The GHG offset potential of the open woodland afforestation in the boreal forest of Eastern Canada

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New-Orleans, LA
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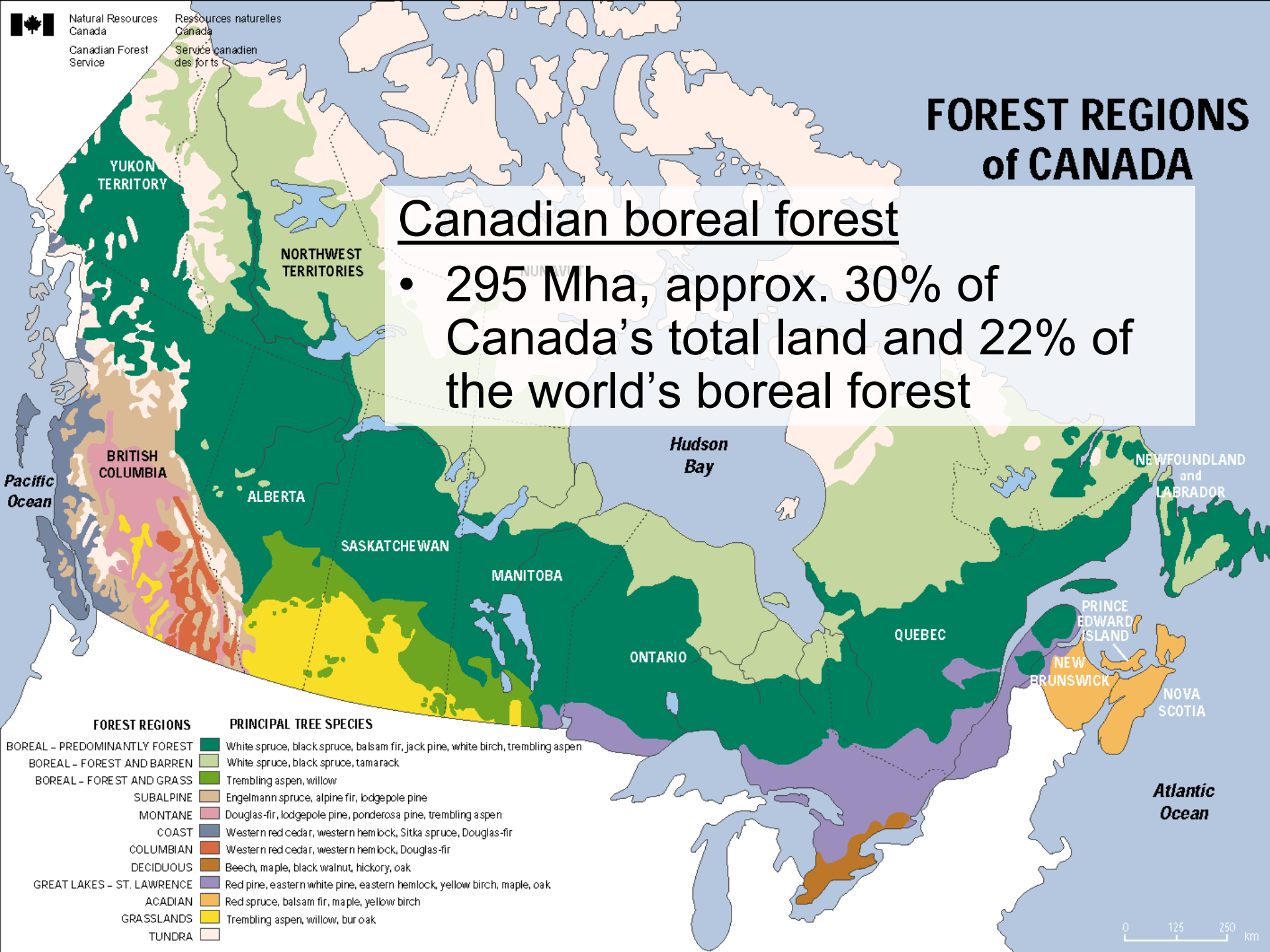

Canadian boreal forest

- 295 Mha, approx. 30% of Canada's total land and 22% of the world's boreal forest

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Date des images satellite : 13 juil. 2006
50°19'49.47"N 70°06'50.25"O élév. 476 m
Altitude 4.28 km

Natural crown cover patchiness of Canada's boreal forest

1. Context

2. Simulated C balance

3. Support capacity

4. C stock permanence

5. Albedo

6. Carbone boréal

Cyclic natural regeneration after wildfire of black spruce stands within the closed-crown boreal forest (~100 years)

Regeneration "failure" after consecutive natural disturbances

Alternative stable state or cyclic maintenance of open black spruce-lichen woodlands (OWs)

(Arseneault and Payette 1992, Payette 1992, Gagnon et Morin 2001, Jasinsky et Payette 2005)

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Cyclic natural regeneration after wildfire of black spruce stands within the closed-crown boreal forest (~100 years)

OWs= 7% or 1.6 M ha within Québec's closed-crown boreal forest

Alternative stable state or cyclic maintenance of open black spruce-lichen woodlands (OWs)

Regeneration "failure" after consecutive natural disturbances

?

(Arseneault and Payette 1992, Payette 1992, Gagnon et Morin 2001, Jasinsky et Payette 2005)

Canadian extent of OWs?

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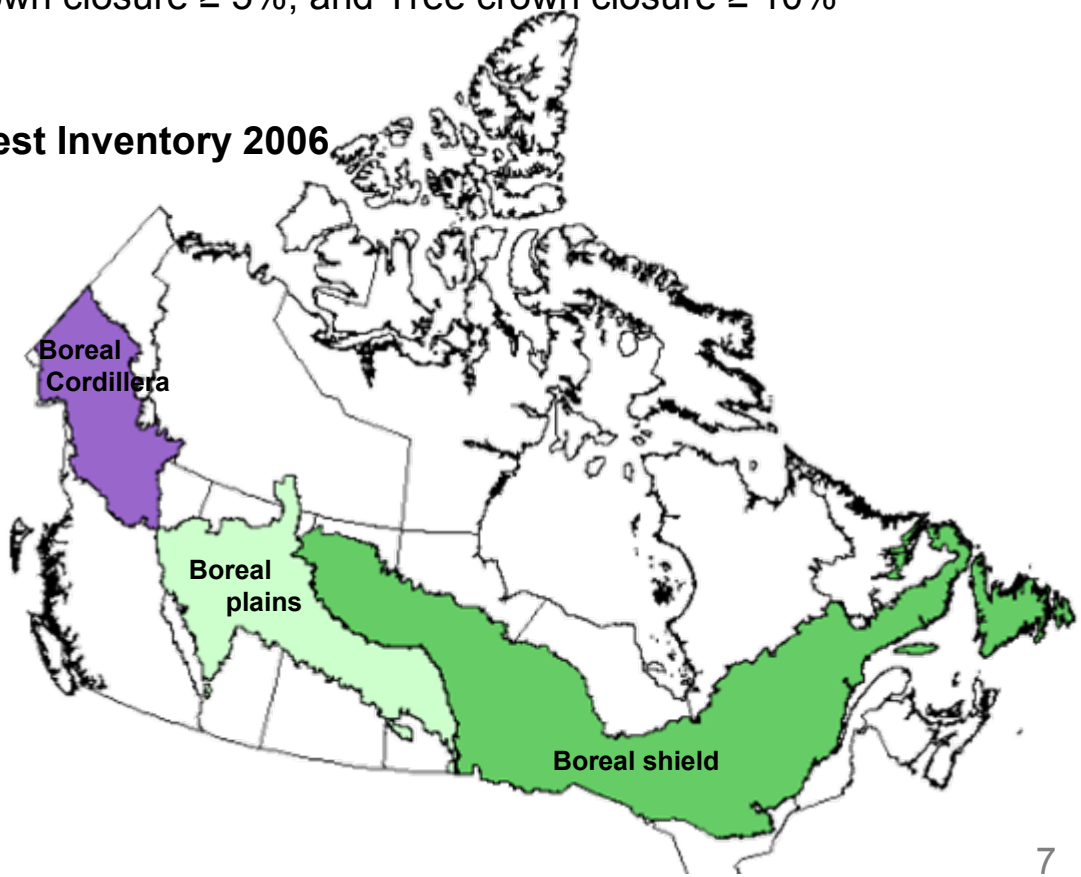
Terrestrial Ecozone	Land cover	Landscape position	Density class	Area (ha)	Volume per ha
Boreal Shield	Vegetated - treed*	Upland	Sparse**	14 907 131	54.8
Boreal Plains	Vegetated - treed*	Upland	Sparse**	1 514 075	61.9
Boreal Cordillera	Vegetated - treed*	Upland	Sparse**	6 825 763	91.6
Total boreal	Vegetated - treed*	Upland	Sparse**	**23 246 969**	66.1

*Vegetated - treed: Vegetated crown closure ≥ 5%, and Tree crown closure ≥ 10%
**Sparse: Treed cover 10–25%

Source: Canada's National Forest Inventory 2006



Assets of afforestation in the boreal zone

1. Context
2. Simulated C balance
3. Support capacity
4. C stock permanence
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- Significant potential territories available across Canada
- No (or very few) loss of opportunities:
  - Forestry
  - Agriculture
- Cheap and low C-intensive mitigation method

The C balance of simulated OW afforestation
(Gaboury et al. 2009)

1. Context
2. **Simulated C balance**
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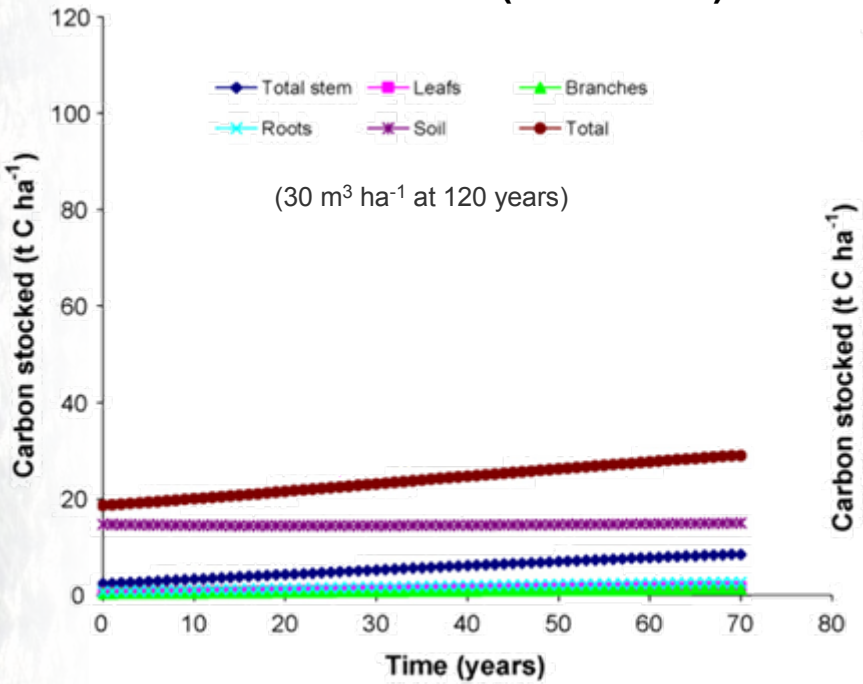
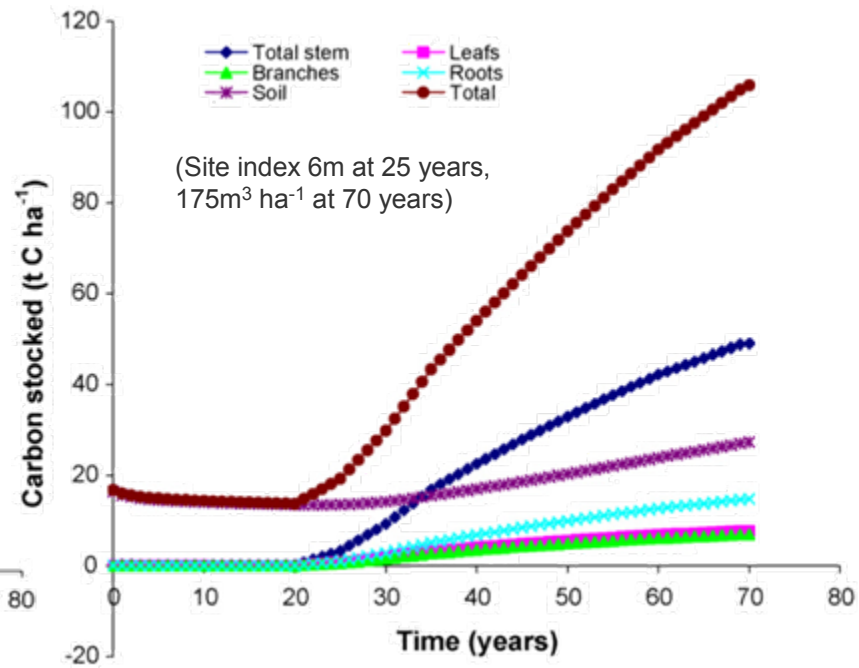
- Life-Cycle Analysis (LCA) approach
- CO2 FIX model

Baseline scenario (intact OW)



Afforestation scenario (planted OW)



The C balance of simulated OW afforestation
(Gaboury et al. 2009)

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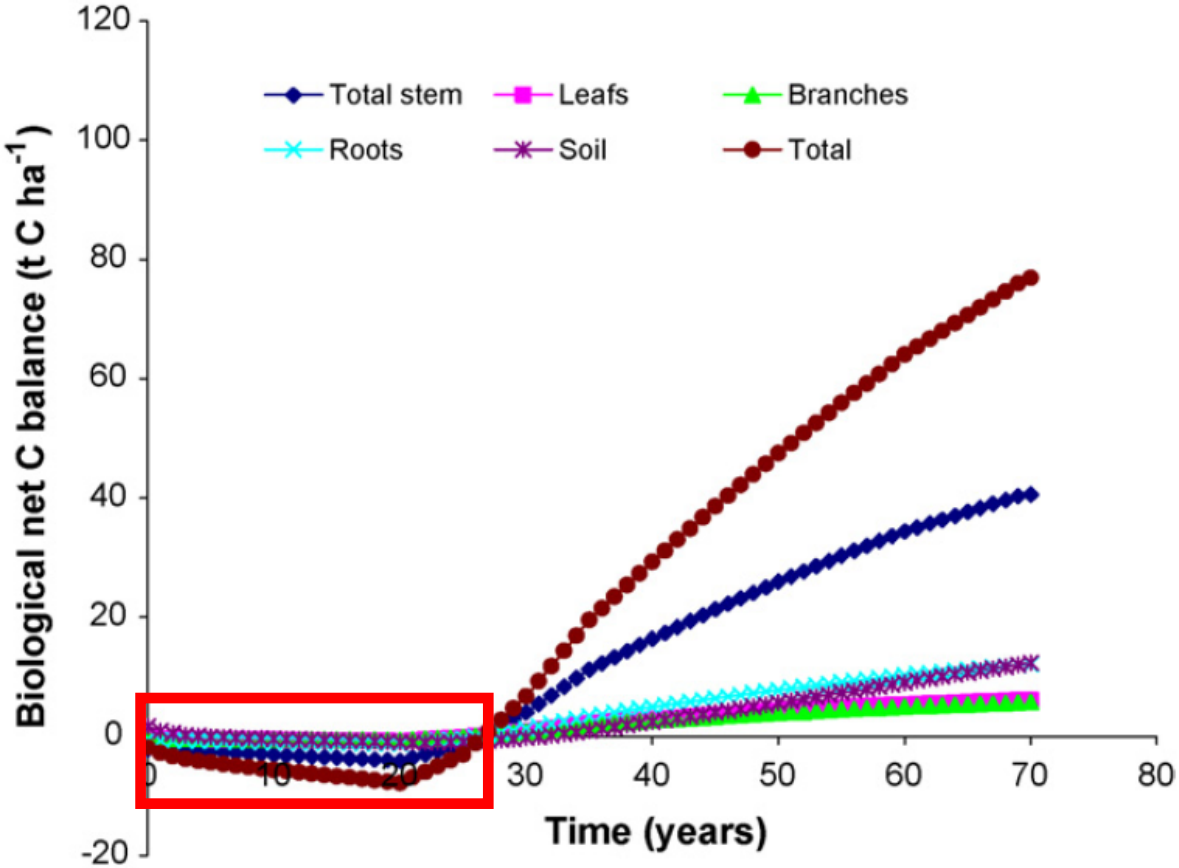

- End-of-project sequestration (70 years) = 77 t C ha^{-1}
- Net C balance: positive after 27 years

  ⟶ initial tree harvesting simulated

Operations related emissions (LCA)

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Seed production

Plantation

Containerized seedling

GHG quantification…

Scarification

<1% of net C sequestration

Transport and site access

Harvesting

Boreal OW afforestation: Known issues

1. Context
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1. Support capacity?
   - Growth and yield (C sequestration)
   - Soil fertility
2. C stocks permanence?
   - Natural disturbances related reversal risk
   - Harvested wood products
3. Albedo (surface radiative forcings)?
   - Albedo management

Support capacity projects: Site location

1. Context
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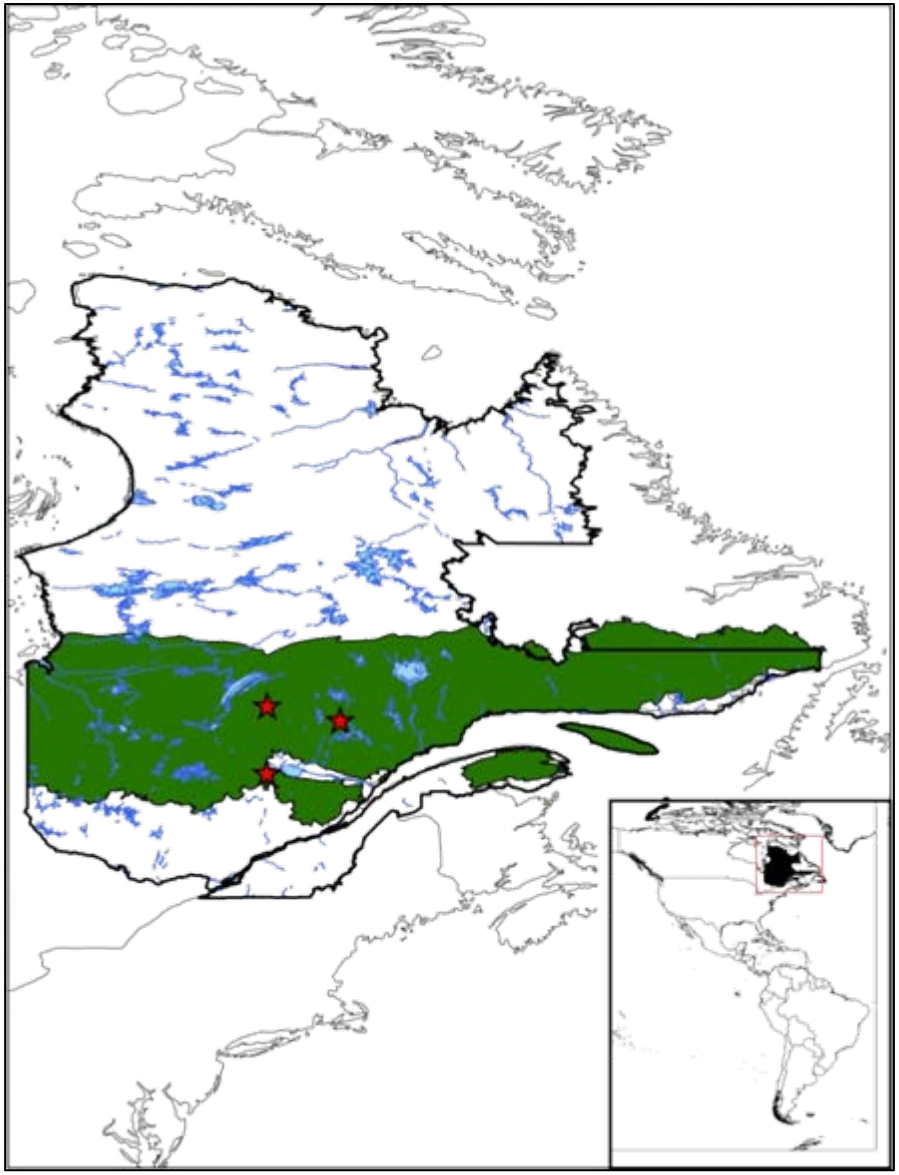

- 7 experimental blocks among 3 sites in Québec's closed-crown boreal forest

Support capacity projects: experimental design

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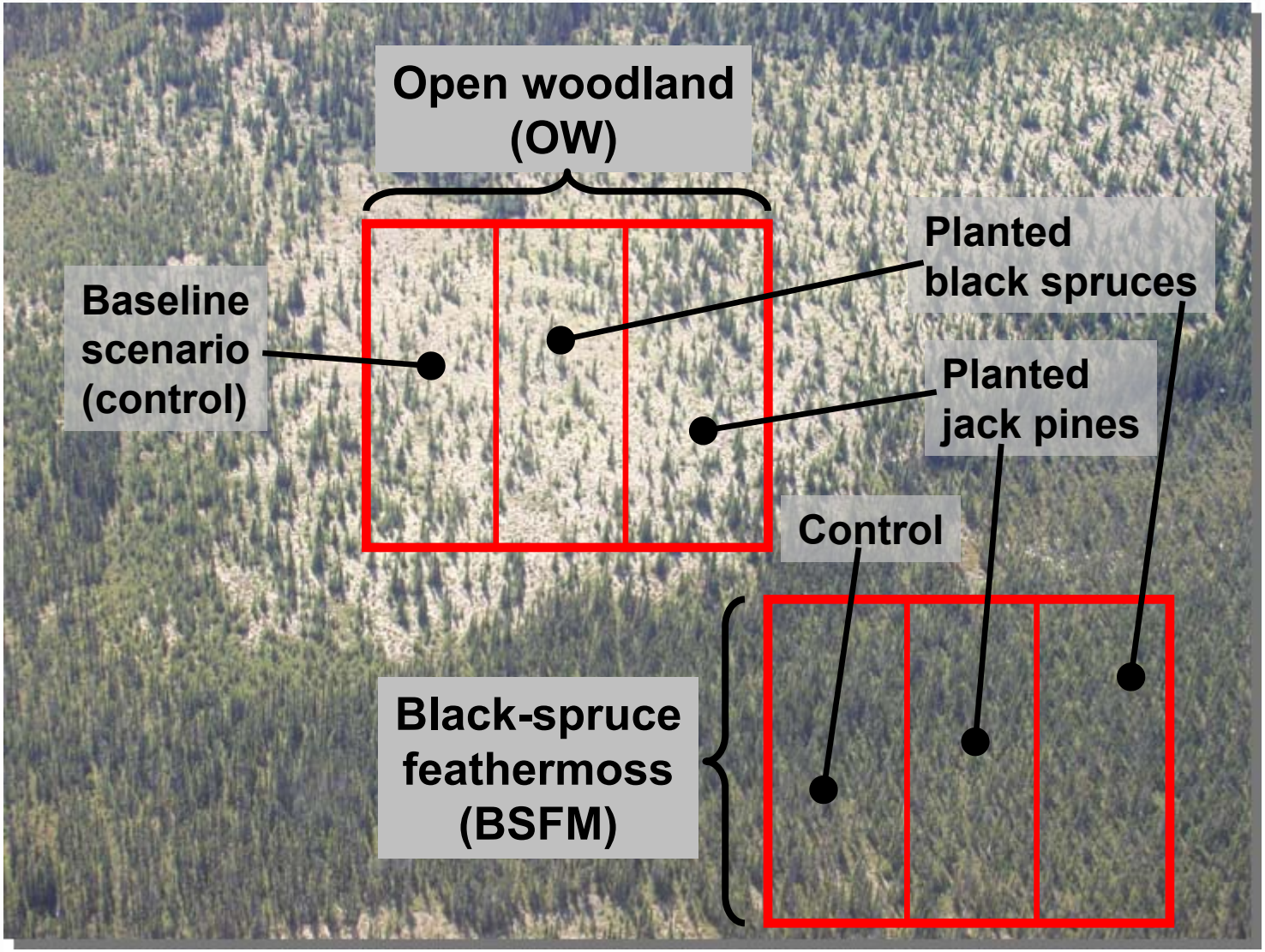

- BSFM = “productive” control

Growth and yield of afforested OWs

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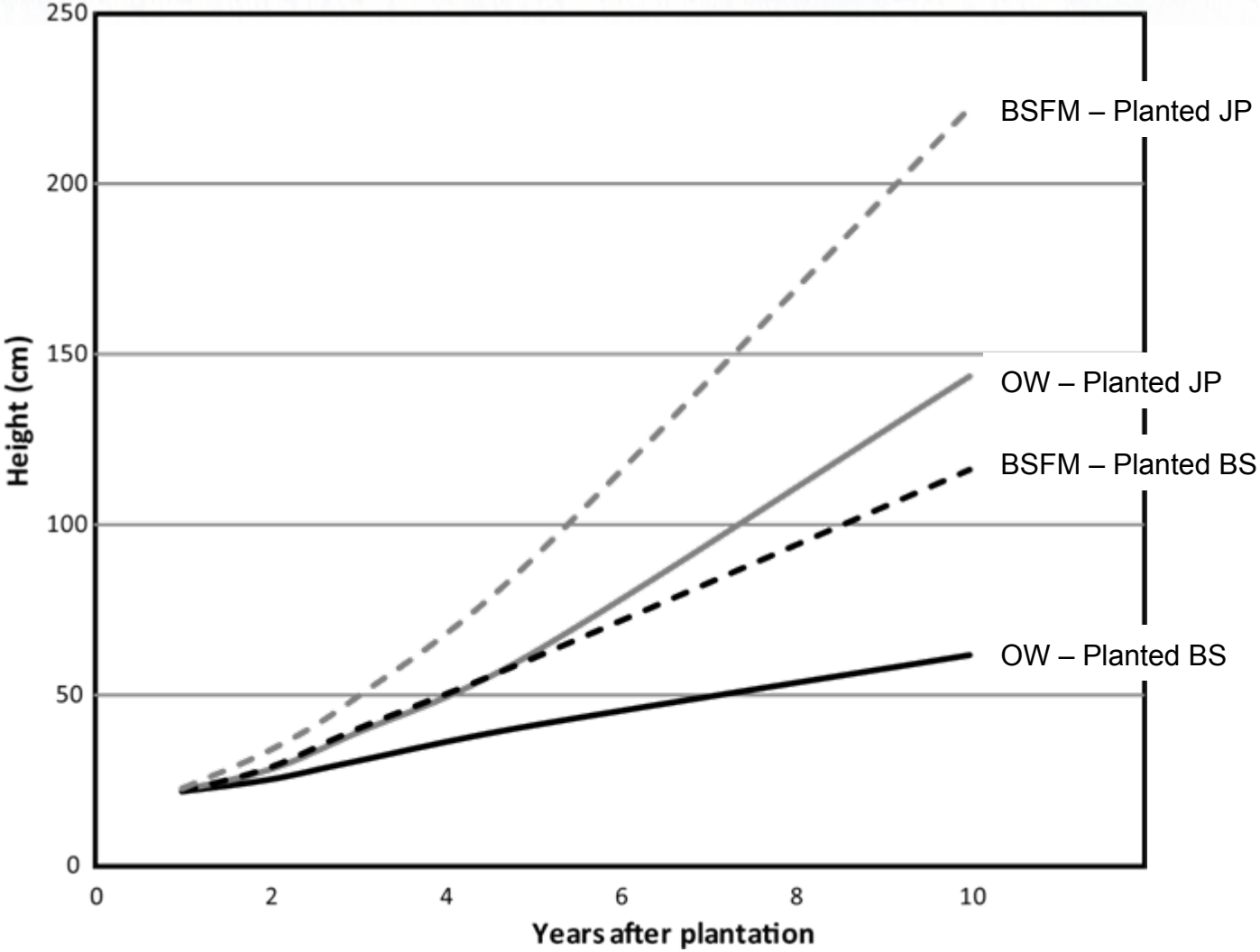

- 65% less height growth in planted OWs than in planted BSFM
- 120% more height growth with jack pine than with black spruce in afforested OWs

(posters #G-163 and #G-164)

Growth and yield of afforested OWs

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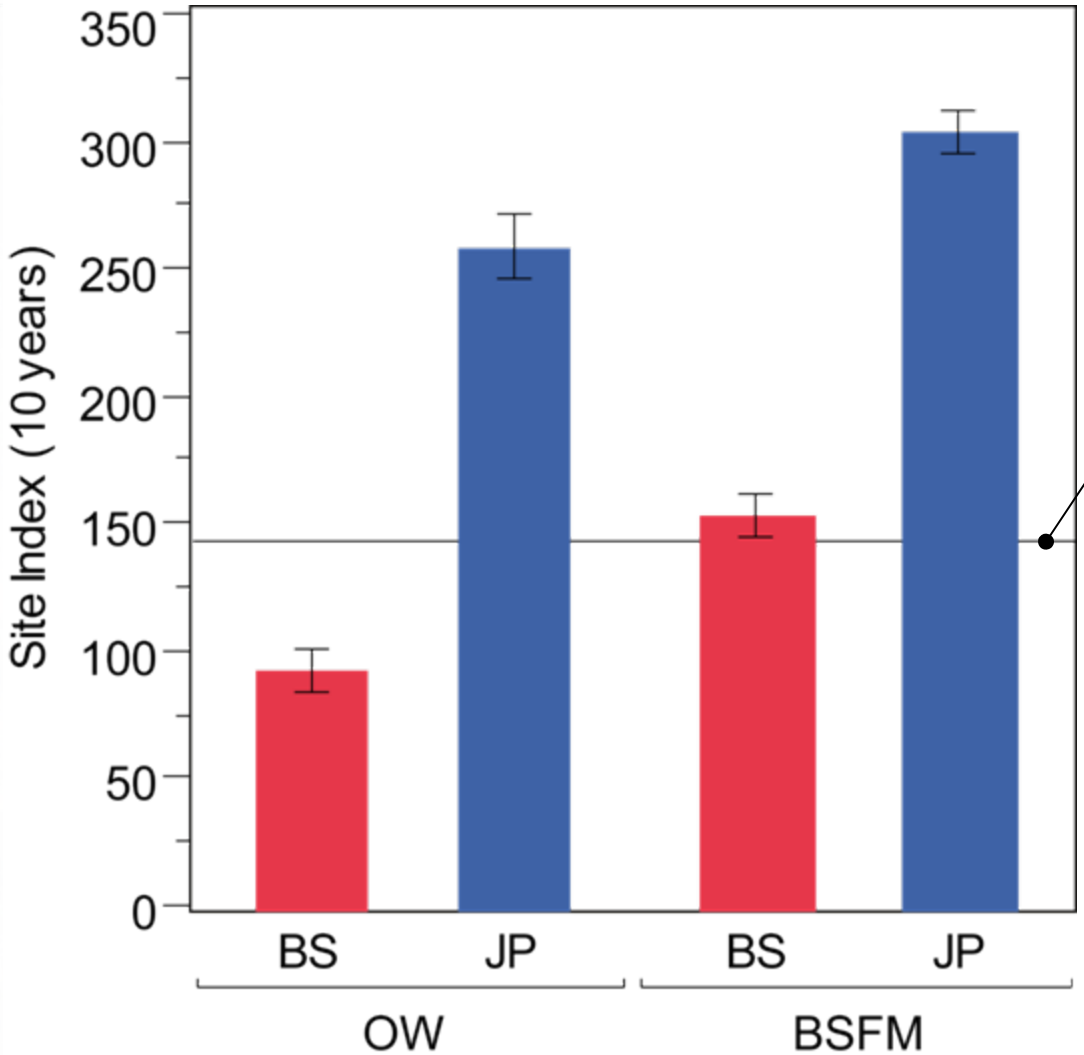

Gaboury et al. (2009) Site Index used (143 cm at 10 yrs)

- Projected yield: not with black spruce!

Support capacity: soil fertility

1. Context
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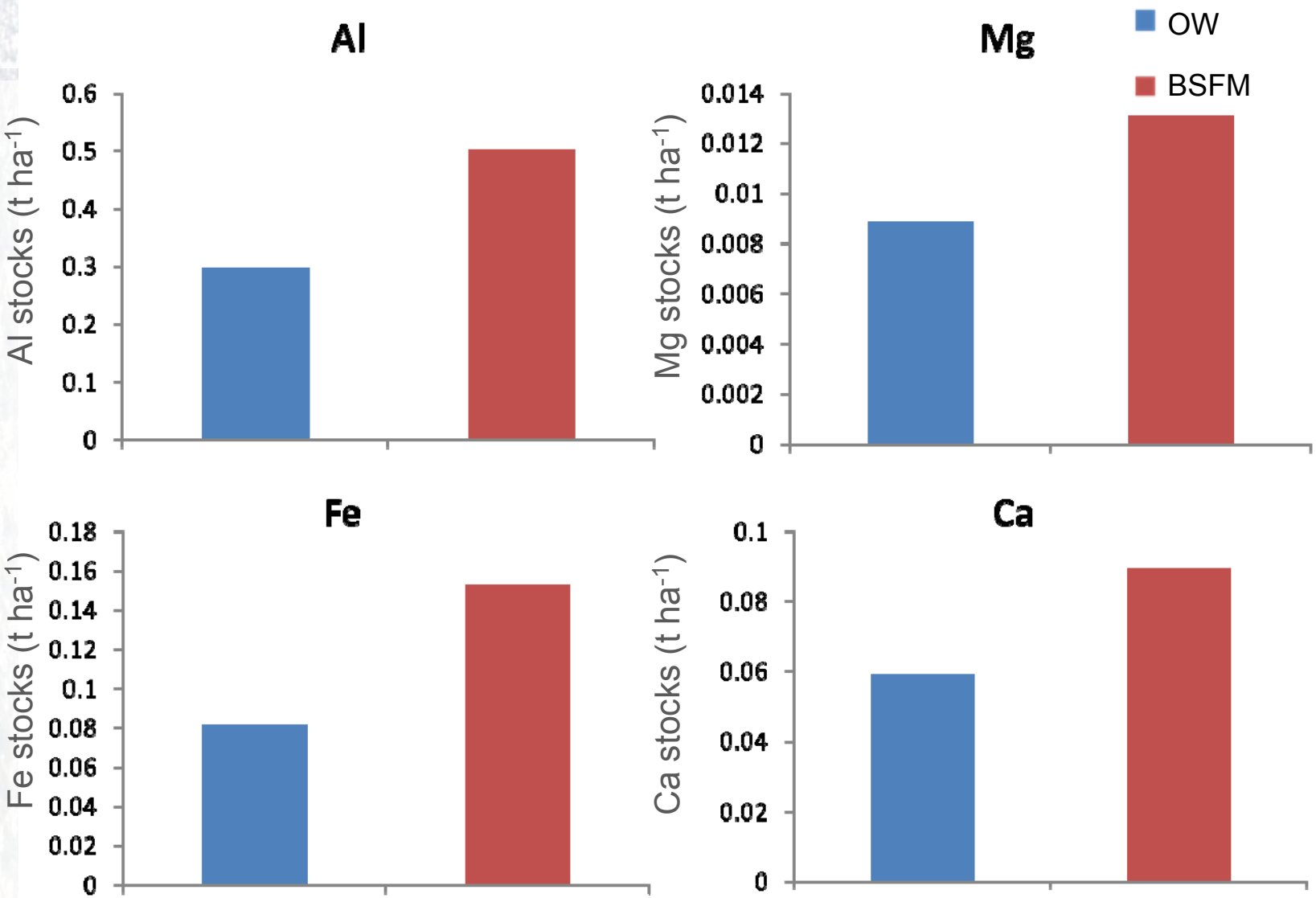

- Sustained (10 years) lower nutrient stocks in OW mineral soils

  ⟶ early growth limitation?

(poster #G-162)

Support capacity: C stock growth

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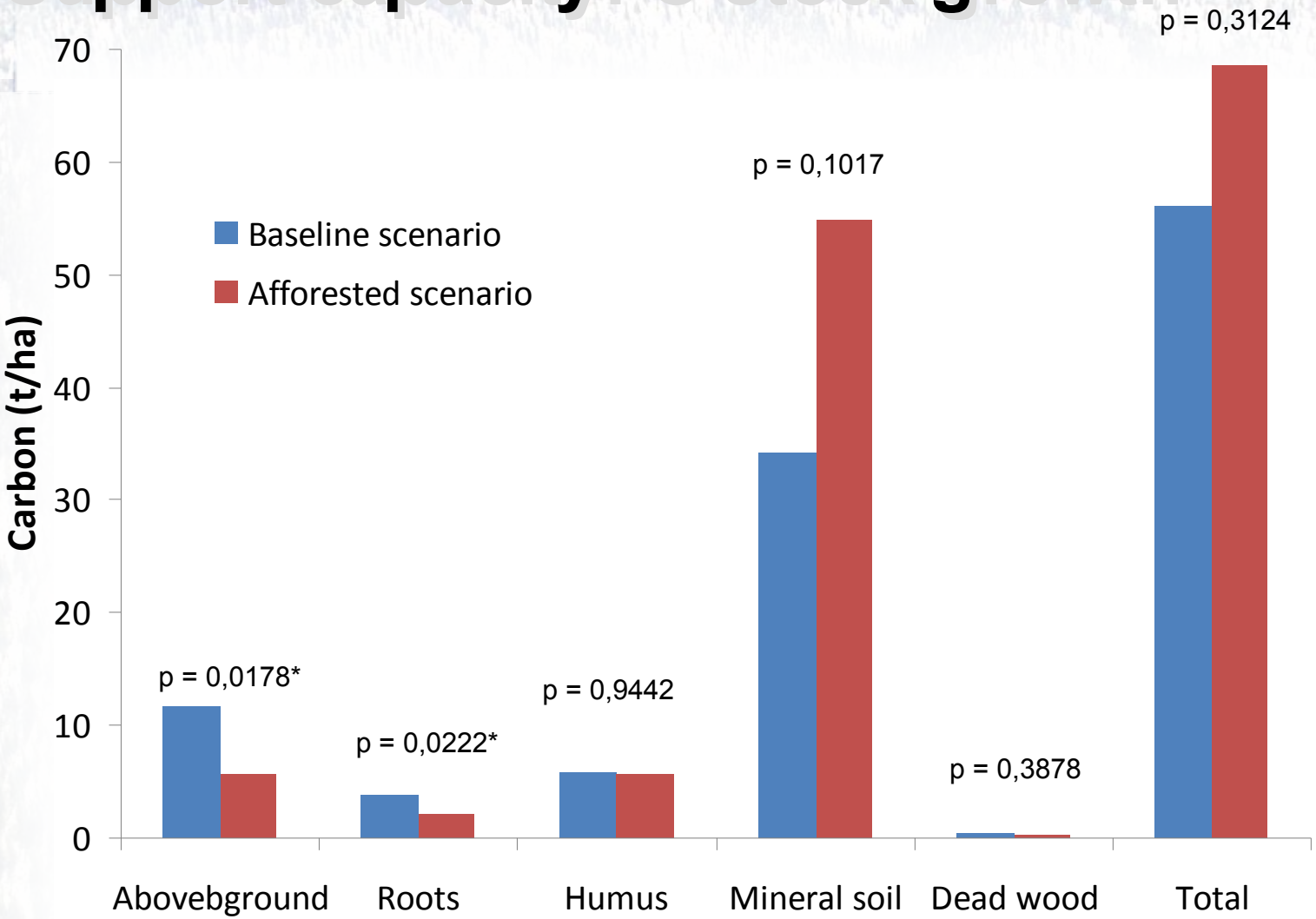

- 10 years after afforestation = predominance of mineral soils (first B horizon)
- **No evidence of net C emissions after 10 years**

(poster #G-165)

Mature OWs VS mature BSFM stands

1. Context
2. Simulated C balance
3. **Support capacity**
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Mature OWs
(=Baseline scenario)

Mature BSFM stands
(≈Afforestation scenario)

Comparable stand characteristics (stand age, soil deposits, slope, aspect, drainage, etc.)

Mature OWs VS mature BSFM stands

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80 yr-old OWs
(=Baseline scenario)
15 t C ha^{-1}

80 yr-old BSFM stands
(≈Afforestation scenario)
113 t C ha^{-1}

C stock permanence: reversal risk

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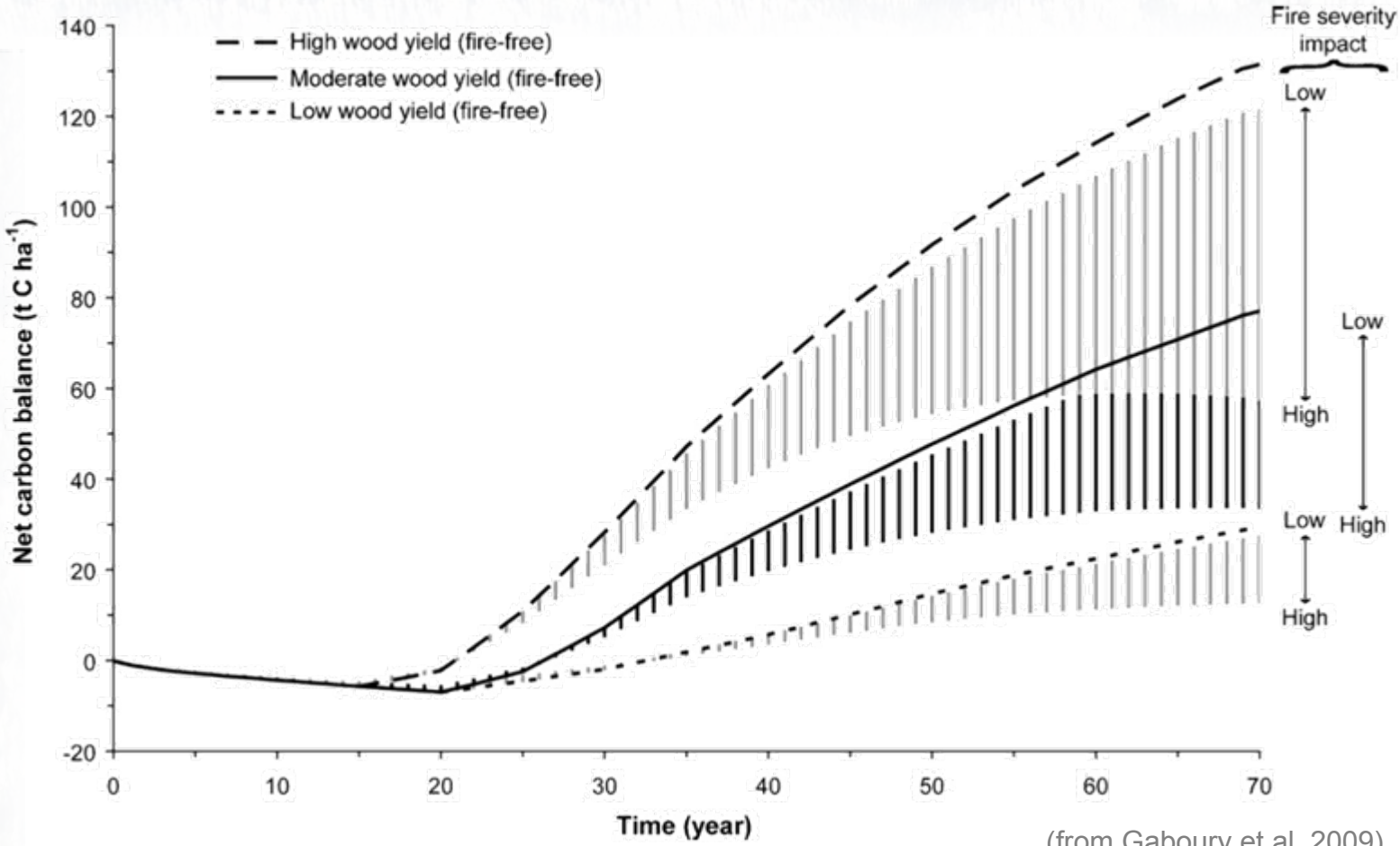

(from Gaboury et al. 2009)

- Reversal risk management =
  - Prevention (spatial dispersion, buffers, fuel management)
  - Accounting (disturbance-explicit C balance, insurance products)
  - Avoidance (harvested wood products + substitution)

Albedo change related forcing

1. Context
2. Simulated C balance
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GEOPHYSICAL RESEARCH LETTERS, VOL. 32, L23705, doi:10.1029/2005GL024550, 2005

Climate effects of global land cover change

S. Gibbard,[1] K. Caldeira,[2] G. Bala,[1] T. J. Phillips,[1] and M. Wickett[1]

GEOPHYSICAL RESEARCH LETTERS, VOL. 28, NO. 2, PAGES 291-294, JANUARY 15, 2001

Land use Changes and Northern Hemisphere Cooling

B. Govindasamy, P. B. Duffy and K. Caldeira

LETTERS TO NATURE

NATURE · VOL 359 · 22 OCTOBER 1992

Effects of boreal forest vegetation on global climate

Gordon B. Bonan*, David Pollard & Starley L. Thompson

letters to nature

NATURE | VOL 408 | 9 NOVEMBER 2000 |

Offset of the potential carbon sink from boreal forestation by decreases in surface albedo

Richard A. Betts

6550–6555 | PNAS | April 17, 2007 | vol. 104 | no. 16

Combined climate and carbon-cycle effects of large-scale deforestation

G. Bala*†, K. Caldeira‡, M. Wickett*, T. J. Phillips*, D. B. Lobell*, C. Delire§, and A. Mirin*

Albedo change related forcing

1. Context
2. Simulated C balance
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- Some hypotheses to test:
  1. Deciduous planted tree species (larch, birch, etc.)?
  2. “Inclusive” baseline scenario = OWs **+** C-intensive products (concrete, steel, etc.)

Carbone boréal in the voluntary C market… a new research funding opportunity

1. Context
2. Simulated C balance
3. Support capacity
4. C stock permanence
5. Albedo
6. **Carbone boréal**

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Merci!

NSERC
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Fonds de recherche
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