Nell Libera,
Jennifer Kissinger,
& Julia Campbell

Student Corner

It Takes a Village: Citizen Scientists and Academics Come Together to Help Resolve a Pollution Debate

The pollution debate

Over the past two decades, freshwaters of rural southwest Nova Scotia (NS), Canada, have been the subject of a water quality debate. In 2009, some community members attributed algal blooms, cattail growth along streams, and nuisance gulls and flies to pollution from the region's fur farming industry (Figure 1). The outcry prompted the local watershed organization, the Tusket River Environmental Protection Association (TREPA) (http://www.trepa.com/), to begin a study of local lakes. The algal blooms appeared to be mostly cyanobacteria, which can be damaging to aquatic ecosystems, and toxic to many organisms, including humans. These rural lake systems are used for recreation and tourism, such as fishing tournaments and canoeing. Several of these lakes are also home to the unique and at-risk Atlantic Coastal Plains Flora. Algal blooms therefore threaten the cultural, environmental and economic resources that these freshwaters provide.

A staple of the region's culture and economy, the Nova Scotian fur farming industry has been around since the early 20th century (Figure 2). Production and profitability increased in the 1990s, when farms switched from smaller "mom-and-pop businesses" to large-scale operations, primarily producing mink pelts. By 2013, pelts became the province's second highest agricultural export. Waste byproducts of fur farming, mainly feces and carcasses, are nutrient-rich, and can fuel algal blooms if not properly managed. This has created a contentious situation between government regulators, mink farmers, and concerned citizens that has been covered by local and national news outlets. However, these rural lakes are also vulnerable to other potential human activities, such as agriculture, forestry or mining, which can influence the water quality in complex ways (Korosi et al. 2012). For example, lakes in southwestern Nova Scotia were especially sensitive to acid rain that peaked between 1970-1990. Lake water quality and ecosystem function can also be negatively impacted by, for example, climate warming, extreme weather events and leaky septic systems. As such, it is important to understand potential sources of pollution over time; however, surface water quality monitoring data for this area are sparse.

Figure 1. The excessive growth of cattails, an aquatic plant that is highly successful in nutrient-rich conditions, on the shoreline of a lake near mink farms.

Fortunately, lake sediments provide a natural archive of environmental history. Paleolimnology is a science that involves the analysis of lake sediments for chemical, biological, and physical indicators preserved in dated sediment cores (Smol 2008). Documenting lake changes over time can lead to a better understanding of our long-term impacts on the environment and, importantly, lead to evidence-based mitigation, remediation, and management strategies. We are part of a team of scientists from five Canadian universities who are studying the limnology and sediments of lakes in southwest NS (Figure 3). However, our contributions would not be possible without previous efforts of stakeholders from the region, such as TREPA and concerned citizens.

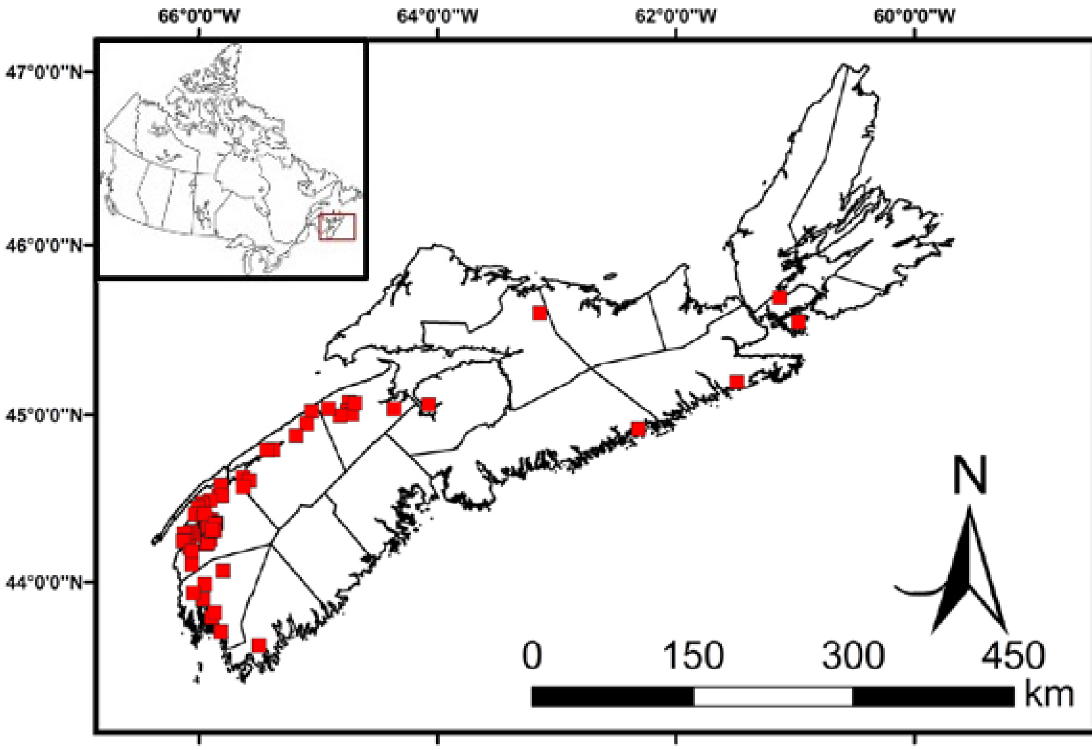

Figure 2. The province of Nova Scotia in relation to rest of Canada. Red squares are the locations of fur farms and related properties (e.g., feed suppliers).

Figure 3. Jennifer Kissinger with a sediment core.

The pioneering role of citizen science

As scientists, we are often "outsiders" to the community or environment we are studying. Citizen science is the participation from the public-at-large or community members in scientific projects. Citizen scientists often provide qualitative information from anecdotes and observations. Additionally, they can collect monitoring data at a high frequency or breadth that is not practical for other scientists. Research questions then become centered around issues the public finds meaningful and truly wants to see addressed.

As citizen scientists, residents of southwest Nova Scotia played a crucial role in this lake ecosystem health campaign. Community members provided safe access points to local lakes, suggested study sites of primary concern, and provided invaluable advice. TREPA provided citizen scientists with water sampling tools – for example, Secchi discs to measure water transparency, and pH probes. They also collected water samples for testing nutrient levels in the laboratory. They were able to sample and monitor the health of the lakes they live next to and care deeply about. For example, these sampling efforts showed that nutrients, which fuel algal blooms, were at least 100-fold above provincial averages in lakes near mink farms and decreased as a function of distance downstream from the mink farms (Stantec Consulting 2017).

Academic scientists fill in the gaps

These water quality data are extremely informative, but only provide information back to 2008, decades after the escalation of the mink fur farming industry. Hence, the TREPA data cannot provide information on the baseline status of the lakes (Stantec Consulting 2017), and therefore cannot show when and how much these lakes have changed. Our paleolimnology team is analyzing sediments of 14 lakes. Our study lakes include those identified of primary concern by TREPA, local community members, and other citizen scientists. Many of the study lakes have reports of algal blooms and are either near to or downstream of mink farms. We also selected a set of five additional lakes that are nearby but within watersheds without mink farming and other human activities. These are considered "reference systems" because they would not be expected to record impacts. However, they might still record impacts from climate change or acid rain. It is important to know how lakes in the region as a whole are changing to compare conditions in lakes near mink farms to regional freshwaters.

We are studying these lakes from multiple scientific vantage points. One research team is inspecting the watersheds of these lakes in a detailed modelling study to understand the hydrology and potential sources of runoff nutrients. Another university laboratory is tracking gull movement and behavior to determine if birds are transporting fur farm byproducts to distant nesting sites. The paleolimnologists on our team are analyzing indicators preserved in the dated sediment cores to reconstruct environmental change through time. Our records extend back to the 19th century or earlier, prior to any intensive land-use or climate change in the region.

One of our main goals is to track nutrient levels over time. To do this, we are examining diatoms, which are microscopic algae with siliceous cell walls preserved in sediment for millennia. Certain diatom species in the sediment record are well-established indicators of nutrient pollution (Figure 4). Diatoms are also reliable indicators of other forms of pollution, such as acidification. For example, diatoms in sediment records provided evidence that played a role in the passing of the U.S. Clean Air Act in 1990, which was successful in reducing the release of contaminants that can acidify lakes. Further, chironomids (non-biting midges), common benthic invertebrates whose remains preserve well in the sediments, are good indicators of the dissolved oxygen content of a lake (Figure 4). Because excess nutrients are often accompanied by a loss of hypolimnetic oxygen, these midges can be used to infer pollution trends. We can also infer how the ecology of a lake has changed by looking at a group of tiny crustaceans, the Cladocera. These invertebrates are sensitive to pollution, and their remains also preserve in sediment. As an important algal grazer, and food source for planktivorous fish, cladocerans provide evidence of food web change due to nutrient inputs and other anthropogenic stressors.

Certain chemical fossil indicators can provide a unique "fingerprint" of pollution. In this case, chemicals in fecal runoff are deposited in sediment and can be used to differentiate the presence of fur farm byproducts from that of human and other sources of nutrient inputs (e.g., agriculture). Specifically, we are analyzing isotopes of carbon and nitrogen and a suite of sterols (e.g., cholesterol). The chemical composition of sediments deposited over time will then be compared with the chemical signatures of samples of mink feces, mink feed, sewage runoff, as well as zooplankton and periphyton naturally present in the lake ecosystems. These chemical measures can also provide information about diet, origin, and position in the food web. As such, analyzing the specific isotopic and sterol fingerprints of a sample will allow us to identify and track nutrient sources.

Finally, our team is using geochemical techniques to track the amount of pollutants in the sediment records of lakes near mink farms. There is concern that fur farm byproducts might contain other pollutants, including mercury, heavy metals, and persistent organic pollutants (POPs), because captive mink are often fed fish from marine systems. In a process known as biomagnification, the concentration of pollutants increases at every trophic level within a food web. If plankton have low levels of the contaminant, small fish that eat the plankton would have much higher concentrations of a contaminant as they must consume large amounts of plankton to survive. Depending on the chemical and the organism involved, contaminants may be excreted in the feces or urine, or may be retained in the tissues. Although pollutants may not be present at levels of concern in the environment, because mink eat fish-based feed, contaminant levels may transfer to such a degree that they accumulate in the environment. Given the volume of mink reared by the industry, contaminant levels could potentially increase in lakes that are receiving runoff of fur farm byproducts.

Figure 4. Microscope slides of a head capsule of a chironomid larvae, found in the sediments of our study lakes.

It takes a village

These data, collected by both citizen and academic scientists, will provide a more complete picture of environmental change in lakes that are potentially impacted by many different stressors. However, it's no easy task to accomplish a project that involves so many different collaborators, and especially when addressing a potentially contentious issue. There are two important factors that will make this project a success: communication and the leveraging of different skill sets. Communication is key in this challenge, because we are scientists living hundreds of miles from each other and from the study sites, and we are synchronizing information that comes from different scientific disciplines. Further, everyone involved has a specific expertise and perspective to contribute. From the beginning, community concerns have played a crucial role in igniting this research and describing the limnological context of the situation. On the other hand, the institutional backdrop of academia provides unique resources to conduct these studies in a way that can be peer reviewed by the scientific community.

The fur farming industry in NS is declining due to decreased global demand and other challenges. However, nutrients accumulate at the bottom of lakes and can be recycled in the ecosystem for centuries (Søndergaard et al. 2003). It is important to understand the extent that nutrients were released or continue to be released from mink farms. Our data will track whether and how lakes have shifted from their baselines, and therefore which management strategies are the most feasible. Regardless of our final conclusions, it is clear industries that have the potential to pollute ecosystems should be provided with effective preventative regulations, as well as the resources to fulfill those regulations. Regular monitoring of lake ecosystems can help avoid pollution issues before they become unmanageable.

If you are noticing water quality issues, or any environmental degradation near your home or in outdoors places that you frequent, don't stand by! Take pictures, record the date, and take notes. Get in contact with local environmental organizations or your local government. It is our duty to take care of aquatic environments. It might just be the citizen scientist in you that will result in scientifically-informed policies for environmental protection.

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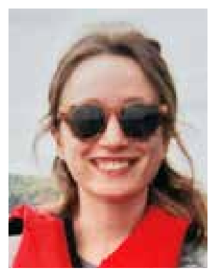
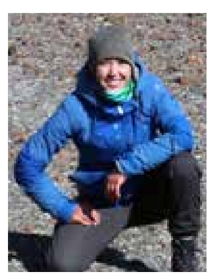
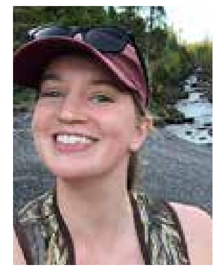


Nell Libera is a Ph.D. candidate in biology at Queen's University, Ontario, Canada, under the supervision of Dr. John Smol at the Paleoecological Environmental Assessment and Research Laboratory (PEARL). Her research has included using paleolimnology to reconstruct environmental change in lakes in Nova Scotia, as well as lakes near the tar sands of Alberta. Nell is particularly interested in how scientific evidence is implemented in policy decisions. She can be reached at Nell.libera@queensu.ca.



Jennifer Kissinger is a Ph.D. student at the University of Ottawa Department of Biology, Center for Advanced Center in Environmental Genomics (CAREG), under the supervision of Dr. Jules Blais. In a previous life she served as a forensic medicolegal death investigator in the USA as well as a researcher in the R&I departments of private companies dedicated to finding novel solutions to slow burn issues. Her research is focused on reconstructing human inputs to the environment through paleolimnological methods. By utilizing molecular techniques, chemical fossils such as isotopes, sterol biomarkers, and sedimentary ancient DNA we can create a unique 'fingerprint' of nutrient inputs to the environment over time making it possible to discern human from other sources, such as animal or industrial, for hundreds of years to centuries. These methods can be applied to investigations of taphonomy, archaeology, and water pollution assessments. Jennifer is especially interested in citizen science and making citizens partners in the research process. She can be reached at Jennifer.kissinger@uottawa.ca



Julia Campbell is an M.Sc. candidate in biology at Mount Allison University, New Brunswick, Canada. She is carrying out her research at the Environmental Change and Aquatic Biomonitoring Lab (ECAB) under the supervision of Dr. Joshua Kurek. Her research uses insect remains in lake sediments to reconstruct environmental change in Nova Scotian lakes. Julia is interested in how citizen scientists and monitoring groups can work together to address water quality concerns. She can be reached at jmcampbell2@mta.ca.

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