Changes in Net Ecosystem Exchange and the Isotopic Composition of Ecosystem Respiration across Permafrost Thaw Gradient in a subarctic mire

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Introduction

- Northern peatlands store ~30% of the world's soil carbon[1]
- Since 2000, the Swedish sub-Arctic mean annual temperature has crossed the significant 0°C threshold[2]
- As the climate warms, possible positive feedbacks driven by changes in peatland carbon cycling could have major impacts on:
  - the atmospheric concentration of carbon dioxide (CO_2)[3,4]
  - cryospheric and ecological processes[3]
- Carbon dioxide is longest lived (50 - 100 years) and most abundant greenhouse gas in the atmosphere (~390 ppmv)
- Measuring net ecosystem (CO_2) exchange (NEE) can provide useful information about an ecosystem total carbon uptake relative to total system respiration

Research Field Site

- Stordalen Mire near Abisko, Sweden (68°21' N, 19°03' E)
- Zone of discontinuous permafrost:
  - ecosystem with distinct moisture and nutrient regimes, which, in turn, create distinct differences in vegetation types[6]
- Primarily composed of three distinct, predominate plant communities along a thaw gradient:

Figure 1) Elevated, dry palsa underlain by permafrost

Figure 2) Intermediate moisture site dominated by *Sphagnum* spp.

Figure 3) Completely thawed wet site dominated by *Eriophorum* spp.

Methodology

- A nine chamber auto system (3 Palsa, 3 *Sphagnum*, 2 *Eriophorum*, and 1 *Eriophorum*/Carex) measured carbon dynamics in the three distinct ecosystems
- Automated chamber measurements were conducted during a 5 minute interval chamber lid closure under ambient [transparent chamber] light conditions (Figure 4)

Fig. 4 Picture of an automated chamber located in the *Sphagnum* site

- NEE and $\delta^{13}C\text{-}CO_2$ were determined using a Quantum Cascade Laser Spectrometer (QCLS)
- Respired $\delta^{13}C\text{-}CO_2$ (‰) was derived from Keeling regressions of isotope and concentration data from automated chamber flux measurements

Results

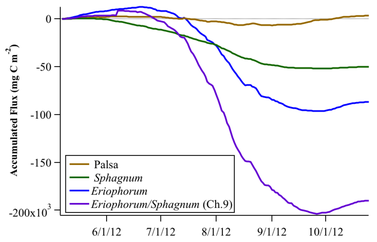

Figure 5) Over the 2012 growing season (May – October), the intermediate thawed *Sphagnum* and completely thawed *Eriophorum* (including Ch. 9) sites are net CO_2 sinks; however, the palsa site with intact permafrost is a net source of atmospheric CO_2.

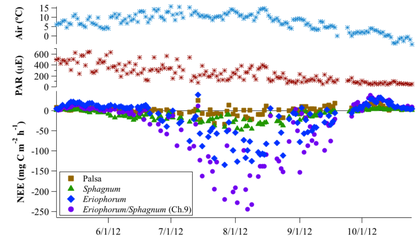

Figure 6) Graph depicting NEE response to variations in PAR and air temperature over the 2012 growing season. Generally, increases in temperature and PAR yield a greater uptake of CO_2.

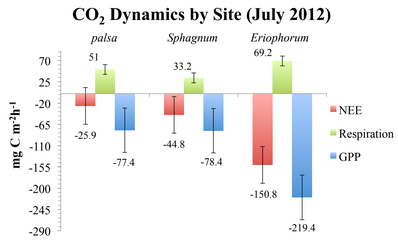

Figure 7) From the palsa to *Eriophorum* site, greater rates of GPP (fixing carbon) possibly occur due to larger leaf area and more productive plants. Respiration (R) was isolated by a shrouding technique, which completely darkened the chamber, following the 5 minute transparent (ambient light) lid closure during the month of July 2012. GPP was calculate by NEE – R (n = 26).

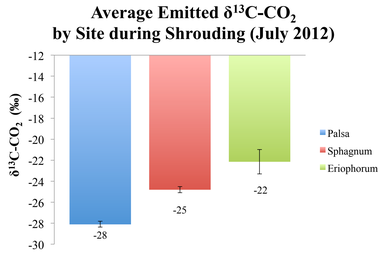

Figure 8) Depicted is $\delta^{13}C\text{-}CO_2$ emitted during shrouding (July 2012). As the sites transitions (Palsa to *Sphagnum* to *Eriophorum*), there is a 3‰ shift (-28 to -25 to -22‰, respectively). This may be due to photosynthesis affecting respired $\delta^{13}C\text{-}CO_2$. However, the respired CO_2, across all sites, may be primarily attributed to decomposition of soil organic matter (n = 26).

Conclusion

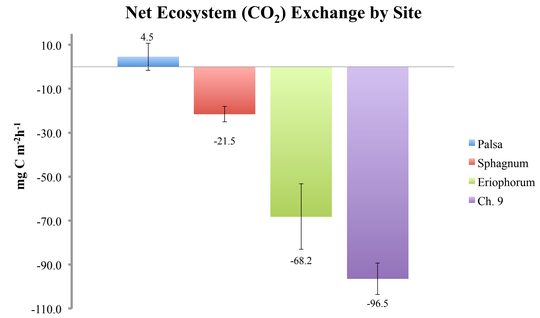

Figure 9) Measurements of net ecosystem (CO_2) exchange (May – October 2012) revealed a shift from a net C source to the atmosphere in the palsa site with intact permafrost to a C sink that increased with thaw for the partially thawed *Sphagnum*, the fully thawed *Eriophorum* sites and Ch. 9, respectively.

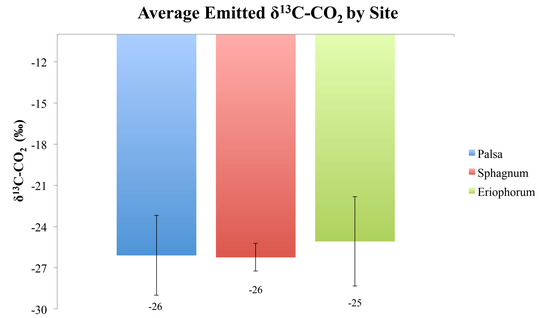

Figure 10) The the isotopic composition of respired CO_2 does not appear to change with thaw. $\delta^{13}C\text{-}CO_2$ (‰) values indicate decomposition of soil organic matter as the primary source of emitted CO_2.

Future Work

- Further investigate the influence of other environmental parameters (*e.g.* water table depth and chamber species composition) on NEE.

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