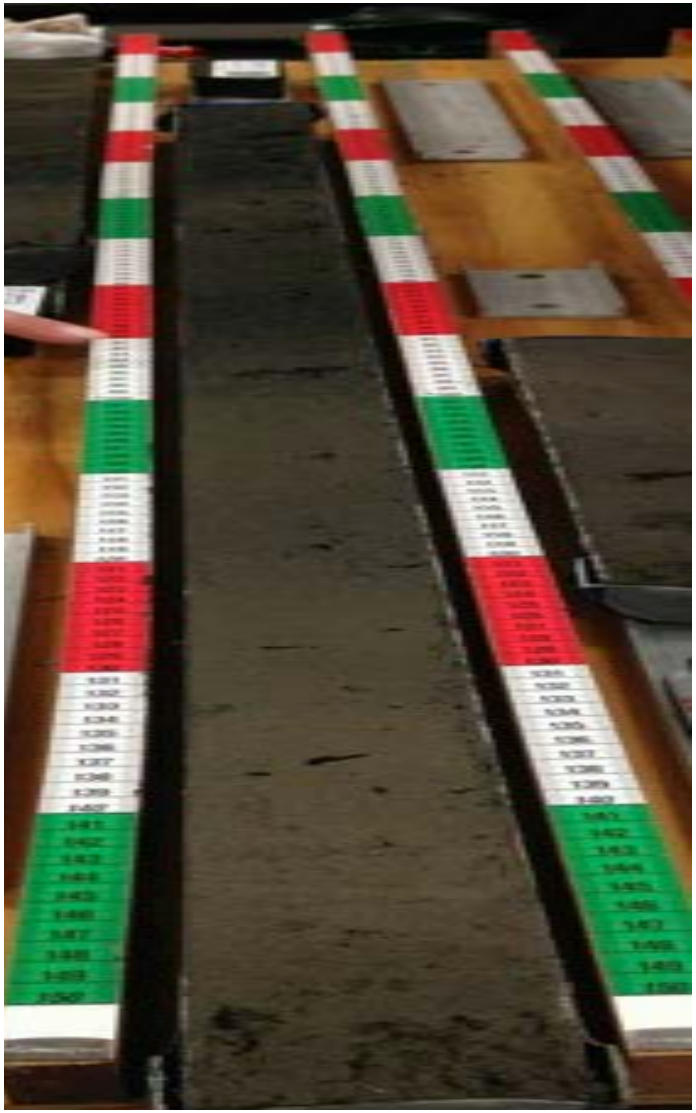


A standing saw was used to cut the cores into two halves. (Photos of author at work)

Research: Segmenting the Cores



The surface of the cores was smoothed and then meter sticks were used to divide the cores into two-centimeter segments.



(Photos of author and by author)

Research: Core Dating

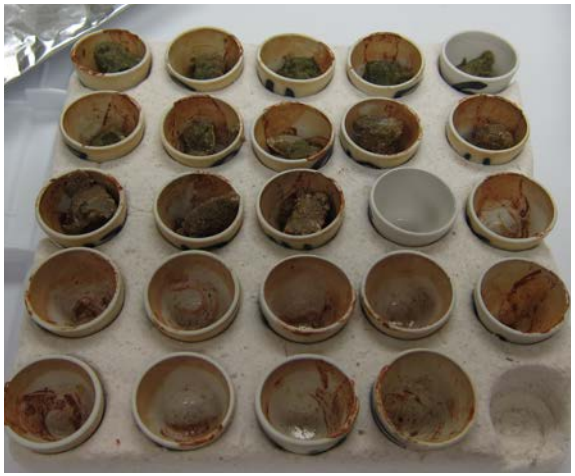
- Because there were no funds available for Pb-210 dating of the cores, I chose to use a technique called loss-on-ignition outlined in the study by Engstrom, Balogh, & Swain (2007) to date the cores.

- Because Engstrom, Balogh, & Swain had used loss-on-ignition coupled with lead-210 dating of lacustrine core samples to establish timelines for prevalence of mercury in 55 Minnesota lakes, one of which was Lake Calhoun. By taking core samples at the same coordinates in Lake Calhoun as Engstrom, Balogh, & Swain did, I was able to compare loss-on-ignition data to those of Engstrom, Balogh, & Swain to date my cores.

Methods: Loss-on-ignition Tests

Loss-on-ignition was run to measure water content, organic matter, carbonate minerals, and siliciclastic diatoms in core samples (Engstrom, Balogh, & Swain, 2007):

- Sediment samples from each core were taken every 2 cm and then placed into crucibles.
- Crucibles were weighed for wet mass and then heated at 100 ˚C in a Lab-Line L-C Oven (Conroe, TX) overnight to ensure that all water was removed.
- Crucibles were cooled, and the dry mass of the crucibles was taken to determine water content of each sediment sample.
- Crucibles were heated again to 550 ˚C in a Fisher Scientific Isotemp programmable muffle furnace (Pittsburgh, PA) for four hours to remove all organic matter; then, the crucibles were weighed to determine organic matter content of each sediment sample.
- The crucibles were again heated for two hours at 1000 ˚C to remove all carbonates, and the mass of the crucibles was recorded to determine carbonate mineral content of each sediment subsample.
- Average loss-on-ignition data for inorganic, carbonates, and organic matter were plotted.

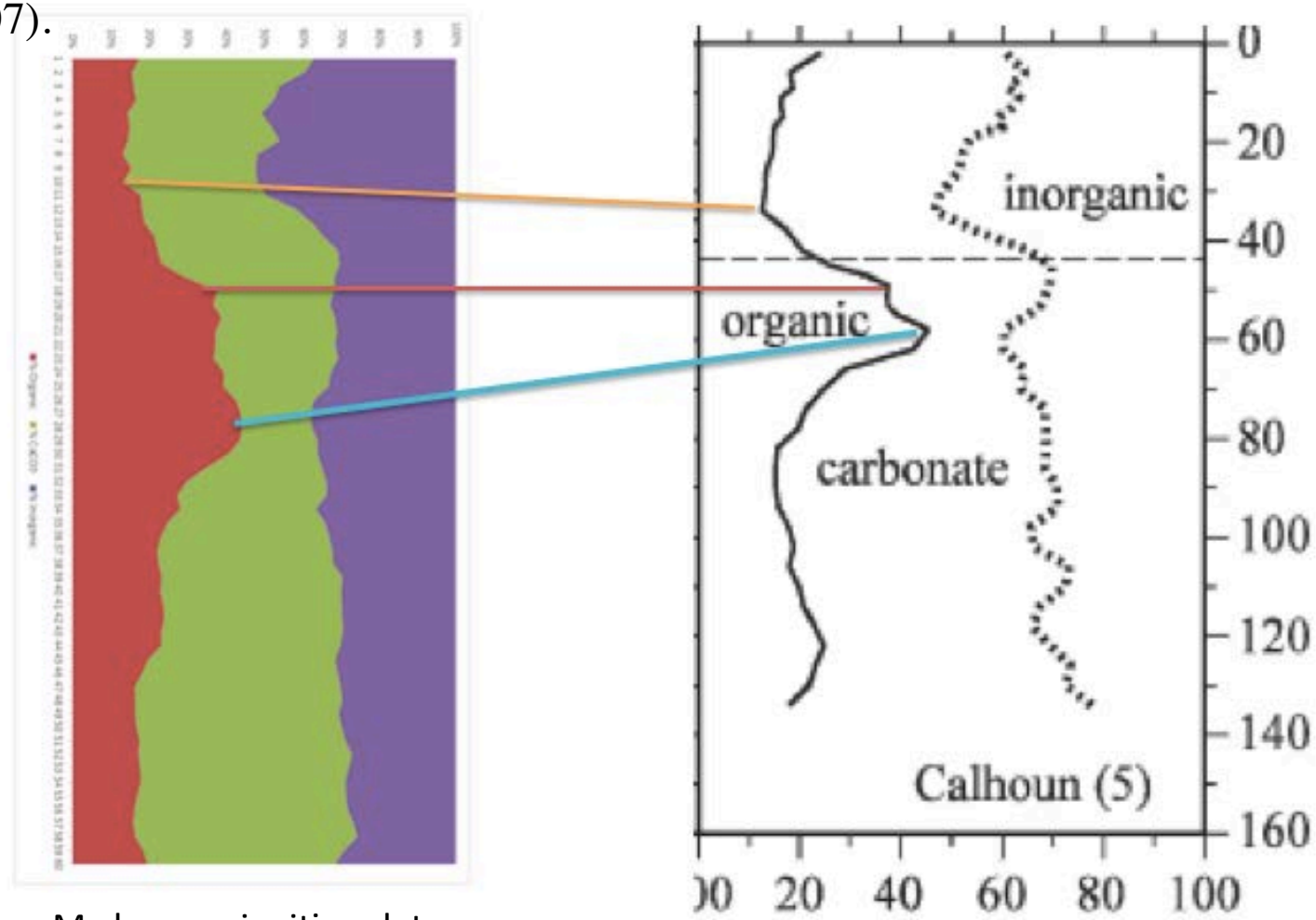


Crucibles loaded for loss-on-ignition tests (http://reubahamas.files.wordpress.com/2012/07/img_1892.jp)

Muffle furnace used to heat crucibles (http://www.xrf.ethz.ch/xrf_gifs/xrf_glass_oven_detail.jpg)

Methods: Dating the Cores

To date cores, peaks from loss-on-ignition results were plotted and then matched to loss-on-ignition peaks for Lake Calhoun reported in Engstrom, Balogh, & Swain (2007).



My loss-on-ignition data

From Engstrom et al., Limnol. Oceanogr., 52(6), 2007, 2467–2483

Methods: Testing and Redesign

My advisor originally suggested studying *daphnia*, which are limnological bio-indicators, in the core samples. After unsuccessfully attempting to isolate *daphnia* from the core, I conducted a literature search, which resulted in my decision to focus to agricultural and land-clearance related pollens. I based this decision on study by McLauchlan (2003) that showed pollen counts can be used as quantitative measures to determine the prevalence of different types of plants at certain time periods.

Research: Pollen counts

- A procedure by Lustek (2010) was used to extract all matter from the core samples except for the pollen.
- Pollen slides were prepared following a procedure by Myrbo, Morrison, & McEwan (2007).
- Pollen from core sections 73-75 cm, 53-55 cm, and 37-39 cm was counted using a Leitz objective microscope (Germany).
- The full pollen count was repeated twice.
- Pollen concentrations were calculated using the equation: number of pollen grains/number of marker grains x number of markers/mL x volume of markers/volume of sediment (Myrbo, Morrison, & McEwan 2011).

Photo of author)

Research: Analysis of Pollen counts

- Unpaired t-tests were run to compare pollen counts for oak, ragweed, and weeds at the time of the village (37-39 cm) to pollen counts ~90 years previous to the village (53-55cm).
- Oak was chosen because pollen counts showed it was the predominate species at both time periods.
- Ragweed and grass pollen were chosen since they are both indicators of human disturbance. When an area is cleared of vegetation, ragweed tends to grow, especially in Minnesota; when corn production increases, grass pollen tends to increase (McLauchlan, 2003).
- Significance was set at $p < 0.05$.

Results: Dating the Cores

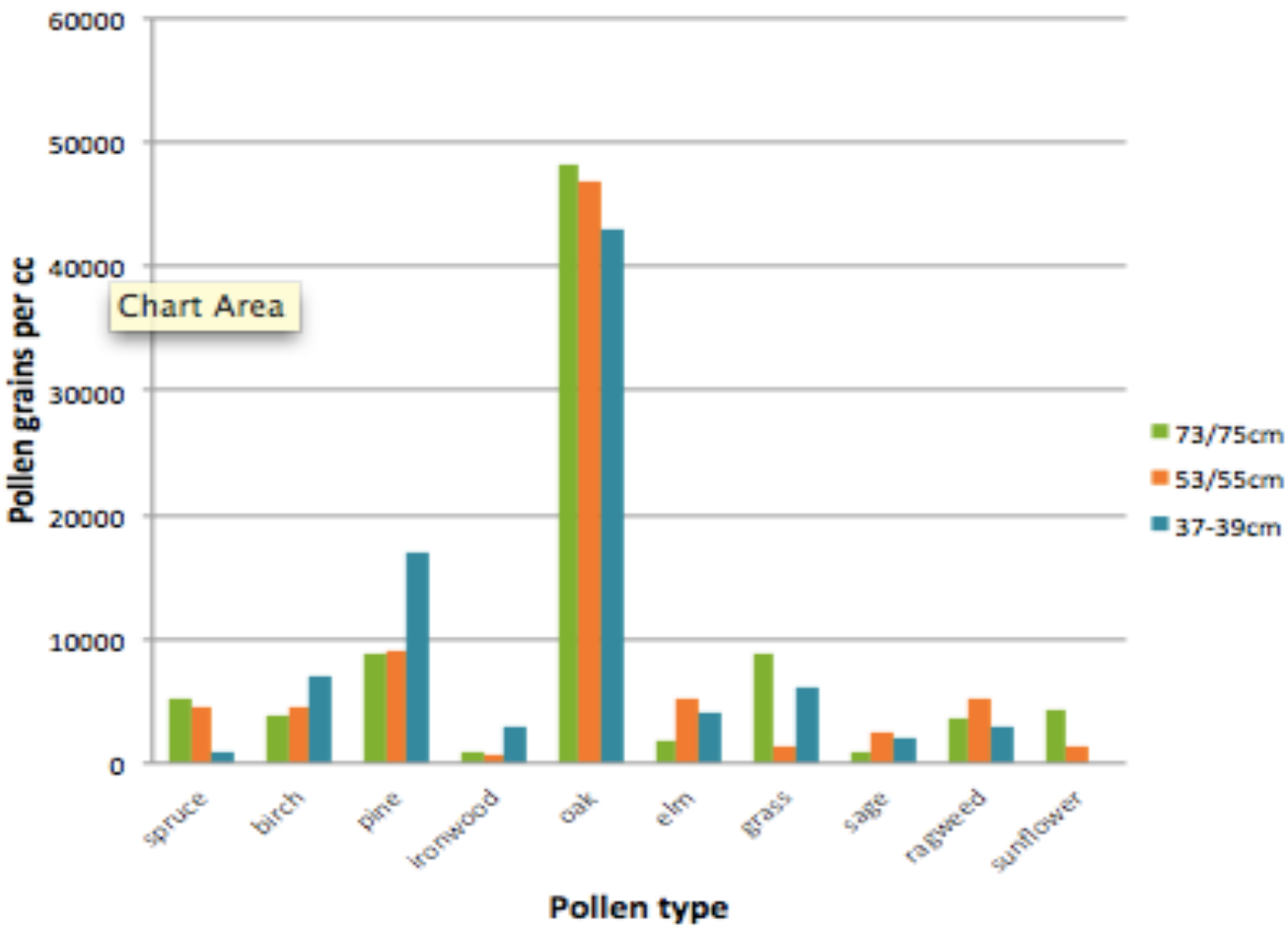
The 37-39 interval is the time period of Eatonville, 53-55 is the peak of the organic matter in the core, and 73—75 is the beginning of the rise of organic matter.

Core interval (cm)		Core dates	
37	39	1830	1840
39	41	1820	1830
41	43	1810	1820
43	45	1800	1810
45	47	1790	1800
47	49	1780	1790
49	51	1770	1780
51	53	1760	1770
53	55	1750	1760
55	57	1740	1750
57	59	1730	1740

Core interval (cm)		Core dates	
59	61	1720	1730
61	63	1710	1720
63	65	1700	1710
65	67	1690	1700
67	69	1680	1690
69	71	1670	1680
71	73	1660	1670
73	75	1650	1660
75	77	1640	1650
77	79	1630	1640
79	81	1620	1630

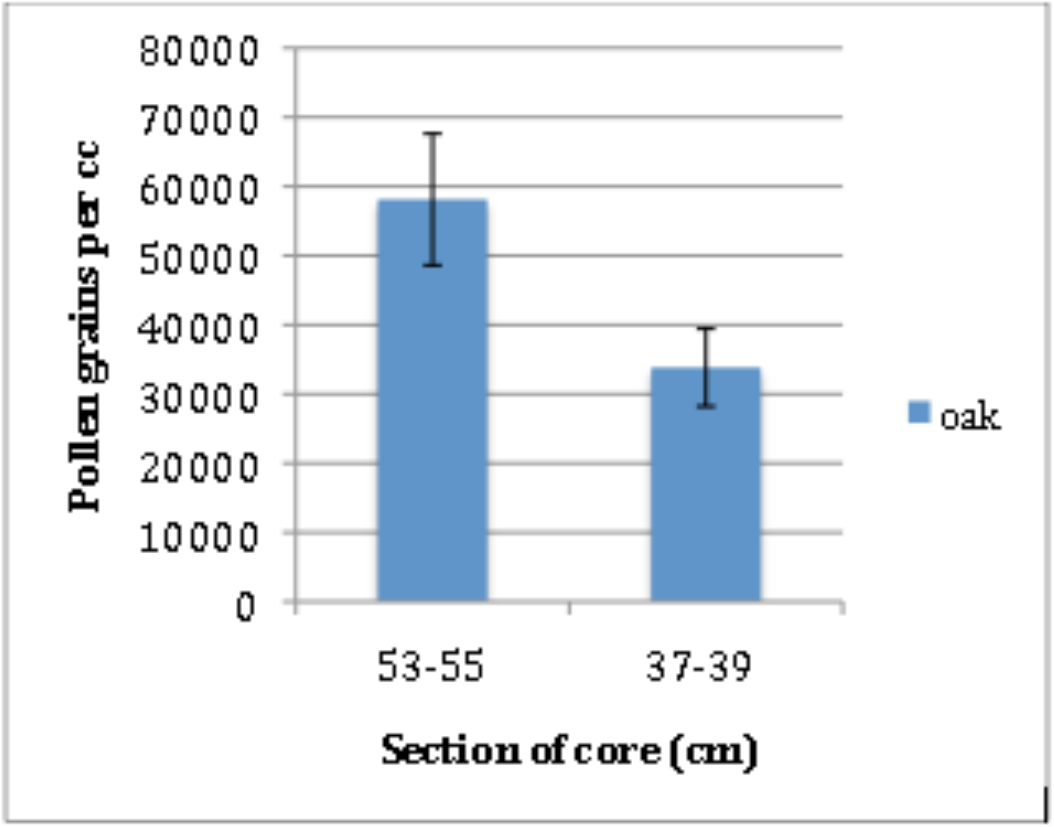
Results: Full Pollen Counts

Spruce, birch, pine, ironwood, oak, elm, grass, sage, ragweed, and sunflower pollen were found in core samples. Pollen concentration [number of pollen/number of marker grains x number of marks/mL x volume of markers/volume of sediment] is reported at 75-77 cm, which is the beginning of the organic matter (blue), at 53-55 cm, which is at the peak of the organic matter (red), and at 37-39 cm, which correlates to the time of Eatonville. The greatest concentration of pollen at the peak and tail of the organic matter and during the time of the settlement was from oak. (n = 2)



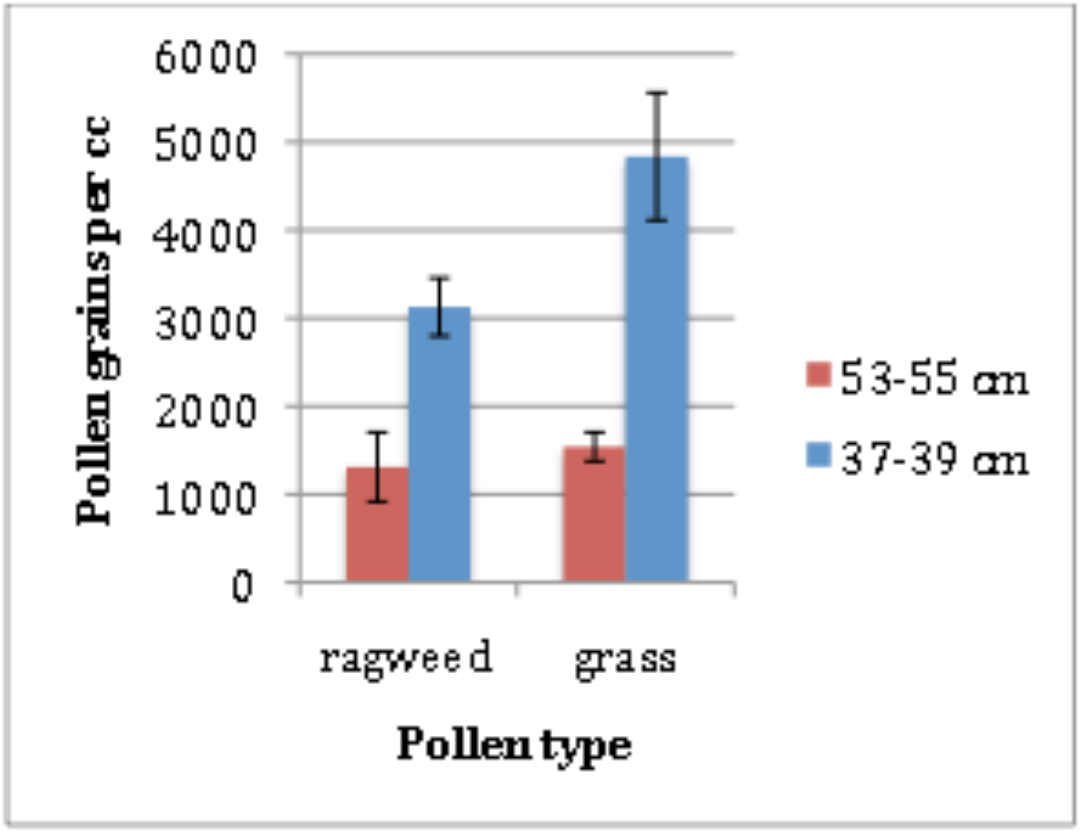
Results: Pollen Counts

A comparison of oak pollen from before (53-55 cm) and during (37-39 cm) Eatonville. Oak pollen concentrations in core samples from oak are not significantly different from the peak of the organic matter (53-55 cm) at the time of Eatonville (37-39 cm) ($p = 0.096$). Unpaired t-test with significance set at $p < 0.05$. ($n = 3$)



Results: Pollen Counts

A comparison of ragweed and grass pollens from before (53-55 cm) and during (37-39 cm) Eatonville. The concentrations of ragweed pollen ($p = 0.039$) and grass pollen ($p = 0.040$) increased significantly during the village time. Unpaired t-test with significance set at $p < 0.05$. ($n = 3$)



Impacts

- Geoscience methods were successfully used to examine impacts of an important early 19th century Mdewakanton Dakota settlement on the ecology of Lake Calhoun in Minneapolis, MN.
- Two highly reproducible methods were used to examine historical lake ecology that can be used in future studies:
  - First, use of loss-on-ignition for core dating was pioneered by comparing loss-on-ignition with loss-on-ignition/lead-210 results reported in Engstrom, Balogh, & Swain(2007), accurately dating the core segments with minimal expense.
  - Second, pollen types were identified in sediments from Lake Calhoun from the time of the Eatonville settlement despite the fact the village was in existence for only ten years.
- The methods developed in this study provide Native communities with a possible freshwater management tool. Being cognizant of the rich history behind their resources is a key first step – the methods outlined in this study can assist with that.

Conclusion/Report

- Loss-on-ignition results showed a marked rise in organic matter between AD 1650-1760 in the cores. Core dating showed that this rise in organic matter was well before the founding of Eatonville (AD 1830-40). This rise in organic matter does not correlate to any historical events recorded about the lake. However, studies by Ulrich, Martin, & Hakon (2011) and Chrisholm (1982) suggest there may have been a period of global climate change at the time, which raises an interesting question for future study.
- Loss-on-ignition results showed that pollen concentrations in core sediment suggest that the shoreline around Lake Calhoun remained predominately oak from the peak of the organic matter to the time of Eatonville. Results also showed that there was a significant increase in ragweed and grass pollen, which could include corn, at the time of Eatonville.
- It is interesting to note that the section of the cores that represents the last 50 years to present time did not show stratification. A possible explanation for this is that humans have so disrupted the natural balance of the lake that it may be anoxic near the bottom. As a consequence, there is a portion of non-stratified material.

Conclusion/Report

Native American tribes, not all, but some have access to incredible natural resources—resources that, for a variety of reasons, have not been unlocked. At the very least, being cognizant of the history as well as the future of these resources is the first step towards unlocking this wealth for our people. This study shows that the geoscience methods involving lacustrine core sampling can serve as tools for Native communities to establish a cohesive history of their freshwater resources.

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References and Acknowledgements

A number of sources were helpful in designing the procedures used:

- Myrbo (2008) provided the impetus and procedure for core sampling.
- Engstrom, Balogh, & Swain (2007) looked at mercury accumulation in sediment of Minnesota lakes. I used this reference to date my core samples.
- I used procedures outlined in studies by McLauchlan (2003) and Lustek (2014) to analyze pollen samples from the core samples.
- I referenced three sources to develop the historical context of the Eatonville:
  - Work by Lanegran & Sandeen (1979) outlined the history of Lake Calhoun, including the development of Eatonville.
  - Imboden & Phillips (2004) gave information on the history of Uptown, Minneapolis, including valuable information on Eatonville.
  - A paper by Shirley (1997) gave an overview of the early history of Lake Calhoun, particularly on Eatonville.

References and Acknowledgements

- Dr. M. Beckman served as my outside advisor
- Dr. A. Myrbo at LacCore trained me in lacustrine coring techniques and helped me take the cores. R. Calcote, also of LacCore, trained me on pollen counting techniques.
- Dr. D. Lansing and Dr. D. Lanegran provided historical guidance regarding Eatonville.
- Ms. L. Fruen served as my teacher in the Advanced Science Research Program