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Supplement of

Ecosystem-scale greenhouse gas fluxes from actively extracted peatlands: water table depth drives interannual variability

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S1 Methods for assessing the effect of extraction activities on CO_2 emissions.

The trail camera was oriented westward and programmed to take a photo when it detected motion in front of it, with a detection range of ~ two peat fields. The photos were visually inspected to confirm the presence of extraction activity. Vacuum harvesting and harrowing activities were distinguished by the unique equipment required for each. To account for the unknown activity on the eastern half of the site, we added thirty minutes before and after the observed extraction activity time window. This was based on personal observations of extraction activity.

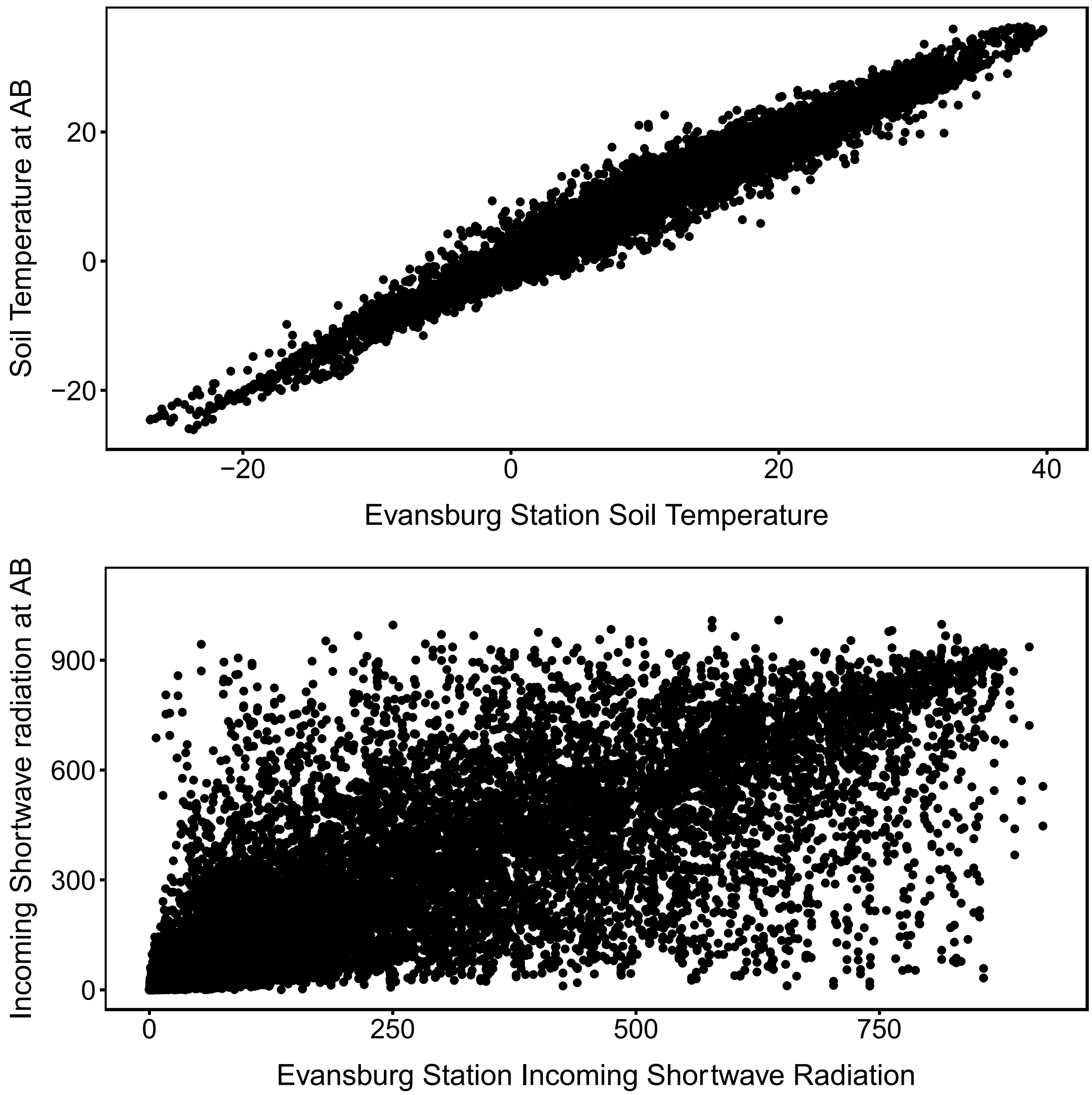

Figure S1 Scatter plot of the average half-hourly air temperature in °C (bottom) and half-hourly incoming shortwave radiation in W m^{-2} (top) obtained from Evansburg 2 ADGM weather station (ACIS, 2023) versus the measured values at AB. The linear regressions were significant for solar radiation ($F_{1,38451}$=103305, p<0.0001; R^2=0.71) and air temperature ($F_{1,14421}$=403386, p<0.0001; R^2=0.96).

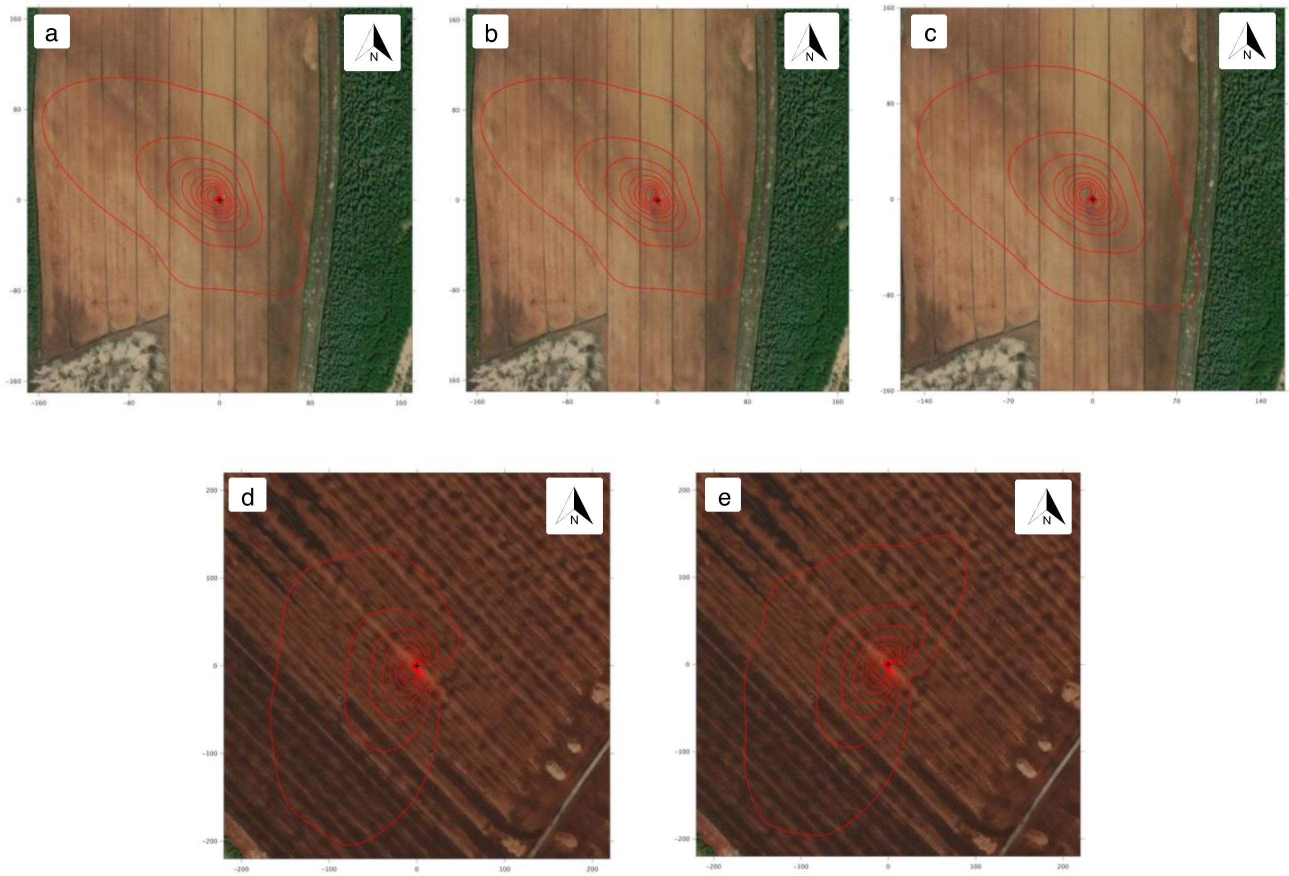

Figure S2 2D flux footprint probability contour maps of CO_2 at the AB site in 2020, (a) 2021 (b) and 2022 (c), and at the QC site in 2020 (d) and 2022 (e). The plots were created using the online tool by Kljun et al., (2015). The scale bars along the x and y axes are in meters. The outermost contour line represents the 90th percentile probability.

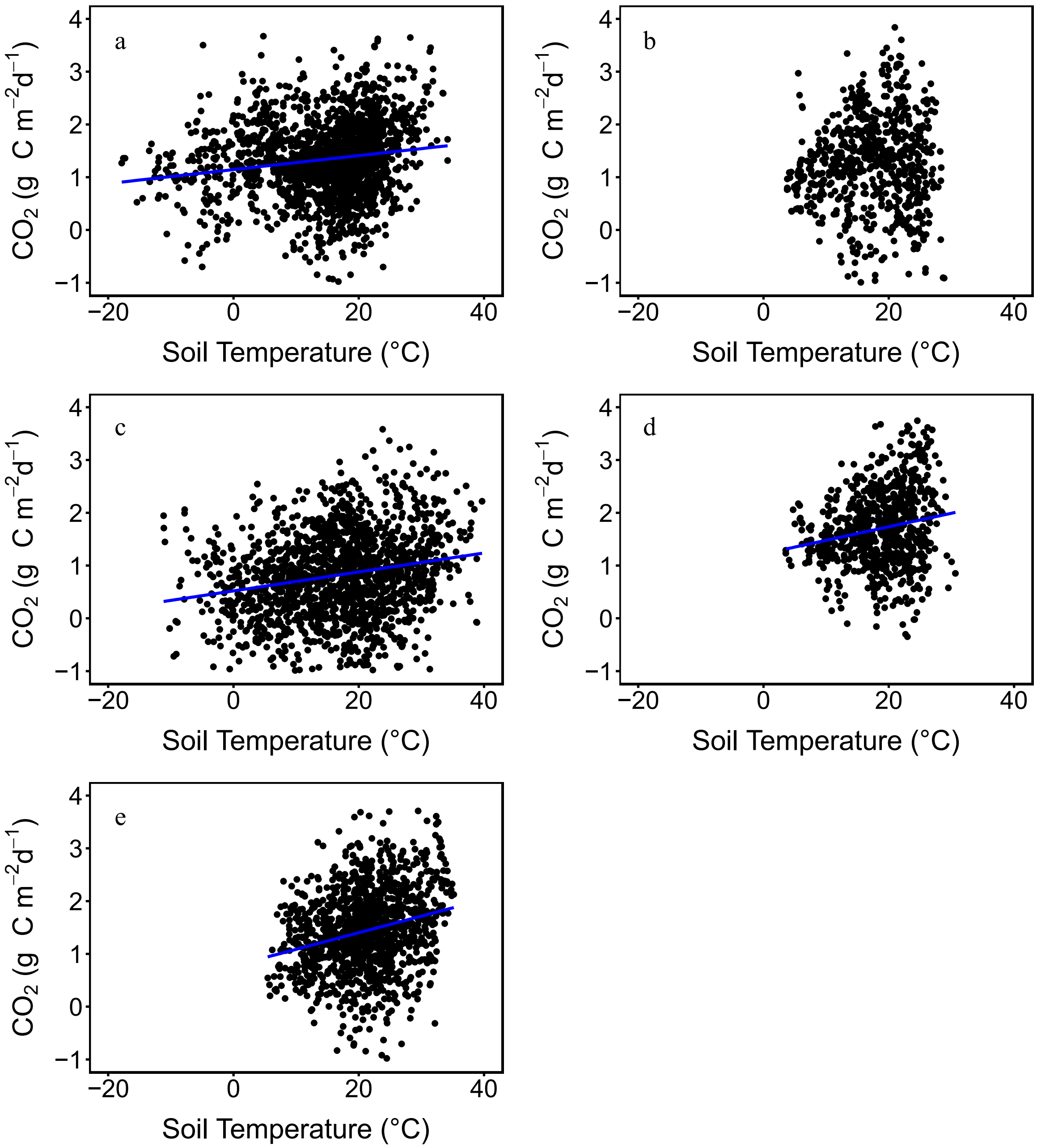

Figure S3 Scatterplots showing the effect of half-hourly air temperature on CO_2 emissions in 2020 (a), 2021 (c) and 2022 (e) at AB, and in 2020 (b) and 2022 (d) at QC. Best fit lines were shown when linear regressions were significant. The explanatory power was 2.5%, 4.3% and 6.3% at AB in 2020, 2021 and 2022 respectively, and 3.5% at QC in 2022.

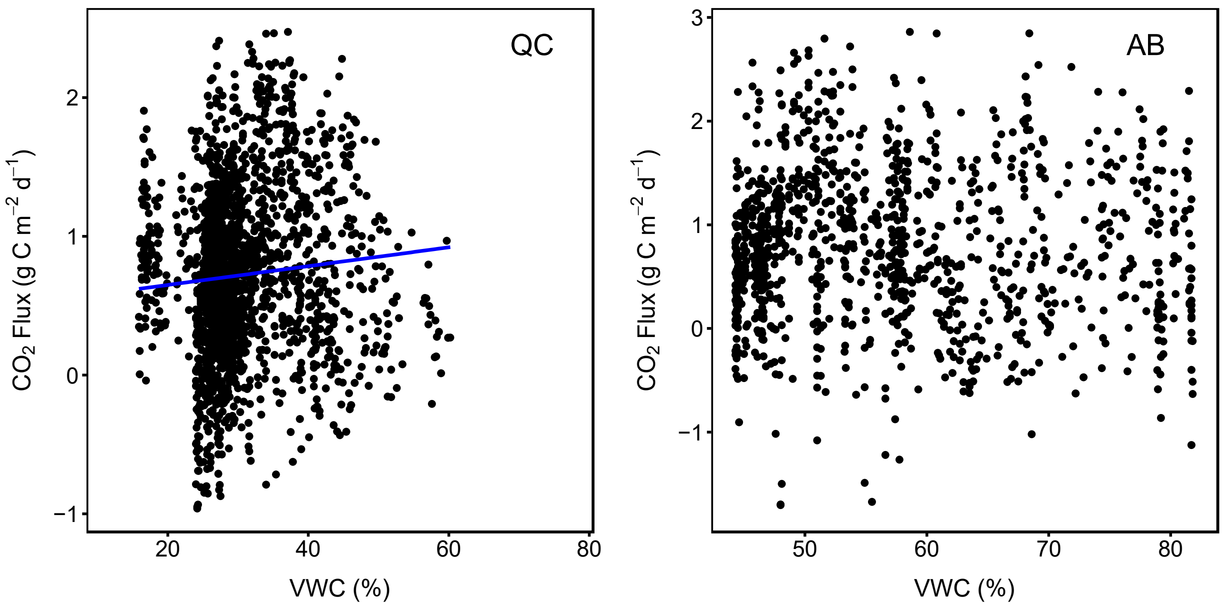

Figure S4 Scatterplots showing the effect of half-hourly volumetric water content (VWC) on CO_2 fluxes at AB and QC. At QC, VWC explained less than 1% of the variation in CO_2 fluxes ($F_{1, 2177}=14.89$, $p=0.0001$).

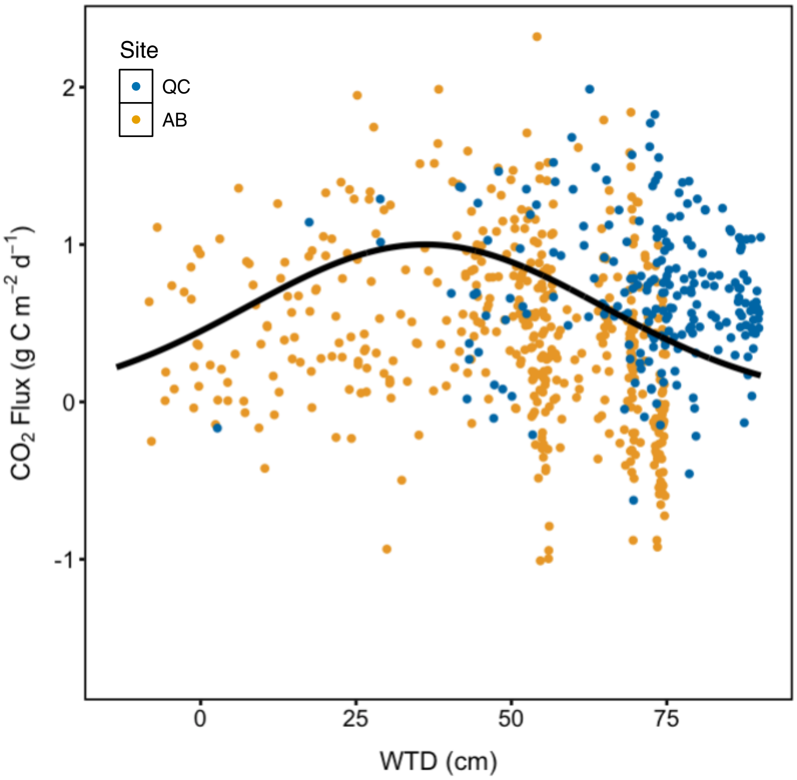

Figure S5 Scatterplot showing the effect of WTD (cm) on daily average CO_2 fluxes (g C m^{-2} d^{-1}) at AB and QC. The data has been fit with a Gaussian relationship (Equation 1 in main text), with fitted WTD_{opt} and WTD_{tol} parameters of 33.1 ± 2.8 and 27.8 ± 2.3 respectively. We observed 95% confidence intervals of 27.4-38.4 and 23.9-32.5 for the two fitted parameters through a non-parametric bootstrap analysis.

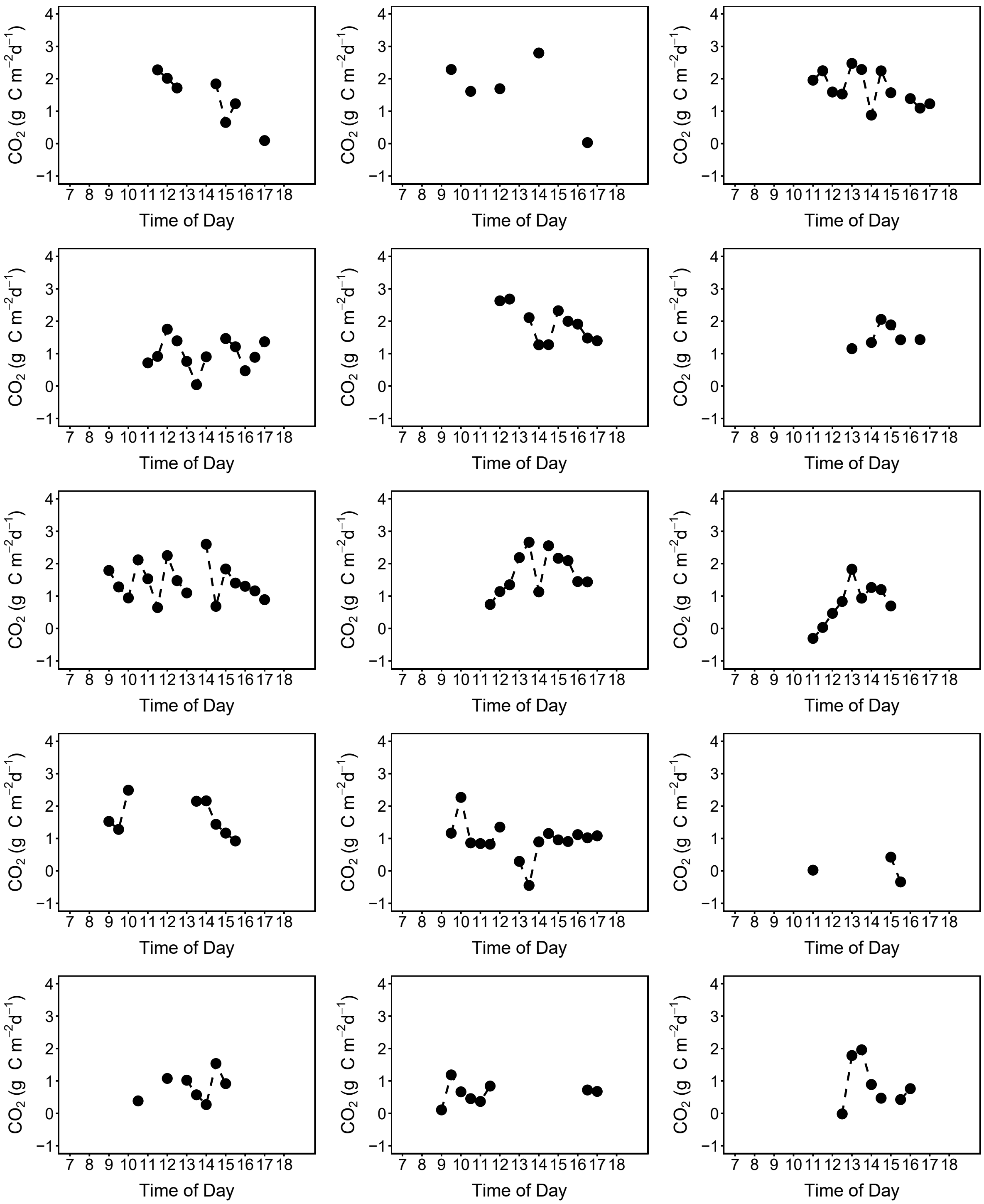

Figure S6 Plot of CO_2 emissions over the course of 15 days during the period of August 17th to September 23rd, 2022 at AB. The purple and green boxes indicate periods when harrowing and vacuum harvesting occurred respectively.

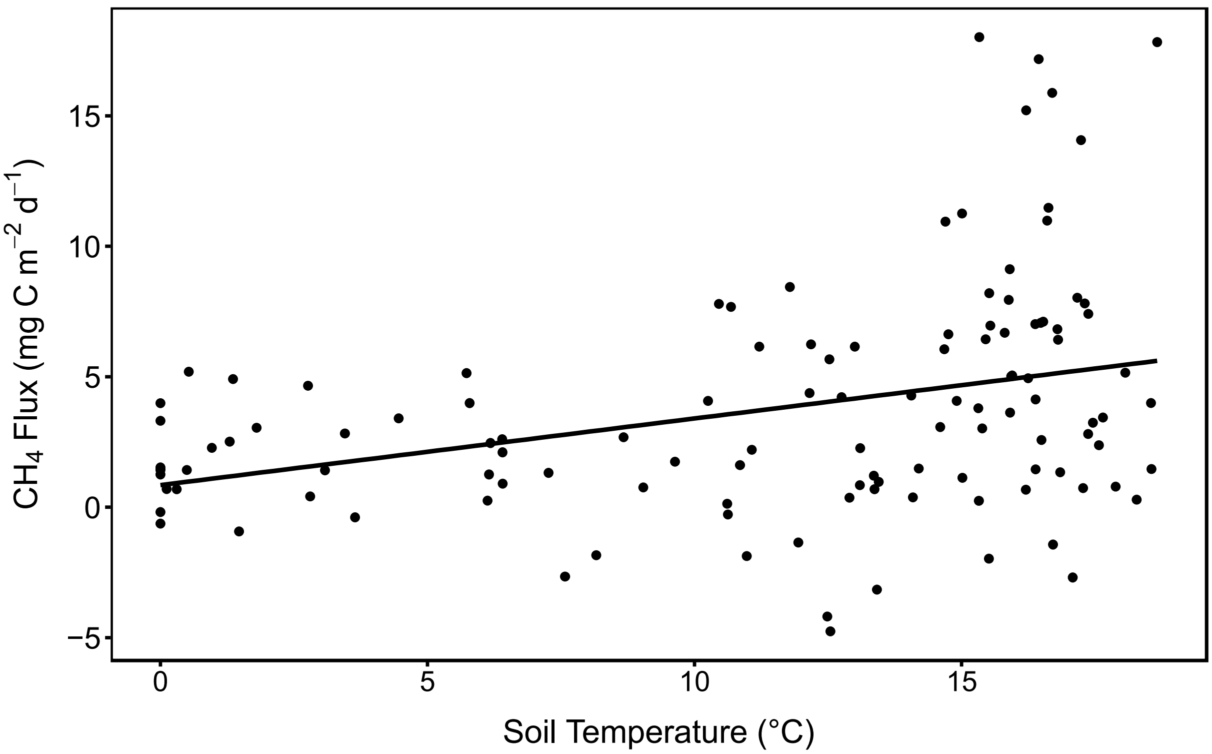

Figure S7 Scatterplots showing the effect of soil temperature on daily daytime (9 am to 5:30 pm) CH_4 fluxes at AB in 2022. The significant linear regression explained 11% of the variation.

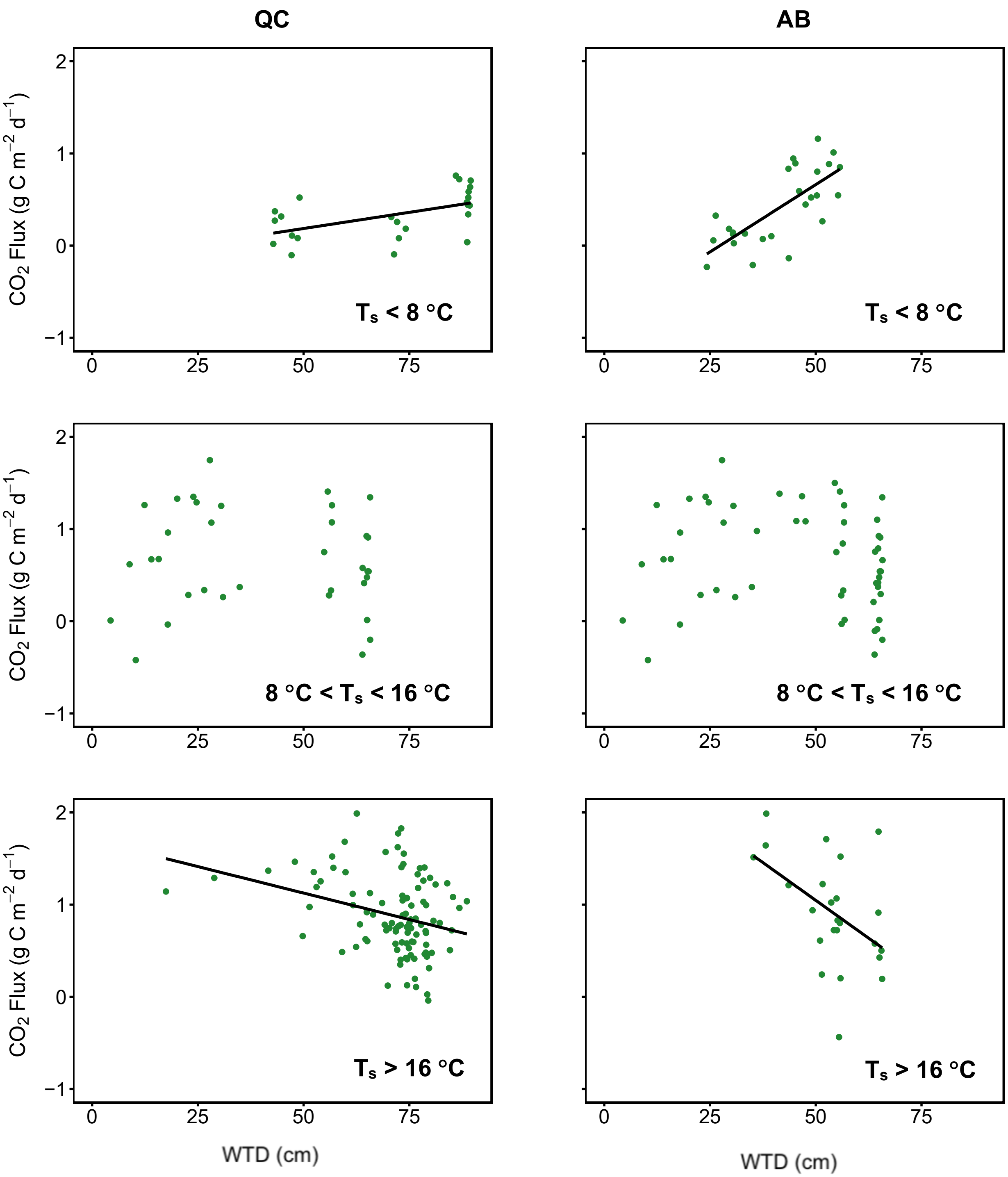

Figure S8 Scatterplots showing the effect of WTD on daily daytime (9 am to 5:30 pm) CO_2 fluxes at QC (left column) and AB (right column) across the study years. The CO_2 data has been divided by 10 cm depth (QC) and 20 cm depth (AB) soil temperature (T_s) , as cool periods (T_s < 8 °C), moderate periods (8 °C < T_s < 16 °C) and warm periods (T_s > 16 °C). All linear regressions were significant (Table S8).

Table S1 Total area (m^2) of the fields and ditches in the 80% and 90% probability flux footprints at AB and QC in the study years.

	AB			QC	
	2020	2021	2022	2020	2022
80% probability					
Ditches	232	366	229	564	407
Fields	6058	8897	6544	18198	19720
90% probability					
Ditches	972	1724	844	2580	2011
Fields	23825	35250	25867	74988	81528

Table S2 Percent of daytime and nighttime CO_2 fluxes per month in each year at AB. A value of n.m indicates that data was not measured that month. Fluxes were categorized as daytime and nighttime when the incoming solar radiation was greater than 20 W m^{-2} and less than 20 W m^{-2}, respectively. In cases when the eddy covariance tower was not operating for the full month, only periods when it was operating were used for calculations.

	2020		2021		2022	
	Percent Daytime Fluxes	Percent Nighttime Fluxes	Percent Daytime Fluxes	Percent Nighttime Fluxes	Percent Daytime Fluxes	Percent Nighttime Fluxes
January	1.4	2.1	20.5	4.7	n.m	n.m
February	14.8	2.8	18.5	5.3	n.m	n.m
March	34.2	8.4	39.1	15.0	n.m	n.m
April	41.7	10.8	50.8	13.3	n.m	n.m
May	37.8	10.3	42.9	10.2	46.5	15.0
June	38.8	4.6	50.1	9.1	27.8	6.1
July	33.2	5.5	37.7	8.2	27.7	2.1
August	38.0	8.1	31.0	3.7	34.9	4.6
September	43.5	4.4	n.m	n.m	40.8	6.2
October	30.8	8.2	n.m	n.m	44.4	7.1
November	13.9	2.8	n.m	n.m	n.m	n.m
December	13.4	2.0	n.m	n.m	n.m	n.m

Table S3 Percent of daytime and nighttime CO_2 fluxes per month in each year at QC. A value of n.m indicates that data was not measured that month. Fluxes were categorized as daytime and nighttime when the incoming solar radiation was greater than 20 W $m^{-2}$and less than 20 W m^{-2}, respectively. In cases when the eddy covariance tower was not operating for the full month, only periods when it was operating were used for calculations.

	2020		2022	
	Percent Daytime Fluxes	Percent Nighttime Fluxes	Percent Daytime Fluxes	Percent Nighttime Fluxes
January	n.m	n.m	n.m	n.m
February	n.m	n.m	n.m	n.m
March	n.m	n.m	n.m	n.m
April	n.m	n.m	n.m	n.m
May	n.m	n.m	44.7	17.1
June	n.m	n.m	38.8	13.2
July	45.3	12.8	42.7	21.3
August	36.5	12.8	38.8	15.4
September	44.6	17.2	50.5	23.9
October	29.7	13.9	45.8	18.8
November	n.m	n.m	n.m	n.m
December	n.m	n.m	n.m	n.m

Table S4 Percent of daytime and nighttime CH_4 fluxes per month in each year at AB. A value of n.m indicates that data was not measured that month. Fluxes were categorized as daytime and nighttime when the incoming solar radiation was greater than 20 W $m^{-2}$and less than 20 W m^{-2}, respectively. In cases when the eddy covariance tower was not operating for the full month, only periods when it was operating were used for calculations.

	Alberta	
	Percent Daytime Fluxes	Percent Nighttime Fluxes
January	n. m	n. m
February	n. m	n. m
March	n. m	n. m
April	n. m	n. m
May	19.3	5.3
June	12.1	1.9
July	10.6	0.2
August	12.4	0.3
September	0	0
October	0	0
November	n. m	n. m
December	n. m	n. m

Table S5 Monthly 9 am to 5:30 pm local time average and median (in brackets) CO_2 emissions (g C m^{-2} d^{-1}) at AB and QC in 2020, 2021 and 2022. A value of n.m indicates that data was not measured that month. Letters indicate when fluxes are significantly different, based on a linear model on the effect of the interaction of location and month on CO_2 fluxes.

	Quebec Site		Alberta Site		
	2020	2022	2020	2021	2022
March	n.m	n.m	0.13^{bc}	-0.01^{ab}	n.m
			(0.17)	(0.01)	
April	n.m	n.m	0.45^{efgh}	-0.19^{a}	n.m
			(0.43)	(-0.19)	
May	n.m	0.91^{klm}	0.34^{cdef}	0.16^{bcd}	0.50^{efghi}
		(0.87)	(0.42)	(0.25)	(0.45)
June	n.m	1.09^{m}	0.40^{cdefg}	0.22^{bcde}	0.68^{ghijk}
		(1.18)	(0.45)	(0.20)	(0.66)
July	0.74^{ijkl}	1.02^{lm}	0.71^{hijk}	0.76^{ijkl}	1.00^{lm}
	(0.75)	(1.07)	(0.68)	(0.78)	(1.01)
August	0.39^{cdef}	0.84^{jklm}	0.74^{ijkl}	0.43^{defgh}	1.00^{lm}
	(0.37)	(0.81)	(0.79)	(0.37)	(1.07)
September	0.55^{fghi}	0.56^{fghij}	0.54^{fghi}	n.m	0.84^{jklm}
	(0.54)	(0.56)	(0.49)		(0.90)
October	0.31^{cdef}	0.53^{fghi}	0.34^{cdef}	n.m	0.52^{fghi}
	(0.21)	(0.55)	(0.37)		(0.59)

Table S6 Monthly 9 am to 5:30 pm local time average and median (in brackets) CH_4 emissions (mg C m^{-2} d^{-1}) at AB 2022. Letters indicate when fluxes are significantly different, based on a linear model on the effect month on CH_4 fluxes.

Month	CH_4 Flux
May	6.54^{a} (7.17)
June	5.48^{a} (5.89)
July	7.73^{ab} (7.63)
August	9.13^{b} (9.35)

Table S7 Outputs of linear model on the effect of soil temperature at 20 cm depth (at AB) and 10 cm depth (at QC) on daily CO_2 emissions across the study years. The CO_2 data has been divided in wet periods (WTD < 25 cm), moderate periods (50 cm > WTD >25 cm), dry periods (75 cm > WTD > 50 cm) and very dry periods (WTD > 75 cm).

	Depth	DF	F	P	R^2
AB site					
	Wet	1, 11	2.62	0.13	0.12
	Moderate	1, 31	47.13	<0.0001	0.59
	Dry	1, 56	0.17	0.68	-0.02
QC site					
	Moderate	1, 18	42.68	<0.0001	0.69
	Dry	1, 92	24.34	<0.0001	0.20
	Very Dry	1, 97	9.95	0.0021	0.08

Table S8 Outputs of linear model on the effect of WTD on daily CO_2 emissions across the study years. The CO_2 data has been divided by 10 cm depth (QC) and 20 cm depth (AB) soil temperature (T_s), as cool periods (T_s < 8 °C), moderate periods (8 °C < T_s < 16 °C) and warm periods (T_s > 16 °C). See Figure S8.

	Soil Temperature	DF	F	P	R^2
AB site					
	Cool	1, 24	27.01	<0.0001	0.51
	Moderate	1, 54	0.95	0.34	0.001
	Warm	1, 23	5.34	0.03	0.15
QC site					
	Cool	1, 22	8.51	0.0079	0.25
	Moderate	1, 86	0.05	0.82	0.01
	Warm	1, 98	10.12	0.0019	0.08