Holocene climate and responding vegetation influenced carbon accumulation patterns and peat fires in boreal bogs, Quebec, Canada

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1 INTRODUCTION

Ombrotrophic peatlands are exclusively dependent on precipitation and therefore form records of hydroclimatological conditions. During dry episodes or when vegetation is prone to burning, a peatland can turn into a temporary carbon (C) source by combustion and post-fire effects on production and decay. The interactions between climate, vegetation and fire on millennial timescales concerning peat fires are complex. The aim of the project is to improve the comprehension of peat fire regimes and their link to carbon accumulation under Holocene climate variations. Because of high spatial variability in peatland vegetation, peat fire dynamics may be complex even within a bog. C accumulation patterns obtained from central and lateral cores of three studied bogs are presented with fire and vegetation reconstructions.

2 STUDY REGION

The studied mires are located in boreal Quebec (Figure 1) and are characterized by hummock-hollow patterns with *Picea mariana* and Ericaceae at the transition to the forest. Mean forest fire frequency is 1 event every 100 years. Peat fires have been rare during the last century, however, a recent fire (1997) has been detected by local *Pinus banksiana* presence in Mosaik bog.

Peat bog	Area (km²)	Max. peat depth (cm)	Age of peat inception (cal BP)
Lac Le Caron (LLC)	2.44	481	7520
La Sterne (STE)	1.73	285	7140
Mosaik (MOS)	2.68	296	7360

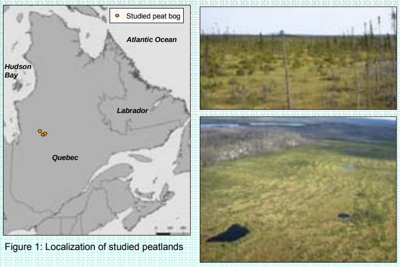


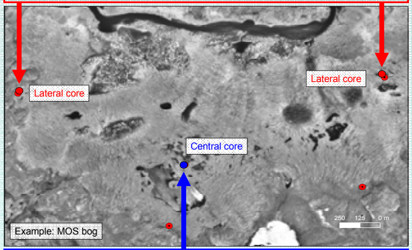
Figure 1: Localization of studied peatlands

3 METHODS

Core analysis

Fire reconstruction and C accumulation (two lateral cores (L) per bog)

- Macroscopic charcoal analysis (>355 µm; 2 cm³ sample; 1 cm resolution);
- LOI and bulk density analysis (1 cm³ sample; 1 cm resolution);
- AMS ^{14}C dating and calibration using BCal (Buck et al., 1999).



Vegetation development, water table reconstructions and C accumulation (one central core (C) per bog)

- Plant macrofossil analysis (4 cm³ sample; 4 cm resolution);
- Testate amoebae analysis (1 cm³ sample; 4 cm resolution) and application of a transfer function to obtain water table depth (WTD) reconstructions (Booth, 2008);
- LOI and bulk density analysis (1 cm³ sample; 1 cm resolution);
- AMS ^{14}C dating and calibration using BCal (Buck et al., 1999).

Charcoal and C anomaly calculations

Charcoal counts (mm² cm⁻³) were converted into charcoal influx (mm² cm⁻² yr⁻¹). Then, charcoal anomalies were calculated and normalized series were averaged per 200-year window for each bog (Carcaillet et al., 2002).

C accumulation rates from both central and lateral cores were determined using bulk density and loss-on-ignition (LOI) analyses. Rates were normalized in the same manner as charcoal influx. A C accumulation rate index curve was created for each bog, being the mean of central and lateral cores.

Sphagnum fuscum stem leaf

4 RESULTS

Vegetation, water table, charcoal and C accumulation rate reconstructions

A period of low C accumulation was recorded in all three peatlands between ca. 3000 and 500 BP (Figure 2, indicated by the red box), with lowest values of 7-10 g m⁻² yr⁻¹ between 2000 and 1000 BP. Characteristic for the 3000-500 BP period is the occurrence of high amounts of macro-charcoal and an increase in decomposed material, ligneous vegetation and Cyperaceae. Of the three mires, LLC bog has undergone the most pronounced changes.

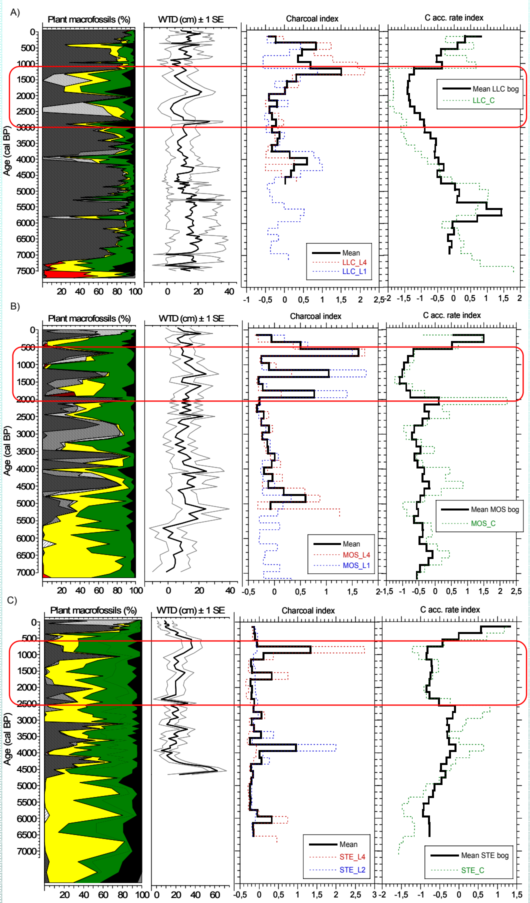


Figure 2: Vegetation, water table depth, charcoal and C accummulation rate index reconstructions for the bogs. Plant macrofossils and WTD are obtained from the central core, charcoal index from lateral cores and C acc. rate index from both core types. A) LLC bog; B) MOS bog; C) STE bog.

4 RESULTS (2)

LORCA and charcoal influx

Mean long-term C accumulation rates (LORCA) (± 1σ) for the central and lateral cores are 17.7 (± 4.4) g m⁻² yr⁻¹ and 14.6 (± 3.2) g m⁻² yr⁻¹, respectively. Mean charcoal influx is 0.088 (± 0.053) mm² cm⁻² yr⁻¹. Figure 3 shows decreasing C acc. rates when charcoal influxes exceed ~0.21 mm² cm⁻² yr⁻¹ (= *Local fire threshold*). These large influxes may therefore be an indication of local burning. Eleven of the 15 periods that exceed this threshold are dated between 1950 and 350 cal BP (Fig. 3).

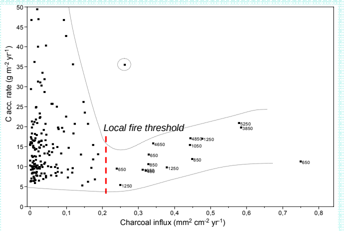


Figure 3: 200-year average C acc. rate and charcoal influx values from all lateral cores. Ages are indicated for periods of which charcoal influx exceeds the local fire threshold

Plant macrofossils at charcoal horizons

Plant macrofossil analyses performed above and below important charcoal horizons indicate some shifts in vegetation assemblages (Figure 4). However, typical post-fire indicators such as *P. banksiana*, *Ceratodon purpureus* and *Polytrichum strictum* have not been identified. The change in the dominant *Sphagnum* section (Fig. 4B) may indicate some local surface burning.

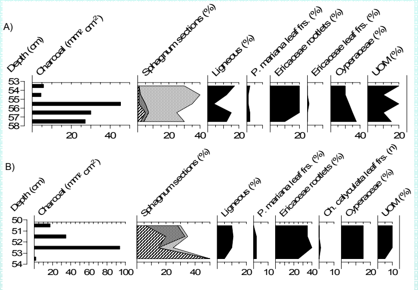


Figure 4: High-resolution plant macrofossil analysis at important charcoal horizons. *Sphagnum* sections legend as in Figure 2. A) LLC_L4; B) MOS_L4.

5 DISCUSSION

A regional increase in forest fire frequencies has been found in correspondence with dry Neoglacial cooling starting ~3000 BP (Carcaillet et al., 2001). Thus, the corresponding trends in C accumulation rates, charcoal influx and vegetation could be the result of this change in climate. The Neoglacial cooling probably caused a change in bog vegetation influenced by lower water tables as well as a decrease in C accumulation rates through low temperatures and a shorter growing season. Consequently, a shift in bog vegetation and more frequent forest fires could explain the increase in peat fire events in some of the studied peatlands. As climatic cooling, fires have probably influenced C accumulation rates between 1950 and 350 BP. The absence of shifts in vegetation assemblages above important charcoal horizons (i.e. after fire) shows that local burning was not profound.

The dynamics of these eastern Canadian bogs can be linked to those of western Canada where permafrost aggradation causing low C accumulation rates has been found starting ~3000 BP (Vitt et al., 2000). Despite the fact that burning is an important factor in western peatland dynamics (Zoltai et al., 1998), peat fires are of minor importance in eastern Canada. In this study, surface peat fires seem to have been most important between 1950 and 350 BP.

6 CONCLUSION

Surface peat fires have probably been a factor in Holocene C accumulation patterns in eastern Canadian boreal bogs from 1950 - 350 BP. Neoglacial cooling and its effect on mire vegetation are likely to have been principal agents on both C accumulation and peat fire.

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