Using a Suite of Biochemical Indicators to Evaluate the Impacts of Harvest Intensity on Black Spruce Seedling Foliar Nutrition

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Study Objectives

With a renewed and fast growing interest in using forest woody biomass for energy production, concerns regarding nutrient loss and impacts to soil quality have also been heightened. In this context, the objectives of the current study were: 1) to document changes occurring to components of the soil N pool resulting from different biomass harvest intensities conducted in black spruce-dominated site types, and 2) to determine if any of the detected changes in soil N indices are correlated to patterns in planted seedling foliar nutrition.

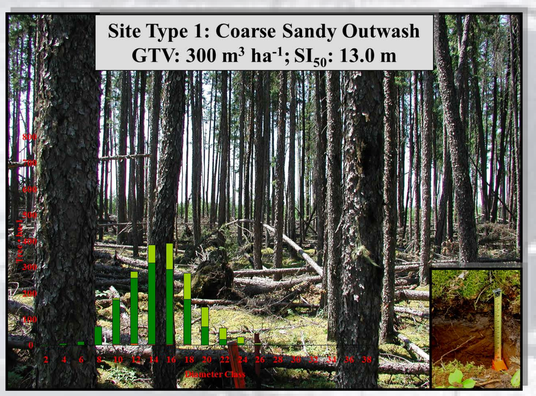
Specific questions addressed include:

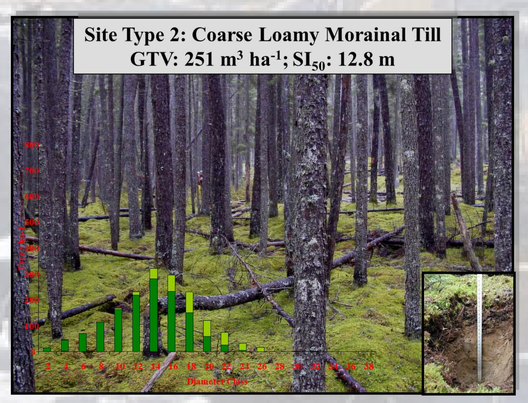
1. Does the level of biomass removal result in lower indices of available N?
2. Are these patterns consistent across diverse site types?
3. Are these soil N reductions correlated to planted seedling foliar nutrition?

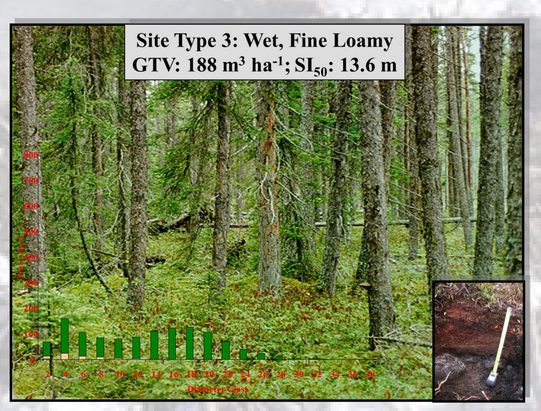
Materials and Methods

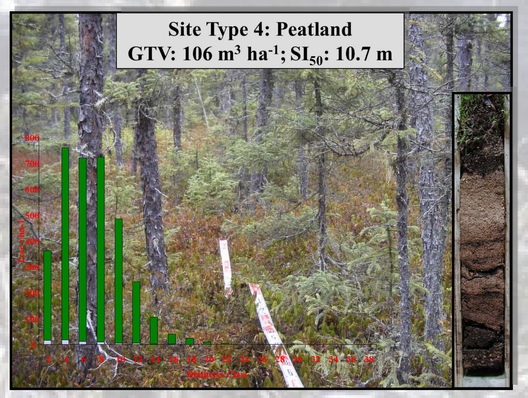
Study Site Descriptions:

The nine study sites selected for this project represent replicate conditions for four discrete vegetative communities commonly occurring along a topographic sequence in northwestern Ontario.









Experimental Harvest Treatments:

In 1994/5, experimental harvests were conducted consisting of 5 replicated treatments: uncut reference state condition, stem only (SO) - coarse and fine slash left on the plots, chipped (CH) - all chipper debris returned to the plot, full-tree (FT) - fine slash removed to roadside, full-tree + blading (FTB) - complete removal of logging debris and upper organic soil layer.

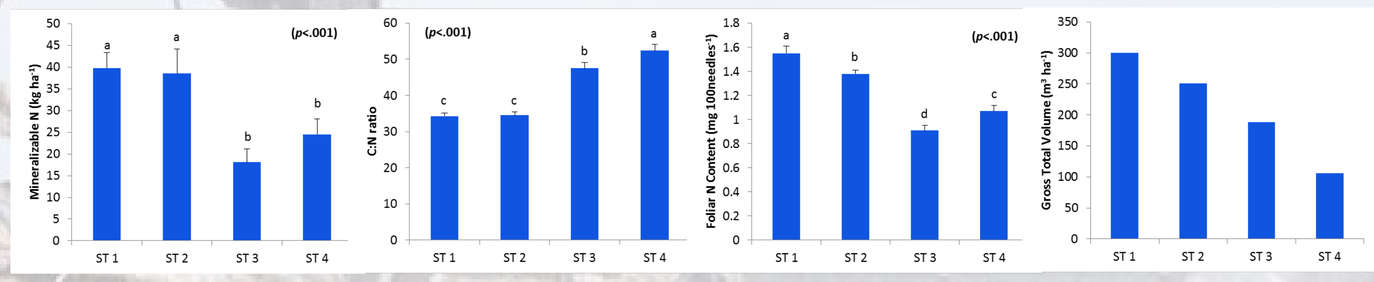
Sampling Design and Procedures:

In the fall of 2005 (10 years since harvest), soil samples were collected from the forest humus layer and upper B horizon (10-15 cm) from 4 locations per plot across all sites and treatment combinations (540 sampling locations). Chemical determinations included: TC (dry combustion), TKN (semimicroKjeldahl digestion), DOC and TSN (K_2SO_4 fresh extraction), microbial biomass C and N (chloroform fumigation-extraction), and mineralizable N (14-day anaerobic incubation / KCl extraction). In addition, current foliage was clipped from the upper ⅓ of the crown on 3 planted black spruce trees located in close proximity to the soil sampling pits (960 seedlings in total). Foliar N indices included N concentration, N content per 100 needles, and, using locally-derived small tree allometric equations, N uptake by current foliage.

Results

Linking Site Productivity to N indices:

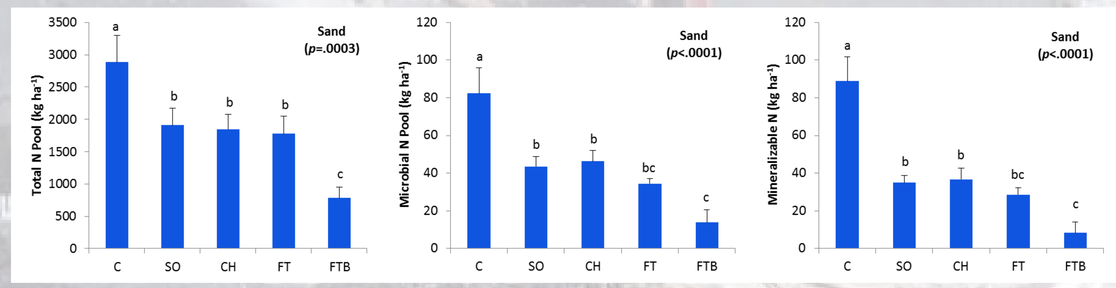
- High soil mineralizable N pool, low C:N ratios, and higher foliar N content corresponded to the higher productivity, upland sites.



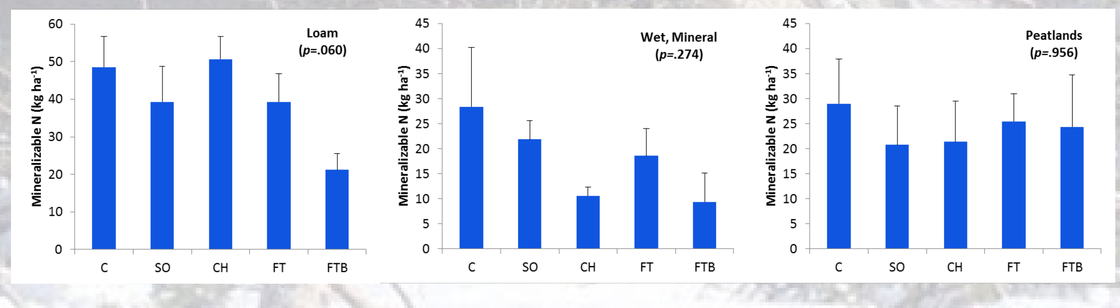
- Other N indices, such as total soil N and microbial N were not indicative of site productivity and tended to be higher on the wetter, lowland sites due to the build up of organic matter.

N Availability Response to Harvest Treatments:

- The site types responded differently to the harvest treatments, with infertile sandy outwashes being most susceptible to N losses resulting from increased biomass removals.

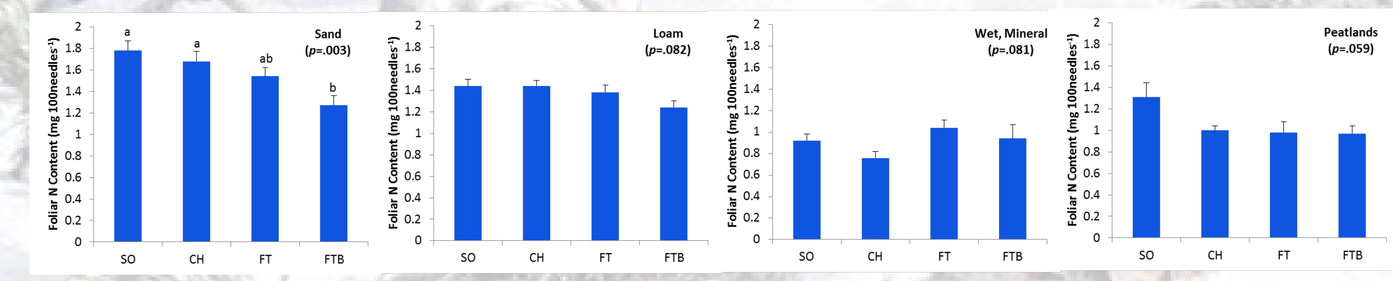


- There were not, however, any significant differences between the operational stem only (SO) and full tree (FT) harvesting methods.
- The more fertile, loamy sites and lowland sites appear to be less sensitive than the outwash sandy sites to biomass removals.

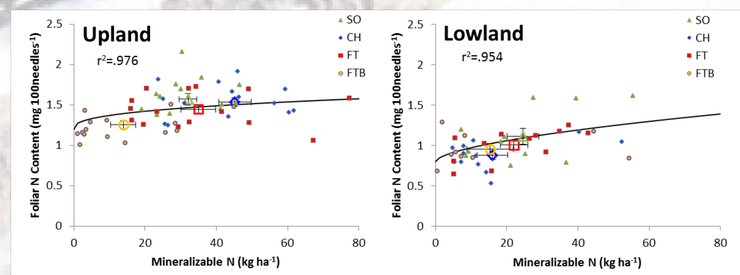


Foliar N Content in Response to Harvest Treatment:

- Similar to the declines in available soil N, foliar N content declined significantly along the biomass removal gradient on the infertile, sandy sites.



- Although not significant, a similar pattern was observed on the loamy sites suggesting a possible response delay on these more buffered sites.
- There is a clear positive relationship between the mineralizable N pool and foliar N content.
- Foliar N content tended to be higher on the upland sites compared to the lowland sites across the range of mineralizable N pools (0 – 80 kg ha^{-1}), suggesting higher *in situ* organic matter turnover rates and root-available N pools.



Conclusions

- Both the available soil N and seedling foliar N indicators were strongly influenced by site type, corresponding to pre-harvest productivity levels.
- There were no significant differences between the operational SO versus FT harvest removal treatments.
- Mineralizable N (14-day anaerobic incubation) is an easily applied technique that should be considered as a valuable indicator in effects and effectiveness monitoring programs designed to evaluate the sustainability of emerging new biomass harvesting alternatives.