A Review of the Emergent Issue of Calcium Deficiency in Algonquin Park

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Introduction

Algonquin Park is the only provincial park where logging is permitted. These logging practices have been identified as a potential concern in regards to calcium deficiency. The purpose of this review is to develop a better understanding of the factors that lead to calcium deficiency and their influence on the Algonquin ecosystem.

Objectives

The purpose of this literature review is to establish the processes by which calcium deficiency occurs, to explore the mechanisms that govern these processes, and finally to develop a better understanding of how the ecosystems of Algonquin Park can be affected. The objectives of this review are the following:

- To examine the processes by which acid rain contributes to Ca deficiency and reduction of soil buffering capacity
- To investigate the physical mechanisms by which Ca is retained and transported through the soil medium
- To develop an understanding of the impact Ca has on forest ecosystems
- To evaluate the effect Ca can have on aquatic systems

Park Ecology & Soils

The mineral content of Algonquin's soils is derived from Ca-poor bedrock and glacial till with a poor buffering capacity, which has lead to Ca leaching and is the primary reason for Ca deficiency in the soil.

Western Algonquin

- The hardwood/hemlock-dominated moist granitic soils of western Algonquin mainly experience Ca deficiency due to leaching from high rainfall and Ca uptake by hardwood tree species

Eastern Algonquin

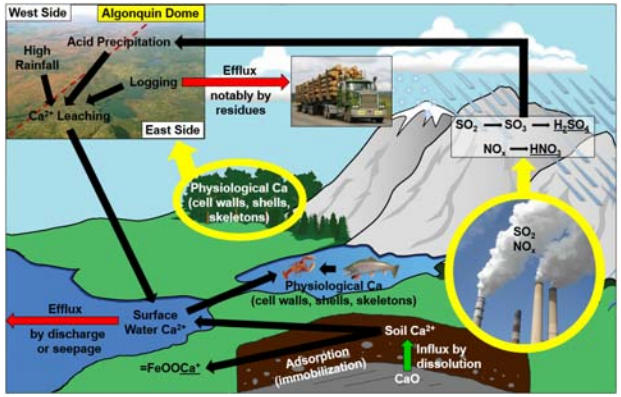
- The pine/poplar-dominated dry sandy soils of eastern Algonquin mainly experience Ca deficiency due to acid deposition and removal of logging residues, which has negative consequences for the health of poplar trees and unpredictable impacts on other soil nutrients

Acid Deposition

- Due to northwesterly winds, pollutants from the Inco Superstack in Sudbury, ON are blown over Algonquin Provincial Park
- Precipitation washes pollutants out of the air, leading to the formation and deposition of sulfuric acid mist (H_2SO_4) from SO_2 and nitric acid (HNO_3) from NO_2

Acidic Mist (H_2SO_4 and HNO_3) → Ca leaching, Al mobilization, N saturation, nutrient stripping of leaves

Calcium Flows



Final Remarks

While the analysis we conducted has been comprehensive in terms of the literature, further research focusing specifically on Algonquin Park will be necessary to fully understand the effect of calcium deficiency on the ecosystem. Although there are no direct studies looking at calcium deficiency for the Park's soils, the inherently low Ca content in parent soils compounded with the high amounts of leaching and tree uptake exacerbate susceptibility. Ca retention in Algonquin Park is likely poor due to lack of clay constituents. Any Ca that is retained could be held too strongly to be biologically active. Forest and aquatic ecosystems are becoming increasingly sensitive to acid deposition. The consequences for park ecology are potentially reversible. Natural recovery is very slow, but alternatives such as liming are available to speed up the process.

Calcium Retention and Mobility

The main mechanisms of Ca retention within soils come from the permanently charged surface sites of phyllosilicate clay minerals, the variable edge charge sites of clays and oxide/(oxy)hydroxide minerals, and the soil organic matter.

- Cation exchange with clay particles is the most significant mechanism for Ca retention; unfortunately, the soils of Algonquin Park have very little clay content
- The Ca complexes formed with the edge sites are strongly held and are not readily available to plant life

$$=FeOO^- + Ca^{2+} \longleftrightarrow =FeOOCa^+$$

Calcium Physiology & Forest Systems

Calcium is important in many physiological processes affecting the cell wall, lignin content, wood fiber, vessel size, and wood increment of trees, which leads to changes in mechanical properties.

- Whole-tree harvesting leads to greater soil calcium deficiency than stem only harvesting
- Whole-tree harvesting leads to increased potential for leaching; this is the most significant mechanism contributing to calcium deficiency
- Leached calcium can come from the underlying soil or from residual logging debris
- The soil turnover caused by logging machinery also encourages the leaching of calcium from soil horizons
- The lack of calcium input in the form of litterfall as a result of fewer trees after harvesting exacerbates the calcium leaching scenario

Calcium & Aquatic Systems

85% of lakes in the Muskoka region are either deficient or severely deficient in calcium. This affects the ecology of the lakes in various ways:

- Mussels exhibit negative growth at concentrations less than 8.5 mg/L
- Daphnia abundance decreases and populations shift from deficiency intolerant to tolerant species
- Taxa richness of macroinvertebrates in general decreases
- Fish require Ca, but since they mainly attain it through their diet they are not directly threatened by Ca deficiency
- However, trophic cascades mean that macroinvertebrate losses impact overall ecology, including the health of fish species

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"Algonquin Dome" photograph taken by Mike Wilton

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