

Fire History and Persistence of Northern Black Spruce Forests

Research Synthesis & Key Findings



Photo by Ariane Langlois

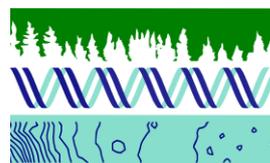
Alice Desaulniers & Guillaume de Lafontaine - 2026

Department of Biology, Chemistry and Geography

Correspondence address: guillaume_delafontaine@uqar.ca

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Why was this study done?

In today's Nunavik, the landscape is mostly composed of open areas dominated by lichens and shrubs called tundra. However, small patches of dense black spruce forest are present, often located in sheltered depressions.

We know that thousands of years ago, these spruce forests covered much more of the landscape. Over the last ~3,500–4,000 years, cooler climate conditions and repeated wildfires have progressively opened the forested landscape. In many areas, after a fire, forests did not successfully regenerate, and the landscape progressively shifted from closed-crown forest to open and lichen dominated vegetation. Therefore, the black spruce forests that are present today in the forest-tundra landscape are the residual patches of what used to be a much more extensively forested landscape.

But an important question remains: **Why have some small spruce forests survived until today, while the nearby landscape has been deforested by fire?**

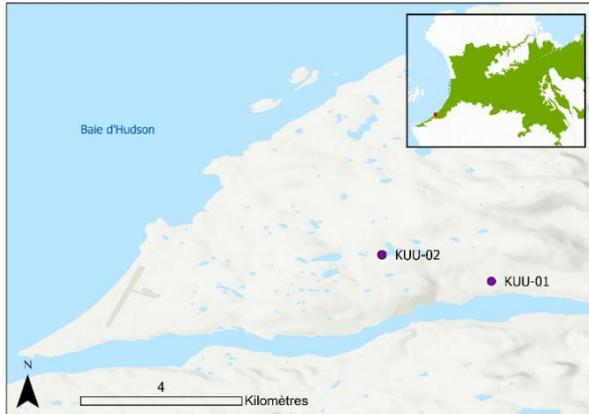
Whether these patches had burned in the past to successfully regenerate afterwards or if they had survived in fire-free refugia remained unknown until now. This study aimed to better understand the role of wildfire and climate in the maintenance or extirpation of these northern forest stands.

Where was the study conducted?

The research was carried out along the eastern coast of Hudson Bay in three regions:



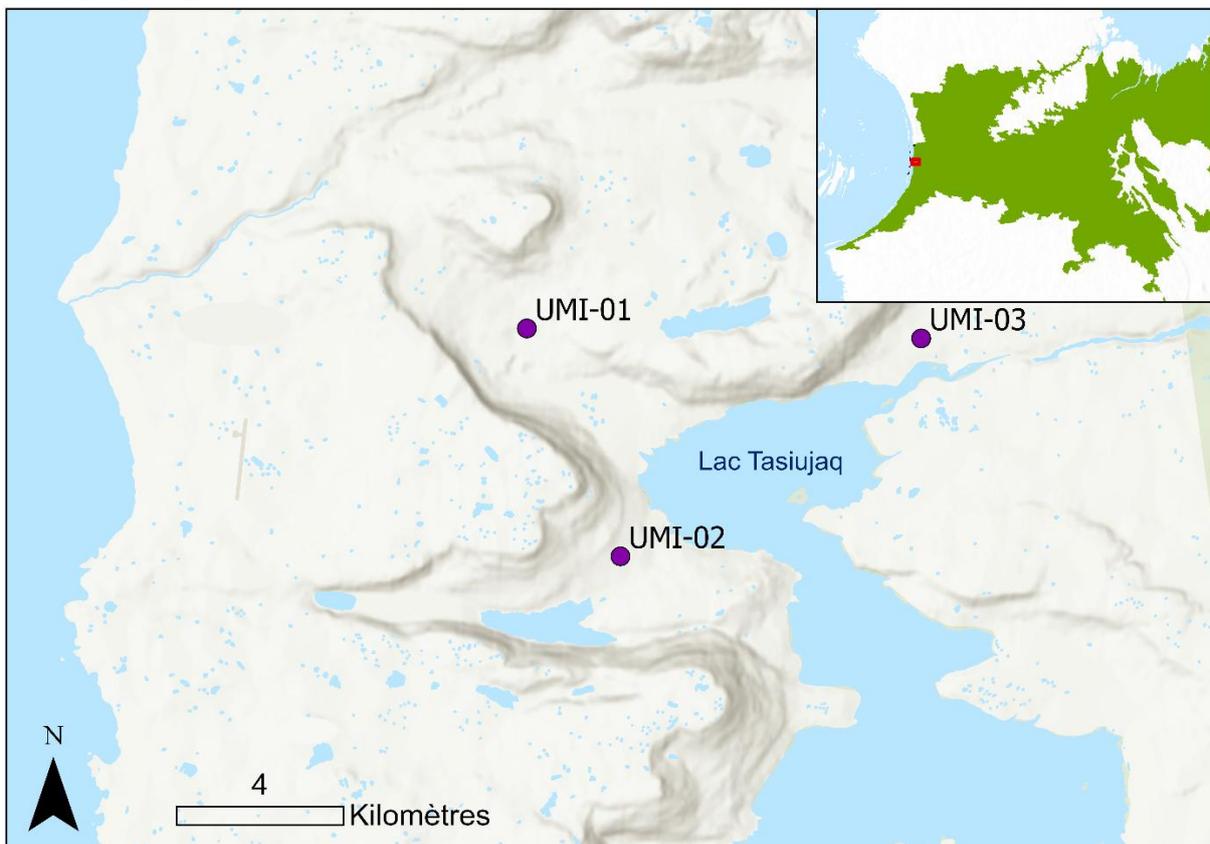
Kuujuarapik-Whapmagoostui Region



Boniface River Region



Umiujaq Region



In total, **six sites** were studied. At each site, our research team compared a **closed-crown forest stand** (spruce-moss forest), and an adjacent **open area** (lichen woodland or open tundra).

Main method: Reading fire history in the soil

When a forest burns, charred wood fragments are deposited on the soil surface. With time, these charcoal fragments are buried due to tree uprooting and freeze-thaw cycles. Wood charcoal are preserved underground for thousands of years. In this study, we proceeded in three steps:

1. We collected soil samples (summers of 2023 & 2024)
2. We extracted wood charcoal particles from soils
3. We radiocarbon dated charcoal fragments

A total of **103 wood charcoal fragments were radiocarbon dated**. This method consists of determining the age of organic materials, like wood, by measuring the decay of the **carbon-14 isotope** fixed by living trees. Radiocarbon dating of wood charcoal allows us to reconstruct fire history **at the site-scale**.

What did we observe?

Forests and open areas are clearly different today

- **Closed-crown forest** stands are dominated by black spruce (*Picea mariana*) trees with various types of moss covering the ground.
- **Open areas** are non-forested stands dominated by crowberry and dwarf birch with lichens covering the ground.



Closed forest

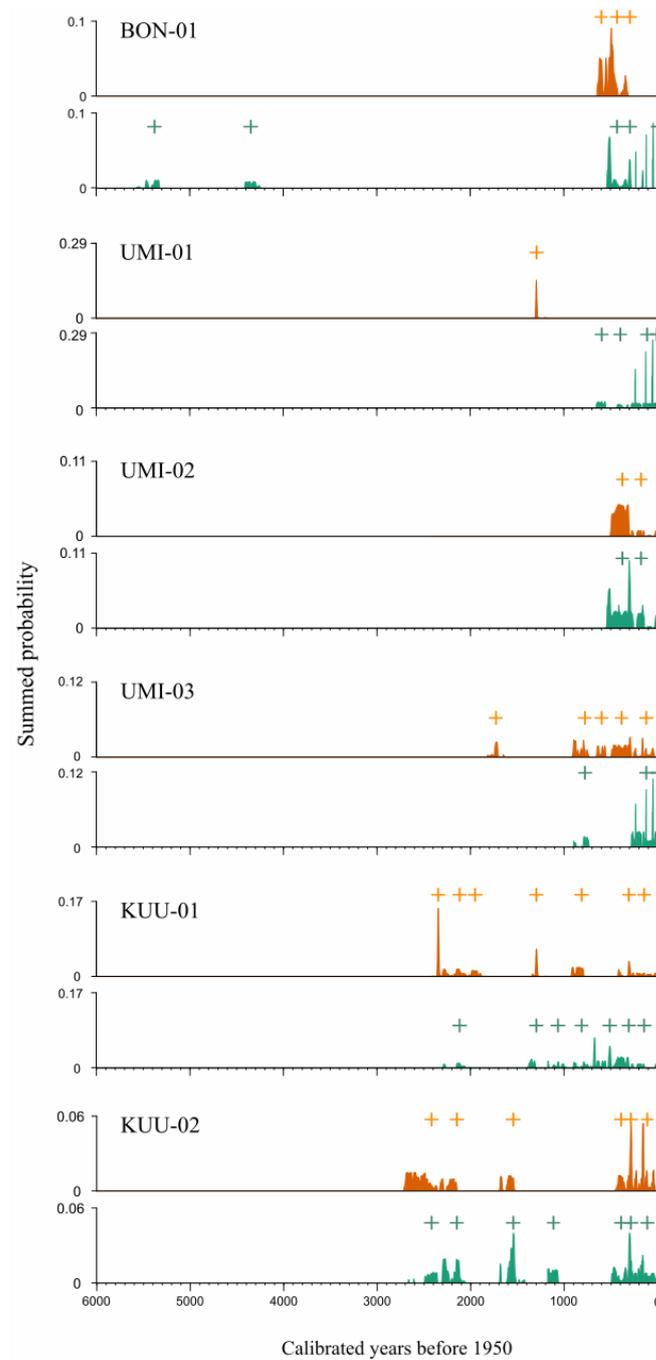


Open area

Key Findings: Fire History

1. Both open areas and closed-crown forests have burned

Reconstruction of the History of Fire Events (+) in closed-crown Forest Stands (green) and adjacent Open Areas (orange) in the Forest Tundra



Current closed-crown forest stands:

- Were not protected from fire events
- Have burned on multiple occasions during the last thousands of years (the Holocene)

Charcoal evidence shows repeated fires in open areas and in closed-crown forests. This means the extant closed-crown forests are **not simply “refuges” that escaped fire during millenia.**

2. No significant difference in fire regime

Statistical analyses show **no significant differences** between open areas and closed-crown forests in terms of:

- Total number of fires
- Time since last fire
- Mean fire interval
- Overall fire frequency

On average, both types of environments experienced **similar fire histories**, meaning that fire alone cannot explain why some areas are forested today and others are open.

3. Fires during colder climate periods

The most recent fire events that led to landscape opening generally occurred during colder periods, especially the **Little Ice Age** (1300–1850): the coldest period of the Holocene. However, all studied closed-crown forest stands also burned at least once during this same period, yet they successfully regenerated afterward. This means that even under cold climate conditions, some forest stands were able to recover after fire.

If not only fire and climate, what explains forest persistence?

Since fire history is similar in both open and closed-crown environments, we might think other local factors have played a role in allowing some forest stands to persist.

Possible **contributing factors** include:

- Topography (position in depressions vs. hilltops)
- Soil depth and moisture conditions

- Protection from wind and snow exposure
- Microsite conditions that favor spruce regeneration

Closed-crown forests generally had:

- Thicker organic soil layers
- Less exposed rock
- More sheltered positions

These conditions may improve black spruce regeneration after fire.

What does this mean for the territory?

1. Northern spruce forests are more resilient than previously thought

Despite repeated fires and cold climate periods, some black spruce stands have burned multiple times, successfully regenerated, and persisted for centuries or millennia. This suggests a high level of ecological resilience.

2. Fire alone does not determine whether land becomes tundra

Open lichen landscapes are not simply the result of “more fire”, or “fire during colder periods”. Both open areas and closed-crown forests experienced similar fire regimes. Instead, subtle differences in local environmental conditions may also influence whether forests recover after fire.

3. Implications for the future under climate change

Climate change will likely:

- Increase fire activity
- Lengthen growing seasons
- Improve seed production in black spruce

If warmer conditions favor regeneration, some currently open areas could potentially experience increased tree establishment in the future. However, increased fire severity could also limit recovery in some places. Understanding the long-term past helps us better anticipate possible future landscape changes.

Conclusion

Most importantly, this study shows that these small forest patches are not accidental survivors, they are dynamic and exceptional ecosystems that have persisted through thousands of years of environmental change.

Presentations & Scientific Outreach

Research Proposal 2023 - Université du Québec à Rimouski, Rimouski, Qc

Oral presentation

CEN Conference 2023 – Université Laval, Québec, Qc

Poster session

International Research Network on Cold Forests Conference 2025 –

Pessamit, Qc

Oral presentation

Research Seminar 2025 - Université du Québec à Rimouski, Rimouski, Qc

Oral presentation