# Interactions between pre-commercial thinning, geological deposit, and climate in controlling black spruce productivity

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# Québec's boreal forests

- 30% managed for Québec's forestry industry
- $16 billion economic sector
- Black spruce: highly abundant, high quality wood fibers, and timber.


Figure 1. Bioclimatic zones of Canada. The largest zone, the boreal forest is highlighted in blue.

# Québec's boreal forests

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- $16 billion economic sector
- Black spruce: highly abundant, high quality wood fibers, and timber.

- Annual Allowable Cut as a forest management tool
- Site Quality Index as a correction factor

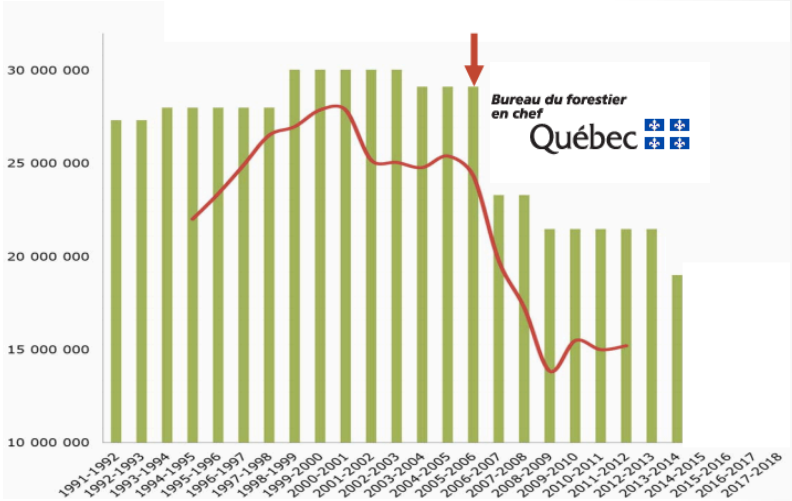



Figure 2. Projected Annual Allowable Cut as determined by BFEC From 1991 to 2014 (green) and actual harvest values

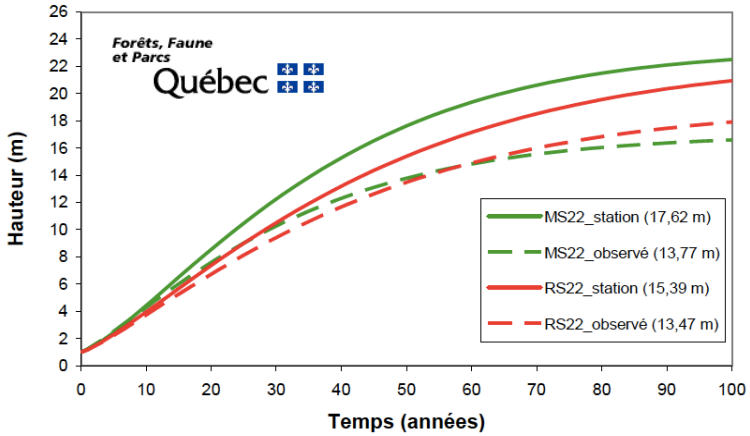



Figure 3. Estimated (solid line) and actual (dashed line) SQI based on measured height at a specific year for species in 2 ecological regions of Québec.

# Climate projections in Québec

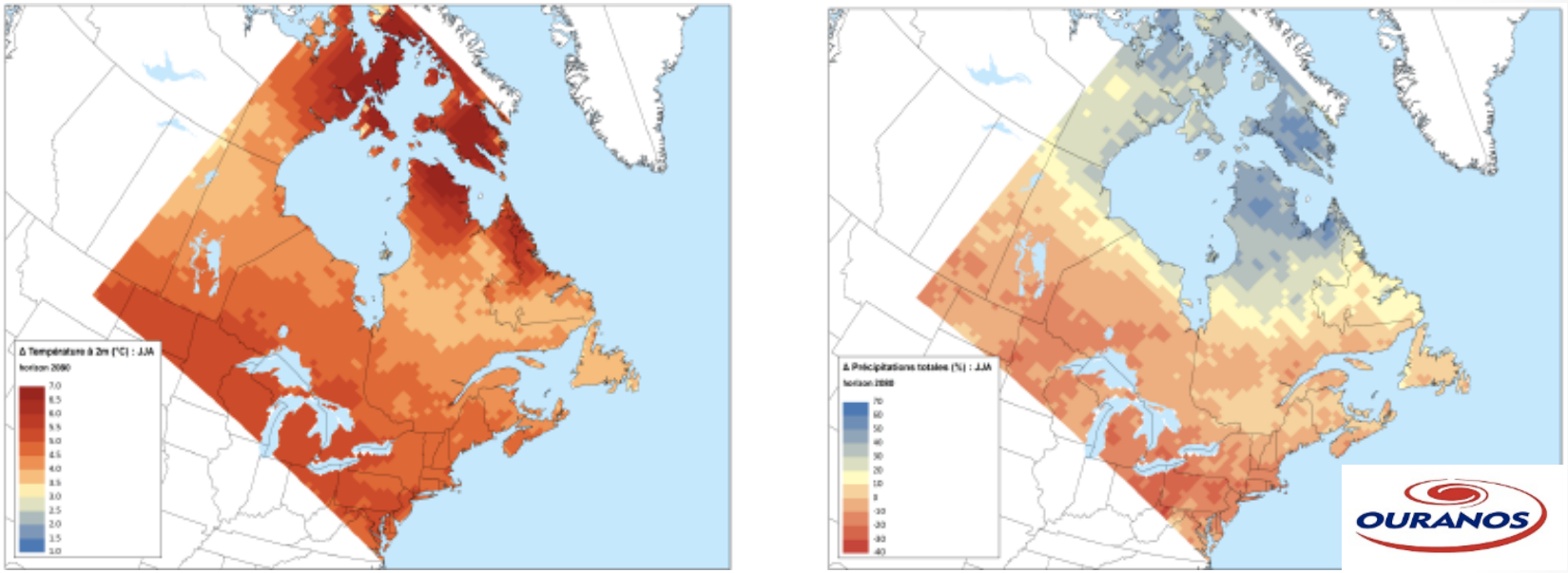



Figure 4. Projected mean changes in a) temperature and b) precipitation in Québec by the year 2080 (Ouranos, 2010).

- How will these forest management interact with global environmental change?

# Pre-commercial thinning (PCT)

- Reduces stand density to remove competitive vegetation and favour specific species composition

- Increase growth rate of residual black spruce stands
- Achieve similar merchantable wood volumes at lower stand density

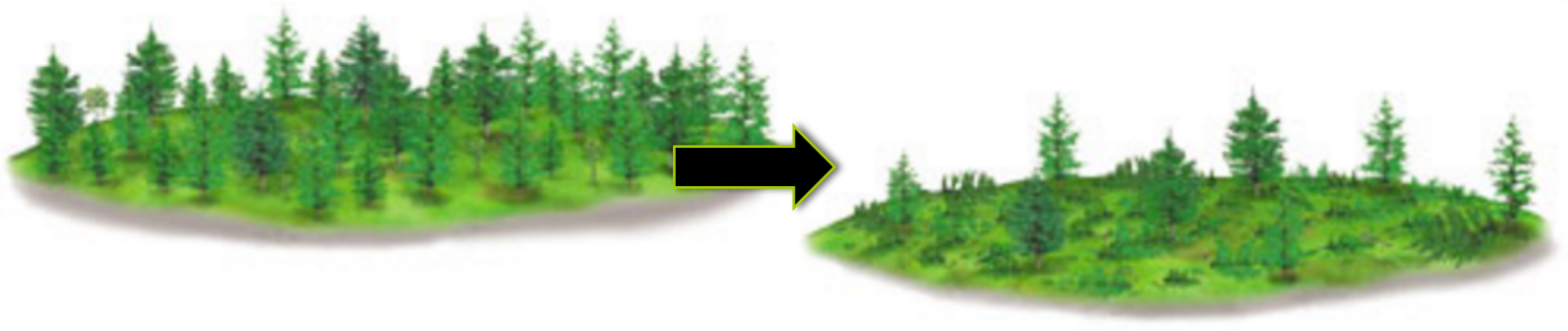
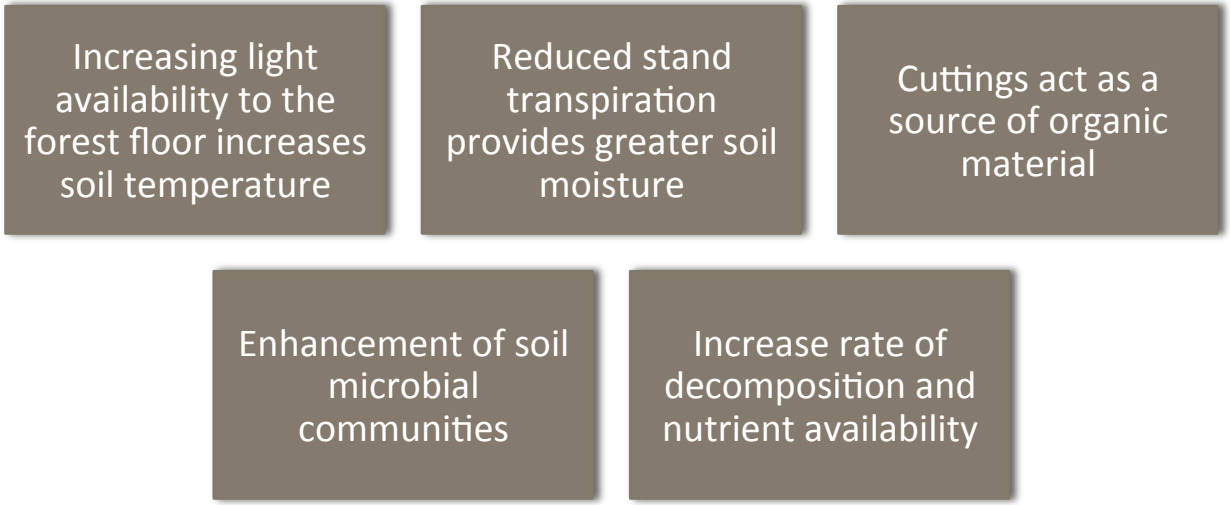


Figure 5. An illustration of stand density and structure before and after pre-commercial thinning (Source: mffp.gouv.qc.ca).

# Mechanisms of post-thinning productivity




- Biotic interactions also depend on soil and climate
- How will these interact with global environmental change?

# Research questions

*What are the interactions between pre-commercial thinning, geological deposit, and climate in controlling black spruce productivity?*

1. What are the interactions between PCT and geological deposit?
2. What are the interactions between PCT and climate?

3. Is post-thinning productivity due to an increase in soil fertility or the release of intraspecific competition?

# Q1. Interactions between PCT & geological deposit?

Clay vs. till soils within a warm/dry region

- Hypothesis 1: PCT stands on clay soils will have a greater relative effect compared to those on till soils.
    - Clay soils = greater soil fertility
    - Till soils = release of intraspecific competition

# Q2. Interactions between PCT & climate?

Cool/wet vs. warm/dry regions on till soils

- Hypothesis 2: PCT stands in warm/dry regions will have a greater relative effect compared to cool/wet regions.
    - Warm/dry region: greater soil fertility
    - Cool/wet region: release of intraspecific competition

# Experimental Design

**PCT plots with :**

- Minimum 50% black spruce
- Between 25 and 35 years old
- 3 drainage classes

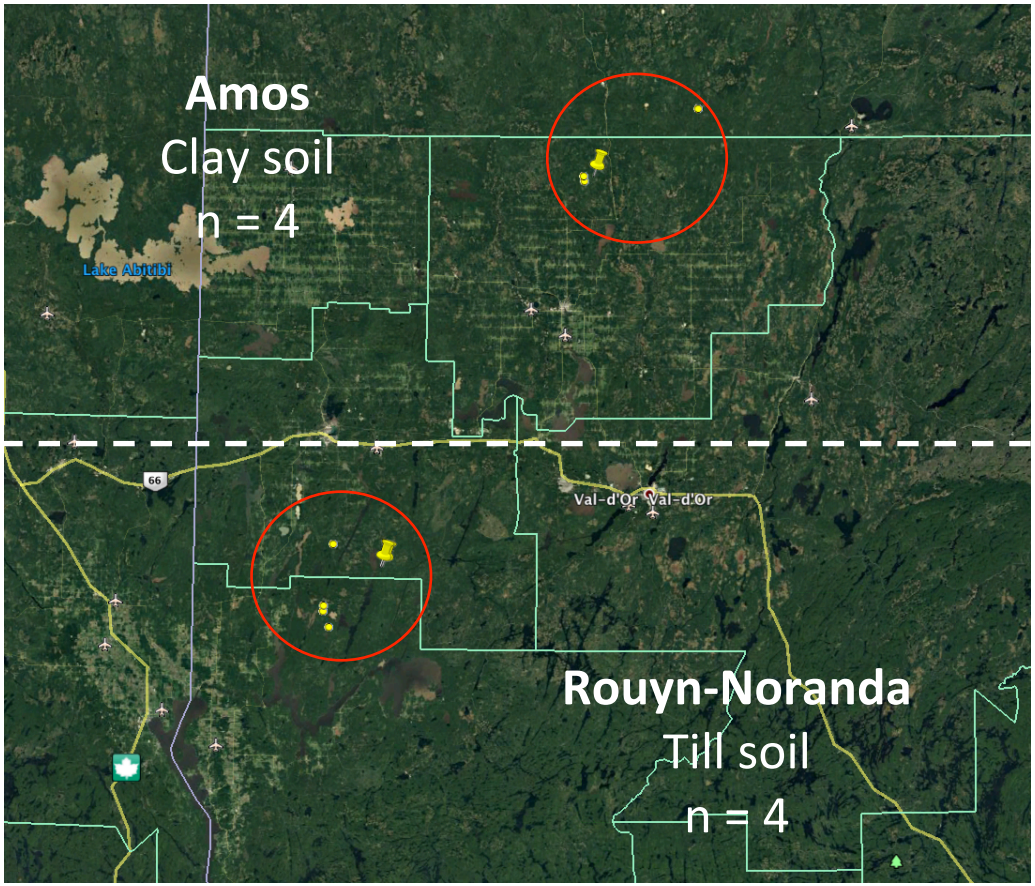
**Table 1.** Characteristics of two distinct climate regimes within the province of Québec

| | Abitibi (warm/dry) | Cote Nord (cool/wet) |
|---|---|---|
| Mean annual temperature | 2.5˚C | 0.0˚C |
| Mean annual precipitation | 950 mm | 1300 mm |
| Growing season length | 150 – 160 days | 140 days |
| Organic layer depth | 8 cm | 18 cm |

# Experimental Design

Figure 7. Location of PCT plots within Québec in each region (n=12 paired plots)

# Experimental Design



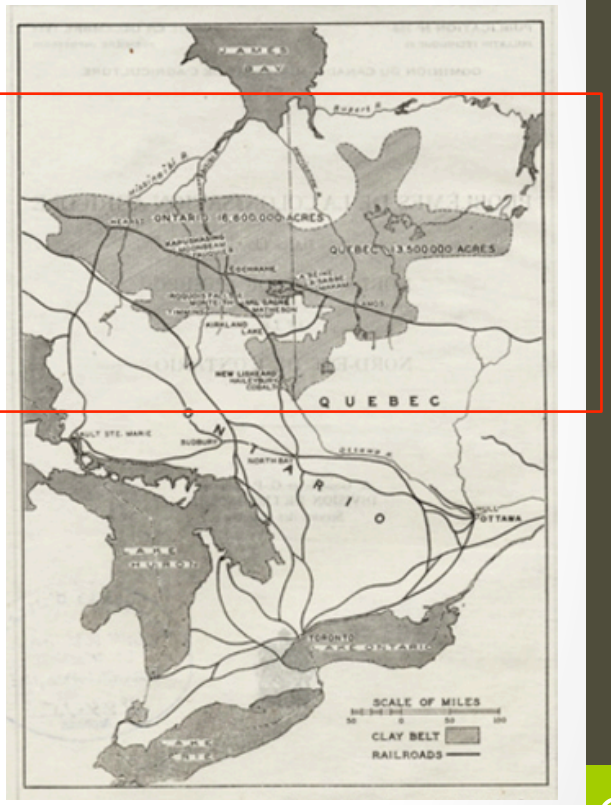




Figure 8. Location of PCT plots in the region of Abitibi with differing geological deposit and b) a map indicating the clay belt region near the city of Amos.

# Field Methods

**Soil and foliar Sampling**

- 1 bulk organic soil and foliar sample
- 3 sampling years (2015 – 2017)

- 1 bulk sample/treatment
- x 2 treatments/plot
- x 4 plots/climate
- x 3 climates

  = 24 samples/sampling year

Photo 1: Foliar sampling in a PCT stand

Photo 2: Soil sampling in a PCT stand

# Laboratory Methods

- **Soil N mineralization:**
  - 30 day aerobic incubation, KCl extraction, segmented flow colorimetry (AutoAnalyzer, Pacific Astoria)
    - Potential N mineralization (µg $NH^+_4$-N per g of soil $day^{-1}$)
- **Soil microbial activity**
  - Microbial metabolic quotient ($qCO_2$) using gas chromatography
    - (basal respiration to microbial biomass ratio)
- **Soil and foliar nutrient content**
  - Total C and N using high temperature combustion (Elementar, Vario Macro CN Analyzer)

# Statistical Analysis

**Question #1-2)** What are the interactions between PCT, geological deposit, and climate in controlling black spruce productivity?

- 2 Linear mixed models (climate and geological deposit)
  - Fixed effects: climate/geological deposit, treatment
  - Random effects: plots, sampling date

**Question #3)** Is post-thinning productivity due to increase in soil fertility or release of intraspecific competition?

- ANOVA of N mineralization with t-test within each climate/ geological deposit

# Results: Nitrogen mineralization

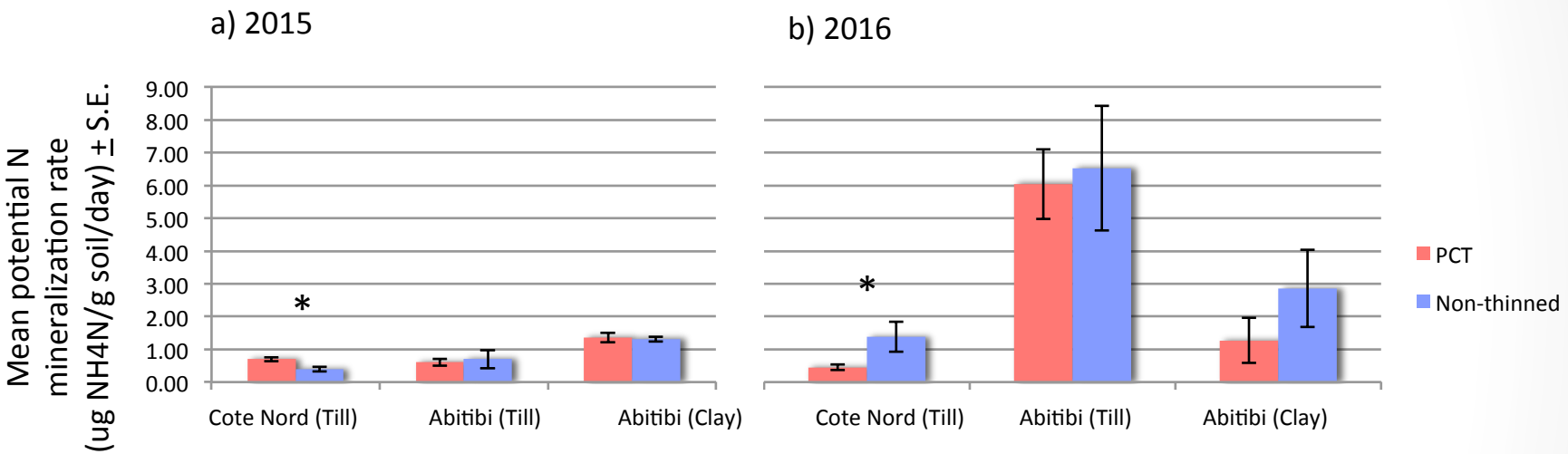



Figure 9. Effect of PCT treatment on soil N mineralization rates between different geological deposits and climate regions in a) 2015 and b) 2016.

- Significant effect of treatment in Cote Nord in 2015 and 2016
- Incorporation of soil bulk density to calculate potential N mineralization **per hectare**

# Results: Nitrogen mineralization

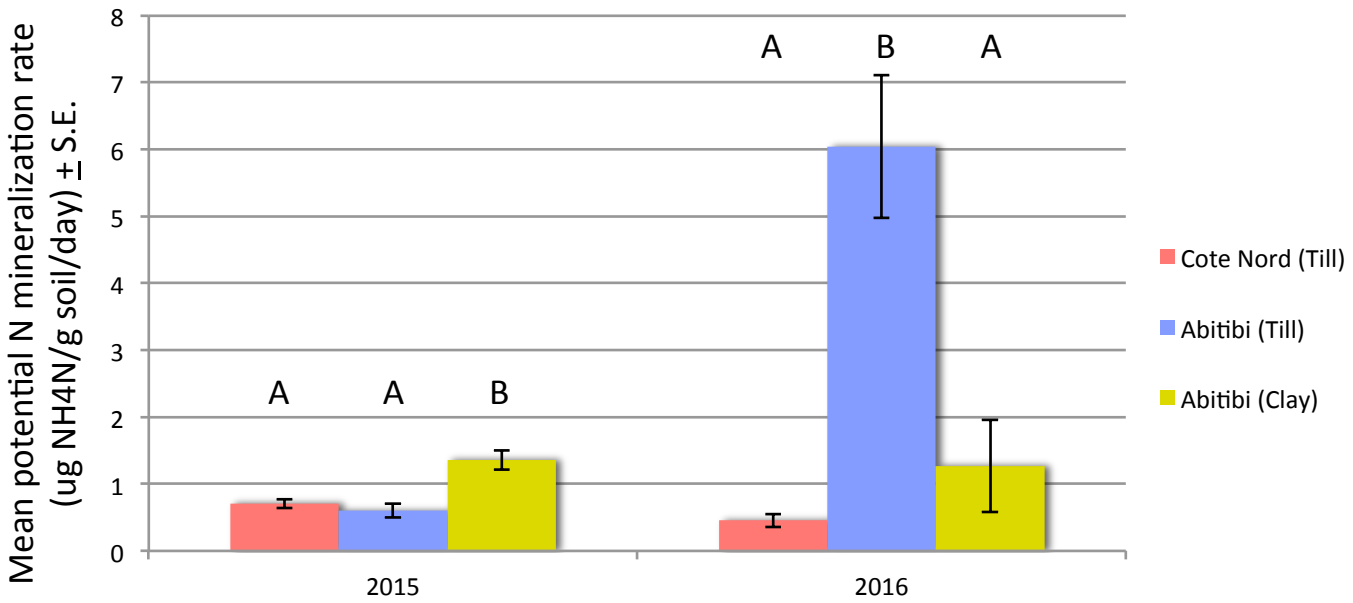



Figure 10. Relative effect of geological deposit and climate regions on rates of soil N mineralization.

- 2015: Significant effect of geological deposit (hypothesis 1)
- 2016: Significant effect of climate (hypothesis 2)

# Results: Microbial activity

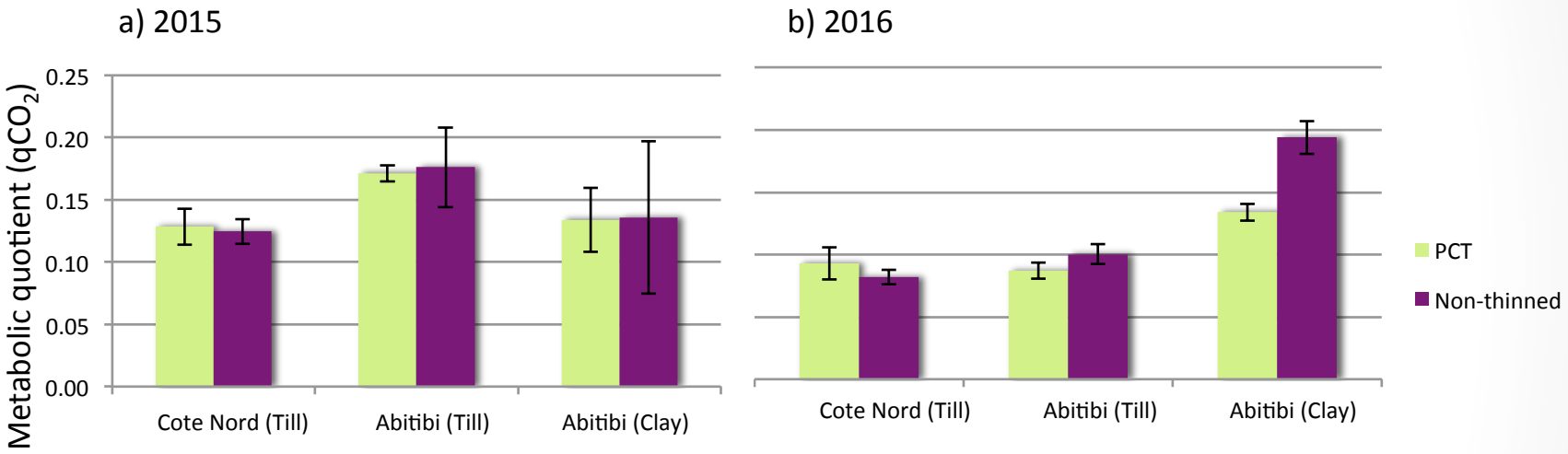



Figure 11. Effect of PCT treatment on microbial metabolic activity between different geological deposits and climate regions in a) 2015 and b) 2016.

- No significant difference between treatments in any climate
- Significant difference between sampling years

# Results: Foliar nitrogen

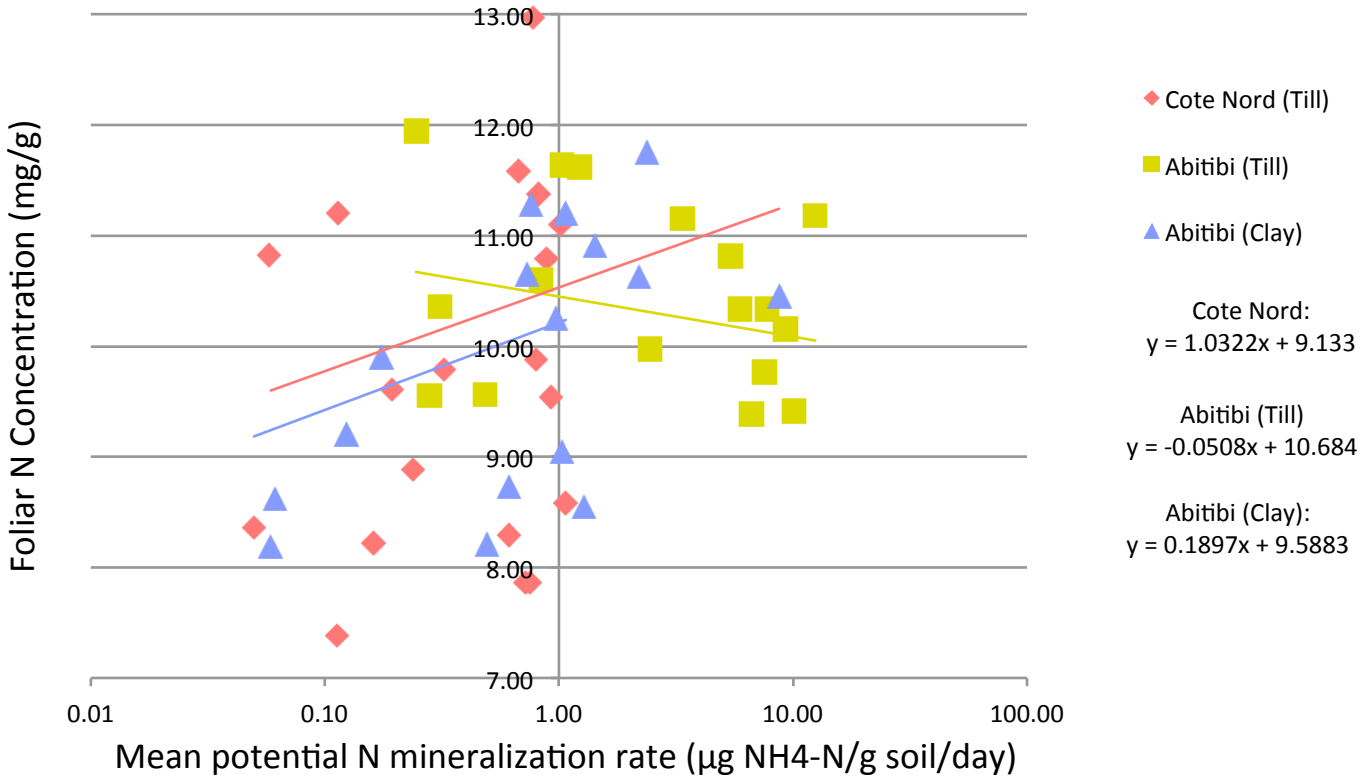



Figure 13. Linear regression of rates of N mineralization and foliar N concentration of geological deposits and climate regions.

# Summary

- Higher rates of N mineralization in non-thinned stands compared to PCT
  - Post-thinning productivity due to the release of intraspecific competition
- Currently observing interactions between PCT geological deposit and climates
  - To be confirmed with N budget (coming 2017)
- Even with increase of soil fertility, nutrient uptake from soil may be limited by moisture availability or competition from ericaceous shrubs

# Still to come

To further investigate the interactions between PCT, geological deposit and climate:

- Confirm rates of N mineralization onto a per hectare basis

- Physiological response of PCT
  - WUE via isotope analysis of $\partial^{13}C$ and $\partial^{18}O$

- Research question #4: Does PCT help to maintain black spruce productivity during years of climate anomalies?
  - Correlate annual tree ring with current soil and foliar data
  - To be paired with regional temperature and precipitation data

# In Conclusion

- Understanding which mechanisms are at play in PCT practices that ameliorate black spruce productivity
- Highlighting the importance of interactions between PCT, geological deposit, and climate to concentrate efforts of forest management
- Contribute a strong knowledge base to the MFFP and BFEC to aid in calculating annual allowable cut.

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Questions?