

Effect of water table drawdown on northern peatland methane dynamics: Implications for climate change

M. Strack, J. M. Waddington, and E.-S. Tuittila^{1,2}

School of Geography and Geology, McMaster University, Hamilton, Ontario, Canada

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[1] As natural sources of methane (CH₄), peatlands play an important role in the global carbon cycle. Climate models predict that evapotranspiration will increase under a 2 × CO₂ scenario due to increased temperatures leading to lowered water tables at many northern latitudes. Given that the position of the water table within a peatland can have a large effect on CH₄ emissions, climate change may alter the CH₄ emissions from peatlands in this area. Research was conducted during 2001–2003 on natural and drained (8 years prior) sites within a poor fen in central Quebec. Flux measurements were made for each site at different microtopographical features that varied in depth to water table and vegetation cover. The quantity of CH₄ dissolved in the pore water was measured in the field and the potential of the peat for CH₄ production and consumption was determined in the laboratory. Methane emissions and storage were lower in the drained fen. Growing season CH₄ emissions at the drained site were 55% lower than the control site, primarily due to significantly reduced fluxes from topographic highs (up to 97% reduction), while the flux from topographically low areas remained high. The maintenance of high fluxes at these hollow sites was related to hydrological and ecological effects of the water table drawdown. The removal of standing water removed a potential zone of CH₄ oxidation. It also enabled plant colonization at these locations, leading to an increase in gross ecosystem photosynthesis (GEP). At the hollow sites, seasonal CH₄ emissions were significantly correlated to seasonal GEP ($R^2 = 0.85$). These results suggest that the response of northern peatland CH₄ dynamics to climate change depends on the antecedent moisture conditions of the site. Moreover, ecological succession can play an important role for determining future CH₄ emissions, particularly from wetter sites.

INDEX TERMS: 0315 Atmospheric Composition and Structure: Biosphere/atmosphere interactions; 1615 Global Change: Biogeochemical processes (4805); 1851 Hydrology: Plant ecology; 1890 Hydrology: Wetlands; **KEYWORDS:** climate change, methane, peatland

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1. Introduction

[2] Northern peatlands play an important role in the global carbon cycle storing an estimated 500 Pg C [Gorham, 1991]. They are also large sources of atmospheric methane (CH₄) [Fung *et al.*, 1991], with estimated annual releases of 46 Tg C-CH₄ [Gorham, 1991]. Large uncertainty exists regarding the ecohydrological response of peatland ecosystems to climate change [Moore *et al.*, 1998] making accurate predictions about the magnitude of future peatland CH₄ fluxes difficult. This research investigates CH₄ emissions and storage in a natural and drained poor fen in central Quebec

in order to better predict the response of these systems to the water table drawdown expected to occur with climate change.

[3] Methane is produced under the saturated conditions present in peatlands by anaerobic decomposition of organic material by methanogenic bacteria [Zinder, 1993]. Once produced, CH₄ can be released to the atmosphere by diffusion, ebullition, and transport via vascular plants. While transport by diffusion is slow and often results in the majority of CH₄ being lost to oxidation in the unsaturated, aerobic zone of the peat profile [Oremland and Culbertson, 1992], transport through the aerenchyma of wetland vascular plants bypasses the oxic zone, serving as an important pathway for CH₄ emission at many sites [Schutz *et al.*, 1991; Greenup *et al.*, 2000]. Vascular vegetation can also affect CH₄ emission by supplying fresh substrate for CH₄ production to anoxic layers through root exudation and decay [Bellisario *et al.*, 1999] and by increasing CH₄ oxidation in the rhizosphere [Bellisario *et al.*, 1999; Popp *et al.*, 2000]. Overall, the presence of

¹Also at Department of Phytology, Université Laval, Quebec, Quebec, Canada.

²Now at Department of Forest Ecology, University of Helsinki, Helsinki, Finland.

Table 1. Site Descriptions Along the Microtopographic Gradient at the Control and Drained Sites

Microtopography	Average Growing Season Water Table (cm relative to peat surface)	Dominant Vegetation
<i>Control Site</i>		
Hummock	−21 to −14	<i>Sphagnum rubellum</i> , <i>Chamaedaphne calyculata</i> , <i>Carex oligosperma</i>
Lawn	−14 to −6	<i>Sphagnum papillosum</i> , <i>Carex limosa</i>
Hollow	0 to 20	<i>Sphagnum cuspidatum</i> , <i>Rhynchospora alba</i> , <i>Scirpus subterminalis</i>
<i>Drained Site</i>		
Hummock	−42 to −26	<i>Polytrichum strictum</i> , <i>Chamaedaphne calyculata</i>
Lawn	−19 to −14	<i>Sphagnum magellanicum</i> , <i>Carex oligosperma</i>
Hollow	−10 to −6	<i>Sphagnum papillosum</i> , <i>Sphagnum cuspidatum</i> , <i>Rhynchospora alba</i>

vascular vegetation leads to enhanced CH₄ emissions relative to unvegetated sites [Shannon *et al.*, 1996; Waddington *et al.*, 1996; Greenup *et al.*, 2000; Tuittila *et al.*, 2000].

[4] Owing to these mechanisms of production, oxidation, and emission, overall CH₄ flux from a peatland is dependent on the water table position [Granberg *et al.*, 1997], peat temperature [Daulat and Clymo, 1998], substrate quality [Kelly and Chynoweth, 1981], and primary productivity [Whiting and Chanton, 1993]. Global climate change will likely alter all of these variables, thus affecting CH₄ emissions. Using a 2 × CO₂ scenario in which temperature and precipitation in northern Canada increased 3°C and 1 mm day^{−1}, respectively [Mitchell, 1989], Roulet *et al.* [1992] used a simple hydrological model and estimated that water tables would decline by an average of 14 cm in northern Canadian peatlands. Incorporating this value into contemporary CH₄-water table-temperature relationships resulted in the conclusion that CH₄ emissions from northern peatlands would decline by 74–81%. This is supported by several studies that have reported lower CH₄ fluxes from drained peatlands relative to undrained controls [Roulet *et al.*, 1993; Nykänen *et al.*, 1995, 1998]. Waddington *et al.* [1998] investigated the effect of the 14-cm decline in water table position predicted by Roulet *et al.* [1992] on net ecosystem CO₂ exchange (NEE) at a fen by considering the potential for ecological succession. When the response of the vegetation community to the water table shift was considered, the resulting carbon balance at the site depended on its initial moisture conditions. It was determined that wet sites (initial mean water table position above 0.1 m below the surface) would become larger sinks for atmospheric CO₂, while drier sites would become sources. Thus, under climate change, ecological succession caused by water table drawdown may lead to increased carbon uptake at wet (hollow) sites, providing substrate for CH₄ production. If ecological succession leads to an increased coverage of vascular plants with aerenchymatic tissues, an increase in plant-mediated transport of CH₄ may impact overall emissions. The extent of this ecological succession and its impact on CH₄ emissions requires further investigation.

[5] The objectives of this study are (1) to determine differences in CH₄ emissions between a natural poor fen and one in which the water table has been reduced by approximately 20 cm, (2) to determine differences in belowground pools of dissolved methane between the two sites, and (3) to investigate both hydrological and ecological

explanations for these changes in order to better predict the effect of climate change on peatland CH₄ fluxes.

2. Materials and Methods

2.1. Study Area

[6] The study was carried out in a poor fen fragment (46°40'N 71°10'W) near St. Charles-de-Bellechasse, Quebec, Canada. Within the fragment are several pool-ridge complexes, one of which had the water table lowered approximately 20 cm 8 years prior to the study (drained). This pool was compared to a natural pool-ridge complex (control). Peat depth at the control site is approximately 120 cm, while at the drained site it is 80 cm. Nine sampling sites were arranged along the microtopographic gradient at each pool. These locations represented a moisture gradient, with three sites at each of hummock, lawn, and hollow. The general characteristics and site description of sampling locations, including mean water table position and dominant vegetation, for both the control and drained sites are shown in Table 1.

2.2. CH₄ Flux

[7] CH₄ flux was determined using the static chamber method [Tuittila *et al.*, 2000] at the sampling locations described above. Samples were analyzed within 48 hours of collection on a Varian 3800 gas chromatograph (GC) equipped with flame ionization detector at 250°C and Porapak N column at 50°C with helium as the carrier gas and a flow rate of 30 mL min^{−1}. CH₄ emissions were measured weekly from July to September 2001 and May to September 2002 and monthly from October 2001 to March 2002 and November 2002 to January 2003.

2.3. Subsurface CH₄

[8] Pore water samplers, consisting of a 20 cm length of 2.5 cm inner diameter (i.d.) PVC pipe, closed at both ends, slotted at the middle 10 cm, and covered in mesh to prevent clogging, were installed at the lawn areas of each pool. Tygon tubing was inserted at the top and extended above the surface of the peat to allow for collection of water with a syringe. Samplers were placed at 25, 40, and 60 cm and 25, 40, 60, 85, and 100 cm below the surface at the drained and control site, respectively. Pore water was collected weekly from May to September in 2002 and 2003, and CH₄ concentration was determined using headspace analysis

[Joffe and Vitenberg, 1982] after equilibration with nitrogen (N₂).

2.4. Potential Methane Production (PMP) and Consumption (PMC)

[9] Cores were hand cut and removed from hollow, lawn, and hummock locations at both sites and returned immediately to the lab, where they were frozen until analyzed. Peat samples for incubation were taken at 10-cm-depth intervals from all cores, resulting in samples centered at 5, 15, 25, 35, and 45 cm below the surface for all sites.

[10] PMP and PMC were determined under anaerobic and aerobic conditions, respectively. For the aerobic experiment, approximately 15 to 25 g of wet peat was placed in 250-mL incubation jars and spiked with 20 mL of a 53 ppmv CH₄ standard, resulting in an initial mean CH₄ concentration of 5.1 ppm. For the anaerobic experiment, peat slurries of approximately 15 to 25 g of wet peat were made in 250-mL incubation jars by the addition of enough distilled water to saturate samples without allowing for standing water. These slurries were then flushed with N₂ for 15 min and sealed. Aerobic and anaerobic samples were incubated at 4° and 20°C in the dark and were sampled initially and every 12 hours over a 48-hour period. Anaerobic samples were mechanically agitated for 20 min prior to sampling to mix the gases within the peat pore spaces and the jar headspace.

2.5. Environmental Variables

[11] Temperature profiles in the peat (surface to 30 cm depth) were measured at each collar on each sampling date using a thermocouple thermometer. Water table position was determined at each collar on each sampling date using 1.3–1.9 cm i.d. PVC wells installed adjacent to the collar.

[12] Leaf area index (LAI) was determined by counting all vascular plant leaves within five 7.5 × 7.5 cm subplots distributed throughout each collar each month. Total leaf numbers within the collar were extrapolated from these values. Individuals of the dominant species were selected outside of the collar at each site, and their leaves were measured biweekly. An average biweekly surface area of leaves was computed and multiplied by leaf numbers to determine LAI.

[13] Gross ecosystem photosynthesis (GEP), at a variety of radiation (PAR) levels, and ecosystem respiration were determined weekly at each collar using a clear Plexiglas chamber and a PP systems EGM-1 portable infrared gas analyzer. Light levels were controlled with shades, and the chamber was covered with an opaque shroud for respiration measurements. The temperature inside the chamber was maintained within 5°C of ambient temperatures using a radiator cooling system. Results were fitted to PAR values using Photosyn Assistant 1.1 software (Dundee Scientific, UK), and these relationships were combined with continuously recorded PAR data to estimate seasonal CO₂ uptake at each collar.

3. Results

3.1. Site Characteristics

[14] As shown in Table 1, water table position was lower at the drained site, ranging from 6 to 42 cm below

the surface along the microtopographical gradient, compared to the control site, which had water table positions in the range of 26 cm below the surface to 20 cm above the surface. The differences in water table position have led to the dominance of different vegetation communities (Table 1).

[15] Peat temperature at 30 cm depth was warmer at the control site for all microtopographic units, with lawns and hollows being significantly warmer (t-test, lawns, $p = 0.01$; hollows, $p < 0.001$). Average 30-cm peat temperatures from May 20 to September 23 for 2002 at hummocks, lawns, and hollows were 16.7°, 17.5°, and 18.8°C at the control site and 16.0°, 15.8°, and 16.5°C at the drained site.

[16] In addition to differences in vegetation community (Table 1), there were differences in LAI between sites. Maximum LAI between May and September 2002 at hummocks, lawns, and hollows was 0.8, 1.0, and 1.4 m² m⁻² at the control site, and 0.3, 4.7, and 1.0 m² m⁻² at the drained site. Despite having a high maximum LAI, the control hollows only had a substantial cover of vascular vegetation after July and a sparse cover of Sphagnum (0–3%). In contrast, drained hollows had vascular vegetation present throughout the sampling period and a *Sphagnum* cover of 80–97%.

3.2. CH₄ Fluxes

[17] The average growing season CH₄ fluxes were 143.4 and 64.4 mg CH₄ m⁻² d⁻¹ at the control and drained sites, respectively. Flux values varied greatly both spatially and temporally (Figure 1) at both sites. The standard deviation on a particular date at control hummocks, lawns, and hollows was 1.0–330.7, 2.7–196.5, and 0.8–206.6 mg CH₄ m⁻² d⁻¹. At the drained sites the standard deviation was 0.5–12.5, 1.4–243.4, and 0.9–245.9 mg CH₄ m⁻² d⁻¹ at hummocks, lawns, and hollows, respectively. Spatial variability is to be expected as the sampling locations were placed along a topographic gradient to reveal the effects of environment on CH₄ flux. Average winter fluxes for each microtope (Table 2) were less variable and substantially lower than growing season fluxes. They are relatively unimportant for the calculation of annual CH₄ emissions from low-lying areas, but may make up about 20% of total emissions from hummocks.

[18] CH₄ emissions were significantly higher at the control site than the drained site for hummock and lawn collars (t-test, $p < 0.01$). However, no significant difference was observed for hollows between the two sites. Average CH₄ emissions were weakly related to average water table position at both sites (Figure 2), showing a unimodal ($R^2 = 0.25$) and exponential relationship ($R^2 = 0.76$) at the control and drained sites, respectively. No significant relationship was found between daily water table position and individual flux measurements. There was also no correlation between average peat temperature and average CH₄ fluxes.

3.3. Subsurface CH₄

[19] The concentration of CH₄ in the pore water at lawn areas was significantly higher ($p < 0.01$) at all depths at the control site when compared to the drained site for both 2002

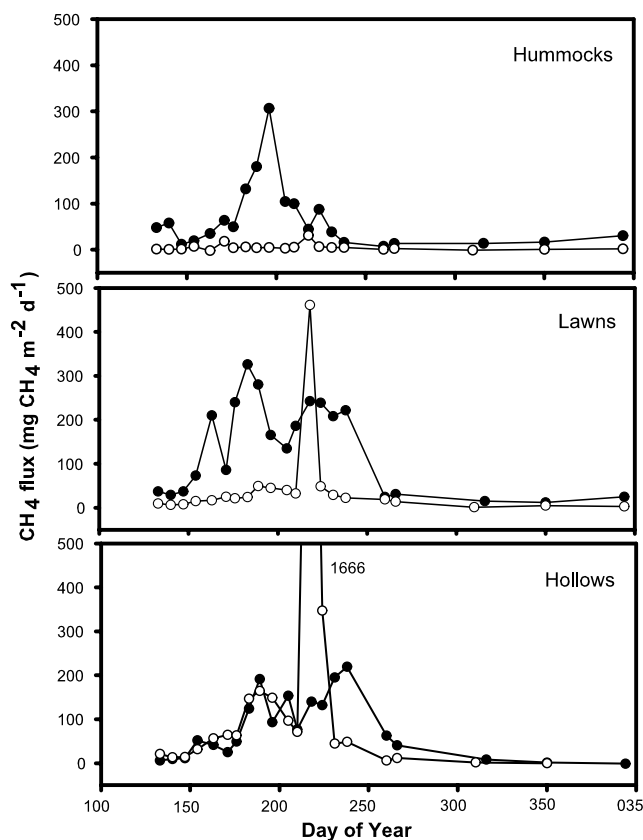


Figure 1. Measured CH₄ fluxes for control (solid symbols) and drained (open symbols) sites along a microtopographic gradient. Each point is the average of the three collars representing a particular microtopographic unit (hummock, lawn, hollow). Data collected between May 2002 and January 2003 are presented. Values outside of the scale of the figure are given as text on the plot.

and 2003. At the control site, average seasonal values of dissolved CH₄ were 1.4–5.8 mg L⁻¹ in 2002 and 1.3–5.3 mg L⁻¹ in 2003. At the drained site values were 0.3–0.7 and 0.6–1.7 mg L⁻¹ in 2002 and 2003, respectively. The profile of average dissolved CH₄ was similar for both years (Figure 3); however, temporal shifts in concentration generally occurred simultaneously for all depths and sites in 2002, but were more erratic in 2003 (data not shown). Profiles of CH₄ collected as bubbles within the peat had a

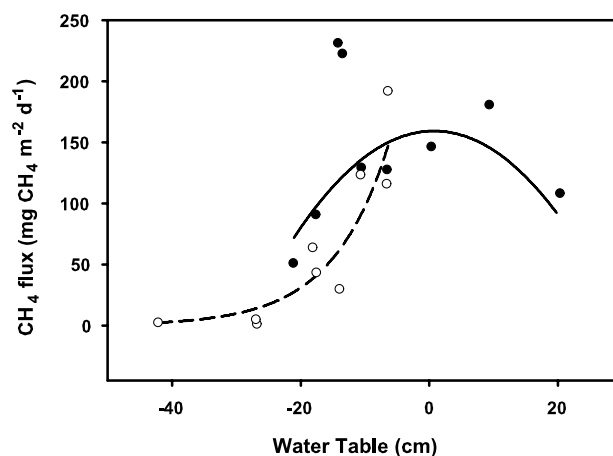


Figure 2. Average growing season CH₄ flux at each collar plotted against average growing season water table at each collar (negative values are below the surface) based on data collected from July 2001 to September 2002. Water table explains some of the variability at the control site (solid symbols, solid line, $R^2 = 0.25$) but is more significant at the drained site (open symbols, dashed line, $R^2 = 0.76$).

similar pattern to pore water concentrations in both years (data not shown).

3.4. Potential CH₄ Production and Consumption

[20] In most cases the rate of CH₄ production and consumption by the peat was not notably different at the two sites. At lawns sites, PMP and PMC were in the range of 2.5–44.7 and 2.8–32.3 ng CH₄ cm⁻³ (fresh peat) d⁻¹ at the control site and 4.2–10.7 and 10.2–18.8 ng CH₄ cm⁻³ d⁻¹ at the drained site. At hummocks, control and drained sites had PMP of 1.8–5.7 and 2.9–6.0 ng CH₄ cm⁻³ d⁻¹ and PMC of 6.3–18.0 and 10.6–26.1 ng CH₄ cm⁻³ d⁻¹, respectively. The only notable differences between the sites occurred at 20–40 cm for lawns and 10–20 cm for hummocks for which the drained site had higher consumption rates than the control site peat, and in the 40–50 cm range at the control site lawn, which had higher production rates than the drained peat.

[21] Q₁₀ values between 4° and 20°C were less than 2 for all cases except for production in the top 10 cm (Q₁₀ = 2.1) and consumption in the upper 20 cm (Q₁₀ = 2.6 from 0–10 cm and Q₁₀ = 2.8 from 10–20 cm) of the control lawn peat sample. This suggests that the reaction rate was limited

Table 2. Winter and Growing Season CH₄ Fluxes

Location	Site	Total CH ₄ Emitted mg CH ₄ m ⁻² d ⁻¹ (Mean (Std Dev))		Winter Flux as Percentage of Total
		Winter (Nov. 1 to April 15)	Growing Season (April 15 to Oct. 31)	
Hummocks	control	3.2 (1.5)	9.7 (1.5)	23.8
	drained	0.2 (0.2)	1.2 (0.9)	17.6
Lawns	control	2.8 (2.7)	16.3 (6.8)	14.4
	drained	1.5 (0.9)	7.6 (1.5)	15.7
Hollows	control	0.1 (0.2)	14.5 (14.3)	1.7
	drained	0.2 (0.2)	22.0 (4.9)	0.8

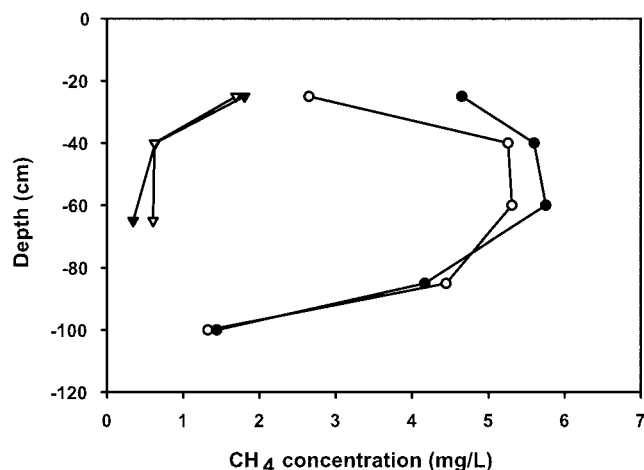


Figure 3. Average dissolved CH₄ concentration at depth in 2002 (solid symbols) and 2003 (open). Circles and triangles represent the control and drained sites, respectively.

by a factor other than temperature for both CH₄ production and consumption at both the control and drained sites.

4. Discussion

4.1. Changes in CH₄ Dynamics

[22] When averages of flux measurements for all collars at each site were compared, growing season CH₄ fluxes were 55% lower at the drained site than the control site. The post-water table drawdown decline was the result of large changes in CH₄ emissions at hummocks (97% decline) and lawns (71% decline), while hollow fluxes were unchanged. This reveals that the antecedent moisture conditions of the site play a significant role in its response to water table changes and thus potentially in its response to climatic change.

[23] Since PMP and PMC are relatively similar at hummocks at the two sites, the reduction in flux is due primarily to the decrease in the size of the anoxic zone and subsequent increase in the size of the oxic zone as opposed to a shift in the peat properties (peat quality, microbial biomass, microbial community). At the lawns the large declines in CH₄ emissions are mirrored by significantly smaller pools of subsurface CH₄ at the drained site. These smaller subsurface pools suggest a reduction in CH₄ production and increase in CH₄ oxidation at the drained site lawns compared to the control site. This is in accordance with the reduced size of the anoxic zone and increased size of the oxic zone. The maintenance of the drained hollow CH₄ fluxes at the same level as the control site is related to both the hydrological and ecological impacts of the water table drawdown.

4.2. Hydrological Effects of Water Table Drawdown on Hollows

[24] The relationship between water table and CH₄ flux at the control site is unimodal, with highest fluxes occurring at intermediate water table positions while sites with large depths of standing water have lower fluxes (Figure 2). Thus a water table drawdown of 20 cm shifts the hollow sites

from the inundated low fluxes toward an “optimal” water table position, suggesting a maintenance or increase in CH₄ emissions. This concept is supported by the exponential water table-CH₄ flux relationship at the drained site, which results from the lack of sites with standing water (the cause of the reduced fluxes at the control site).

[25] Reduced fluxes at sites with standing water are likely the result of differences in substrate availability, temperature regime and the potential for oxidation between flooded and nonflooded sites. A lower availability of fresh substrate at flooded areas is suggested by the lower productivity of these sites. In Figure 4 the two sites with standing water are present in the lower left-hand corner of the figure and thus have the lowest GEP of all the sites studied. Analysis of the peat temperature profile measured on each sampling day reveals that peat temperatures were significantly higher ($p < 0.001$) at the control site hollows (18.8°C) than drained hollows (16.5°C) at 30 cm depth. The dark color of the water and sediment likely increases the absorption of radiation leading to preferential heating of the pools. A similar observation was made by *Weyhenmeyer* [1999], who found high sediment temperatures in beaver ponds and suggested the dark color of the sediment as the cause of this warming. Thus temperature actually declines at the hollows due to drainage, which should promote a decline in CH₄ emissions; however, this was not observed.

[26] Wind mixing of open water may introduce dissolved oxygen (DO) into the water column, creating a partially aerobic zone in which CH₄ can be oxidized as it is transported to the surface by diffusion. The deep control hollows have standing water year round, whereas the hollows at the drained site are only periodically flooded at snowmelt and after heavy summer rains. At this time, standing water is

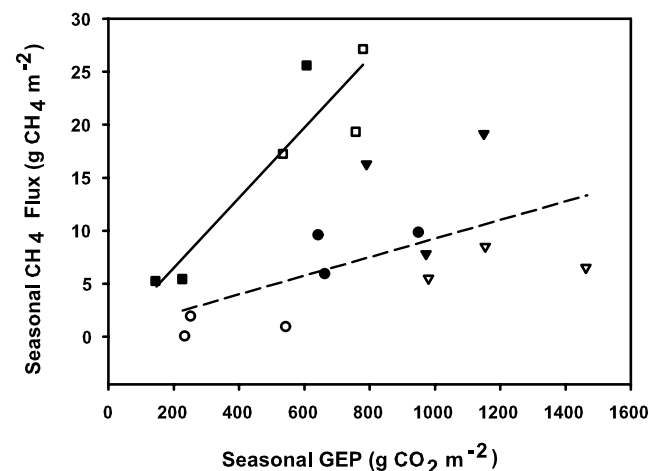


Figure 4. Cumulative growing season CH₄ emissions as a function of cumulative growing season gross ecosystem photosynthesis (GEP) for 2002. Solid symbols represent control site plots, while open symbols are drained sites. Circles, triangles, and squares represent hummocks, lawns, and hollows, respectively. Relationship between GEP and CH₄ emissions for hollows shown as solid line, ($p < 0.01$, $R^2 = 0.85$), and for hummock and lawns sites, dashed line, ($p = 0.07$, $R^2 = 0.29$).

Table 3. Comparison of Average Growing Season CH₄ Emissions Between Initial Conditions (Control Site) and Perturbed Conditions (Drained)^a

Site	Initial CH ₄ Flux, mg CH ₄ m ⁻² d ⁻¹	Perturbed CH ₄ Flux, mg CH ₄ m ⁻² d ⁻¹	Percent Change
Overall	143	64	-55
Hummocks	125	3	-97
Lawns	160	46	-71
Hollows	152	144	-0.05
<i>Roulet et al.</i> [1992] floating	116	30	-74
<i>Roulet et al.</i> [1992] nonfloating	74	14	-81

^aCalculations of changes in CH₄ emissions with water table drawdown from *Roulet et al.* [1992] model predictions are also shown for comparison.

only present for several days. Dissolved oxygen content in standing water at the control hollows was 6.2 mg/L at the surface, declining to 2.3 mg/L at a depth of 25 cm. This indicates that the water column may be a zone of oxidation. The slow rate of diffusion in water (10⁴ times slower than air) allows substantial time for CH₄ oxidation as CH₄ moves through the water column, leading to reduced CH₄ fluxes from these sites.

[27] The maintenance of CH₄ emissions at the drained hollows in a range similar to the control site results from the fact that at these locations the 20-cm water table reduction removes standing water, but maintains water tables relatively close to the surface. Therefore the oxic zone within the peat profile of drained hollows remains small, limiting CH₄ oxidation and maintaining high CH₄ fluxes. This effect is enhanced by the fact that the removal of standing water (which contains some dissolved oxygen) may actually eliminate a source of CH₄ oxidation. As well, peat in hollow areas may be “floating,” having a surface that oscillates with water table changes. Thus, when the water table drops, the peat surface also drops, maintaining relatively stable moisture conditions within the peat column and limiting the development of an oxic zone. *Dise et al.* [1993] found no significant relationship between CH₄ flux and water table at floating sites because of surface level oscillations. A similar response is likely at play at drained hollow sites in this study.

4.3. Ecological Effects of Water Table Drawdown on Hollows

[28] The removal of standing water from the drained hollows has also enabled ecological succession, which may in turn have affected CH₄ fluxes. Of the hollows at the control site, those with standing water have no *Sphagnum* cover and contain only *Scirpus subterminalis*, which does not have a substantial leaf area until July. This results in low levels of GEP at these sites in May and June (data not shown). Drained hollow sites have a high surface cover of *Sphagnum* (>80% cover) and a diverse vascular community. These differences in vegetation community between the control and drained hummocks result in large differences in seasonal gross ecosystem production (GEP), with average seasonal GEP of 325 and 690 g CO₂ m⁻² d⁻¹ at control and drained hollows, respectively. At the hollows of both the control and drained sites, a good relationship between seasonal GEP and seasonal CH₄ emissions was found (Figure 4, $p < 0.01$, $R^2 = 0.85$). Several other studies have

also found a linear relationship between site productivity and CH₄ emissions [*Whiting and Chanton*, 1993; *Waddington et al.*, 1996; *Bellisario et al.*, 1999]. The correlation between productivity and CH₄ emissions is the result of the provision by vascular vegetation of fresh substrate for CH₄ production and a conduit for CH₄ release. A much weaker relationship ($p = 0.07$, $R^2 = 0.29$) was present between seasonal GEP and seasonal CH₄ emissions for hummock and lawn sites (Figure 4) where vascular plants with aerenchymatic tissues were less abundant (Table 1). *Waddington et al.* [1996] found a similar pattern in which the role of vascular vegetation was more pronounced when water tables were near the surface. Since lawn and hummock sites are much drier than the hollows, it is likely that moisture conditions are exerting an overriding influence on CH₄ production and oxidation, making the impact of ecosystem productivity secondary. Thus at sites with relatively dry initial conditions and vascular plant community whose roots are located in the permanently oxic layer, the impact of ecological succession caused by water table drawdown plays a less significant role in the maintenance of CH₄ flux as these sites become drier.

5. Climate Change Implications

[29] The reduction in CH₄ flux by 55% observed in this study is much lower than the 74–81% reduction predicted by *Roulet et al.* [1992] (Table 3). The reduction observed at the lawn sites (71%) is similar to the *Roulet et al.* [1992] model prediction. This similarity may result from the fact that the lawn sites in this study had a similar water table position to the average used for calculations by *Roulet et al.* [1992]. Our findings reveal the importance of antecedent moisture conditions and peatland ecotope in determining the response of a site to water table drawdown and thus potentially to climate change. Sites situated at the low-lying extreme of the microtopographic gradient did not experience a reduction in CH₄ fluxes with water table drawdown because at these sites this resulted in the removal of standing water and allowed for ecological succession, which has the potential to enhance CH₄ flux. This study has shown that ecological succession can have a significant impact on the response of peatland CH₄ fluxes to long-term shifts in water table, and this feedback should be included in future predictions of peatland climate change response. As well, further research is needed to quantify the evolving effects of vascular vegetation on CH₄ fluxes between natural and

drained sites, as well as the time frame for ecological succession following water table drawdown.

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M. Strack and J. M. Waddington, School of Geography and Geology, McMaster University, Hamilton, ON L8S 4K1, Canada. (strackm@mcmaster.ca; wadding@mcmaster.ca)

E.-S. Tuittila, Department of Forest Ecology, University of Helsinki, P.O. Box 27, FIN-00014, Helsinki, Finland. (tuittila@mappi.helsinki.fi)