ANTHROPOCENE ENVIRONMENTAL CHANGE IN GLACIER NATIONAL PARK, MONTANA

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Project Summary

- Human-induced global climate change and Euro-Americans land use as part of the establishment of Glacier National Park, Montana, USA has led to environmental change in the region
- Our research focuses on changes in sedimentation rates in Redrock, Fishercap, and Swiftcurrent Lakes over the past ~200 years, with the goal of determining if changes in sedimentation occurred because of climate change, human activity in the Park, geomorphic differences between lakes, or a combination of all three. Here we examine sedimentation rates in three lakes in Swiftcurrent Valley using lead-210 dating on lake cores collected in July 2024
- While we do not yet have our lead-210 results, additional data was gathered (including LOI and SEM) that will assist in our interpretation of driving forces of change in the lakes
- We anticipate sedimentation rates will be higher in northern Swiftcurrent Lake, since it is the most downvalley of the three lakes and is adjacent to the Many Glacier Hotel and access roads
- We expect sedimentation rates in Fishercap Lake to be very low based on shallow water depths and existing radiocarbon ages; we anticipate Redrock Lake sedimentation is less than in Swiftcurrent Lake as it is further away from Park infrastructure
- Sedimentation rates in Grinnell Valley range from 0.1-1 mm/yr.; we expect Swiftcurrent Valley sedimentation rates will be higher than those found in Grinnell Valley lakes due to Park infrastructure, and human activity/visitation

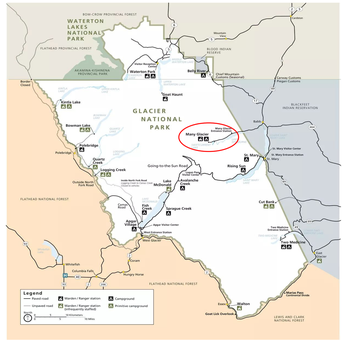


Figure 1 (above). National Park Service map of Glacier National Park, Montana. The majority of visitation occurs through the West Glacier entrance. Swiftcurrent Valley is located in the Many Glacier region (red circle).

Figure 2 (left). Authors holding their first core on Fishercap Lake in July 2024.

Glacier National Park, Montana, USA

Swiftcurrent Valley is located on the eastern side of Glacier National Park on the ancestral home of the Blackfeet Nation. The region was carved by glaciers, and when they retreated ~18,000 years ago they left behind a series of lakes. Water flows from melting snow and ice high in the valleys, transporting water and sediment into downvalley lakes. Previous work (MacGregor et al., 2011; Schachtman et al., 2015) examined the glacial and environmental history of Swiftcurrent Lake and Grinnell Valley by analyzing lake sediment cores.

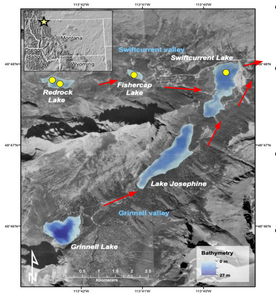


Figure 3 (above). *Inset:* Glacier National Park, Montana is located near the U.S./Canadian border on the eastern edge of the Rocky Mountains. *Main:* Overview of the two valleys and chains of lakes of the study area. Bathymetry shown in blue shading; note Fishercap Lake is shallower than all other lakes in Swiftcurrent and Grinnell Valleys. Flow direction of water shown in red arrows. Location of paired cores collected in July 2024 (this research) shown as yellow dots.

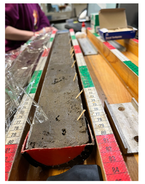
- Water and sediment transfer through Swiftcurrent Valley flows from Redrock Lake, to Fishercap Lake, and into Swiftcurrent Lake
- Sedimentation rates in northern Swiftcurrent Lake are 2-3x higher than those in the southern basin; this may mean that Swiftcurrent Valley supplies significant sediment to the northern basin
- Previous Swiftcurrent Lake cores showed significantly different patterns of deposition in the southern and northern subbasins, raising questions about sediment delivery through Swiftcurrent Valley
- Fishercap Lake is shallow (~1 m deep) compared to Redrock Lake (6.5 m) and northern Swiftcurrent Lake (~12 m); lake depth and morphology will likely impact sedimentation in addition to climate and land use changes

Figure 4 (above top). Photo of Redrock Lake
Figure 5 (above middle). Photo of Fishercap Lake; shallow water depths (~1 m deep) with heavy foot traffic and daily moose sightings!
Figure 6 (above bottom). Photo of the northern subbasin of Swiftcurrent Lake; Many Glacier Hotel is visible on the eastern shore and includes road along the north and east slides of the lake.

Methods

- Our Keck Geology Research Experience for Undergraduates (REU) took place in June-July 2024
- Lake sediment cores were collected from inflatable kayaks lashed together using push coring in 1-9 m water depth
- Four pairs of cores were collected (two in Redrock Lake, and one each in Fishercap and Swiftcurrent Lakes); one core from each pair was subsampled in the field for lead-210 analyses, and the other was analyzed and preserved at the Continental Scientific Drilling (CSD) lab at the University of Minnesota (Twin Cities)
- Intact cores were scanned using the Geotech Standard and XYZ Multisensor Core Loggers, and split, photographed, and assessed using smear slide analysis
- All cores were subsampled at 0.5-1.0 cm intervals for Loss On Ignition (LOI) to determine water, organic carbon, and inorganic carbon content. LOI was conducted on the lead-210 samples to allow for mapping of age dates onto intact cores (future work)
- Scanning Electron Microscopy (SEM) analyses were conducted on several samples from each core to determine mineral grain shapes and content of sediment cores.
- In addition to lead-210 analyses (sent to St. Croix Watershed Research Station), we picked charcoal from the base of several cores for radiocarbon dating to extend sedimentation rate data further back in time

Figure 7 (above left). Photo of core extraction. Note inflatable kayak platform and polycarbonate sampling tube
Figure 8 (above right). Photo of lead-210 subsampling; subsampling at 0.5 cm intervals required focus and extensive labeling and tracking



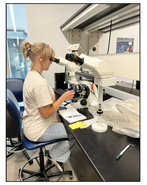
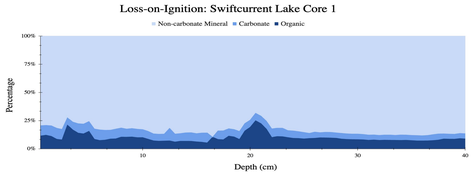


Figure 9 (above left). Photo of split core (working half) at the CSD facility. Toothpicks show locations of smear slide sampling and analysis
Figure 10 (above right). Photo of smear slide analysis. Petrographic microscopes at CSD were used to examine content of sediment in cores

Preliminary Findings

Loss On Ignition



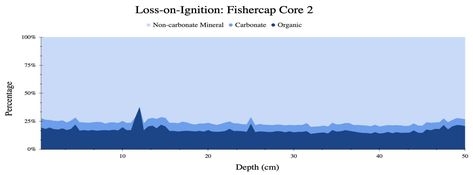


Figure 11 (above). Loss-on-Ignition (LOI) data collected from Swiftcurrent Lake **(above)** and Fishercap Lake **(below)**. Dark blue = organic carbon percent, medium blue = carbonate percent, light blue = clastic percent. Variability in organic carbon and carbonate percentage is used to correlate paired cores so that lead-210 ages can be matched to existing intact core.

- Average organic carbon content ranged from 5-20%, with some peaks in organic carbon >30%
- Carbonate content was typically 5-10% in all cores, with values ranging 0-25%
- Carbonate content increased slightly in all lakes toward the present
- Organic carbon and carbonate variability will be used to correlate paired cores; this will provide high resolution age controls for intact core material over the past ~200 years
- Detrital carbonate originates from the highest elevations in the valley, likely produced by glacial erosion and downvalley transport
- Higher carbonate content may reflect enhanced downvalley transport of glacially-derived sediment as a result of increased meltwater flux and/or flooding toward present

Preliminary Findings

Scanning Electron Microscopy

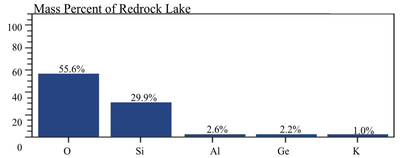
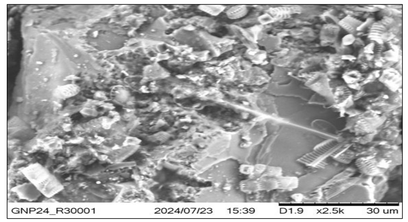


Figure 12 (above). Elemental mass percent data of a Redrock Lake core. Note abundance of O and Si; this is typical of cores from all three lakes

Figure 13 (below). SEM image of Redrock core showing diatoms and minerals



- SEM analyses were conducted on several samples from each intact core
- Elemental analysis showed >50% of samples were Si and O, reflecting clastic minerals and presence of significant concentrations of both benthic and planktonic diatoms
- SEM images confirmed clastic and carbonate grains showed rounded edges and are detrital
- Diatom abundance is greatest in shallow Fishercap Lake

Figure 14 (right). Photo of research team with Park Ranger Bob Schuster at an evening campfire talk, July 2024

Grinnell Valley sedimentation

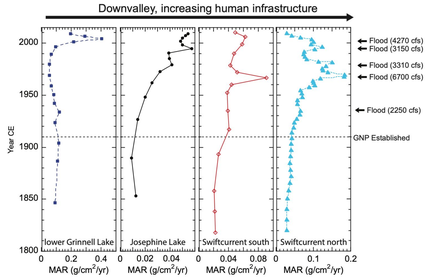


Figure 15 (above). Figure of lead-210 derived mass accumulation rate (MAR) in four lakes in Grinnell Valley. Note the increasing sedimentation rate in all lakes over the past ~200 years (from MacGregor et al., in review). MAR values increase 2-5 times in all lakes toward the present. Stochastic peaks in sedimentation correlate with known flooding events in Swiftcurrent Creek. Note the data were collected in 2010; current work will extend these results to the present and provide lake sedimentation rates for Swiftcurrent Valley

Discussion & Future Work

- Both LOI data and smear slide analysis show an increase of carbonate content in lake sediment toward the present, suggesting increased transport of glacially-derived sediments from high in the valley
- We anticipate lower sedimentation rates in Fishercap Lake based on lake morphology
- We expect sedimentation rates will increase toward the present in all three lakes as a result of changing climate and land use
- Detailed age data obtained from in-progres lead-210 and radiocarbon dating will allow us to determine sedimentation rates in Swiftcurrent Valley and compare them to existing data for Grinnell Valley
- Sedimentation rate results will be instrumental in understanding anthropogenic environmental change in the Park and the impacts of visitation on lakes
- Fire history through charcoal counting, pollen analyses, and microplastics content assessment will be future targets of research in the region

Acknowledgments

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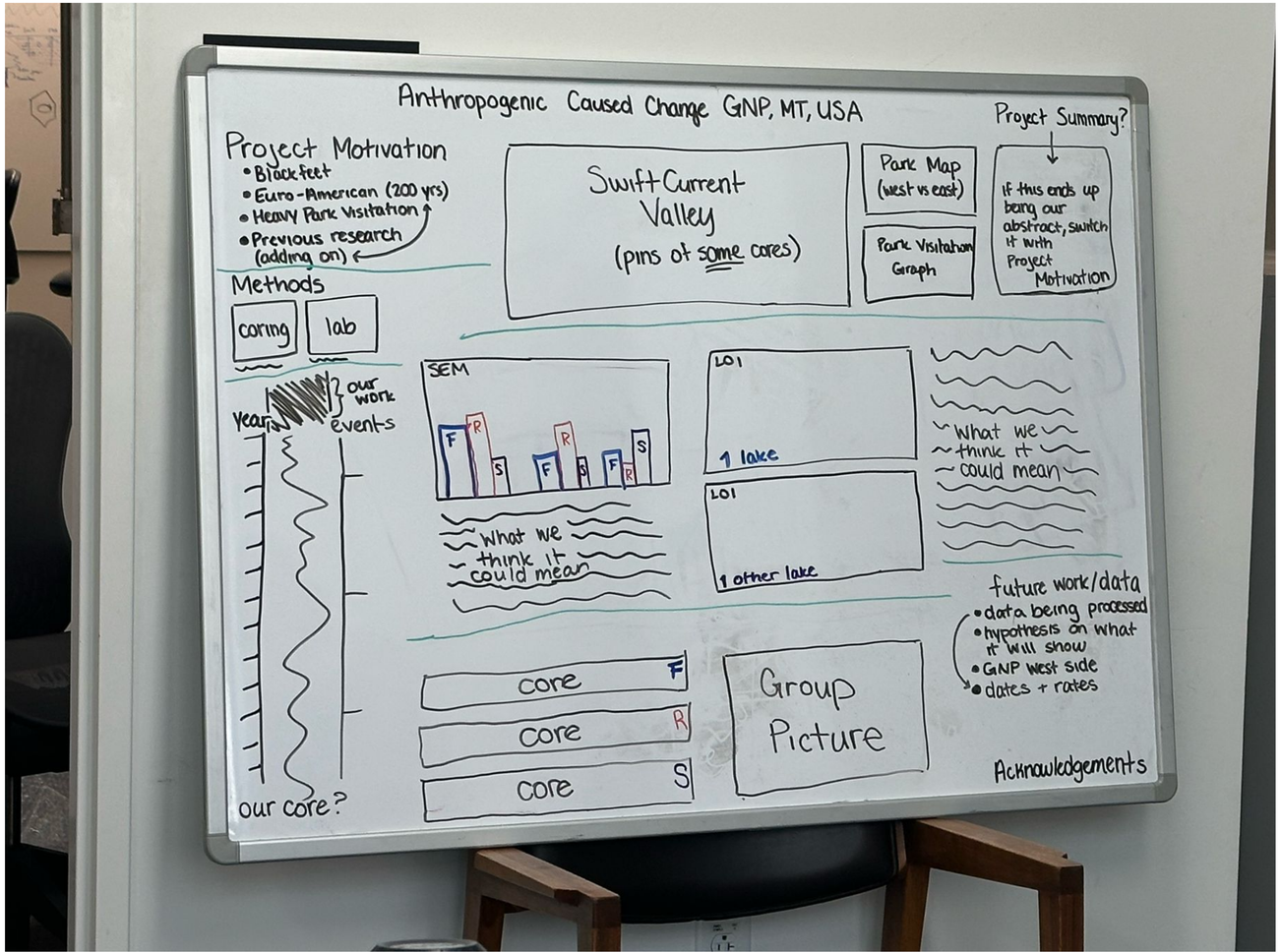
Anthropogenic Caused Change GNP, MT, USA
Project Summary?
If this ends up being our abstract, switch it with Project Motivation
Project Motivation
• Blackfeet
• Euro-American (200 yrs)
• Heavy Park Visitation
• Previous research (adding on)
Swift Current Valley
(pins of some cores)
Park Map (west vs east)
Park Visitation Graph
Methods
coring
lab
Year
our work
events
our core?
SEM
F
R
S
What we think it could mean
LOI
1 lake
1 other lake
What we think it could mean
core F
core R
core S
Group Picture
future work/data
• data being processed
• hypothesis on what it will show
• GNP west side
• dates + rates
Acknowledgements