Paleoecology: I analyze past vegetation changes using fossil pollen and charcoal from lake sediments. Every year plants give off pollen, some of which falls or is carried into lakes and buried in the sediment. The sediment also contains fossil diatoms (photosynthetic algae with glass shells) that can be identified to species. Each species responds differently to changes in water depth, dissolved carbonates, and nutrient availability, all of which can indicate changes in groundwater or runoff into the lake.

I'm currently working on microfossils from a 12m-long core of lake sediment from Crystal Lake Ohio, northwest of Dayton. Crystal Lake is a glacial kettle that formed over 18,000 years ago in the southern edge of the ice margin during the last ice age, further south than most natural lakes in the United States. Colleagues (including Dr. Tom Lowell of the University of Cincinnati) and I drilled down into the bottom of the lake in 2008, first collecting surface sediments that were recently deposited, then deeper layers containing older material, back to gravels deposited by the ice sheet that melted back from central Ohio (Fig. 1). Undergraduate students have worked with me to generate pilot data from plant macrofossils, tiny mollusk shells, and the chemical composition of the sediment itself. In 2018, a graduate student analyzed fossil pollen from different layers within the core. We also obtained several recent and ancient radiocarbon dates.

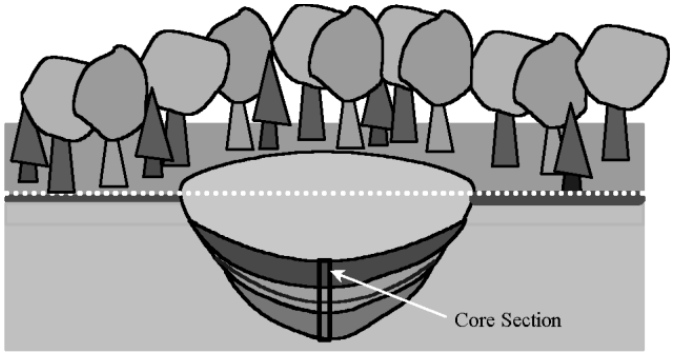

Figure 1: Diagram showing a core section in a lake-sediment context

The question I'm trying to answer right now is whether Ohio developed natural (not anthropogenic) prairie during a period of relatively warm Northern-Hemisphere summers 8,000 to 5,000 years ago. In the Upper Midwest of the US and Canada, that peak of warmth is marked by a "prairie period", a shift to drier conditions. Pollen records from those lakes indicate that forest or sparse woodland returns to the lake area after the prairie period. However, there was no visible increase in prairie taxa in my graduate student's record from Crystal Lake, which may mean that prairie didn't displace forest as far east as Ohio. There were treeless patches in western Ohio in the early 19th century when the area was surveyed for homesteading, but those could have been Native American farm fields. I'm working on obtaining material for radiocarbon dates from sediment 7000 to 4000 years old. I'm also having a student examine fossil charcoal to for evidence of past patterns of wildfire.

Educational Research: I teach classes using a variety of types of active learning (described in my teaching statement) and assess the effectiveness of these techniques. This year, I'm trying to determine the effectiveness of a couple of educational interventions by measuring whole-course content-knowledge gains. I gave my students a short pre-test on the first day of class and a post-test with the same questions on the last day of class and compared the results. I've used a standardized test for some classes, but I'm working to develop and assess my own tests as well. I

saw (statistically) substantial score gains from pre- to post-test in classes that created plate-tectonics pop-up books, so I'm working on a paper to describe that project well enough that other instructors can develop similar and similarly effective exercises.

I'm also looking at who benefits from cooperative learning. Within a group, some students are likely to be better prepared to take a test than others. When they take a test together, the best-prepared students often explain their preferred answers to the group, which is an opportunity for them to understand the material better and to remember it. I have detailed records of scores from classes taught using team-based learning (TBL). The students take every test twice: alone the first time and working with a group the second time. For most teams over a semester, the team outscores all the individuals within it. However, the student with the highest individual-test score often has the greatest pre-to-post-test gain over the course of the semester. This student may end up "teaching" the rest of the group during the test, which may increase retention of the content over the semester. I am also trying to determine the best group size.

Modern Human Impacts: Recently, I have been working with environmental chemists to study lead-pollution patterns. In our most recent paper, we analyzed concentrations of lead in sediments in the springs and creeks in a nearby nature reserve and worked out the cause of the spatial variations. My colleague, Audrey McGowin, has 7 years of water-quality data from the reserve, showing severe impacts from upstream farms and human activity in general. I've been mapping these data using ArcGIS, so we can see changes over time in the two watersheds that run through the reserve.