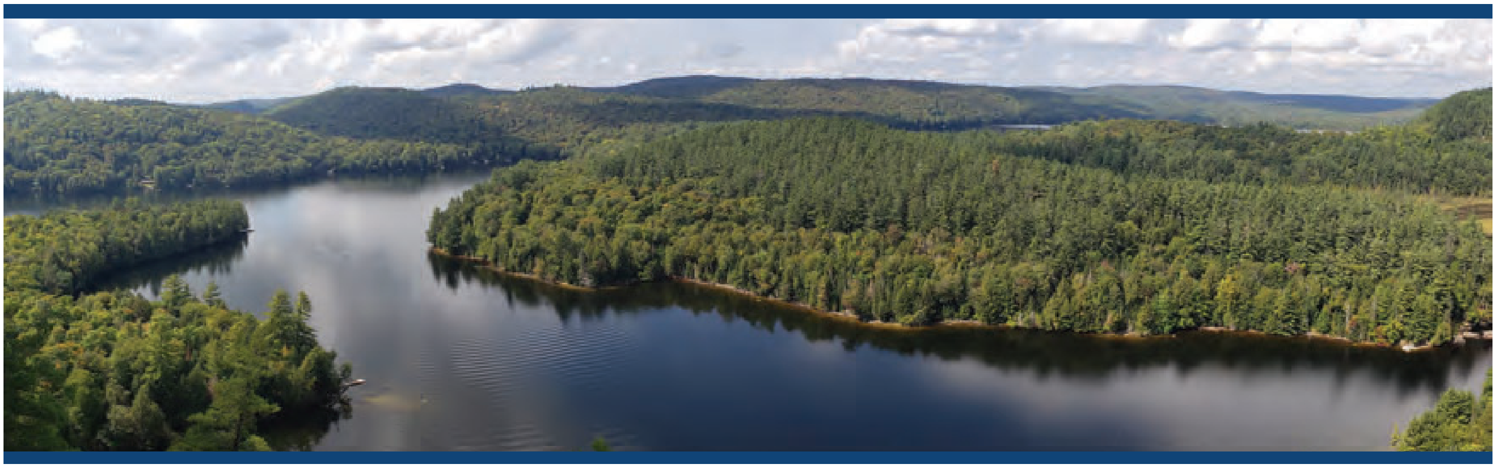
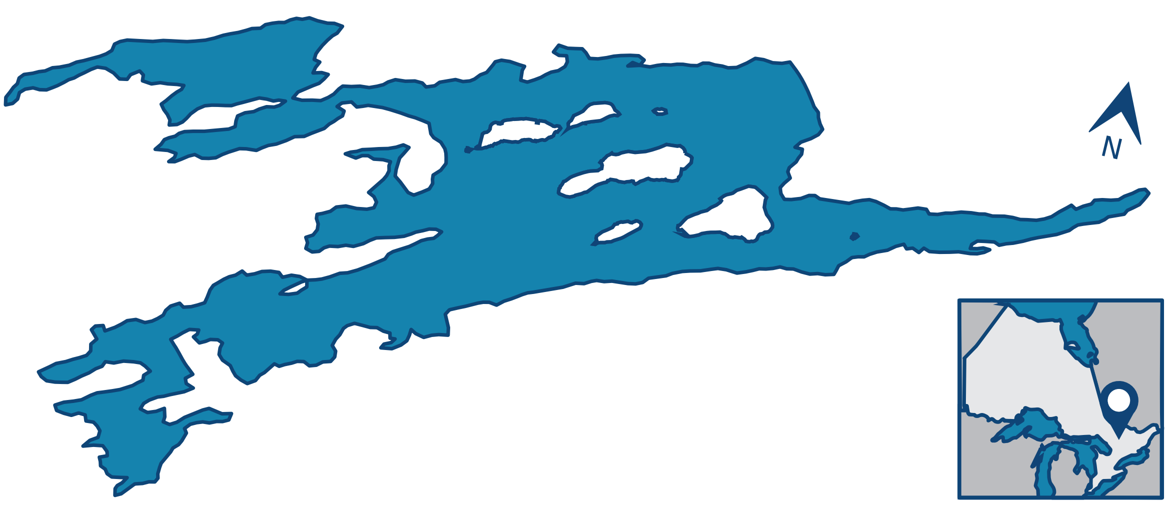


Photo courtesy of Adam Pifko

Calcium Decline, Impacts, and Potential Mitigation Efforts in Kawagama Lake

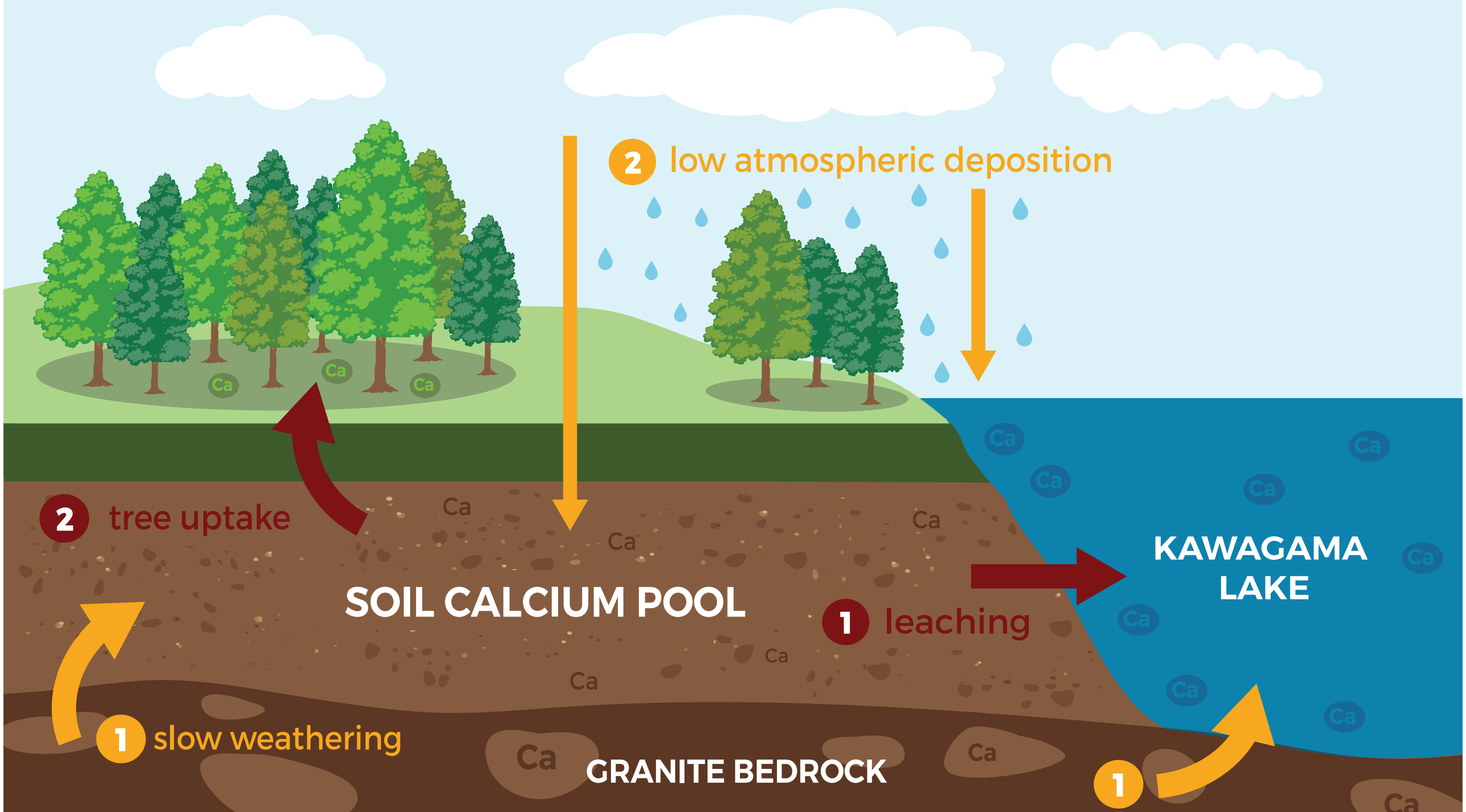
Overview

Calcium is an essential nutrient vital for physiological and structural processes of living species[1]. Within the past decade, calcium decline has emerged as a stressor for softwater lakes across North America and Europe. Calcium decline is a legacy of long-term acid deposition and can be further exacerbated by timber harvesting and subsequent forest regrowth[1]. Adverse ecological impacts of calcium loss such as extirpation of calcium-rich keystone species, dominance of calcium-poor competitors, food web changes, and increased algal blooms have been reported[2]. Potential mitigation strategies include catchment-based forest management plans, use of wood ash and lime in forests, application of dust suppressants and in-stream liming. This booklet describes the calcium status in Kawagama Lake in Ontario, Canada, and discusses potential biological impacts and mitigation efforts.



Where Does Calcium in Lakes Come From?

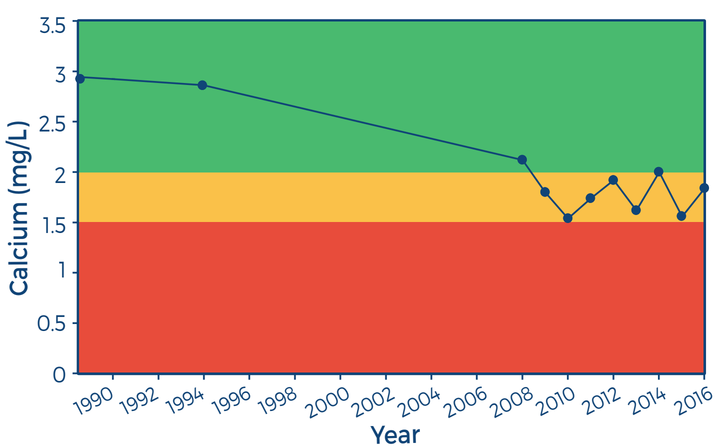
In an undisturbed ecosystem, calcium outputs are balanced by inputs in the calcium cycle. Lake calcium is controlled by the amount of calcium available in soils and how rapidly it is leached from and replenished in the soil[1]. → Ca inputs → Ca outputs



Kawagama Lake has naturally low calcium levels because it is located on the Pre-Cambrian Shield, a geological region characterized by weather-resistant bedrock and shallow, low-calcium soils[3].

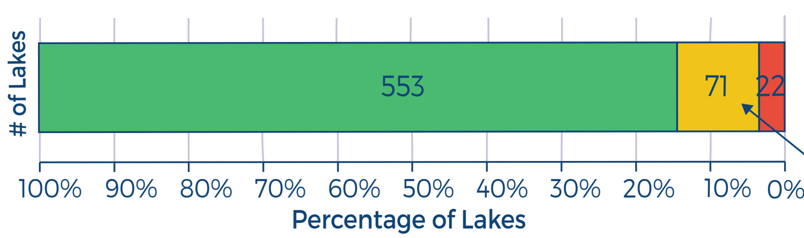
Calcium Levels of Kawagama Lake from 1990 to 2016

Normal (> 2.0 mg/L) Vulnerable (1.5 – 2.0 mg/L) Stressed (< 1.5 mg/L)



Calcium concentrations in Kawagama Lake have been in decline since the 1990s[4]. Currently, the average concentration of 1.80 mg/L falls wthin the vulnerable category for calcium biosensitive biota[2].

This suggests a need for close monitoring and potential mitigation action, as severe effects on keystone aquatic species have been observed in lakes with concentrations below the critical level range of 1.5–2.0 mg/L[2].



Status of Calcium Levels in Ontario's Inland Lakes[4]

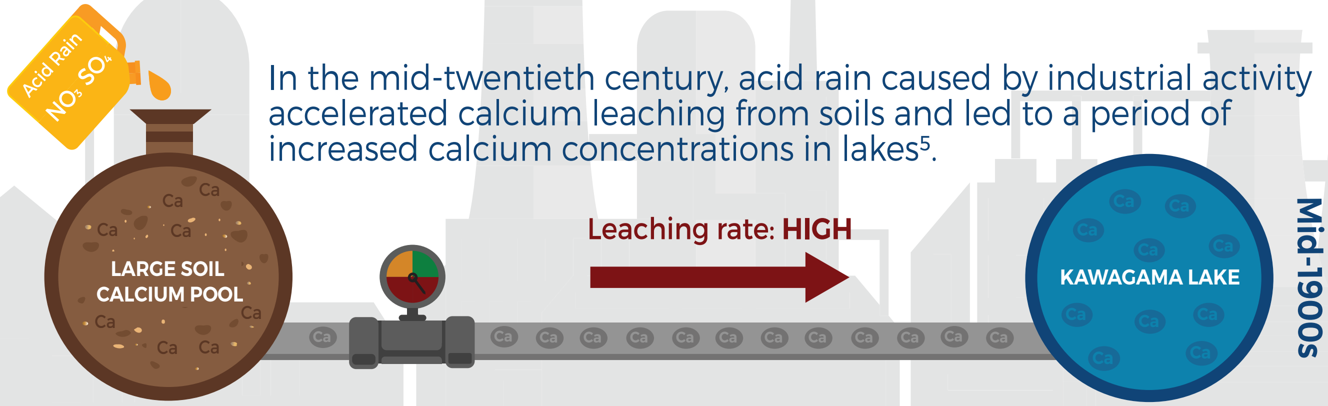
Kawagama Lake

Causes of Calcium Decline

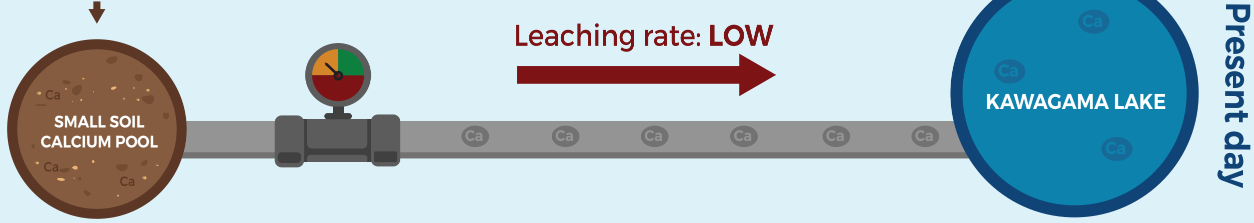
The main mechanisms attributed to the depletion of calcium from soil pools and changes in lake calcium concentrations are elevated rates of calcium leaching caused by decades of acidic deposition combined with forest harvesting and the subsequent re-growth of forests[1].

Reason #1: Acid Rain

In the mid-twentieth century, acid rain caused by industrial activity accelerated calcium leaching from soils and led to a period of increased calcium concentrations in lakes[5].

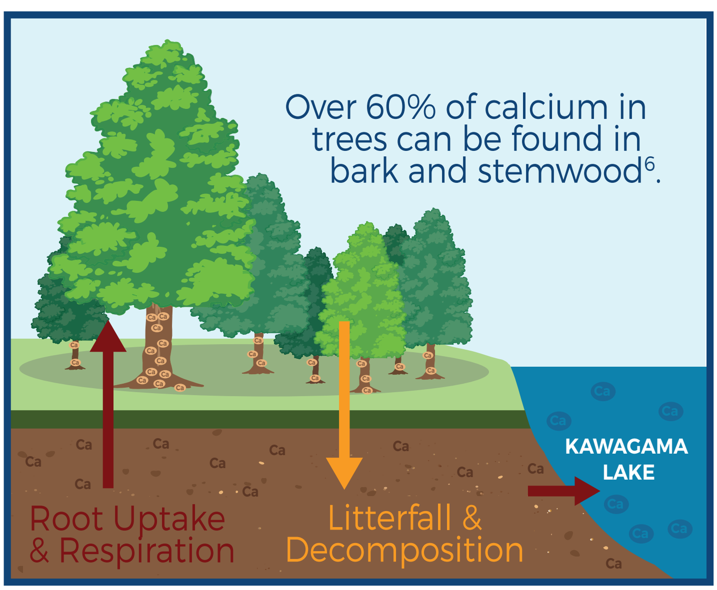


Over time, the pool of available calcium in the soil was depleted, as the leaching rate exceeded the low calcium replenishment rate from bedrock[5].

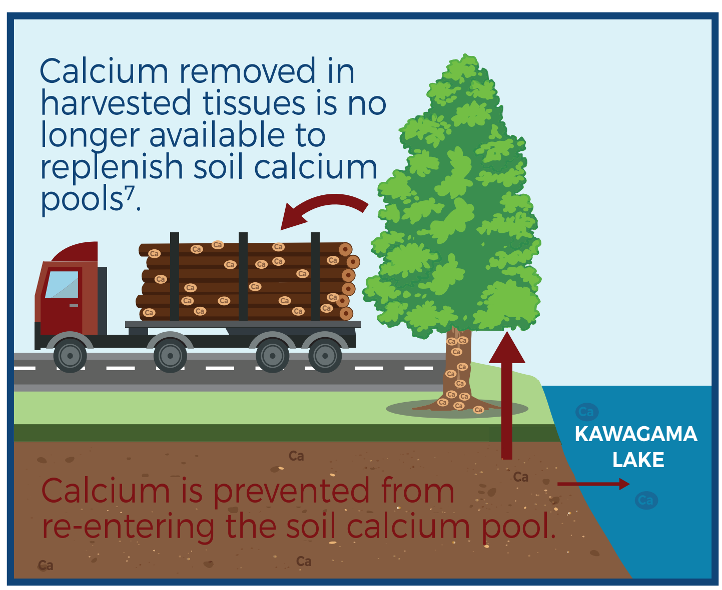


Air pollution policies since the 1970s have successfully decreased acid rain, therefore, even less calcium was leached from residual soil calcium pools, which contributes to observed calcium declines in the lake[5].

Reason #2: Tree Harvesting



No Harvesting Scenario:
Size of soil calcium pool and lake calcium remain the same.



Harvesting Scenario:
Soil calcium pool shrinks over time, thus less calcium is available for leaching into the lake and as a result, lakewater calcium declines.

Why is Calcium Important?

Calcium is an essential nutrient required in large quantities by terrestrial and aquatic biota[2]. Species vary in their calcium requirements, and as calcium concentrations decrease, species such as sugar maple and crayfish can become unhealthy and die. In the past, calcium concentrations have been higher and have maintained species diversity in both terrestrial and aquatic environments. Further declines of calcium can affect components within the ecosystem.

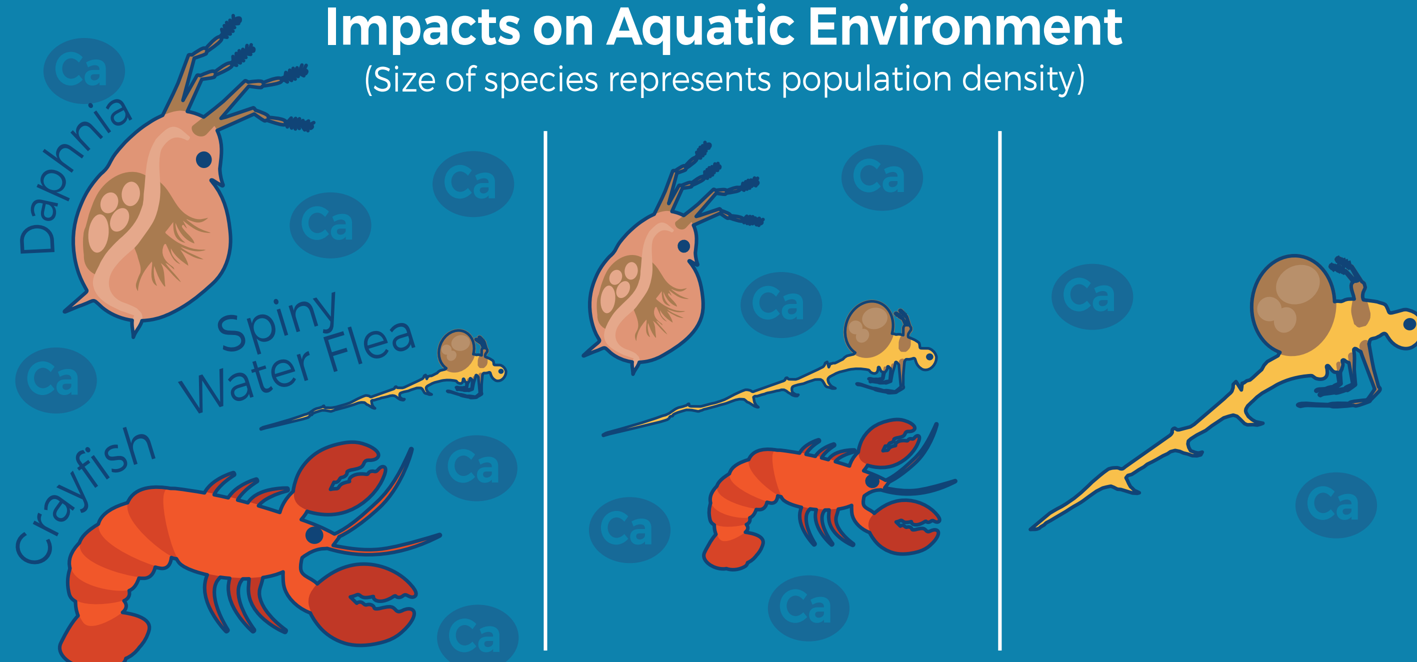
Impacts on Terrestrial Environment

As calcium concentrations decrease, sugar maple trees experience slower growth and become more vulnerable to pathogens and drought events, and eventually suffer from declining overall health[8]. Sugar maples will be replaced by lower calcium demand species such as the American beech.

As calcium declines over time

Impacts on Aquatic Environment

(Size of species represents population density)



As calcium concentrations fall, calcium-rich species such as crayfish and Daphnia begin to struggle to establish and thrive, whereas the invasive species known as the spiny waterflea will successfully establish as its population density will increase with the lack of calcium present[9].

Potential Mitigation Efforts

Below are four mitigation strategies that have the potential to increase calcium concentrations in Kawagama Lake.

1. Catchment-based forest management

Catchment based forest management plans are longer term efforts, typically twenty year plans in the Muskoka River Watershed[9]. Leaving the bark, branches, and foliage on site help minimise soil calcium loss as the bark is calcium rich, while the foliage and branches are generally not of great use to industries. This would help retain calcium in the catchment and facilitate overall calcium replenishment[9].

Photo courtesy of Adam Pifko

2. Supplementing calcium in the watershed

i) Wood ash and/or lime application

Wood ash and lime application have been found to improve soil calcium concentrations when 4-8 metric tonnes of wood ash or lime are applied after harvesting[9]. Application at riparian zones may assist in increasing lake calcium concentrations due to greater calcium transfer from the soil to the lake aided by hydrological connectivity.

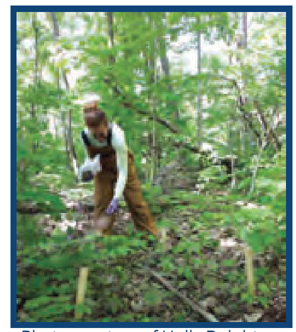


Photo courtesy of Holly Deighton

ii) Dust suppressant application

Dust suppressant application on unpaved roads in the forest near the lakeshore occurs several times over the summer months. While this has been a primary method for slowing the process of calcium loss, some lakes have experienced an increase in calcium concentrations over a short period of time[10].

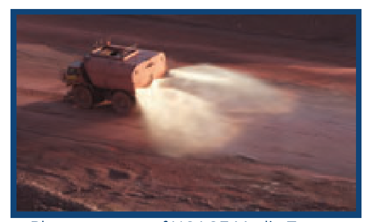


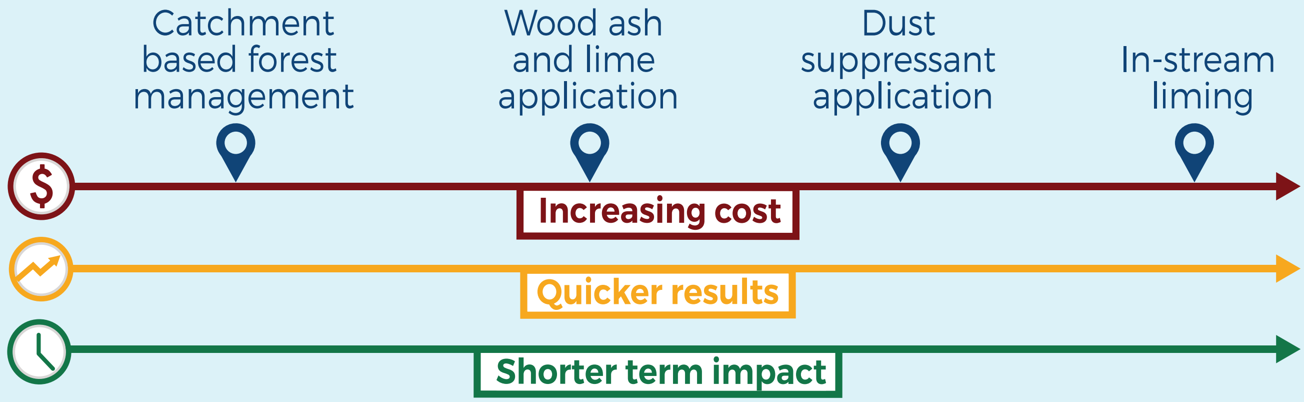
Photo courtesy of NGAGE Media Zone

iii) In-stream liming

Direct addition of lime to the stream or lake will result in the rapid increase of calcium concentrations in surface waters. Although it is the most expensive form of mitigation, in-stream liming can be used for short-term recovery of lakes with critically low calcium concentrations (e.g. Sudbury lakes) to potentially prevent short-term loss of species[11].

Photo courtesy of Rickard Gillberg

Comparison of Methods



Conclusion

Calcium concentrations are falling in Kawagama Lake and other waterbodies in the surrounding watershed. It is important to understand both the background of calcium decline and the interactions between aquatic and terrestrial environments before selecting a method for mitigation.

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In the order from left to right: Roshelle Chan, Ankit Tripathi, and Marissa Pucci

Acknowledgements

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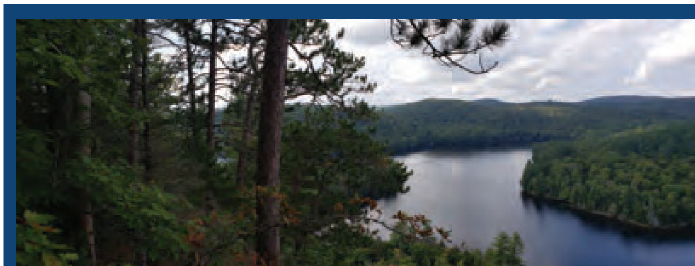

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