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Global changes, fire and spruce-forest dynamics in Québec-Labrador during the Holocene.

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Context

Boreal ecosystems provide numerous goods and services essential to human activities, such as wood and paper supply or the regulation of natural phenomena (floods, diseases) (Hassan et al., 2005). They also play a major role in the global climate balance, storing ~32% of the world's biogenic carbon (Pan et al., 2011; Bradshaw, 2015). Their dynamics are also intrinsically linked to fire activity, main disturbance driver in North American boreal forests (Kuuluvainen and Aakala, 2011), mainly controlled by climate-vegetation interactions (Ali et al., 2012). Under global warming, recent work predicts an increase of fire regimes, and a potential shift of the carbon sink function (Walker et al., 2019). However, Labrador and eastern Quebec regions remain poorly studied on multimillennial time scales. This study provides new insights on fire-climate-vegetation interactions in eastern Canadian forests, allowing us to better characterize the mechanisms by which climate change impacts fire regimes, and consequently forest structure and functioning.

Material and methods

To cover a wide range of fire-climate-vegetation interactions, this study is based on a North-South transect of 5 lacustrine sediment cores, covering the last 6,000 to 10,000 years across Quebec and Labrador regions. Chronologies were based on ^{210}Pb/^{137}Cs and ^{14}C dating. Finally, to reconstruct local fire regimes, vegetation dynamics and climatic fluctuations during the Holocene, our study is based respectively on macrocharcoals (≥ 150 µm), pollen grains and chironomids assemblages.

Results and Discussion

Our study reveals that black spruce (*Picea mariana* (Mill.)) is the dominant species across the transect, but its proportion varies greatly, and is marked by a codominance with balsam fir in the south and with green alder in the north. In the south (white birch fir stand and spruce-lichen woodlands bioclimatic domains), our results show a high frequency but relatively low fire sizes during the warmest and driest periods, such as the Holocene Climate Optimum (HCO), followed by a reverse trend during the coldest and wettest periods such as the Neoglacial Period (NG), probably due to a longer fuel accumulation time promoting larger fires (Carcaillet et al., 2001). In the North (forest tundra bioclimatic domain), the HCO is marked by the absence of fire, whereas the NP is characterised by a strong increase in fire frequency, related to the progressive increase of black spruce after the deglaciation. Despite this north-south contrast, possibly related to the impact of the Atlantic Ocean, all sequences show an increase in both fire frequency and size after the industrial revolution, inducing a major change in vegetation trajectory towards more open environments marked by an increase in pioneer taxa.

Conclusion

During the Holocene, climate change induced variations in fire regimes in eastern Canada, but show spatial differences explained by black spruce dynamics and moisture inputs. Our study also reveals that temperature rises over the last 150 years have led to an increase in the frequency and size of fires and consequently to a progressive opening of the environment. This could ultimately alter the carbon sink function of boreal forests in the future (Bastianelli et al., 2017).