How important is the soil fertility and planted tree nutrition to the carbon sequestration of afforested boreal open woodland

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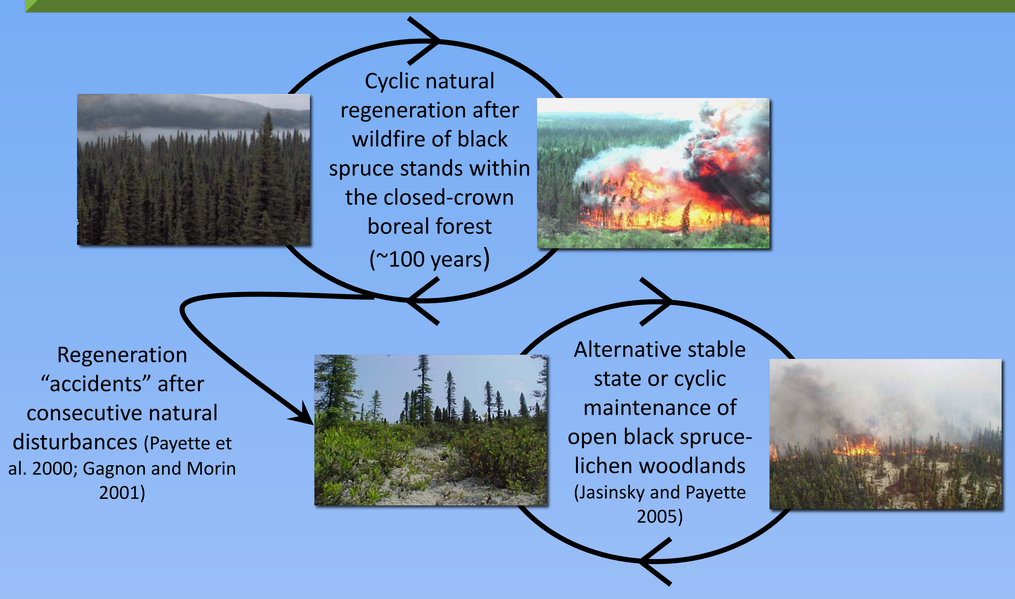
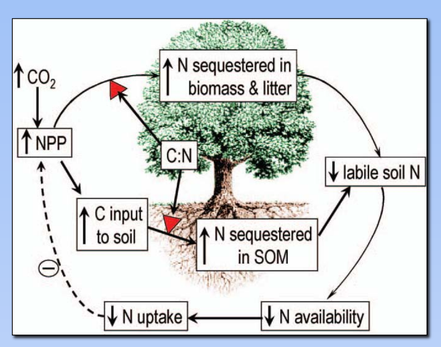
carbone boréal MD

RATIONALE



OWs support capacity ⟷ **Carbon sequestration**



(Luo et al., 2004)

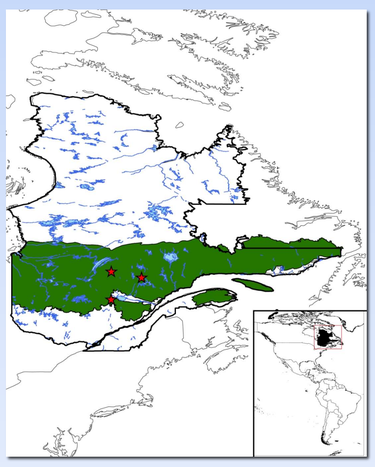
Nutrient availability

- ❖ OWs = unproductive lands
  - Limitations = ericaceous shrub & lichens = poor soil, competition, allelopathy, and cold soil microclimate
  - There is no evidence of natural redensification
- ❖ Unproductive = unfertile ??

THE STUDY

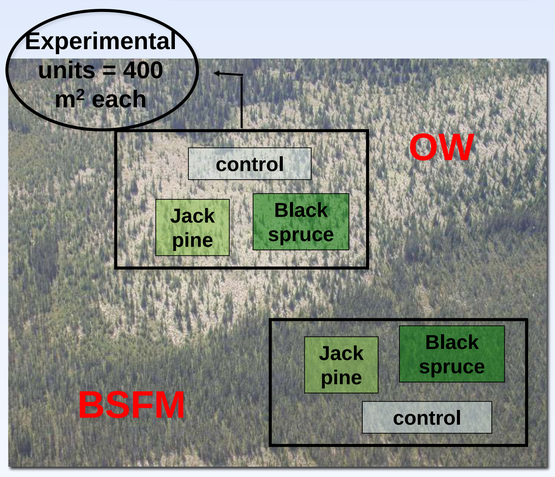
HYPOTHESES

- ❖ 10 years after afforestation, soil fertility is equivalent in OWs and BSFM stands.
- ❖ Planted species used in afforested OWs could have a greater impact on their environment than in black spruce-feathermoss (BSFM) adjacent stands, whose fertility have already been demonstrated.
- ❖ A functional connection exists between planted tree (black spruce and jack pine) traits and soil fertility (results not shown).

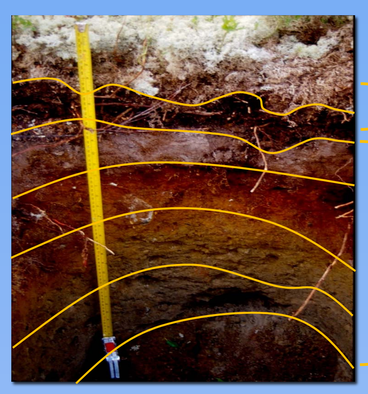


EXPERIMENTAL DESIGN

- ❖ 7 experimental blocks among 3 study sites in Québec's closed-crown boreal forest
- ❖ 2x3 split-plot design
- ❖ 2 different stand types (OW, BSFM)
- ❖ 3 different silvicultural approaches (scarification with planted black spruces, scarification with jack pines, control)



RESULTS



❖ Podzolic soils and their horizons:

Organic horizon : The major organic horizons are L, F, and H, which are mainly forest litter at various stages of decomposition and humus.

Mineral horizons:
- Contain 17% or less organic C
- Usually composed of three different types of horizon
  - A : formed at or near the surface in the zone of leaching or eluviation of materials in solution or suspension, or of maximum in situ accumulation of organic matter or both.
  - B : characterized by enrichment in organic matter, sesquioxides, or clay, or by the development of soil structure; or by a change of color denoting hydrolysis, reduction, or oxidation.
  - C : comparatively unaffected by the pedogenic processes operative in A and B

(The Canadian system of soil classification 1998)

Table 1. *P* values from the ANOVA for nutrient stocks in the mineral B soil horizon

	MINERAL SOIL STOCKS (B HORIZON)		
ELEMENTS	STANDS (OW, BSFM)	PLANTATION (BS, JP, none)	STANDS * PLANTATION
C Tot	0.1469	0.3622	0.9190
N tot	0.1846	0.2515	0.8174
K	0.5734	0.2518	0.2812
Ca	**0.0434***	0.6866	0.3473
Mg	**0.0148***	0.8661	0.4657
Mn	0.2856	0.6090	0.7073
Al	**0.0347***	0.5409	0.7992
Fe	**0.0263***	0.3583	0.8717
Na	0.2266	0.4162	0.4273
S	0.2512	0.3329	0.5363
C.E.C.	0.1084	0.8747	0.4500
S.B.	0.7631	0.8137	0.4083
pH	**0.0300**	0.8890	0.9440

*The data were cube root transformed

- ❖ Each plot was sampled with an Auger soil sampler in 10 year-old afforested OWs and planted BSFM stands (in between the scarification furrows in the planted plots). Only the first B horizon was sampled.
- ❖ There was a significant effect of stand types (OWs, BSFM) only on major cations (Ca, Mg, Al, Fe) in the first B horizon.
- ❖ There was no significant effect on any nutrient stocks of the plantation approach (JP, BS, no plantation or control) and of the interaction between stand types and the plantation approach.
- ❖ The mean carbon stocks: OWs = 40.96 t ha^{-1} BSFM = 55.68 t ha^{-1}

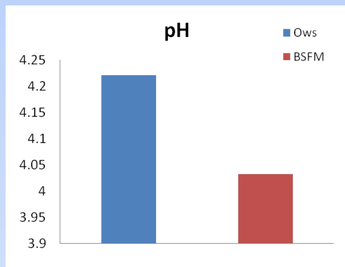


Figure 1. Mineral B horizon pH in OWs and BSFM stands

- ❖ There was a significant effect of stand types (OWs, BSFM) on soil pH, independently of planted species (JP, BS, none).
- ❖ The mineral B horizon soil in OWs was significantly less acidic than that in BSFM stands.

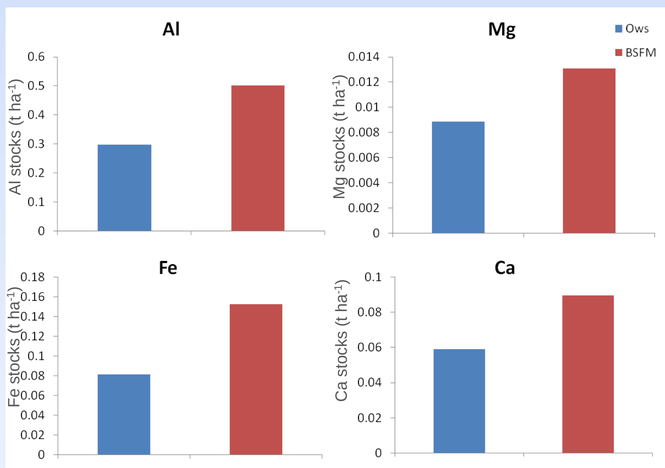


Figure 2. Mineral B horizon nutrient stocks in OWs and BSFM stands

- ❖ The mineral B horizon nutrient stocks in major cations (Al, Mg, Fe, and Ca) were higher in BSFM stands than is OWs (Fig. 2), despite their higher acidity (see Fig. 1).
- ❖ This difference in major cations between OWs and BSFM stands has been also observed in younger plantations (results not shown) ➔ 10 years of plantation growth does not mitigate the initial lower soil fertility in afforested OWs?

CONCLUSION

- ❖ Initial lower mineral soil stocks in major cations (Al, Mg, Fe, and Ca) in afforested open woodlands (OWs) is still existing after ten years of plantation growth.
- ❖ Even with contrasting differences in initial stand structure, 10 year-old afforested OWs have equivalent mineral soil carbon stocks to 10 year-old comparable black-spruce feathermoss (BSFM) planted stands.
- ❖ Some unanswered questions:
  - Are lower stocks in major cations limiting to planted tree growth?
  - Are there also differences in the humus layer nutrient stocks after 10 years of plantation growth?
  - What would be the soil fertility in or near the scarification furrows, where planted trees grow?
  - Are there going to be longer term positive impacts of plantation growth on soil fertility in afforested OWs?

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