Extended abstract No. 354

EFFECTS OF SHORT TERM WARMING AND LONG-TERM WATER TABLE ALTERATIONS ON VEGETATION AND CARBON CYCLING IN A GREAT LAKES PEATLAND

Chimner, Rodney A, John A Hribljan, Tom Pypker, and Evan Kane. School of Forest Resources and Environmental Science, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931, rchimner@mtu.edu

SUMMARY

We began a research project in 2007 in a large poor fen peatland complex in Seney National Wildlife Refuge (SNWR) to assess long-term (~70 years) drainage and flooding affects on ecosystem processes. At each of the six sites we installed open top chambers (OTC's) to warm the soil. We found that increasing the water table over a 70 year period increased bulk density, NEE, CH_4 emissions, and DOC. Conversely, lowering the water table decreased bulk density, NEE and CH_4 emissions, but also increased DOC. In ambient sites, warming decreased NEE, but NEE did not change with warming in either the higher or lower water table manipulated sites. Warming also had no discernable influence on CH_4 emissions.

KEY WORDS: Poor fen, carbon, warming, flooding, dewatering

INTRODUCTION

Carbon cycling in peatlands is expected to be modified by future anthropogenically induced changes in temperature and hydrologic conditions. Only a small number of studies have been conducted on the effects of altered hydrology on peatland C cycling in the southern boreal forest regions of the northern hemisphere, mostly confined to mesocosm studies (e.g., Updegraff et al. 2001). Other studies have either been short-term drainage manipulations (e.g., Strack et al. 2006a, Turetsky et al. 2008) conducted in boreal regions or long-term peatland drainage investigations, such as in Finland (e.g., Laine et al. 1995). Long-term drainage may show different responses in gas fluxes than short-term drainage. Therefore, the objective of this study was to determine how long-term changes in water table levels coupled with short-term warming alters ecosystem carbon and hydrological cycling in a peatland hydrologically altered ~70 years ago.

METHODS

The study took place in a large peatland complex, in the Seney National Wildlife Refuge, in the Upper Peninsula of Michigan. Historically these sites were one large poor fen complex, but a levee was built (~70 years ago) flooding one side and partially draining the other (Figure 1). We chose six sites that represent a gradient of long-term water manipulations to examine how decadal changes in water tables alter carbon cycling. At each site we installed open top chambers (OTC's) to warm the soil. A clear plexiglass chamber (60 cm x 60 cm x 60 cm) connected to an infrared gas analyzer (PP-Systems, EGM-4, Amesbury, Massachusetts) was placed on a galvanized steel collar permanently installed 10 cm into the peat in the center of each plot to quantify NEE, ER, and GPP. Three eddy flux towers with auto-CH_4 sampling and bi-weekly chamber data was collected over several years. A series of groundwater wells and piezometers were installed to measure hydrologic conditions and allow for detailed DOC measurements. Detailed plant and soil surveys were also conducted to assess how they changed in relation to hydrological changes.

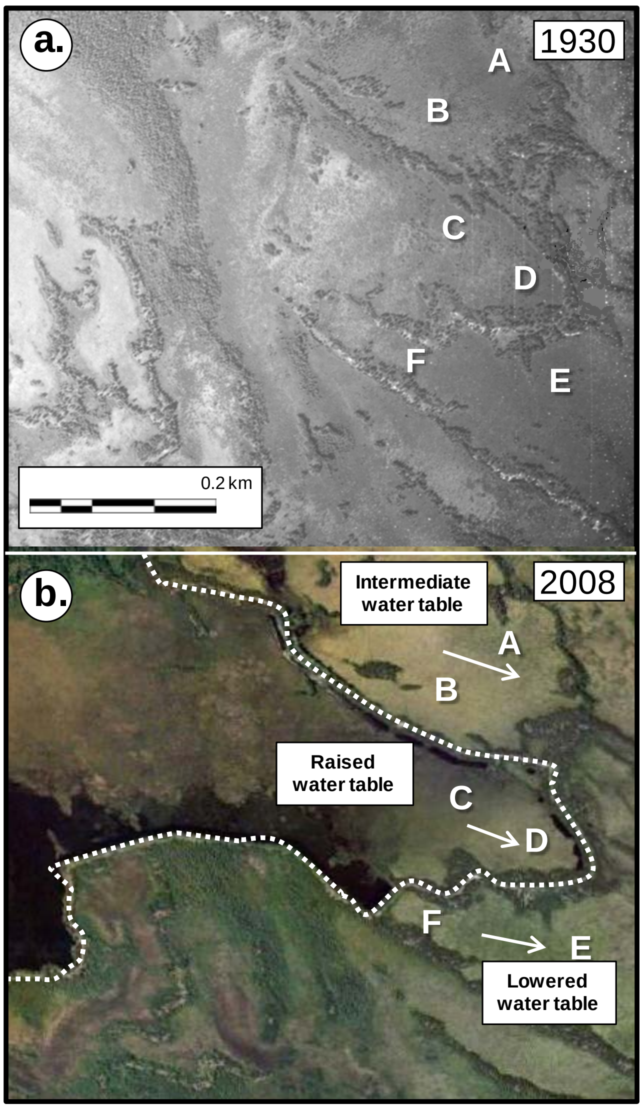

Figure 1 (a). Arial photograph from1930 before earthen dike was constructed. (b). Arial photograph from 2008 illustrating location of the six research sites positioned across the three water table treatments. Surface water impounding behind the dike has elevated the water table at sites C and D and lowered the water table at sites E and F. Arrows indicate approximate WT flows within each treatment based on horizontal hydraulic gradients between sites.

RESULTS

We found that NEE was greatest in the flooded portion, and lowest in the drained portion of the fen (Table 1, Figure 2). Although GEP was decreased in the flooded area, ER was lowered even more, increasing NEE. Conversely, ER increased more than GEP in the drained portion, causing a decrease in NEE. As expected, CH_4 emissions increased with flooding and decreased with drainage (Table 1). In ambient sites, warming decreased NEE by lowering GEP and increasing ER. Conversely, NEE did not change with warming in either the flooded or drained sites. Warming also had no discernable influence on CH_4 emissions.

Table 1. Average (se) environmental parameters, DOC, ecosystem C-fluxes (chambers) and eddy flux (eddy) for Seney during 2009-2011 arranged by water table and warming treatments.

Measurement	Intermediate	Raised	Lowered
pH	3.77	3.90	3.70
Conductivity	63	49	76
WT (cm)	31	16	41
DOC (mg L^{-1})	43.0	62.0	56.7
$NEE_{chambers}$ (umol m^2 sec^1)			
Ambient	2.07 (0.18)	2.16 (0.14)	1.76 (0.14)
OTC warming	1.65 (0.13)	2.28 (0.13)	2.13 (0.17)
$ER_{chambers}$ (umol m^2 sec^1)			
Ambient	2.32 (0.13)	1.98 (0.11)	2.99 (0.15)
OTC warming	2.40 (0.14)	2.17 (0.11)	3.09 (0.15)
$GPP_{chambers}$ (umol m^2 sec^1)			
Ambient	4.40 (0.24)	4.03 (0.21)	4.86 (0.19)
OTC warming	4.05 (0.17)	4.31 (0.18)	5.21 (0.21)
$CH_{4chambers}$ (mg m^2 hr^1)			
Ambient	0.38 (1.3)	0.63 (2.6)	0.13 (0.6)
OTC warming	0.40 (1.5)	0.44 (1.4)	0.21 (0.7)
$NEE_{eddyflux}$ (g m^2 season) 2010[1]:2011[2]	215:152	393:418	75:108

[1] *data from 6 May to 31 August 2010*
[2] *data from 16 June to 15 September 2011*

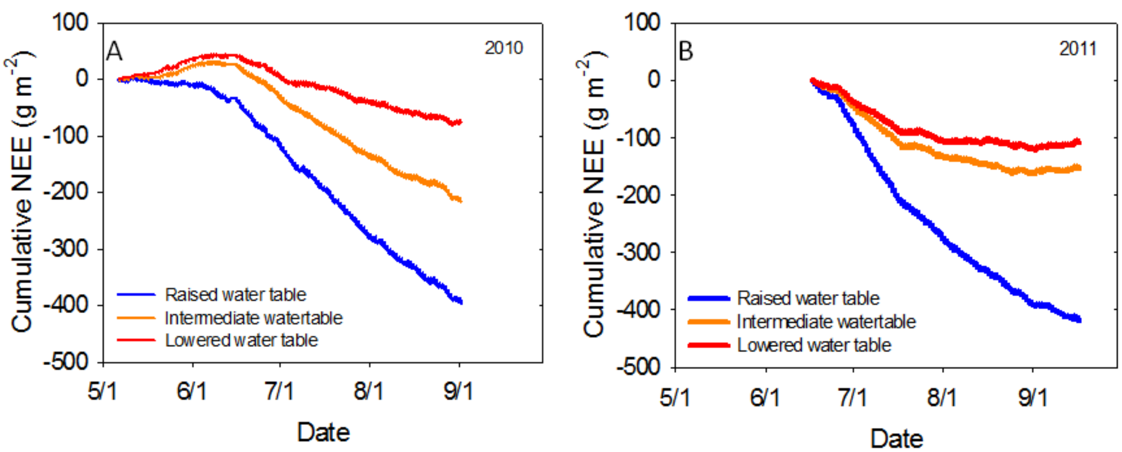

Figure 2. Growing Season Cumulative CO_2 Fluxes for A) 2010 and B) 2011.

Interestingly, both increasing and decreasing the water table levels increased DOC concentrations and altered the chemical composition of the DOC. Throughout the upper 75 cm of the peatland DOC has increased in the raised and lowered treatment (30% and 26% respectively) in comparison to the intermediate treatment (Table 1). Additionally, analysis of pore water DOC substrate quality revealed significant changes in aromaticity, humification, molecular size of compounds, phenolic concentrations, and nutrients (data not shown). The lowered treatment DOC is generally more aromatic, rich in HMW compounds and the highest DOC/phenolic ratio. The raised treatment DOC contains a greater percentage of humic acids, is rich in HMW compounds and has a slightly lower DOC/phenolic ratio. The raised treatment pore water DOC has the most liable carbon source which is proposed to be the result of algae input that are readily decomposed by microbes.

DISCUSSION

In summary, we found that ecosystem carbon cycling and CH_4 rates in peatlands are influenced by changes in long-term water table levels. The long-term water table levels influenced directly the CO_2 and CH_4 flux rates by altering redox and oxygen levels in the soil, and indirectly by altering plant community composition. We did not find much of a temperature response in any of the water table treatments. This is likely due to the lack of warming from the OTC's, which was also found in a nearby companion study (Johnson et al. 2012).

ACKNOWLEDGEMENTS

The authors gratefully acknowledge Robin Conklin, Elizabeth Boisvert, Laura Kangas, Jamie Bourgo, and Laura Matkala for their help with site construction, as well as field and lab work. This research was supported by the U.S. Department of Energy's Office of Science (BER) through the Midwestern Regional Center of the National Institute for Climatic Change Research at Michigan Technological University. Additional support was provided by the Ecosystem Science Center at Michigan Technological University. The project would not have been possible without the cooperation of the Seney National Wildlife Refuge in allowing us to access this site.

REFERENCES

Johnson, C.P., Hribljan, J.A., Chimner, R.A., Pypker, T.G. (2012). Open top chambers and infrared lamps: A comparison of heating efficacy and CO_2/CH_4 dynamics in a sub-boreal peatland. Submitted to *Global Change Biology*.

Laine, J., Vasander, H., Laiho, R. (1995) Long-term effects of water level drawdown on the vegetation of drained pine mires in southern Finland. *J of Applied Ecol* **32**, 785-802.

Strack, M., Waddington, J.M., Rochefort, L., Tuittila E.S. (2006a) Response of vegetation and net ecosystem carbon dioxide exchange at different peatland microforms following water table drawdown. *J Geophys Res* **111**(G2).

Turetsky, M.R., Treat, C.C., Waldrop, M.P., Waddington, J.M., Harden, J.W., McGuire, A.D. (2008) Short-term response of methane fluxes and methanogen activity to water table and soil warming manipulations in an Alaskan peatland. *J Geophys Res* **113**.

Updegraff K, Bridgham SD, Pastor J, Weishampel P, Harth C (2001) Response of CO_2 and CH_4 emissions from peatlands to warming and water table manipulation. *Ecol Appl* **11**, 311-326.