

# Soil C quantification and CO<sub>2</sub> efflux: a comparison of 5 boreal forest types, James Bay, Quebec, Lagacé Banville Jessica<sup>1,2</sup>, Michelle Garneau<sup>1,2</sup> and David Paré<sup>3</sup>

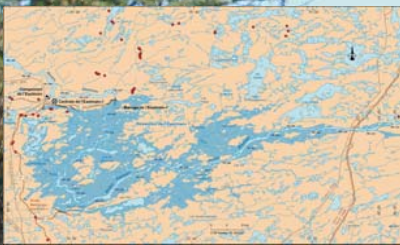
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## Introduction

Almost half of the carbon contained in the global forest ecosystem is located in the boreal forest biome with a considerable proportion in forest soils which is considered as one of the largest biosphere carbon reservoir. Soil heterotrophic respiration contributes largely to release CO<sub>2</sub> to the atmosphere by the mineralization of soil organic matter. These effluxes are believed to be very sensitive to temperature and in a context of global temperature rising, soil could participate to enhance CO<sub>2</sub> emissions to the atmosphere. However, the soil C accumulation and soil respiration rates may vary considerably between forest stands. Improving estimates of soil C stock and mineralization rates coupled with the factors influencing variability among different stands are very important in understanding the role of forest soil in global C cycle. Various physico-chemical and microbial properties of boreal forest soils regulating soil organic C (SOC) accumulation and decomposition are poorly understood. In this study, we present data of SOC stock and CO<sub>2</sub> efflux of five different boreal forest types along the Eastmain River watershed, James Bay region, Quebec.

## Study area

The study area is located in the James bay region, boreal Québec (51° 56' - 52° 20'N, 75° 05' - 76° 10'W)



## Objectives

1. To quantify and compare the amount and quality of soil organic carbon between forest types.
2. To determine the role of several site-specific variables influencing carbon storage
3. To determine labile vs recalcitrant fraction of the SOC carbon by quantification of mineralization rates using soil incubation.

## Methods

Soil samples were collected from 5 different forest types that are recognizable by remote sensing, coniferous closed canopy (CC), coniferous open canopy (OC), deciduous (TA), recently burned sites (2yB) and 15 years old burned sites (15yB). Mineral soil (0-20cm) and forest floor (FH)

**Litter fall:** Litter has been collected over a one year period.

**Incubation:** Soil are incubated at three temperatures: 2, 14 and 28°C. Respiration rates are measured periodically over 116 days of incubation.

**Stand age, soil pH, C:N ratio, sand/clay content, slope, drainage** have also been measured for each site.

## Results

### A) Carbon stock:

The quantity of SOC does not differ significantly among stand types. However, there is a large Variability between stands in the same forest type (Figure 2).

- We assume that variations are mostly attributable to drainage and stand age (Figure 3-4).

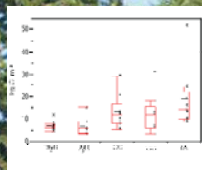


Figure 2: Total soil organic carbon (kgC/m<sup>2</sup>). The black line inside the plot shows the mean total soil organic carbon (SOC) for each forest type. Box plots are used to illustrate the variability within each type. CC and TA present the most important carbon stock.

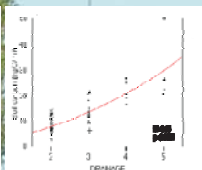


Figure 3: Non-linear relationship between drainage classes and total SOC.

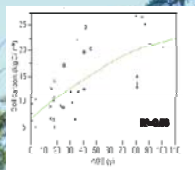


Figure 4: Non-linear relationship between stand age and total SOC.

### B) Respiration and mineralization

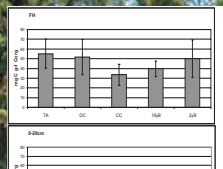


Figure 5: Specific cumulative carbon mineralized at 29°C after 116 days incubation. Each bar represents the mean value of the 5 stands and the error bar is the standard deviation.

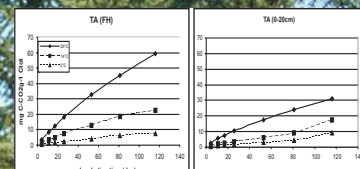


Figure 6: Example (TA) of cumulative specific carbon mineralized (mg C-CO<sub>2</sub> g<sup>-1</sup> C<sub>org</sub>) at three T° referring to initial carbon content for a period of 116 days. Rates are affected by temperature and soil layers.

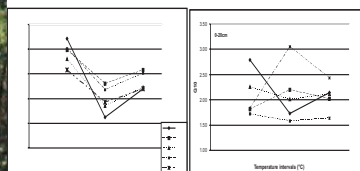


Figure 7: Average Q10 of each forest type compared to incubation temperature intervals. Q10 is obtained by the following equation:  $Q_{10} = (R_2/R_1)^{10/(T_2-T_1)}$  where respiration rates are obtained after 116 days of incubation. On average, the Q10 in the interval 2-14°C was higher than the 14-28°C interval. Respiration rates correspond to the mean value of 7 periods of measurements.

### B) Respiration and mineralization

- Cumulative carbon mineralized is similar among forest types with the highest value in OC and TA stands and the lowest in CC. In 0-20cm, recently burned sites have the highest mineralized carbon. The error bars show that there are significant variations between stands (Figure 5).

- Carbon mineralization rates seem to be dependent on temperature. Respiration rates are twice more important in FH layer than mineral for the three T° (Figure 6).

- Q10 is increasing with decreasing temperature for most sites and more importantly for FH layer than for mineral soil (Figure 7).

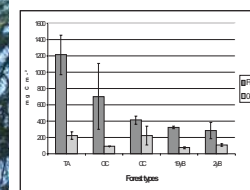


Figure 8: Potential of carbon mineralization of the organic and mineral layers per square meter at 29°C. These results are based on the mean respiration rates (mg C-CO<sub>2</sub> g<sup>-1</sup> C<sub>tot</sub>) of each forest types and their total soil carbon stock (kg C m<sup>-2</sup>). Trembling aspen and open canopy forest types have the most important potential of mineralization for the FH layer. Closed canopy, mostly composed of black spruce, does not have a high potential of carbon mineralization in organic layer (FH) but have the highest rate in mineral (0-20cm).

## Conclusion:

Largest carbon stocks were found in poorly drained sites. Anaerobic conditions induce slow decomposition rates and carbon accumulation. A stand age soil organic carbon stock relationship indicated that the recovery of soil organic carbon stocks and cycling by litter is a process lasting for a long period (Figure 4).

The trembling Aspen (TA) type had the most important total as well as mineralizable carbon stocks. While black spruce (CC) stands contained also large stocks of carbon, the amount that is potentially mineralizable C was lower. The amount of mineralizable carbon may reflect the productivity of stands and is perhaps linked to recently fixed C. The C:N ratio on TA stands were low (avg 20). This suggests that they might have sufficient N for microbial growth and allow decomposition to proceed.

Carbon mineralization rates were dependent on temperature. However respiration rates are more constant at lower temperature. In the recently burned sites, organic and mineral layers have very similar respiration rates, this may be attributable to the formation of recalcitrant component after fire (charcoal). Low respiration rates in closed canopy forests (FH) may be related to the poor quality of the substrate due to abundance of mosses.

Other factors such as the quality of the organic materials and the soil moisture content could influence the mineralization process.

## References

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