Management Alternatives in Poorly Drained and Rewetted Peatlands

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CONTEXT

- Peatlands have been historically drained and used for agriculture and pasture due to their high productivity.
- However, drainage of peat soils releases greenhouse gases (GHGs), making it a significant source of GHGs from the agricultural sector.
- Rewetting drained peatlands limits organic matter decomposition and reduces GHG emissions. However, there are uncertainties on how much reduction is achieved.
- GHG dynamics in rewetted peatlands also depend on peat nutrients and vegetation.

JUSTIFICATION

- Improving the quantification of GHG emissions in rewetted peatlands is necessary to determine GHG reductions under rewetting scenarios. This data could be used to inform decision makers on the best practices for rewetting.

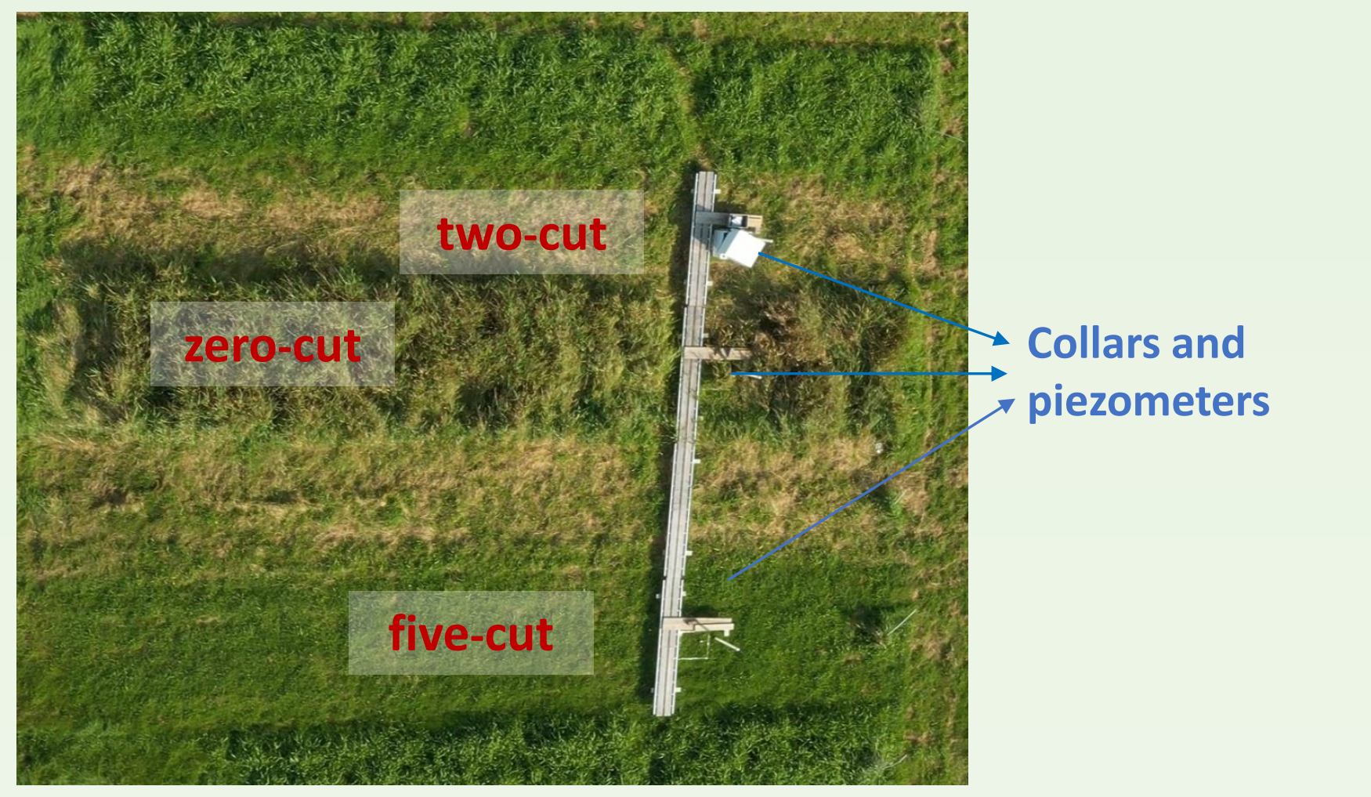
OBJECTIVE

- In this study, we aim to determine the influence of management on CO_2 and CH_4 emissions in a poorly drained fen peatland. Additionally, we evaluate how soil and water nutrients relates to these emissions.

STUDY AREA

- Study was conducted between May 2021 and May 2022 in a riparian fen peatland located in Vejrumbro in central Denmark.
- Peatland was shallow drained and previously used for pasture. At the time of this study, site was poorly drained and in transition to rewetting.
- Reed canary grass sown in 2018 in the studied plots.
- Four plots selected; Three harvest treatments (zero cut, two cut, five cut per year) in each plot.
- 200 kg N ha^{-1} y^{-1} applied equal in split doses to the two and five cut harvest treatments.

Study site, Nørrea valley, Vejrumbro



DATA COLLECTION

- Biweekly CO_2 and CH_4 flux measurements collected using a transparent manual chamber connected to an LGR-ICOS^{TM} GLA131-GGA gas analyzer using different shroudings to create four different radiation levels on each measurement including opaque condition.
- Nutrient concentrations (NO_3-N, NH_4-N, total N, total dissolved N, total P, total dissolved P, total organic C, dissolved organic C, and Fe) measured in water samples collected biweekly from piezometers.

DATA PROCESSING

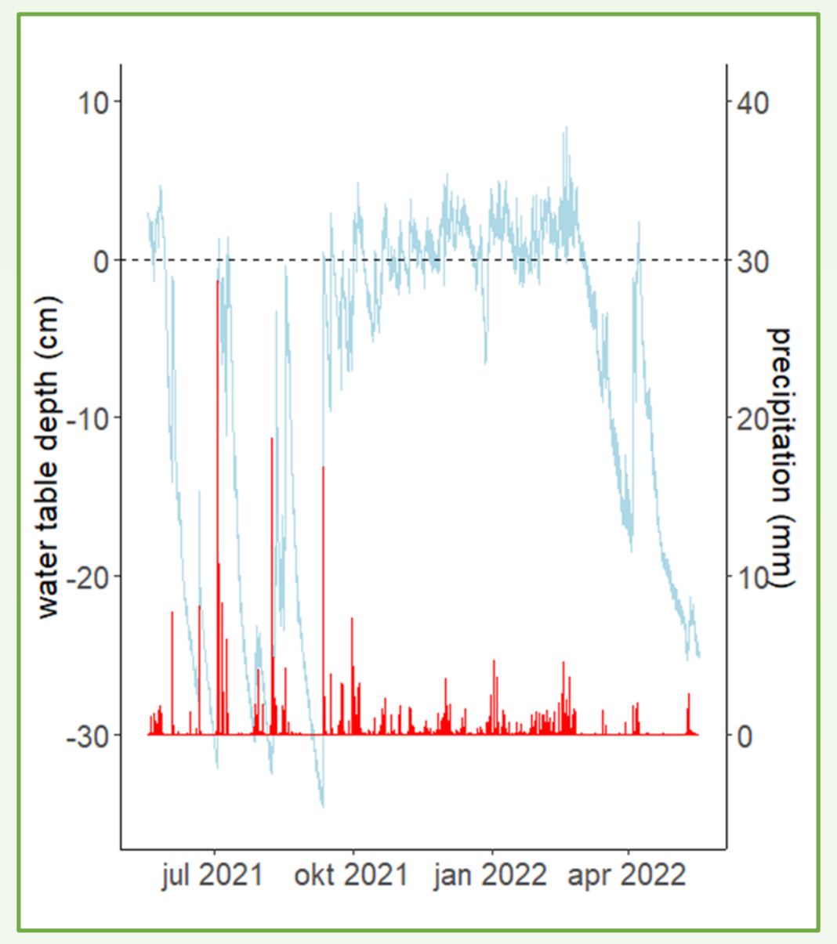
CO_2 We used hourly water table (WTD), soil temperature (Ts), photosynthetic active radiation (PAR), and a photosynthetic index (RVI) to model and obtain annual soil respiration (Reco), and gross primary productivity (GPP)

$$Reco = t1 + (a * RVI) * e^{\left[b * \left(\frac{1}{T_{10} - T_0} - \frac{1}{T_S - T_0}\right)\right]} + [(WTD - WTD_{max}) * C]^2$$

$$GPP = \frac{GPP_{max} * PAR}{k + PAR} * \left(\frac{RVI}{RVI + \alpha}\right) * FT$$

Net ecosystem exchange (NEE) = GPP - Reco

CH_4 was linearly interpolated to get annual budgets



Water table depth and precipitation at the study site

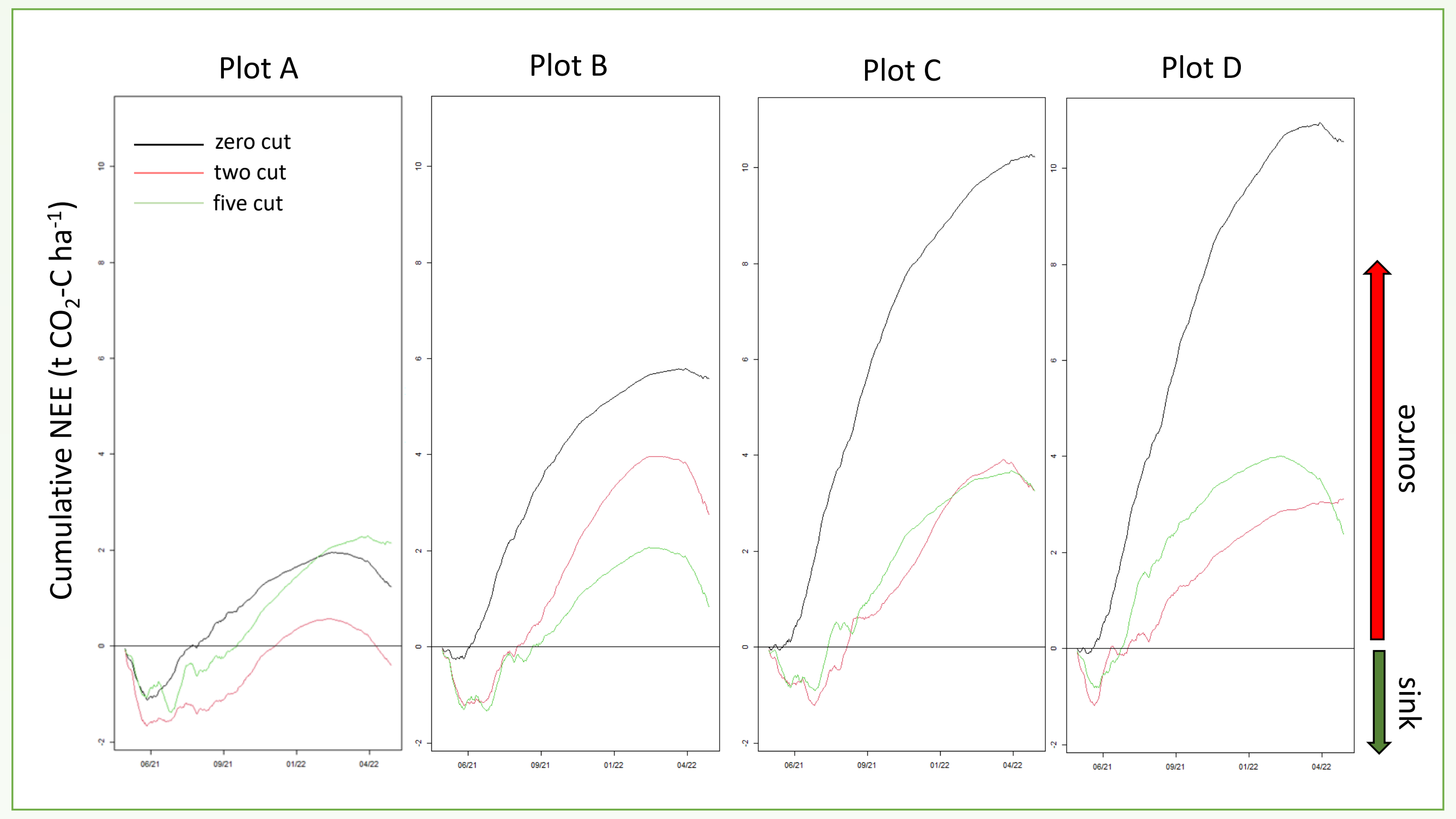
KEY FINDINGS

Plot	Harv. treatment	Reco t CO_2-C ha^{-1} yr^{-1}	GPP t CO_2-C ha^{-1} yr^{-1}	NEE t CO_2-C ha^{-1} yr^{-1}	Yield t C ha^{-1} yr^{-1}	NECB t C ha^{-1} yr^{-1}
A	0	15.43	-14.19	1.24	NA	1.24
B		18.61	-13.02	5.59	NA	5.59
C		26.23	-16	10.23	NA	10.23
D		29.43	-18.88	10.55	NA	10.55
Average ± SE		22.43 ± 3.25	-15.52 ± 1.28	6.9 ± 2.2	NA	6.9 ± 2.2
A	2	14.9	-15.29	-0.39	1.92	1.53
B		23.57	-20.82	2.75	4.52	7.27
C		26.36	-22.04	4.32	4.63	8.95
D		23.7	-20.59	3.11	5.03	8.14
Average ± SE		22.13 ± 2.5	-19.69 ± 1.5	2.45 ± 1	4.03 ± 0.71	6.47 ± 1.68
A	5	20.6	-18.45	2.15	3.48	5.63
B		21	-20.17	0.83	3.88	4.71
C		23.66	-20.39	3.27	3.53	6.8
D		24.26	-21.88	2.38	4.5	6.88
Average ± SE		22.38 ± 0.92	-20.22 ± 0.7	2.16 ± 0.5	3.8 ± 0.23	6.0 ± 0.52

- GPP was different between harvest treatments. Harvesting the biomass leads to more biomass production.
- We found marginally significant differences in Reco and net ecosystem C balance (NECB) between studied plots.
- Biomass harvest reduced NEE.

- Most CH_4 emissions took place during summer.
- There we differences between plots in CH4 emissions.
- At the point of this study, CH4 emissions contributed 11.7% to the net C emission.

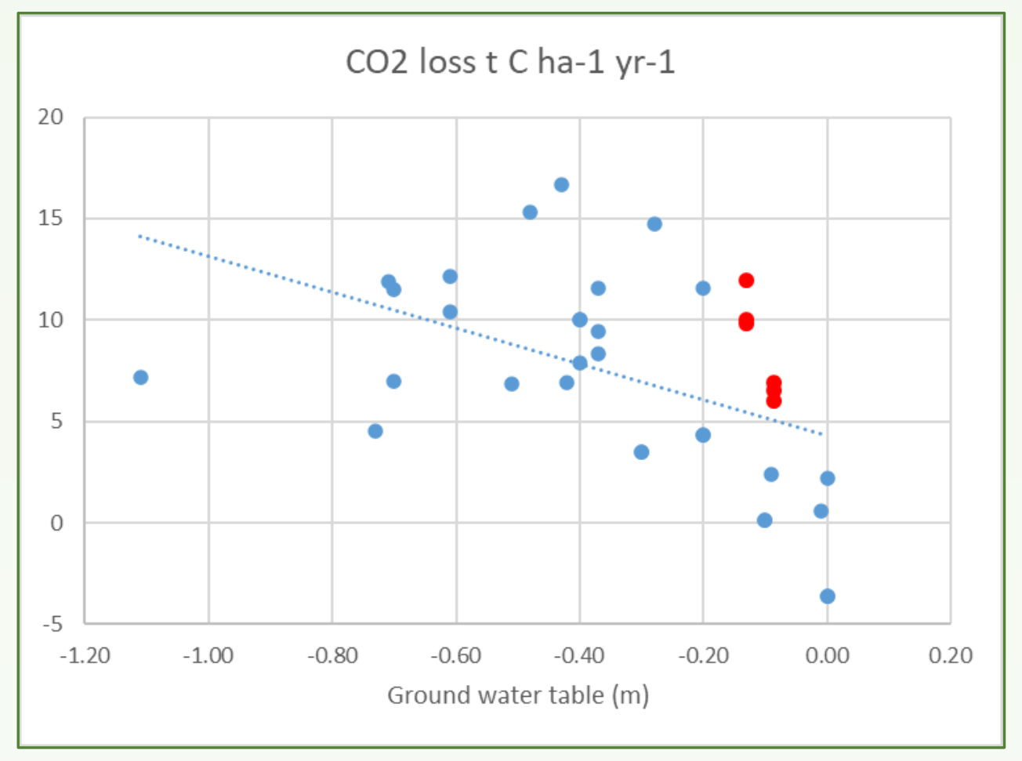
Plot	Harvest treatment	CH_4 emissions kg CH_4 ha^{-1}
A	0	204.9
	2	159.5
	5	131.6
	mean ± SD	165.4 ± 30.2
B	0	124.2
	2	132.6
	5	112.4
	mean ± SD	123 ± 8.3
C	0	35.5
	2	41.4
	5	68.1
	mean ± SD	48.3 ± 14.2
D	0	139.2
	2	201.1
	5	61.4
	mean ± SD	133.9 ± 57.2
Total average		117.65



- Studied plots showed differences in CO_2 emission patterns indicating variability in emissions within the peatland.

Plot	pH	EC mS cm^{-1}	Turbidity NTU	TOC mg L^{-1}	DOC mg L^{-1}	TN mg L^{-1}	TDN mg L^{-1}	NH_4-N mg L^{-1}	NO_3-N mg L^{-1}	TP mg L^{-1}	TDP mg L^{-1}	Fe mg L^{-1}
A	5.61±0.05 (a)	0.19 ±0.01(a)	25.4 ±2.01(ab)	164 ±9 (a)	129 ±7 (a)	14.1±0.9 (a)	12.8 ±0.8 (a)	1.56 ±0.25 (a)	4.98 ±3.18	0.49 ±0.04 (a)	0.40 ±0.04 (a)	12.2 ±0.9 (a)
B	6.40 ±0.04 (c)	0.34 ±0.01(c)	29.6 ±2.95 (b)	212 ±7 (b)	160 ±5 (b)	16.8 ±0.4 (b)	15.5 ±0.5 (b)	1.50 ±0.15 (a)	1.38 ±0.58	0.81±0.04 (c)	0.69 ±0.05 (b)	22.9 ±1.1(b)
C	6.22 ±0.04 (b)	0.34 ±0.01(b)	40.3 ±3.76 (c)	193 ±10 (b)	135 ±6 (ab)	18.6 ±0.9 (b)	16.2 ±0.7 (b)	3.34 ±0.29 (b)	2.97 ±1.49	0.68 ±0.04 (b)	0.50 ±0.03 (a)	19.0 ±1.6 (b)
D	6.25 ±0.04 (b)	0.32 ±0.01(b)	26.7 ±3.85 (a)	209 ±16 (b)	137 ±8 (a)	19.6 ±1.2 (b)	18.9 ±1.2 (b)	2.95 ±0.24 (b)	3.58 ±1.90	1.07 ±0.08 (c)	0.91±0.08 (b)	36.3 ±3.6 (c)
ditch	6.65 ±0.07	0.32 ±0.01	41.9 ±32.9	66 ±8	42 ±3	7.2 ±1.8	4.6 ±0.3	1.2 ±0.2	1.09 ±0.21	1.13 ±0.23	0.93 ±0.2	3.9 ±1.1
Harvest treatment												
0	6.13 ±0.05 (b)	0.26 ±0.01(a)	27.3 ±2.4	191±9	137 ±5	16.0 ±0.8 (a)	14.5 ±0.7 (a)	1.96 ±0.16 (a)	0.15 ±0.03	0.83 ±0.06	0.63 ±0.05	20.3 ±1.9 (a)
2	6.04 ±0.05 (a)	0.31±0.01(b)	33.3 ±3.0	189 ±10	136 ±6	18.5 ±0.9 (b)	16.9 ±0.9 (b)	2.69 ±0.30 (b)	7.49 ±2.64	0.71±0.04	0.59 ±0.05	23.3 ±1.9 (b)
5	6.20 ±0.04 (b)	0.33 ±0.01(c)	30.5 ±3.1	203 ±10	148 ±6	17.3 ±0.7 (ab)	16.1±0.7 (ab)	2.36 ±0.18 (ab)	1.87 ±0.49	0.76 ±0.05	0.63 ±0.05	24.3 ±2.2 (ab)

- Higher nutrient concentrations generally found in plots C and D (plots with highest CO_2 emissions), similarly, lowest nutrient concentrations found in plot A.
- Higher concentrations of N forms in fertilized treatments.
- Significant differences found in pH, electroconductivity (EC), and turbidity exemplify variability within the peatland.



CO_2 emissions from Danish peatlands from Koch et al. (2023). Added red dots mark results from this project

CONCLUSIONS

- Biomass harvesting (paludiculture) did not increase GHG emissions during early rewetting stages.
- The use of harvested biomass to replace fossil fuels could reduce the total carbon footprint.
- Variability in peat nutrients and emissions within rewetting peatlands should be considered in best practices for rewetting to minimize GHG emissions.

EJP SOIL has received funding from the European Union's Horizon 2020 research and innovation programme: Grant agreement No 862695