Autochamber measurements of Net Ecosystem (CO_2) Exchange at a subarctic mire in Northern Sweden

ECSU Research Experience For Undergraduates 2015

Arctic Team

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Abstract

Permafrost stores 50% of the global soil organic carbon. Increasing climate temperatures in the arctic region have given rise to permafrost thaw, exposing once stable organic carbon to decomposition, and potentially altering the global carbon budget. In this study, we present a secondary data analysis of high frequency net ecosystem (CO_2) exchange measurements made using a quantum cascade laser spectrometer connected to a nine member autochamber system positioned in the three dominant vegetation communities at Stordalen Mire in Northern Sweden (68° 21'N, 18° 49'E). Over DOY 121 – 260 during the year 2013, the magnitude of net ecosystem (CO_2) exchange (NEE) followed the moisture gradient with increasing CO_2 uptake from the dry Palsa site (- 0.3 ± 1.6 mg C m^{-2} h^{-1}), to the wet intermediate melt feature with Sphagnum spp. (- 22.1 ± 0.9 mg C m^{-2} h^{-1}), to the fully wet Eriophorum spp. site (- 49.9 ± 4.2 mg C m^{-2} h^{-1}), with highest uptake occurring in the fully thawed *Eriophorum/ Sphagnum* (Ch. 9) collar (- 87.2 ± 6.0 mg C m^{-2} h^{-1}) (overall mean ±1 SE, n = 1267, 2334, 1211, 772). All mean fluxes were statistically different from each other ($p < 0.0001$). At all sites, PAR was the best environmental predictor of NEE. Although increased warming has resulted in permafrost thaw, any possible loss of old carbon in the form of CO_2 from thawing or thawed sites was more than offset by a greater net uptake of CO_2 occurring in the wetter sites.

Northern Permafrost Zone

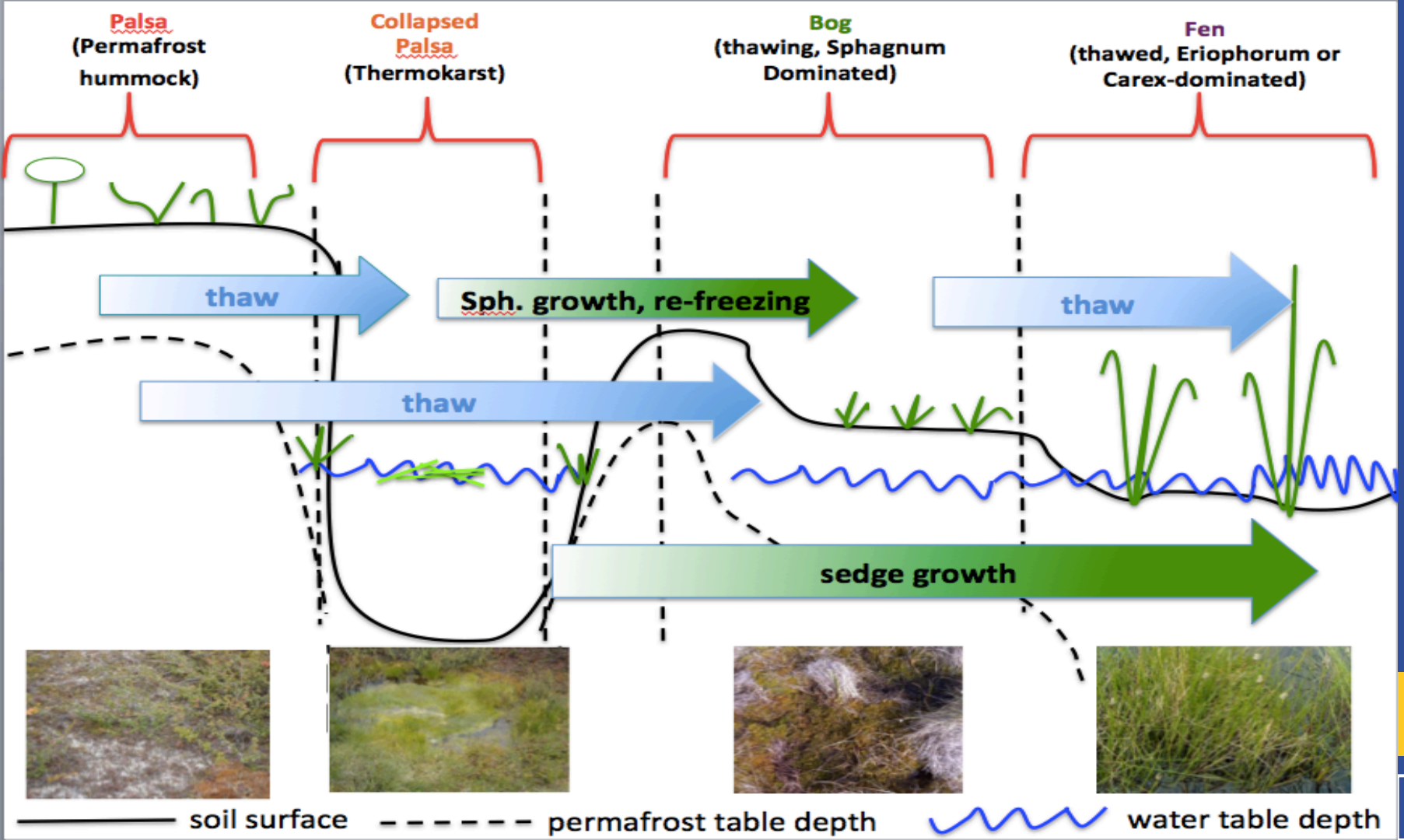
Figure 1. Latitudinal zonation of permafrost. Source: Brown and colleagues (1998).

- A peatland is a wetland with organic soil.
- Sub arctic peatlands are cover with cryogenic soil; underlain by permafrost .

The star indicates the location of Stordalen mire.

Effects of permafrost degradation

Adopted from the NERU PowerPoint


Palsa
(Permafrost hummock)
Collapsed Palsa
(Thermokarst)
Bog
(thawing, Sphagnum Dominated)
Fen
(thawed, Eriophorum or Carex-dominated)
thaw
Sph. growth, re-freezing
thaw
thaw
sedge growth
soil surface
permafrost table depth
water table depth

Stordalen Mire

- A subarctic mire underlain with discontinuous permafrost
- Dominant Vegetation Communities

Palsa Site - permafrost soil, dry area

Sphagnum – intermediated thawed, varying water table depths

Eriophorum – wet completely thawed

Stordalen Mire AC system

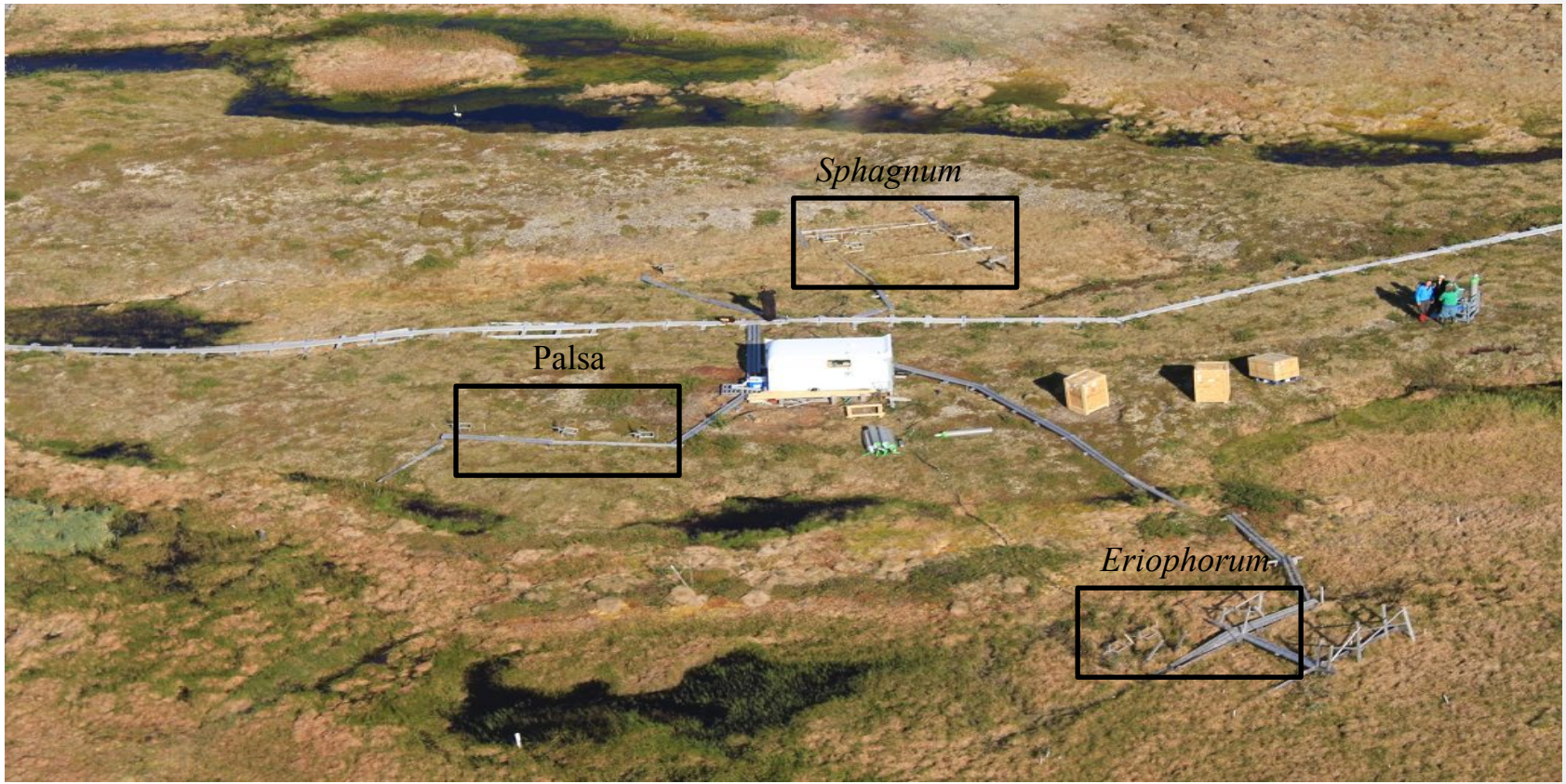


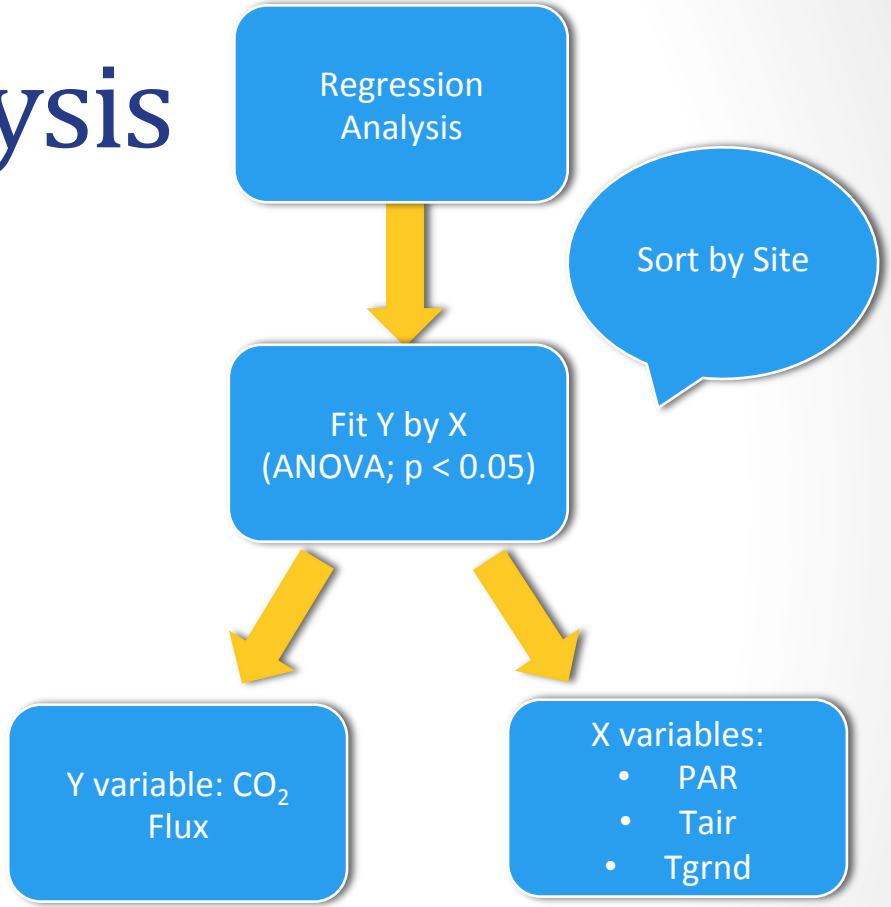
Photo: Niklas Rakos 2011

Objectives

- Perform secondary data analysis of CO_2 flux measurements from Stordalen mire
- Determine the correlation of NEE & environmental variables (i.e. PAR, air and ground temperature)
- Conclude whether Stordalen mire is an atmospheric C sink or source

Statistical Analysis

- JMP 12
  - Statistical software
- Filter original data set
  - Green Season (DOY 120 – 260)
  - $r^2 > 0.87$
    - Ensure 95% Confidence Level
  - PAR to 0



Environmental Conditions

	Min	Max	Average
PAR (µmol photon $m^{-2}s^{-1}$)	**0**	**1743**	**214**
Air Temp. (C°)	**-11.5**	**34.8**	**10.1**
Ground Temp. (C°)	**-4.2**	**37.4**	**9.2**

Table 1 shows the min, max, and mean of three of the environmental variables studied for this research over the course of the green season. The average PAR was lower than normal during the 2013 green season. This could be a result of a cloudy green season.

Spatial Variability of Flux Ranges

- The data produce a wide range of fluxes for each site

Study Location	Min	Max
Palsa Site	-274.6 $mgCm^{-2}h^{-1}$	147.2 $mgCm^{-2}h^{-1}$
Sphagnum Site	-188.6 $mgCm^{-2}h^{-1}$	115.4 $mgCm^{-2}h^{-1}$
Eriophorum Site	-609.8 $mgCm^{-2}h^{-1}$	281.2 $mgCm^{-2}h^{-1}$
Sphagnum/ Eriophorum (Ch 9.)	-642.3$mgCm^{-2}h^{-1}$	253.6 $mgCm^{-2}h^{-1}$

Table 2 Display minimum and maximum of CO_2 fluxes for of the dominant vegetation communities (including Ch. 9). This table shows the wide ranges of fluxes during the green season.

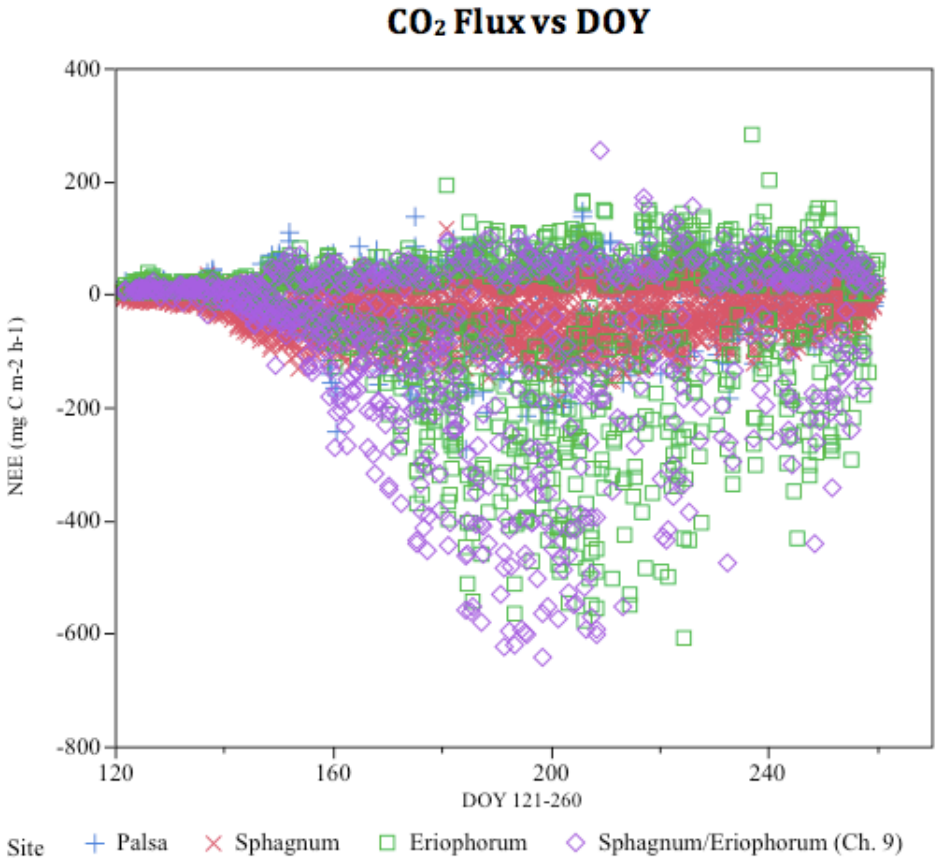


Figure 2 This figure shows the CO_2 fluxes of each site over the green season (DOY 120-260). The flux ranges varies for each of the sites. The uptake of carbon increases for each as throughout the green season.

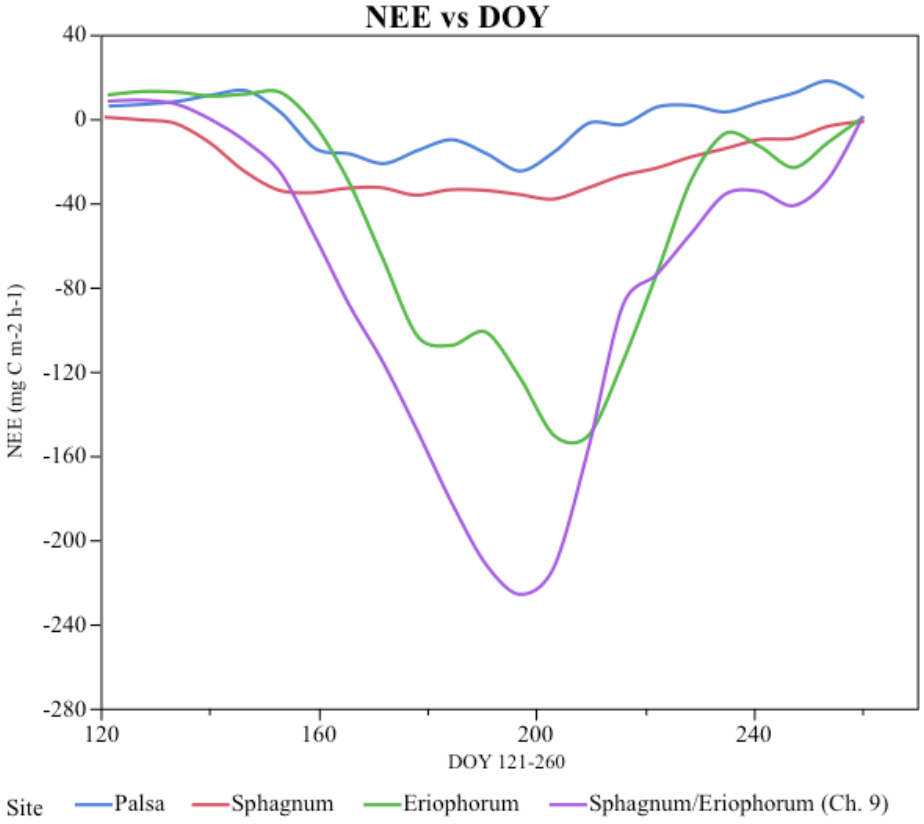


Figure 3 Shows the diurnal measurements of NEE in conjunction with DOY for the green season.

NEE & Environmental Correlation (Whole mire)

	PAR	Tair	Tgrnd
r^2	0.30	0.18	0.04
Equation	NEE = 8.86 – 0.19*PAR	NEE = 39.18 – 7.07*Tair	NEE = 10.99 – 4.83*Tgrd

NEE & Environmental Correlation (Palsa Site)

	r^2	Equation
PAR	0.50	NEE = 23.28 – 0.19*PAR
Tgrd	0.26	NEE = 50.63 – 5.21*Tgrnd
Tair	0.010	NEE = 41.83 – 4.60*Tair

NEE & Environmental Correlation (Sphagnum Site)

	r^2	Equation
PAR	0.48	NEE = 0.75 – 0.010*PAR
Tair	0.42	NEE = 26.68 – 4.39*Tair
Tgrd	0.15	NEE = 13.27 – 3.95*Tgrnd

NEE & Environmental Correlation (Eriophorum)

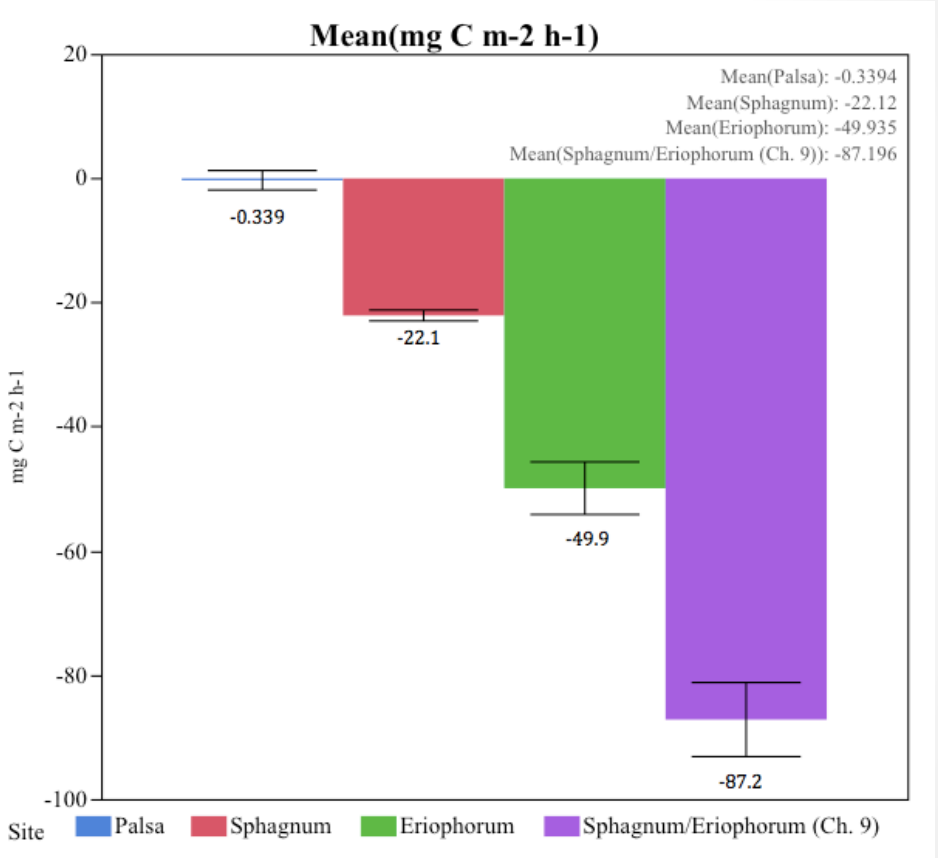
	r^2	Equation
PAR	0.35	NEE = 14.44 – 0.28*PAR
Tair	0.27	NEE = 88.86 – 12.89*Tair
Tgrd	0.017	NEE = -6.95 – 5.55*Tgrnd

NEE & Environmental Correlation (Sphagnum/Eriophorum)

	r^2	Equation
PAR	0.31	NEE = -13.22 – 0.27*PAR
Tair	0.30	NEE = -6.62 – 11.04*Tair
Tgrd	0.05	NEE = 9.94 – 11.03*Tgrnd

Conclusion

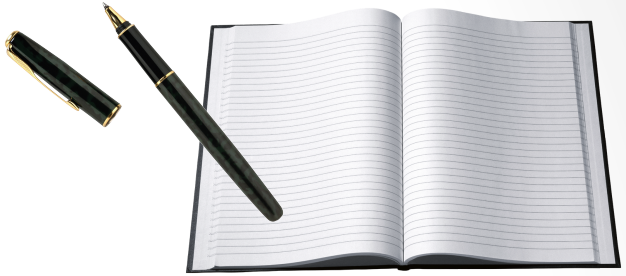
- Storadalen mire was a atmospheric C sink that increased with thaw
- PAR was the strongest environmental predictor of NEE



Future Work

- Incorporate active layer and water table depth data
  - Variables shown to influence NEE

References



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Questions?