*Flux measurements*

The experimental set up focused on comparing vascular and non-vascular plant communities in the restored peat fields and former drainage ditches at the restored peatland. Six vascular plots and three non-vascular plots were set up in the features (field, ditch), respectively, for a total of 18 plots. Plot selection was done based on the dominant vegetation within the respective features, with *E. vaginatum* and *Sphagnum* spp. chosen in the restored peat field while plots with *Typha latifolia* and bare ditch areas were selected in the former ditches. While the bare ditch plots were initially devoid of vegetation, vascular plants did spread through the area over the course of the season. Sprouts within the collars were removed on a regular basis. Boardwalks were used to span the former ditches and to traverse the restored peatland. An additional six *Sphagnum* plots were created in the adjacent undisturbed peatland, located within the same peatland complex, which was used as a reference site.

Net CO2 and CH4 flux measurements were carried out using the closed chamber technique on permanently installed collars. A laser gas analyzer (LGR-UGGA, Los Gatos Research, CA, USA) connected to a clear polycarbonate chamber enabled simultaneous measurements of CO2 and CH4 (and H2O) concentration at 1 Hz. A rectangular chamber (60 x 60 x 30 cm; 0.108 m3) and collar combination was used at the restored field plots while a cylindrical chamber (100 cm height x 26 cm diameter; 0.053 m3) and collar combination was deployed in the former ditches, to accommodate vertical growth of *T. latifolia*. We equipped the chambers with fans to maintain a well-mixed headspace, as well as a cooling system to prevent excessive warming during closure. NEE and CH4 flux were calculated from the linear change in CO2 and CH4 headspace concentration, respectively, over a measurement period of 2 min. A tarp was used to block incoming radiation within the chamber over a successive closure. Gross primary productivity (GPP) was calculated from the difference between the unshrouded measurement (NEE) and the fully dark measurement which provided ecosystem CO2 respiration (ER).

Gas temperature (TSAMPLE, °C) was measured at 1 Hz by the LGR-UGGA while photosynthetically active radiation (PAR; *µ*mol m-2 s-1) was recorded every 10 sec during chamber closure by a quantum sensor. Following chamber deployment, soil temperature (TSOIL) at 2, 5, 10, 15, 20, 25 and 30 cm was measured next to each collar using a digital thermocouple temperature probe, while water table depth (WTD) was manually measured at adjacent wells. Dataloggers (CR5000 and CR23X, Campbell Scientific, AB, CAN) were used to record half hourly air temperature (TAIR), and TSOIL at multiple depths (5, 10, 20, 40, 60, 80 cm) in the restored field and former ditch locations over the measurement season using type T thermocouples (Omega Engineering). Paired Leveloggers and Barologgers (Model 3001, Solinst, Ontario, Canada) determined half hourly WTD in proximity to the TSOIL profiles.

A total of 600 chamber closures were performed over the snow-free season of 2016. Standard chamber flux calculations were made for linear changes in headspace CO2 and CH4 over time. In the case where CH4 bubbling was captured with the LGR-UGGA, a piece-wise linear fitting routine was used to separate linear from non-linear CH4 increase in headspace concentration. Methane ebullition occurred repeatedly in the ditch plots and was characterized by a sudden break in the slope of the CH4 mixing ratio over short durations (generally < 20 sec). The first difference of the CH4 mixing ratio time series and standard deviation of the first difference were used to distinguish non-linear events. In total, 78 non-linear events passed the criteria in 2016 and were separated out from the linear dataset. The linear slope before and after the concentration jump was determined in order to quantify jump magnitude as well as baseline magnitude, which theoretically should continue during bubble events. Bubble magnitude was calculated as the difference between the jump magnitude and baseline magnitude and then converted to CH4 mass released (mg CH4) using chamber volume, temperature and pressure. The fraction of total emissions attributed to the ebullition pathway was estimated by calculating the cumulative ebullitive and diffusive flux over the periods where sampling took place.

*Pore water sample collection and analyses*

*In-situ* concentration of dissolved organic carbon (DOC), DIC and dissolved CH4 (dCH4) was determined using six replicate sets of pore water samplers installed 0.2 m and 0.8 m below the former ditch and restored field surface, respectively, as well as at the reference site. Pore water samplers were made of a 0.2 m length of ABS pipe (25 mm I.D.) closed at both ends, slotted at the middle 0.1 m, and covered in mesh to prevent clogging. Tygon tubing connected to one end was extended above the soil surface to allow for water collection by syringe from a stopcock. Installations occurred 30 days in advance of sampling and temporally representative samples were obtained by removing 60 mL of pore water from each sampler 48 hours before sampling (Strack and Waddington, 2008). The headspace degassing technique was used to acquire gas from the water samples. Ambient air was drawn into the syringe in equal volume to the collected pore water (30 mL) and the sample was degassed by shaking the sample vigorously. Gas samples were then transferred to evacuated 12 mL sealed vials (Exetainers, Labco, UK) and stored in a cooler for transport to McGill University, Montreal, Canada for analysis. Gas concentrations of CH4 and CO2 were determined using a gas chromatograph (Mini-2, SRI Instruments, California, USA). The remaining water sample was passed through 0.45 µm paper filters (Macherey-Nagel MN 85/90) and acidified before being analyzed for DOC concentration on a total organic carbon analyzer (TOC-V, Shimadzu, Maryland, USA).

Pore water sampling to determine δ13C and acetate concentration was undertaken on DOY 163 (June 11, 2016), 200-201 (July 18-19, 2016), 216-217 (August 3-4, 2016) and 242 (August 29, 2016). The experimental set-up targeted the root zone (0.2 m) and below the root zone in the cutover peat (0.8 m) using “sipper” sets (rhizosphere and deep) permanently installed in the flux collars. Sippers are 6 mm diameter stainless steel tubes with mesh-covered holes drilled at the base and a length of Tygon tubing with a stopcock. Sippers were flushed with a small amount of soil water prior to slowly drawing 20 mL using a syringe. Stable carbon isotope samples were filtered in the field through 0.1 µm in-line syringe filters (Whatman Grade GF/D glass microfiber) and injected into 11 mL evacuated glass vials sealed with 20 mm-thick butyl rubber septa. Samples were duplicated and acidified in the field with 1 mL of 30% H3PO4, and stored upside down on ice before being express shipped to Florida State University, Tallahassee, FL, USA. A 2-hour wait period was followed in the case of same-day sampling for δ13C and acetate. Duplicate acetate samples were filtered in the field through 0.1 µm in-line syringe filters into 5 mL plastic vials and frozen prior to being shipped to Lund University, Lund, Sweden. Acetate concentration was additionally sampled directly from the roots of *T. latifolia* and *E. vaginatum* plants. This was undertaken by threading individual roots through a tiny hole in a syringe with attached Tygon tubing and stopcock. Three roots were sampled from for six plants of each species (36 roots total), with a blank syringe (root hole included) placed in the vicinity of each sampled plant (12 blanks total). Deionized water was replaced in the root syringes 24 hours prior to sampling in order to have a temporally representative sample. Note that δ13C and acetate sampling in the field plots was prevented beyond June by a water table deeper than 0.2 m and by strong resistance when drawing up pore water from 0.8 m. Extraction was made difficult by the nature of the cutover peat, which had low porosity caused by subsidence after drainage.

Isotope samples were brought to ambient pressure with helium, pressurized to one atmosphere and shaken to extract gas into the headspace. The gas concentration and isotopic ratio in the headspace were determined by direct injection on a gas chromatograph combustion-interfaced isotope ratio mass spectrometer (MAT Delta V, Finnigan, USA). We determined the dominant CH4 production pathway at the sampling points in the soil profile using two stable isotope abundance metrics. First, acetate fermentation (acetoclastic methanogenesis) yields CH4 whose δ13C values fall within a typical range of -65 and -50‰ whereas CH4 from H2/CO2 reduction (hydrogenotrophic methanogenesis) has δ13C values typically between -110 and -60‰. Second, the apparent fractionation factor for carbon (α) (see in Equation 2.8) is a measure of the separation between CH4 and co-occurring CO2. The factor is referred to as apparent, because while CO2 is a precursor for CO2 reduction, it is not an immediate precursor for CH4 formed from acetate fermentation. Nonetheless, variation in α is interpreted to represent variations in CH4 production mechanism. Microbial culture-derived α values for H2/CO2 reduction are found to range between 1.031 and 1.077, while α values between 1.007 and 1.027 are characteristic of acetate fermentation. In general, values of α>1.065 and α<1.055 are characteristic of environments dominated by H2/CO2 reduction and acetate fermentation, respectively.

Organic acid concentrations, e.g., acetic acid/acetate, were analyzed using a high-pressure liquid chromatography tandem-ionspray mass spectrometry system. The system consisted of a chromatography system (ICS-2500, Dionex, Sunnyvale, California, USA) and a triple quadrupole mass spectrometer (2000 Q-trap, Applied Biosystems, Foster City, California, USA). Further analysis details and quality controls can be found in Ström *et al.* (2012). Results are presented in µM of acetate, given that acetate dominates at pH > 4.76. Other organic acids, namely, citric, formic, glycolic and lactic, were also detected, but were present at insufficient amounts to pursue further analysis.