Notes from the FOREST

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Field Station and Environmental Education Center

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Reconstructing Climate Change and Ice Retreat at Lake Lacawac

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It's difficult to imagine Lake Lacawac covered by several-kilometer-thick ice today, but this was the reality for much of North America 25,000 years ago. At this time, glacial ice globally reached its maximum extent across the world, and eventually began to retreat (melt) back into the north. Parts of the US and the majority of Canada were covered by multiple ice sheets, with the largest of them - the Laurentide Ice Sheet - extending from Hudson Bay to as far south as the Midwest and Northeast US. While these ice sheets are now completely extinct, scientists are continually reconstructing them in great detail by examining the landforms and deposits (sediment and rocks) left behind within the landscape. But why does the reconstruction of a long dead ice sheet really matter in the modern day? Well, climate change is monitored and understood through the analysis of ice sheets, such as the Greenland and Antarctic Ice Sheets, and alpine glaciers in mountain regions. However, modern observational records of ice growth and retreat don't go that far back, so information from the decline of extinct ice sheets may shed some light on the timing of the current climate crisis. However, to ensure these large-scale ice sheet reconstructions are accurate, the behavior and timing of ice movement and retreat on and around the margins of these extinct ice sheets needs to be further understood.

April Howden, a PhD student at Liverpool John Moores University (UK), is working to understand the timing and environmental effects of deglaciation of the Laurentide Ice Sheet within Northeast Pennsylvania (NEPA). When Laurentide ice was at its maximum extent, portions of northwest Pennsylvania and NEPA were covered by the southern margin of the ice sheet. As part of her undergraduate dissertation, April began work analyzing NEPA lake sediments in Luzerne County with researchers Kathryn Adamson (Manchester Metropolitan University), Tim Lane (Liverpool John Moores University) and Matt Finkenbinder (Wilkes University). At PhD level, this project has expanded to include multiple lakes across NEPA, starting with Lake Lacawac.

Global ice began to retreat from its maximum extent sometime between 25,000 to 19,000 years ago. As the ice melted and retreated further to the north, basins formed by glacial scouring and/or damming by glacial sediments created numerous lakes in NEPA. Lakes rapidly filled with sediment and meltwater as ice retreated further north. Since its initial formation, Lake Lacawac has continuously been infilled with sediments and organic material washed in from the landscape. These sediments, when 'cored' (Fig. 1) and analyzed, can provide a detailed archive of environmental change.

Figure 1: Wilkes University undergraduate students Jessica Zajac and Erika Wintersteen holding a surface sediment core taken from the bottom of Lake Lacawac in October of 2021.

Analyzing these cores from top (the most recently deposited sediment) to bottom (the oldest) means that changes in sediment composition (i.e. concentration of mineral and organic material, etc.) can be traced throughout the record, reflecting changes in the landscape throughout time (Fig. 2). For example, glacial sediment deposited as the ice melted and retreated out of the catchment reflects an unstable landscape with high mineral matter and little to no organic material. This is because a freshly deglaciated landscape is covered with loose geological materials, soils are not developed, and plants are not present on the landscape due to cold, windy, and dry climate conditions.

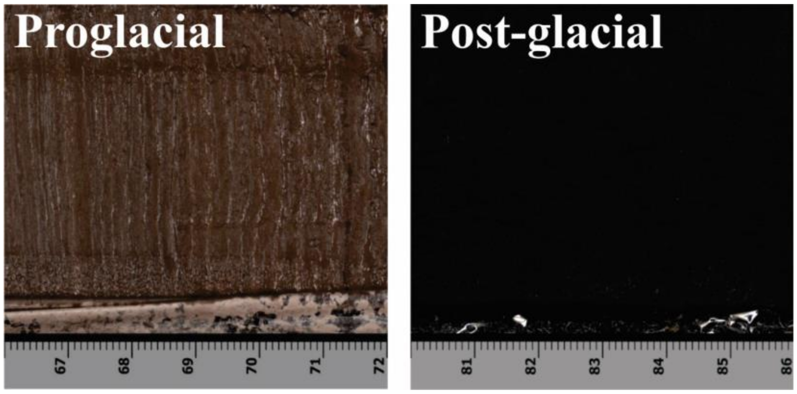

Figure 2: Images of sediment cores showing representative proglacial sediments (mm-scale layers and lighter-color due to high mineral matter and low organic matter) and post-glacial sediments (homogeneous and darker-color due to low mineral matter and high organic matter). Images are from Nuangola Lake in Luzerne County.

Alternatively, post-glacial and organic-rich sediments reflect a stable and well-vegetated landscape with a climate similar to today, long after ice has retreated. Temperature changes can be supported by other paleoclimate proxy datasets such as pollen assemblages, which provide insights to the vegetation cover in the catchment and surrounding region. For example, if pollen from modern day tundra plants is found within the lower parts of the sediment, this will suggest that temperatures at the time of deposition were much cooler than today. A later shift to boreal forest taxa (spruce trees) and later mixed deciduous forest will document climate warming and the transition to modern day conditions. Environmental changes will also be reconstructed using a variety of biological and geochemical proxy datasets, which will provide further insights into deglaciation and landscape development changes.

All these methods will be used to reconstruct a detailed picture of the local environment at Lake Lacawac over time through radiocarbon dating techniques. To do this, small 'macrofossils' (fossils visible to the naked eye) such as pieces of wood, charcoal, or seeds will be obtained from within the sediment. Living things such as plants and animals contain the radioactive isotope carbon-14 (14C) which decays over thousands of years to stable nitrogen-14 (14N). Using the known decay rate (or half-life) of carbon-14 of 5,730 years, and the concentration of carbon-14 in macrofossils from the cores, an age to depth model can be developed. The age to depth model will allow us to calculate the age for any depth in the core sequence, and therefore permit us to evaluate the timing and magnitude of climate and environmental changes over time.

At the end of the project, with dated sediment sequences from multiple sites in NEPA, it will be possible to detect changes in the climate and the landscape throughout time (Fig. 3) and gain a better insight into the timing of local ice sheet retreat. The composition of the sediment will reveal whether ice retreated fast or slow, and just how quickly the landscape was colonized with plants post-retreat. Ancient pollen identification will show what type of plants were on the landscape throughout time, and this will help to constrain changes in local temperature as time progressed. Overall, the project will provide a detailed record of local climate, therefore supporting larger reconstructions of the Laurentide Ice Sheet. These detailed records are therefore vital for our understanding of climatic, atmospheric and oceanic processes across the globe.

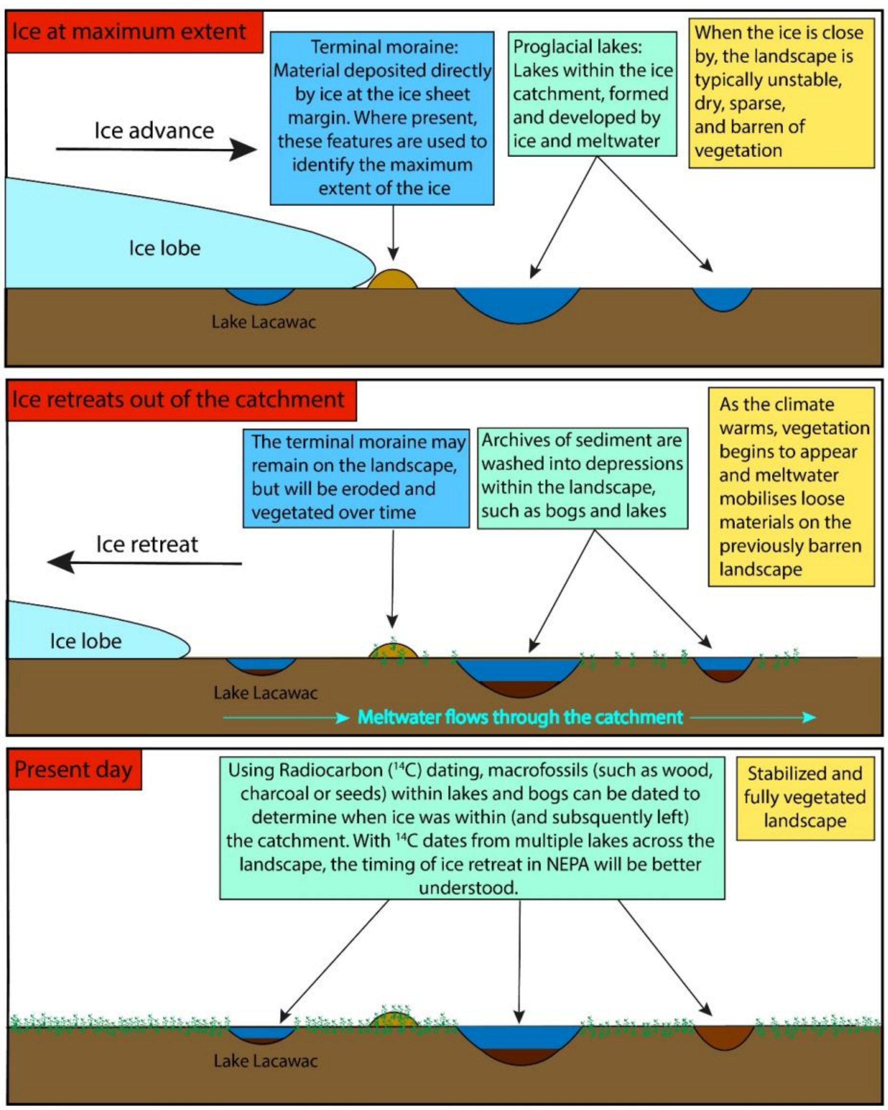

Figure 3: Conceptual diagrams of ice sheet advance and retreat. The terminal moraine refers to a feature deposited by ice directly at the margin at the beginning of retreat. Imagine Lake Lacawac is the leftmost lake, once covered by glacial ice. As ice retreated northward (to the left) with increasing temperatures, the lake was exposed and filled with sediments transported by glacial meltwater. If several of these lakes and the terminal moraine are dated, this will tell a detailed story of glacial retreat throughout time.