Calcium in Ontario's Inland Lakes

Calcium is a nutrient that is required by all living organisms. For example, water fleas (*Daphnia*, Figure 1), which are tiny organisms called zooplankton, are very sensitive to declining calcium levels. *Daphnia* use calcium in the water to form their calcium-rich body coverings when they moult.

Figure 1. Image of a calcium-rich Daphnia (Photo credit: Dr. Derek J. Taylor)

Recent experiments have shown that the reproduction of most *Daphnia* species is jeopardized at lake calcium concentrations below 1.5 mg/L. There are many other aquatic animals that need calcium, such as mollusks, clams, amphipods, and crayfish. Calcium concentrations of 0.5 mg/L and between 1-2.5 mg/L are the survival thresholds for daphniids and crayfish, respectively. However, these results are based on laboratory experiments; in nature, where organisms must cope with multiple stressors, limiting calcium concentrations could be higher.

Based on a dataset of 770 lakes in Ontario, approximately 35% currently have calcium levels below 1.5 mg/L. Many lakes on the Precambrian Shield in Ontario are nearing or have recently crossed this important threshold.

Ecosystem Disturbances & Lake Calcium Decline

Under natural conditions (i.e., without human influence), calcium levels in soils are governed by inputs from mineral weathering of rocks and atmospheric deposition of calcium-rich dust, and losses through uptake by growing forests, and leaching to lakes and rivers (Figure 2a).

The two main human causes of calcium decline in soils, and thus in lakes, are acidic deposition ("acid rain") and forest harvesting, which are described on page 2.

Acid Rain

The majority of Ontario's lakes are located in the Precambrian Shield region where the bedrock is very hard and resistant to weathering. This is why most Ontario lakes have soft waters that are low in calcium. These low calcium concentrations can make lakes vulnerable to acid rain because they are less able to neutralize or 'buffer' incoming acids.

In the early days of acid rain (early to mid-1900s), calcium was leached from watershed soils into lakes faster than it could be replenished through weathering or deposition from the atmosphere (e.g., dust). This accelerated leaching of calcium from watershed soils likely led to a period of increased calcium levels in some lakes (Figure 2b).

In recent years, acid deposition rates have fallen, and rain is 50% less acidic now than it was in the 1980s. This means that less calcium is being leached from watershed soils into lakes. In addition, with no or very slow replenishment of calcium to watershed soils, the available pool of calcium has slowly decreased in size. This has resulted in noticeable declines in calcium concentrations in lakes and streams (Figure 2c).

Forest Harvesting

Acid rain is not the only stressor affecting calcium levels in Ontario's Precambrian Shield lakes. As mentioned previously, forest growth is one way in which calcium is removed from watershed soils. The removal of timber, and the re-growth of forests following timber harvesting, can further diminish the supply of calcium in soils that is available for export to lakes (Figure 2c).

Climate Change

Calcium decline is likely exacerbated by climate change. A recent study examined 29 years of calcium data from three intensively-studied lakes in south-central Ontario and found that calcium decline has worsened with recent warming. Climate change in this region has led to decreased water flow, resulting in less calcium being exported from watersheds to lakes.

How is the Ministry of the Environment and Climate Change monitoring calcium in Ontario?

Scientists at the Ministry of the Environment and Climate Change's Dorset Environmental Science Centre (DESC) have been monitoring calcium levels in south-central Ontario lakes and streams since 1976. They have found that calcium concentrations have declined significantly over the period of record in their long-term study lakes.

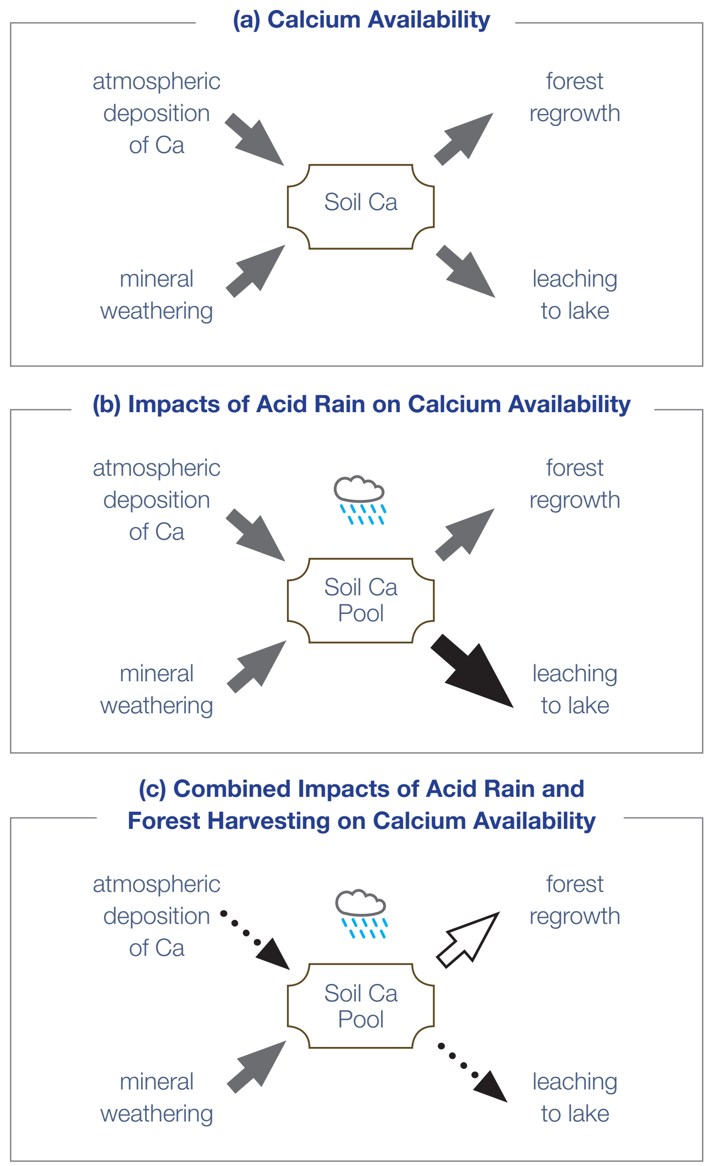
Calcium concentrations have been measured from water samples collected by the Ministry's Lake Partner Program volunteers since 2008.

The DESC is also involved with monitoring lakes for water chemistry (including calcium) throughout the province as part of the Broad-scale Monitoring Program, a collaborative monitoring program with the Ministry of Natural Resources and Forestry.

What can we do to reduce the potential impacts of calcium decline?

Calcium in soils is normally replaced by the weathering of bedrock, which is a slow process. Long-term, sustainable solutions to address calcium decline have yet to be developed. Here are some examples of what we can do to reduce the potential impacts of calcium decline:

1. Support the government's efforts to reduce SO2 and NOX emissions to reduce acid deposition rates;
2. Work with the Ministry of Natural Resources and Forestry to consider soil nutrients, especially calcium status, when they set logging quotas;
3. Join Ontario's Lake Partner Program to help monitor Ontario's lakes. You can visit **www.ontario.ca/lakepartner** or **www.desc.ca** for more information.



Modified from Smol J.P., 2010. Freshwater Biology 55:43-59

Figure 2. (a) Ca availability prior to human influence. In this undisturbed ecosystem, calcium concentrations remained relatively stable because calcium outputs were balanced by inputs. Specifically, mineral weathering of rocks and atmospheric deposition of calcium-rich dust were the main sources of calcium to soils. The major outputs were forest re-growth and the leaching of calcium to lakes and rivers;

(b) The impacts of acid rain on calcium availability. During the early stages of acidic rain (early to mid-twentieth century), the leaching of calcium from watershed soils was accelerated, and the calcium available in soils decreased over time; and

(c) The combined effects of acid rain and forest harvesting on calcium availability. Eventually, with continued acid rain, the pool of available calcium in watershed soils was diminished to the point that calcium leaching was greatly reduced. In addition, other disturbances, such as forest harvesting, caused additional loss of calcium from the ecosystem. Following harvesting, forest regrowth removed more calcium from the soil.