Buried wood – or the role of bryophytes in the deadwood cycle of humid boreal forests

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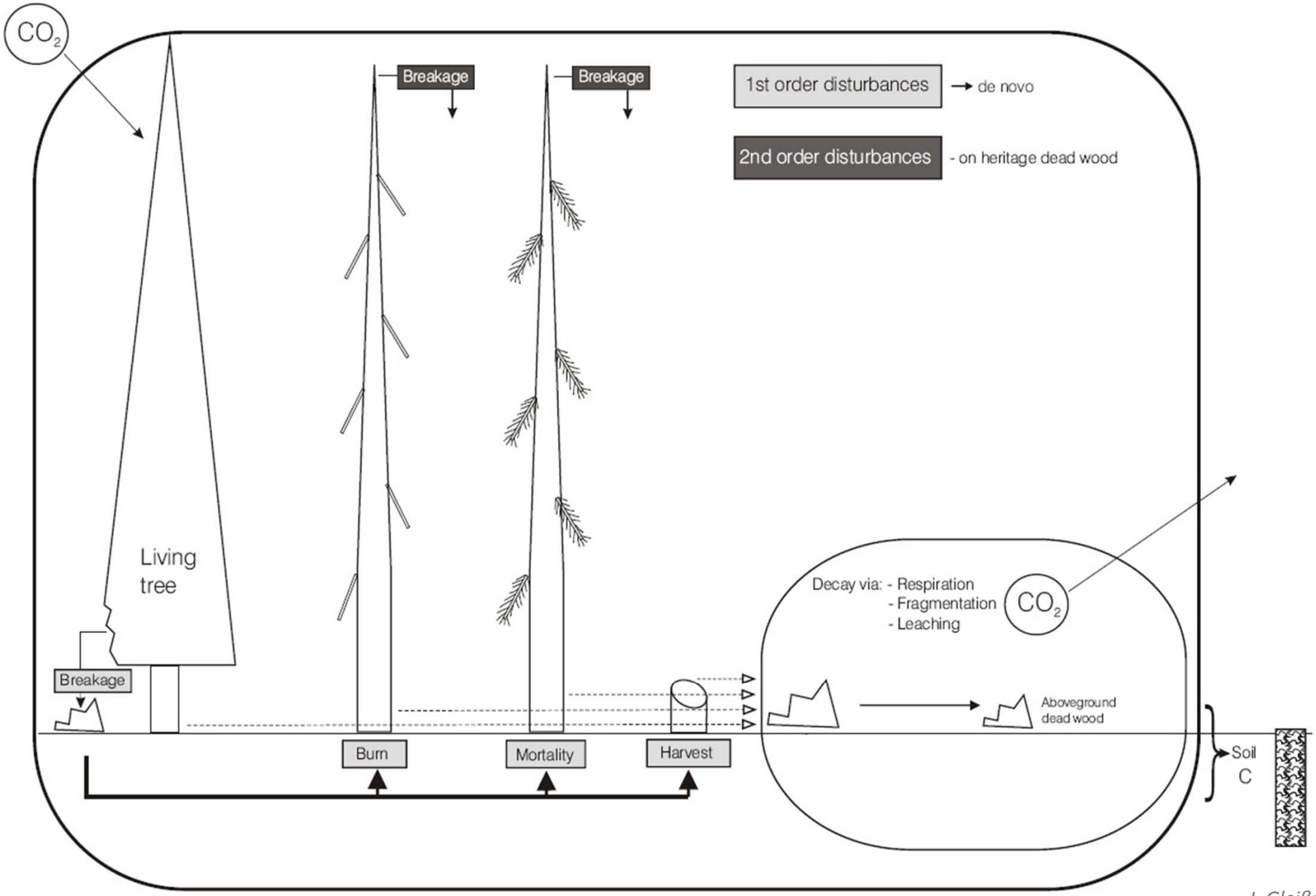
Deadwood Cycle



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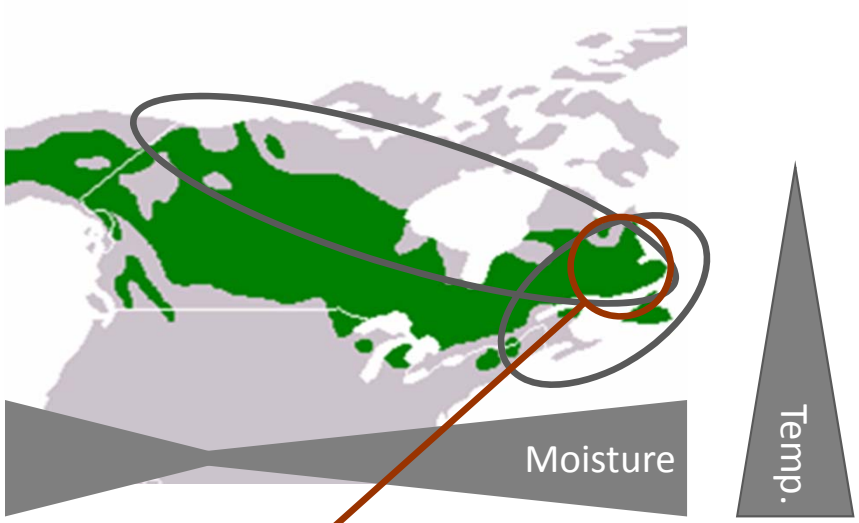
Study Region and Sites



Study region: Labrador

- High-boreal forest
  - Cold (MAT < -1.0˚C)
  - Perhumid (MAP ~1000 mm)
  - Fire-driven (interval 300-500 yrs)
  - Black spruce (*Picea mariana*)

Study sites

- Old-growth (n = 3)
- Clearcut harvested (1, 17, 34-36 years) (n = 3)
- Middle-aged burned (21 years) (n = 3)

Deadwood Stocks

Deadwood types

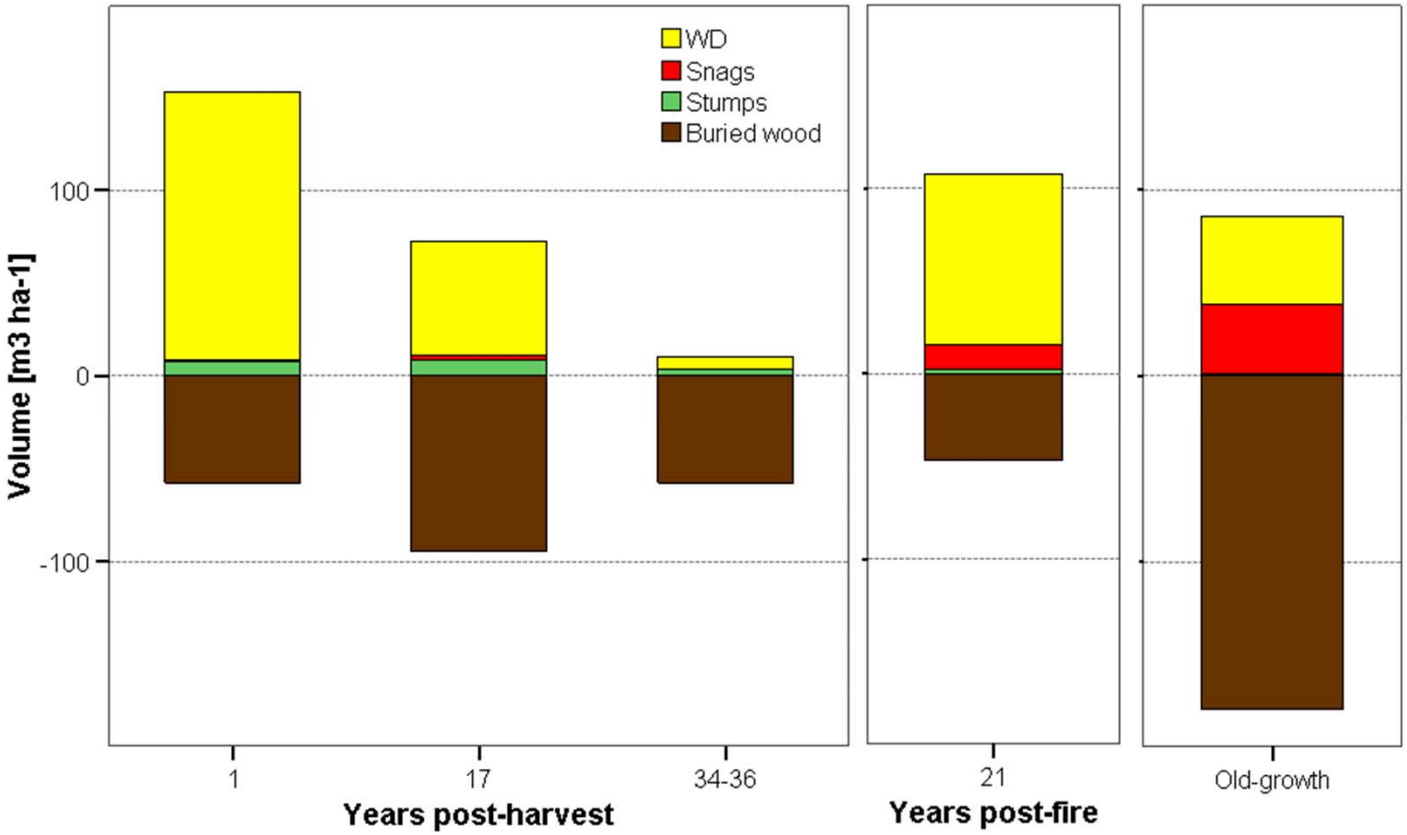
- (Downed) Woody debris
- Snags
- Stumps
- Buried wood

Ø BW C stocks

5.8 ± 2.8 to 37.3 ± 6.6 Mg C ha^{-1}

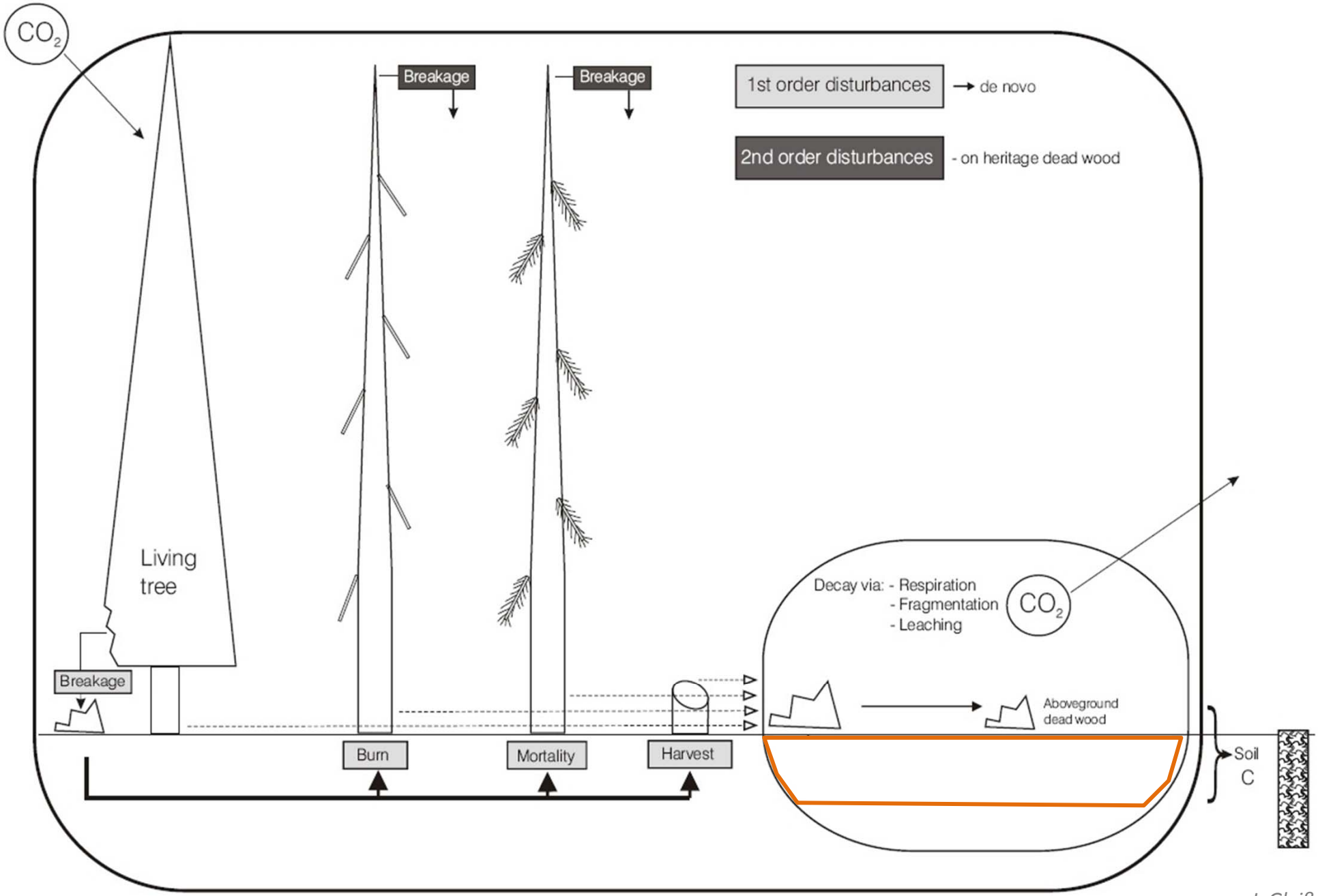
Ø BW volume

57 ± 28 to 389 ± 67 m^3 ha^{-1}



Hagemann et al. (2009) Can. J. For. Res.

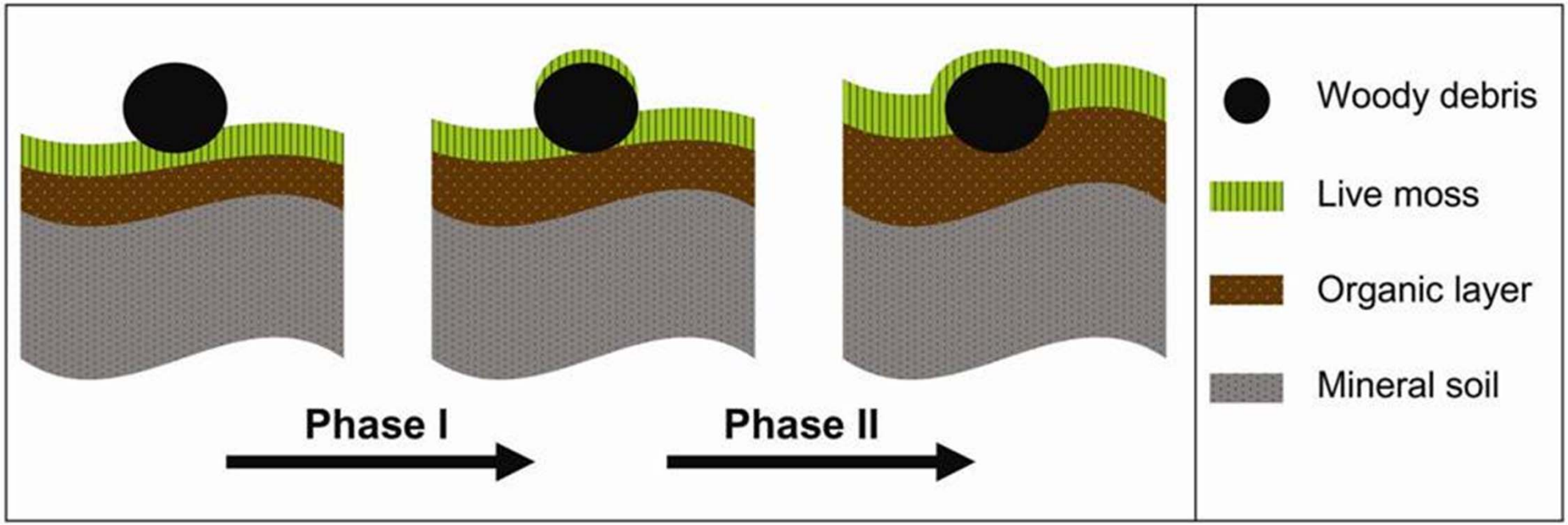
Deadwood Cycle



J. Gleißner

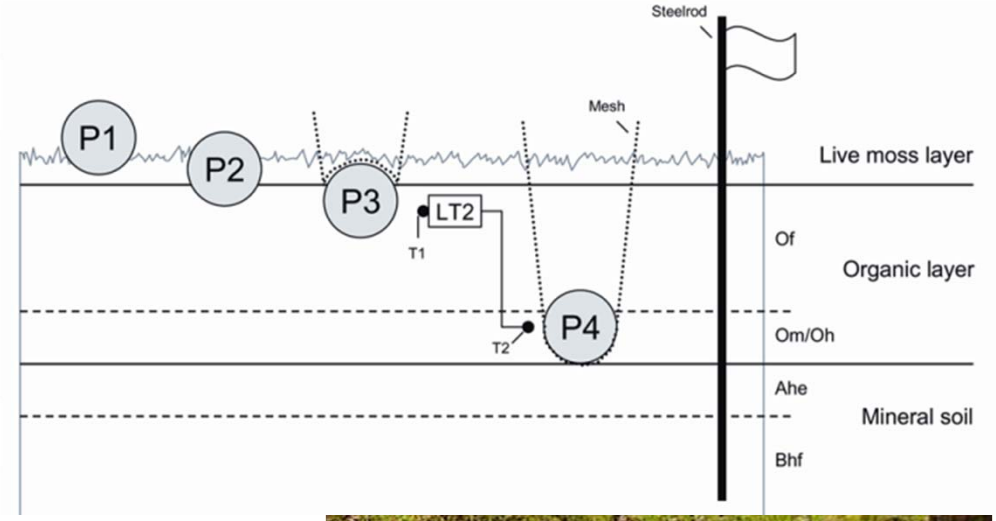
Buried wood

- Process of WD burial
  - WD is gradually overgrown by moss and incorporated into organic layer
  - Expected:
    - ↓ temperature
    - ↑ moisture
    - ↓ decomposition
  - Required conditions: cool and wet climate, vital moss layer, high groundwater table, long fire return interval, WD for burial, …?



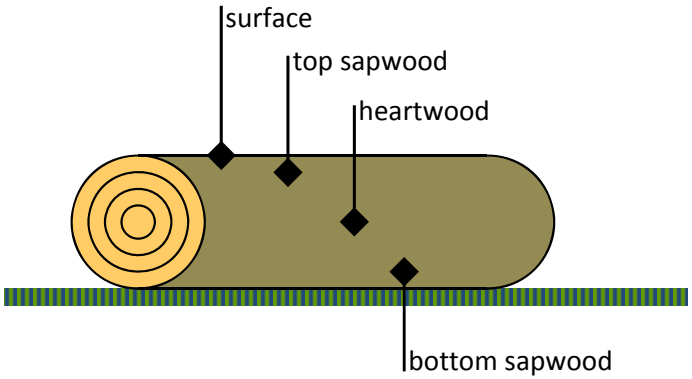
Burial Experiment

- Burial of
  - 36 standardized spruce logs
  - 4 placement positions
  - Ends sealed



- DWD respiration
  - Closed dynamic chamber – IRGA
  - Bi-weekly measurements (12/07–01/09, 2008)

- Environmental variables
  - Temperatures
    - Air
    - Soil (2 and 10 cm depth)
    - DWD (surface, top sap, heartwood, bottom sap)
  - Relative humidity
  - DWD and soil moisture content



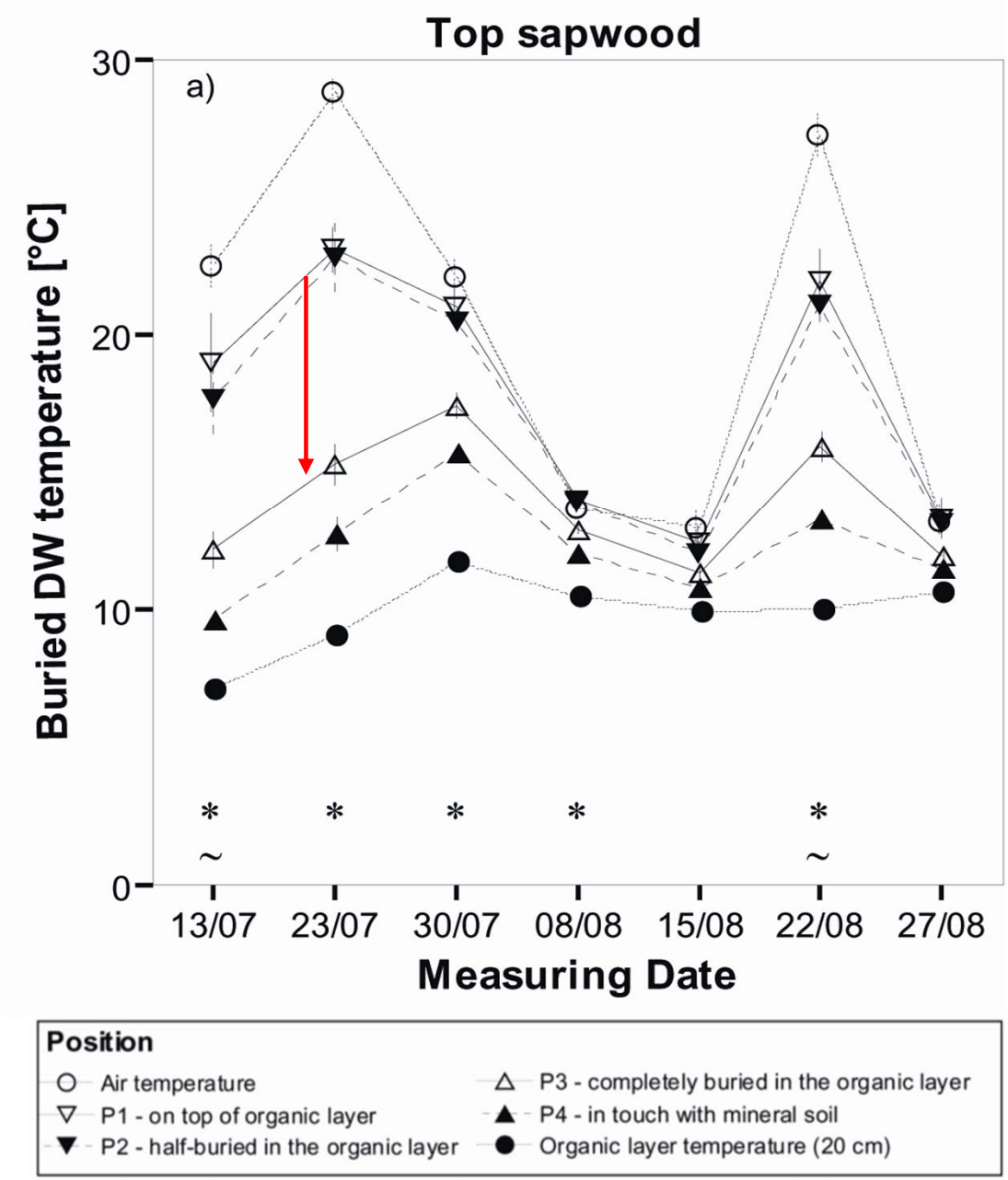
Results I

Temperature

- Temperature of moss-covered logs significantly lower than of uncovered logs
- Differences most pronounced on warm days

Mosses influence buried wood (& organic layer/mineral soil) through

- Insulation



Hagemann et al. (2010) Ecosystems

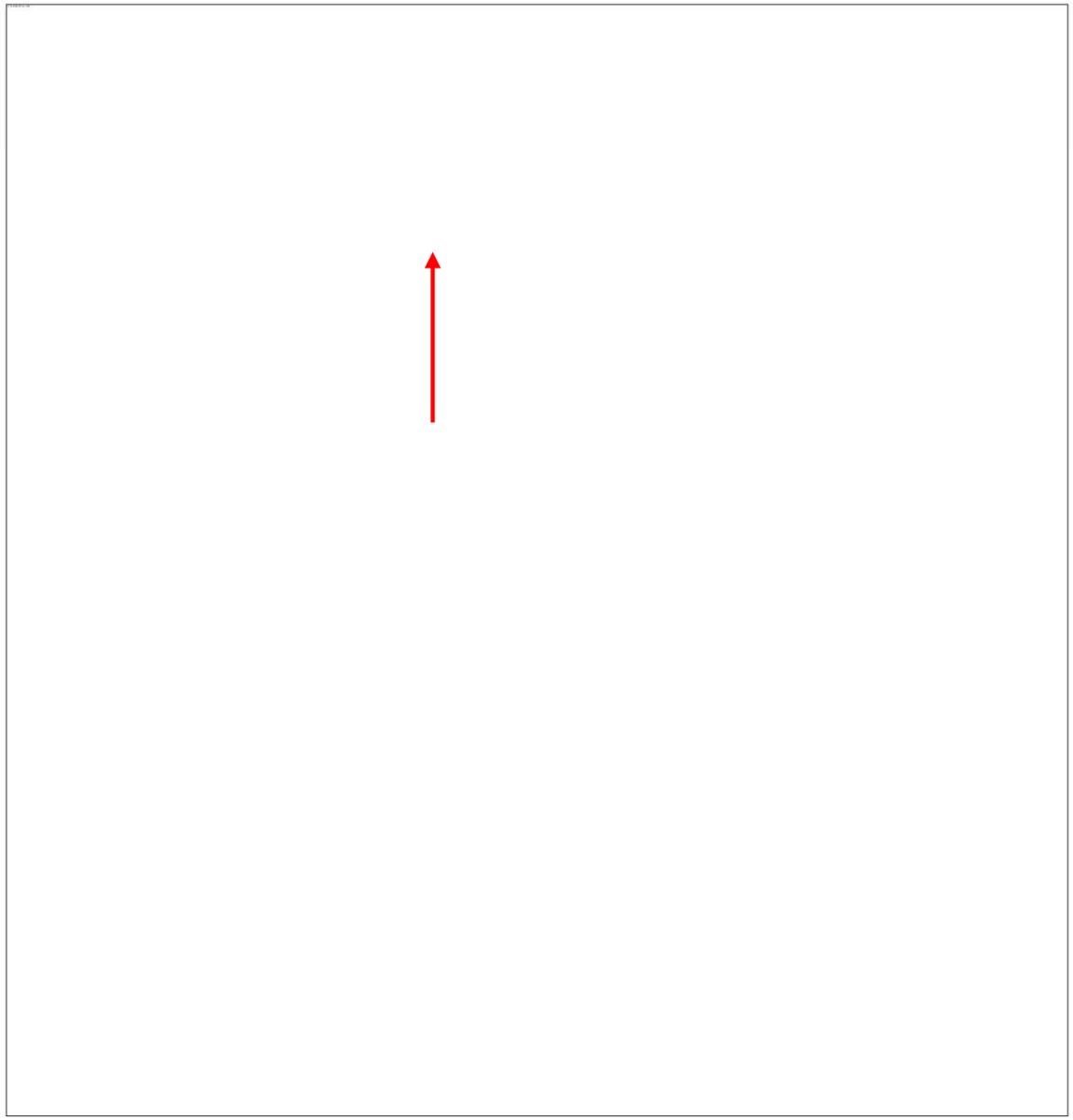
Results II

Moisture

- Moisture content increases with burial depth
- High variability due to variability in wood density

Mosses influence buried wood (& organic layer/mineral soil) through

- Insulation
- Water retention



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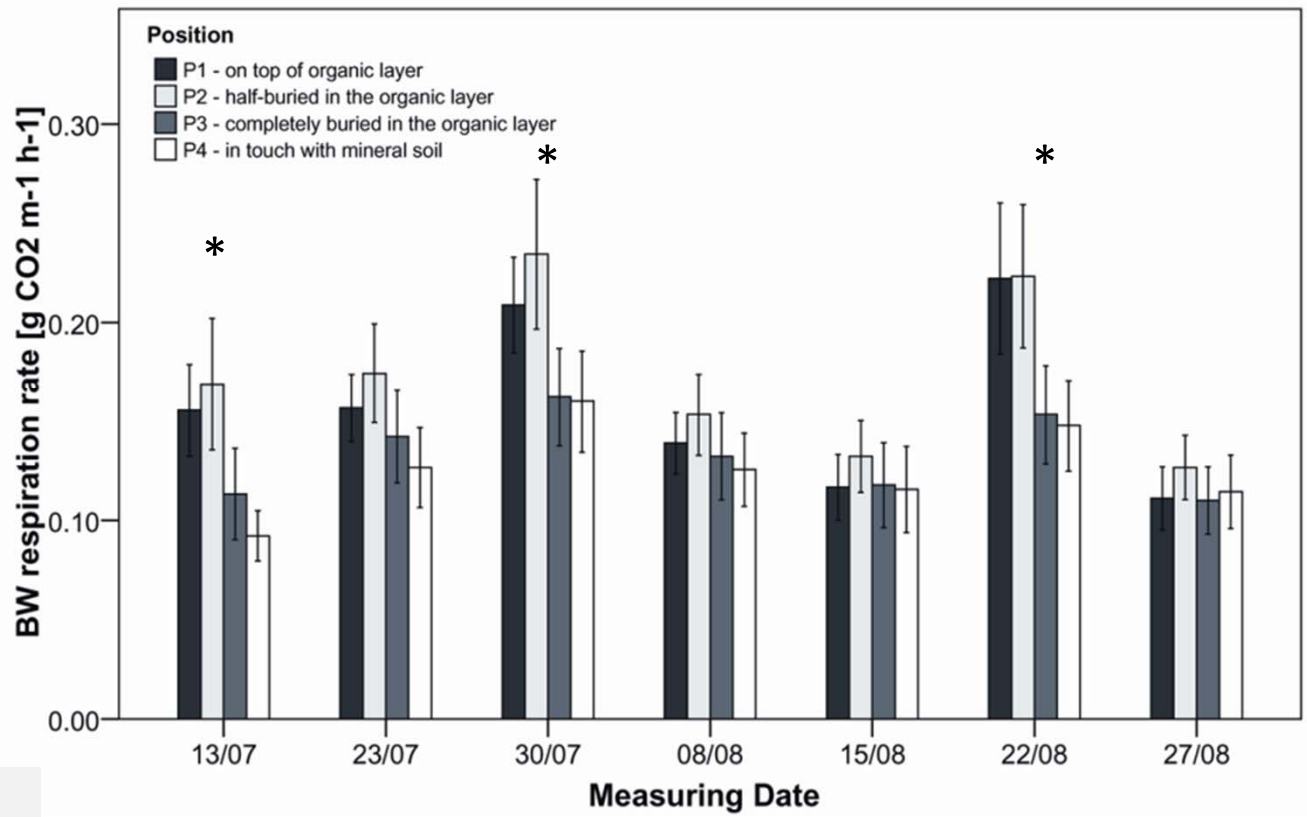
Results III

Respiration

- High variability
- 68% of variability due to temperature, moisture & density
- Decreasing trend with burial depth
- Decrease in respiration initiated by moss cover, not by burial depth



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Mosses influence buried wood (& organic layer/ mineral soil) through

- Insulation
- Water retention

→ Reduction of decomposition

→ Initiation of preservation

Buried wood preservation

^{14}C Dating

- Age range 200-450 years
- Some samples likely preserved for 250-300 years after tree death
- Bias towards younger samples

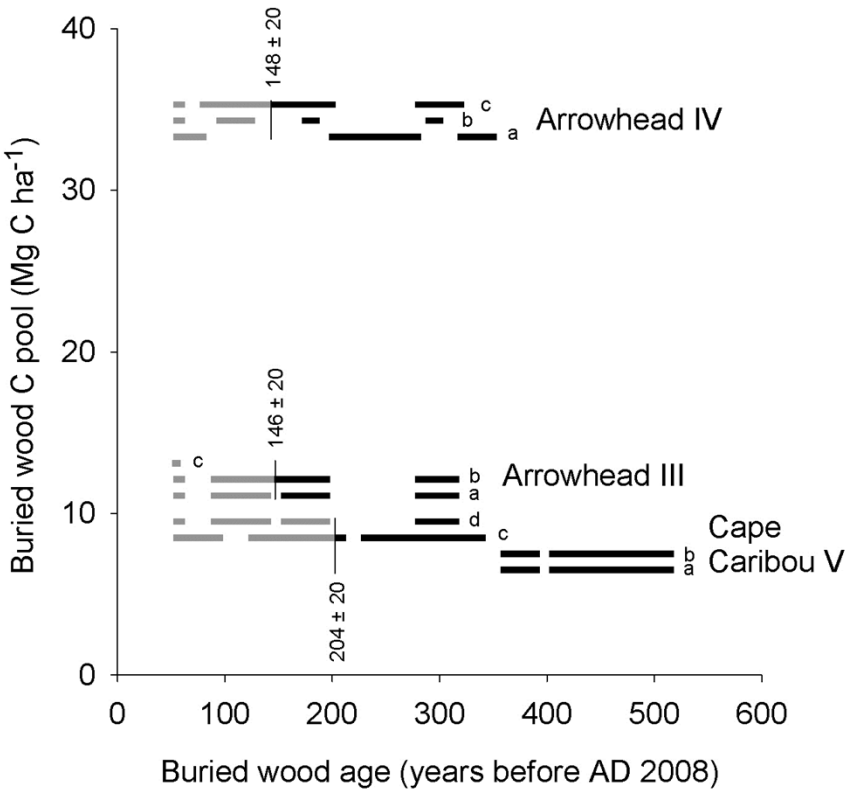
Mosses influence buried wood (& organic layer/ mineral soil) through

- Insulation
- Water retention

→ Reduction of decomposition

→ Initiation of preservation

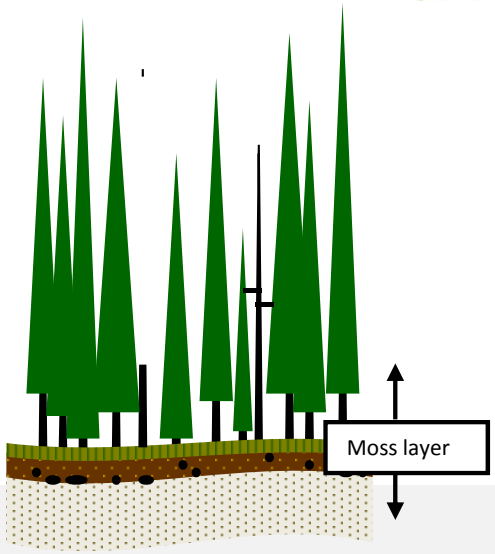
→ Buried wood is a (possibly very) long-lived ecosystem C pool



Moroni et al. (2010) Ecosystems

Synthesis I

- WD burial requires a vital moss layer which can overgrow WD before it has completely decomposed
- WD burial is a 2-phase process: I) Initialization and II) Burial
- Moss influences buried wood (& organic layer/mineral soil) through insulation, water retention … and chemistry?!
- Decomposition rates of buried wood greatly reduced

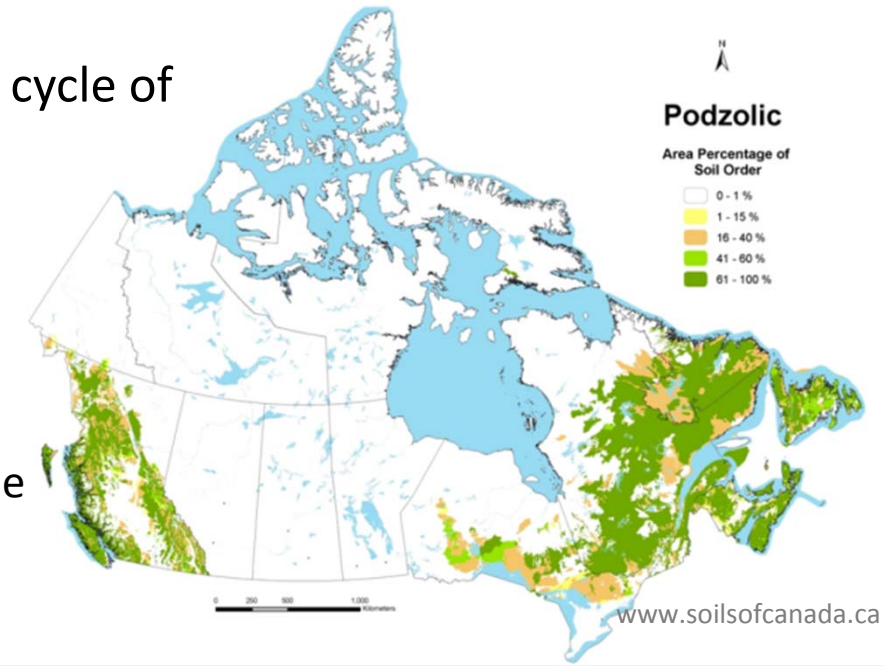


Bryophytes with disproportional effects on organic layer, buried wood & mineral soil C pools

Bryophytes are a key driver of the deadwood and C cycle of <u>humid boreal black spruce forests in Labrador</u>

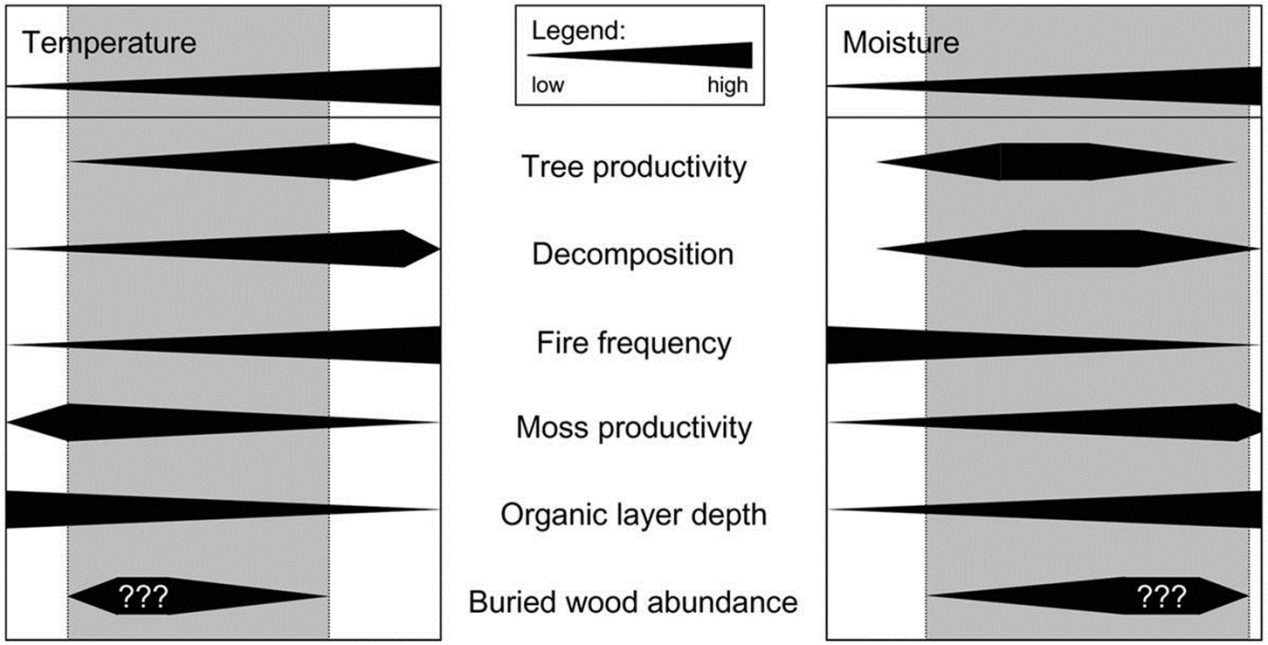
Elsewhere?

- Mosses are an integral component of
  - Most boreal forests
  - Many coniferous forests outside the boreal biome
  - Micro-habitats of mixed forests



Buried wood likely occurs over a wide range of environmental conditions

Synthesis II



Buried wood occurrence linked to the ecological relevance of bryophytes

Effects of bryophytes on ecosystems processes increase with deteriorating soil drainage (paludification)

Moisture and bryophytes determine patterns of soil C storage at landscape and regional scales

Bryophyte-regulated forests may release large amounts of CO_2 from buried wood and soil C pools due to decreased bryophyte productivity and enhanced decomposition

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TECHNISCHE UNIVERSITÄT DRESDEN

Institute for Biodiversity, Ecosystem Science & Sustainability

Innu Nation

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Thank you for your attention …

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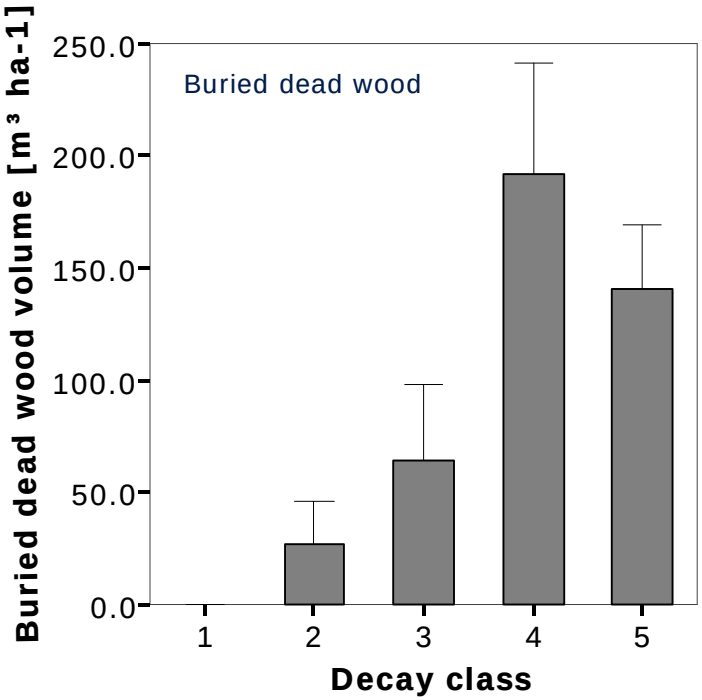
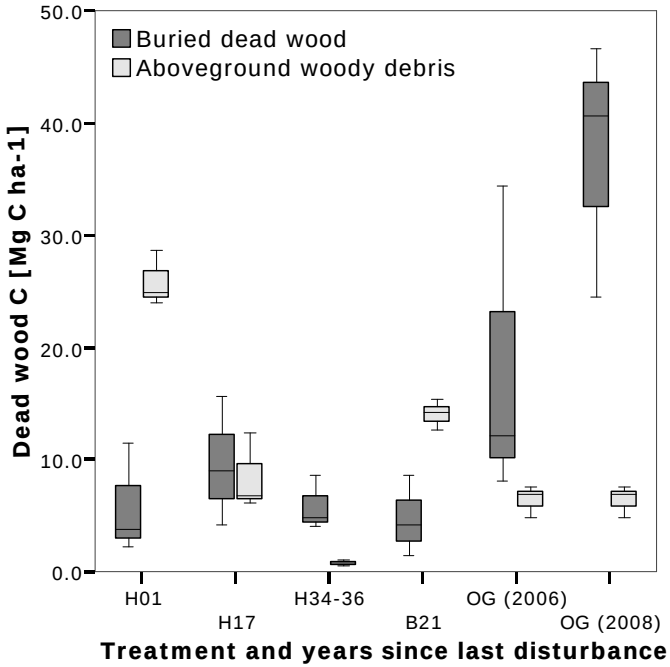
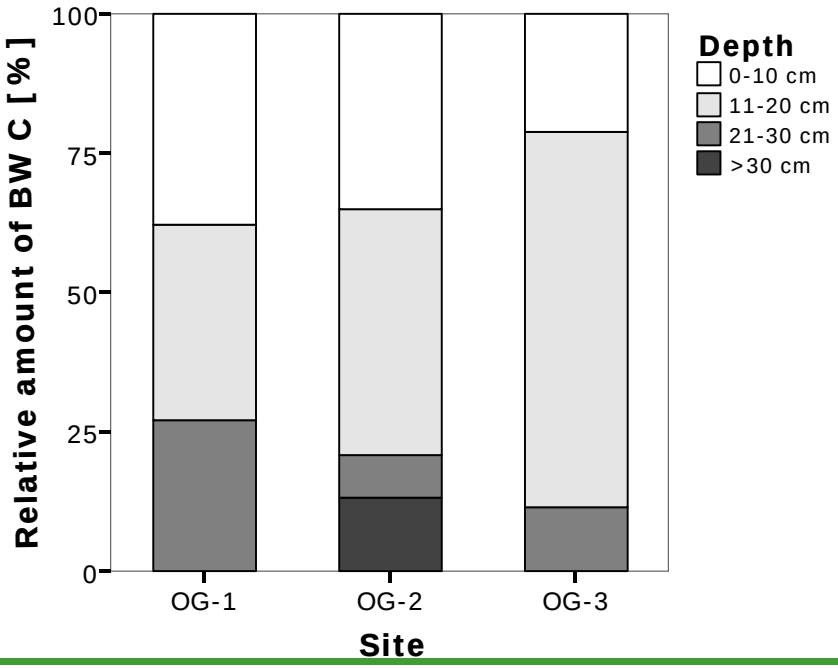
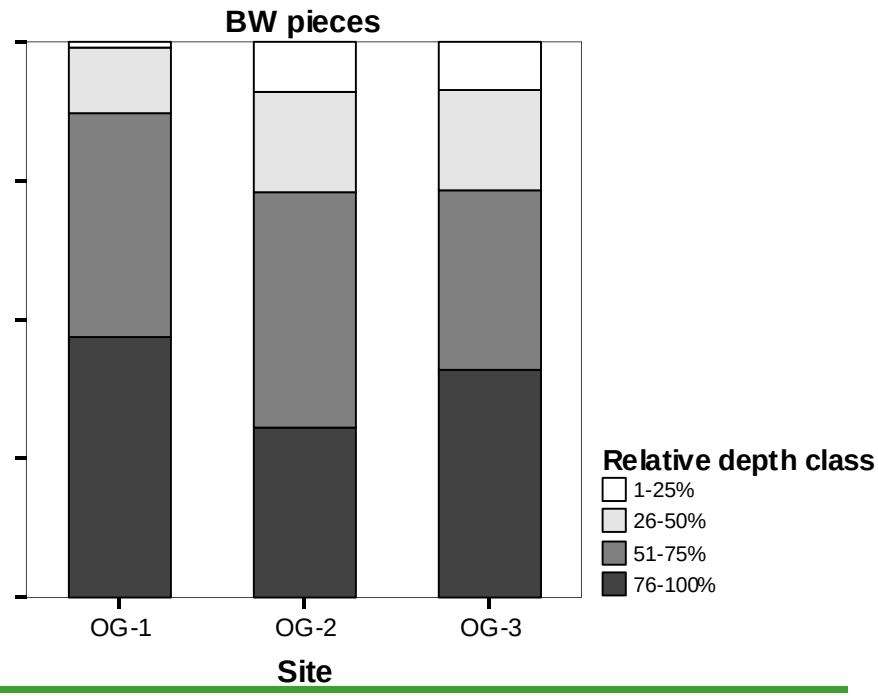

Buried dead wood
Buried dead wood volume [m³ ha-1]
250.0
200.0
150.0
100.0
50.0
0.0
1
2
3
4
5
Decay class

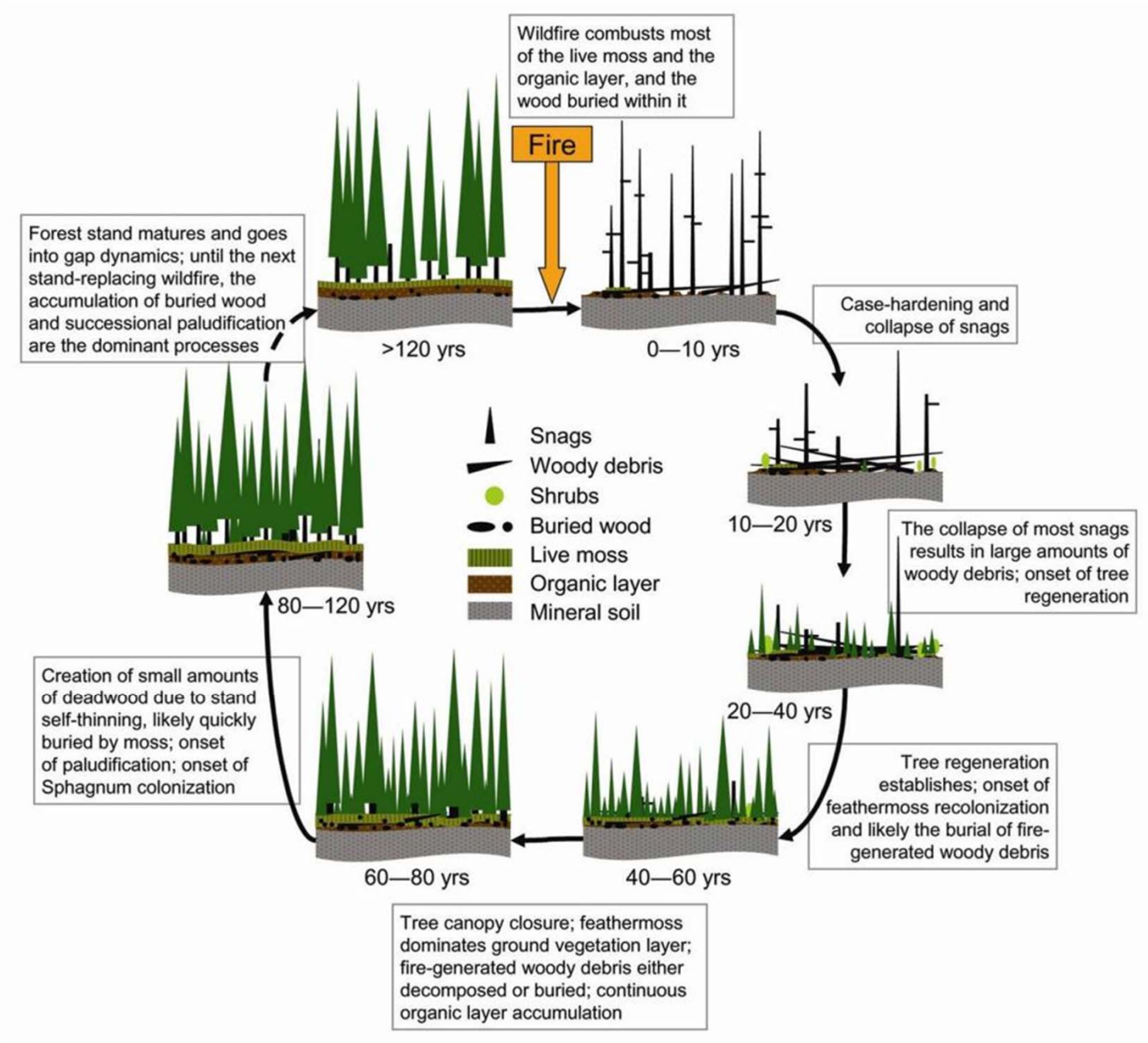

Buried dead wood
Aboveground woody debris
Dead wood C [Mg C ha-1]
50.0
40.0
30.0
20.0
10.0
0.0
H01
H17
H34-36
B21
OG (2006)
OG (2008)
Treatment and years since last disturbance


Relative amount of BW C [%]
100
75
50
25
0
OG-1
OG-2
OG-3
Site
Depth
0-10 cm
11-20 cm
21-30 cm
>30 cm


BW pieces
OG-1
OG-2
OG-3
Site
Relative depth class
1-25%
26-50%
51-75%
76-100%

WD respiration … vs. mass loss rates

- Standardized sample log:
  - Diameter 13.9 cm and length 31 cm
  - Volume 0.0047 m^3 and surface 0.135 m^2
  - Weight 2 kg and density 425 kg/m^3
  - C content 50%
- Respiration rate
  - Measured 0.2 g CO_2 m^{-2} h^{-1}
  - Per day 4.8 g CO_2 m^{-2} d^{-1}
  - Per year 0.864 kg CO_2 m^{-2} yr^{-1} (assuming 180d)
  - Equaling 0.236 kg C m^{-2} yr^{-1}
  - Per log 0.032 kg C m^{-2} yr^{-1}
- Life-time <u>31.3 years</u> (steady linear decay)
- For 300 years ~0.02 g CO_2 m^{-2} h^{-1} (10%)


Wildfire combusts most of the live moss and the organic layer, and the wood buried within it
Fire
Forest stand matures and goes into gap dynamics; until the next stand-replacing wildfire, the accumulation of buried wood and successional paludification are the dominant processes
>120 yrs
0—10 yrs
Case-hardening and collapse of snags
Snags
Woody debris
Shrubs
Buried wood
Live moss
Organic layer
Mineral soil
10—20 yrs
The collapse of most snags results in large amounts of woody debris; onset of tree regeneration
80—120 yrs
20—40 yrs
Creation of small amounts of deadwood due to stand self-thinning, likely quickly buried by moss; onset of paludification; onset of Sphagnum colonization
Tree regeneration establishes; onset of feathermoss recolonization and likely the burial of fire-generated woody debris
60—80 yrs
40—60 yrs
Tree canopy closure; feathermoss dominates ground vegetation layer; fire-generated woody debris either decomposed or buried; continuous organic layer accumulation