Monitoring Peatland Carbon Sources and Sinks in Permafrost Areas

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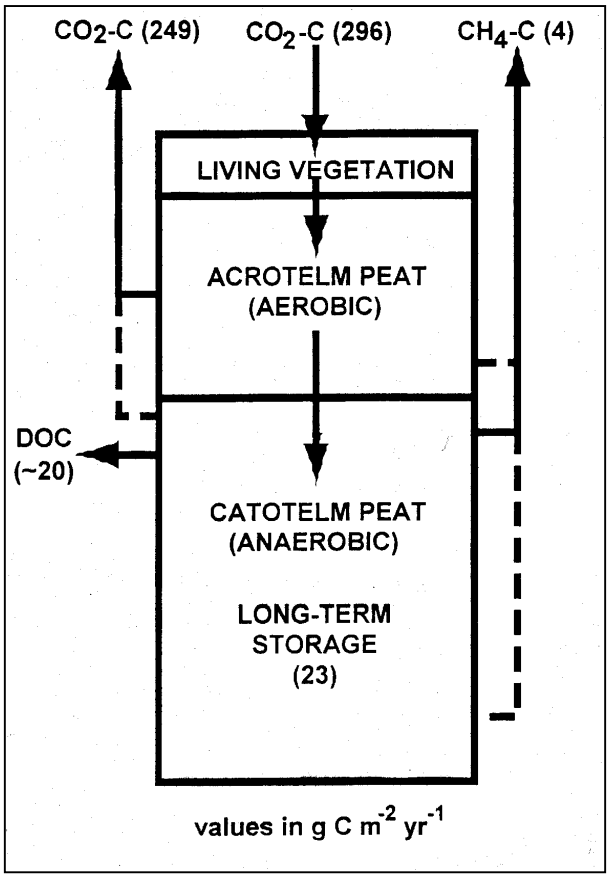
- Currently no monitoring in permafrost regions

Carbon Sources and Sinks: Why are they important?

- Northern peatlands contain about 5×10^{17}g organic carbon (about 1.5×10^{17}g in Canada (60% more than is stored in our forests)
- About 35% of this total is in permafrost
- Peat has accumulated at an average rate of about 1×10^{17}g yr^{-1}, which represents
  - About 100 years of fossil fuel consumption
  - A reduction in atmospheric C02 by about 40 ppm
- Near surface layers are in a constant state of flux, the magnitudes and carbon species of which are tightly controlled by the water table.
- Frozen peatlands are distinct from unfrozen peatlands because the residence time in frozen peat is large. Forests are transient sinks.



There are three main scientific questions:

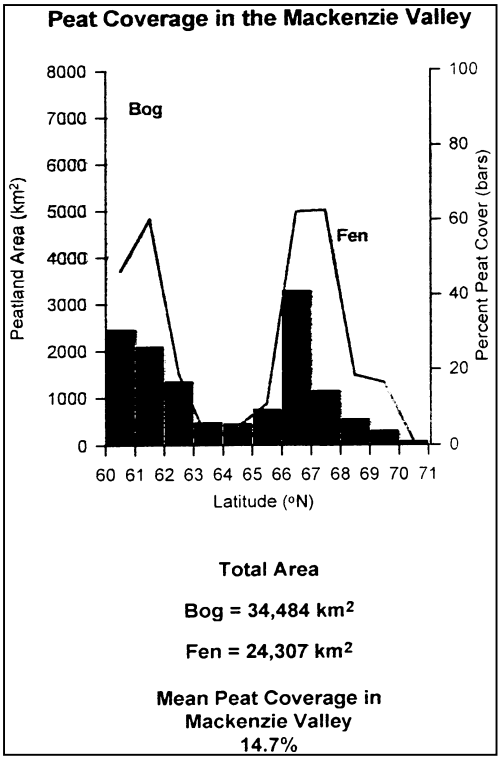
1. *Baseline Carbon stocks and accumulation rates*
   - How much peat/soil carbon do we have in Canada?
   - At what rate is it accumulating (or degrading)?

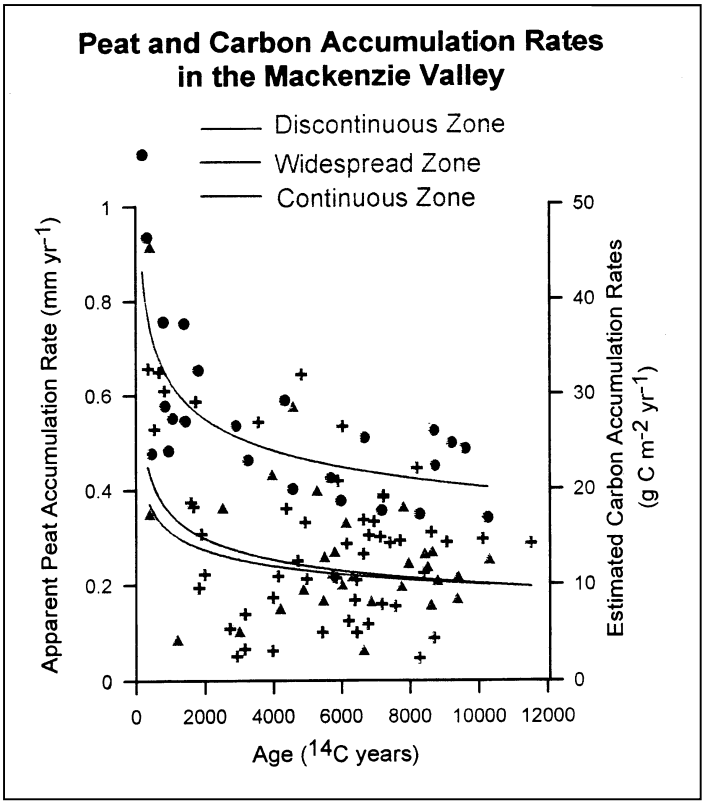
2. *Fluxes between surface and atmosphere (contemporary monitoring)*
   - What are the fluxes of C02 and CH4 in and out of peatlands?
   - How do fluxes vary at different time and space scales?

3. *Changes to both stocks and fluxes (natural and climate change-induced) (Process studies)*
    - Impacts of melting permafrost, changes in water table and temperature upon current stocks, as well as future fluxes
    - What is the effect of ecosystem change?

Where do we stand on these questions?

1. *Baseline Carbon stocks and accumulation rates*
    - How much peat/soil carbon do we have in Canada?
        - Peatland Map of Canada (Tamocai et al.)
        - Well defined, with ongoing efforts to improve
        - Main problem is converting areal coverage to a carbon stock, since little is known about thickness and density
    - At what rate is it accumulating (or degrading)?
        - Long term rates are moderately well constrained for the Mackenzie Valley
        - Other regions are poorly covered
        - These rates won't necessarily apply under climate change





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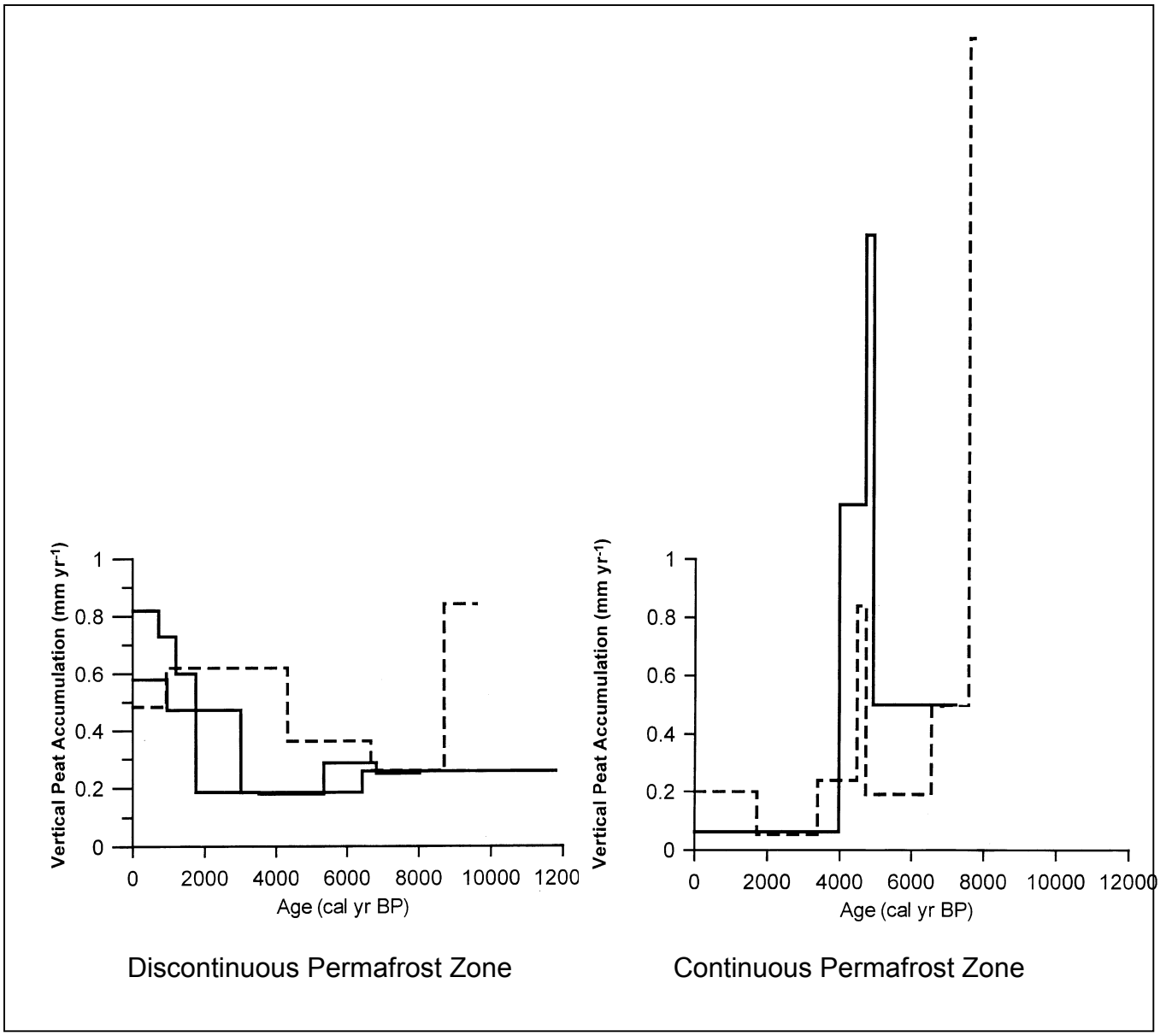
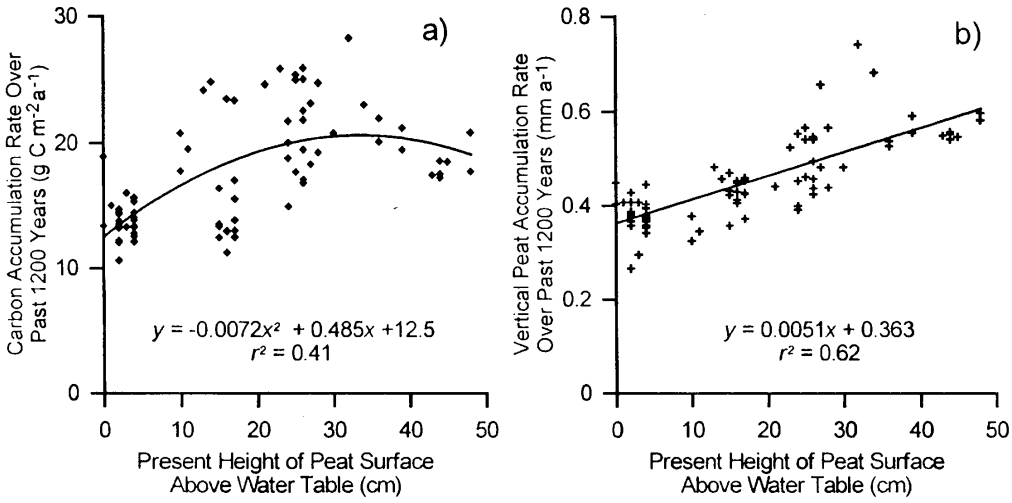
2. *Fluxes between surface and atmosphere (contemporary monitoring)*
   - What are the fluxes of C02 and CH4 in and out of peatlands?
     - In the discontinuous permafrost zone
       - Fort Simpson, N.W.T. (CH4, one summer only)
       - Thompson, MB (CO2 and CH4, data for several years)
       - Schefferville, PQ (CO2 and CH4,data for several years)
       - Hudson Bay Lowlands (CO2 and CH4, one summer only)
     - None of this work is ongoing, and therefore poor in terms of assessing annual variablity and ongoing change.
     - In the discontinuous permafrost zone 0 Churchill, MB (CO2, ongoing?)
     - There is currently only one site in Canada where measurements are ongoing to assess interannual variability in carbon fluxes: Mer Bleue, near Ottawa.



3. *Changes to both stocks and fluxes (natural and climate change-induced) (Process studies)*
   - Studies are required that examine the impacts of
     - Landform change
     - Vegetation change
     - Fire
     - Change in hydrology
     - Change in thermal regime
   - There are very few process studies, some modelling, and general predictions



What do we need to do?

- Currently, data are sporadic and not well coordinated
- At bare minimum:
  - Improve estimates of peat thickness and density
  - Multi-year flux studies in permafrost environments
  - Process studies examining changes in carbon, water table, and vegetation structure in permafrost environments
  - Site-specific modelling of carbon storage
- Additionally:
  - Detailed integrated flux studies in a wider range of climates (similar to BOREAS)
  - Linking peatiand models to climate models through realistic surface climate schemes.

What is going on in Canada?

- Funding for carbon cycle science:
  - $189 million (US) in United States
  - $1.1 million (Can) per year for 3 years
- Unlike agriculture and forestry, there is no federal mandate for wetlands/peatlands

"Given the diversity of possible responses by boreal and subarctic peatiands to climatic warming, it is impossible at present to predict their future contributions to the global carbon cycle" (Gorham, 1991)

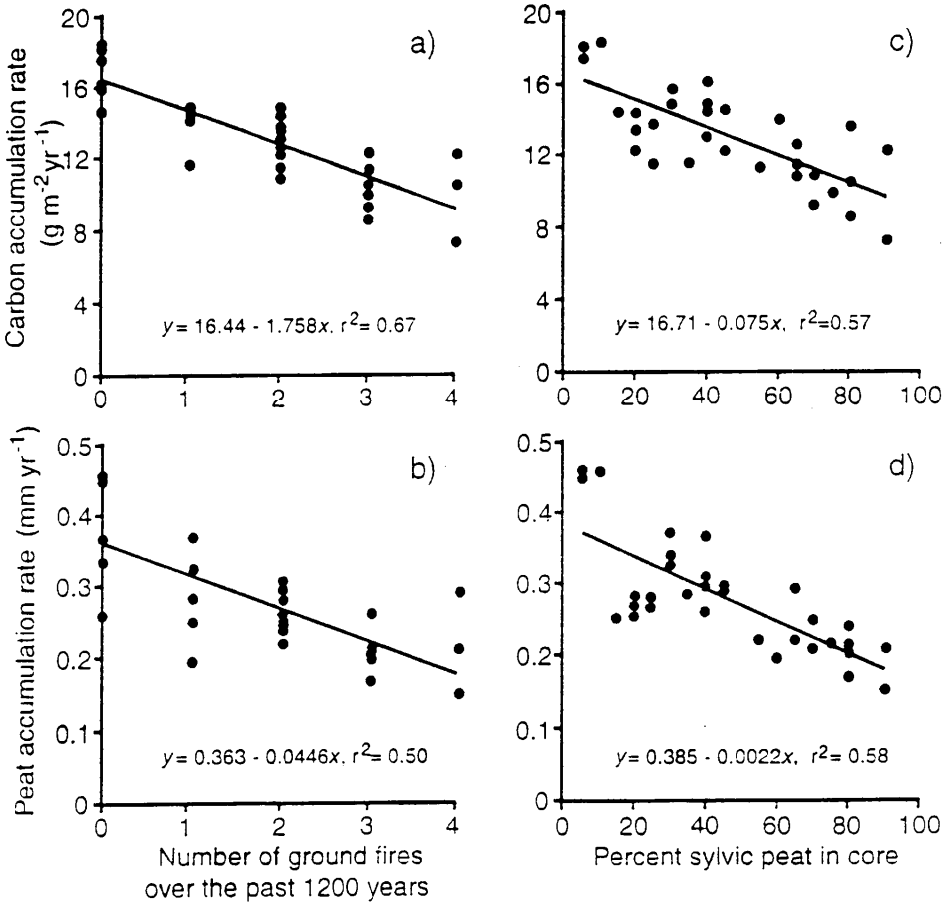


Figure 5.7. Relationship between the number of fires in a peat plateau core over the past 1200 years and a) carbon accumulation rate, and b) vertical peat accumulation rate, and the relationship between the % sylvic peat in a core, as an indication of permafrost maturity, and c) carbon accumulation rate, and d) vertical peat accumulation rate.