Rewetting of drained peatlands provides permanent and fast GHG mitigation

Kristiina Lång, Daniël van de Craats, Henri Honkanen, Lars Elsgaard, Rudi Hessel, Hanna Kekkonen, Tuula Larmola, Jens Leifeld, Poul Erik Lærke, Andres Rodriguez, Sanna Saarnio, Junbin Zhao

- Greenhouse gas (GHG) emissions from drained peatlands are >100 Mt CO_2 eq. annually in EU.
- In rewetting, water level is raised to mitigate emissions of CO_2 and N_2O from peat decomposition.
- Paludiculture is the practice of rewetting coupled with crop biomass harvest.
- Studies on paludiculture at selected sites showed:
  - Raising the water table decreases peat decomposition.
  - It is difficult to reach net carbon (C) sequestration.
  - Biomass harvest does not necessarily compromise improvement in the C balance.
  - High range of N_2O emissions (from minor to high).
  - Moderate CH_4 emissions.

Introduction

Rewetting of previously drained agricultural peat soil coupled with continued cultivation in the form of paludiculture is not widely practiced, and experiments are needed to understand its environmental impacts. In the INSURE project (INdicators for SUccessful carbon sequestration and greenhouse gas mitigation by REwetting cultivated peat soils) we measured GHG emissions and crop yields in rewetted agricultural fields.

Description of the Issue

Peat accumulates when water slows down decomposition of plant residues. Drainage reverts this and causes high GHG emissions from peat decomposition. Global warming further enhances emissions. Alternatives to agriculture on drained peatland are restoration to natural ecosystem or paludiculture. Both options can reduce GHG emissions but neither of them completely restores degraded peatlands. Restoration leads to higher nature value while paludiculture allows for continued biomass production and nutrients removal, potentially easing subsequent restoration with natural vegetation adapted to low nutrient status.

Figure 1 A grass field in paludiculture. The cultivated grass may be used for animal bedding, fodder, or growing media in horticulture.

©Tuula Larmola, Luke

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

KEY MESSAGES FOR POLICY MAKERS

Recommendation One: Promote rewetting of drained peatlands in climate policies

Simulation of the Zegveld site indicates that rewetting can significantly reduce GHG emissions. However, the results suggest that if climate warming is high, rewetting alone will not be sufficient to curb the increase in the emissions. Nevertheless, rewetting is crucial as, without rewetting, the situation will be worse.

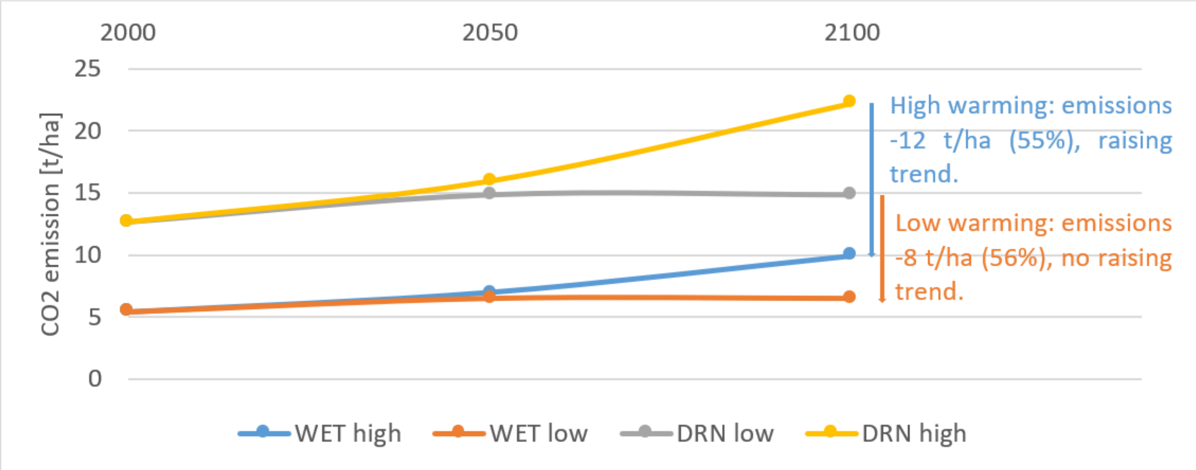

Fig. 2 Simulated CO_2 emissions from a peatland site in Zegveld (NL) in drained (DNR) or rewetted (WET) management and low (+1.6°C) and high (+4°C) global warming scenarios.

The EU strives to be climate-neutral by 2050. This requires:

- decreasing GHG emissions and
- increasing carbon sinks in the Land Use sector.

Rewetting drained peat soils can contribute to both objectives, but its potential is not well understood in the implementation of climate policies. Because the carbon sink of the land use sector comprises of carbon pools in both soils and biomass, mitigating emissions from peatlands is as relevant for strengthening the carbon sink as increasing the carbon stock in forest biomass and has several co-benefits such as biodiversity improvement and protection against flood events.

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

Recommendation Two: Make paludiculture a viable management option via CAP and industrial policies

INSURE found out that it is possible to reduce CO_2 emissions significantly and manage even fertilized sites after rewetting without increasing N_2O emissions [1-3]. Methane emissions remained at a moderate level. Biomass production of grasses was possible at higher than conventional ground water levels, and wet management did not excessively hamper grass yield (Fig. 3). Compared to restoration, paludiculture partly compromises the carbon balance as some carbon is exported in harvest. However, partial raise of the water level does not protect the peat C stock in the long run. Productive use of rewetted sites can be recommended as an alternative to abandonment if nature restoration is not feasible.

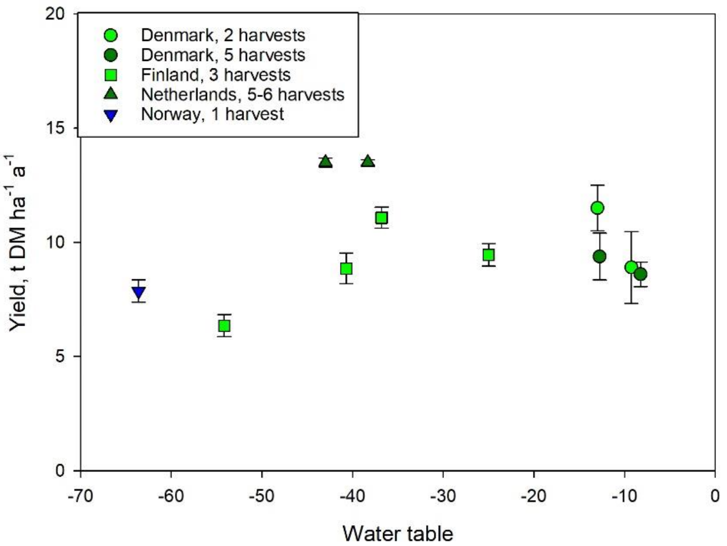

Fig. 3 Grass yields from INSURE sites were good even in wet management.

Abandoning cultivated peat soils without active rewetting is not a desirable form of land management as these sites drift out from food production while the GHG emissions remain high. Paludiculture, crop production under wet conditions, allows farmers to produce crop and receive income from rewetted land.

Common agricultural policy (CAP). More funds are currently used for supporting cultivation of drained peat soils than for mitigating their environmental impacts. It is important to modify the CAP to support GHG mitigation by rewetting. This requires:

1) More support for rewetting
2) Less support for keeping peat soils drained.

Industrial policies. Production and logistics of paludiculture biomass are challenging due to wet soil and undeveloped markets. In order to upscale paludiculture, there must be incentives for industry to use biomass from paludiculture e.g. in construction materials and R&D funding to develop solutions for harvesting, logistics and processing of the novel biomass types.

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

Methodology

GHG emissions and soil properties were measured for 2-4 years at five sites across northern Europe. See details in the original papers [1-3].

Current and future scenarios were modelled for the Zegveld site (NL) with SWAP-ANIMO model [4-5] using a site-specific model calibration based on measurements on a drained and rewetted plot in 2020 to 2023. Hydrology, grass growth and CO_2 fluxes were modelled for the current climate (1990-2020) and future climates (2035-2065; 2085-2115) for the shared socioeconomic pathways SSP1-2.6 (low) and SSP5-8.5 (high) emission pathways [6]. Numbers presented in Fig. 2 represent means of modelled yearly emissions related to peat oxidation.

Affiliations of the Authors

Kristiina Lång, Henri Honkanen, Hanna Kekkonen, Tuula Larmola and Sanna Saarnio: Natural Resources Institute Finland

Daniël van de Craats, Rudi Hessel: Wageningen Environmental Research

Lars Elsgaard, Poul Erik Lærke: Aarhus University

Jens Leifeld: Agroscope

Junbin Zhao: Norwegian Institute of Bioeconomy Research

References

[1] Lång, K., Honkanen, H., Heikkinen, J., Saarnio, S., Larmola, T., Kekkonen, H. (2024). Carbon balance and emissions of methane and nitrous oxide during four years of moderate rewetting of a cultivated peat soil site. Available at: https://doi.org/10.5194/egusphere-2024-934.

[2] Nielsen, C.K., Liu, W., Koppelgaard, M., Lærke, P.E. To harvest or not to harvest: management intensity did not affect greenhouse gas balances of Phalaris arundinacea paludiculture. Submitted.

[3] Zhao, J., Mastepanov, M., Klutsch, C., Silvennoinen, H.M., Fjelldal, E., Kniha, D., Kjær, R. Elevated water level could turn a cultivated peatland from a source to a sink for greenhouse gases in the Arctic Norway (in preparation).

[4] Kroes, J.G., van Dam, J.C., Bartholomeus, R.P., Groenendijk, P., Heinen, M., Hendriks, R.F.A., Mulder, H.M., Supit, I., van Walsum, P.E.V. (2017) SWAP version 4. Theory description and user manual. Report 2780, Wageningen Environmental Research, Wageningen, the Netherlands.

[5] Groenendijk, P., Renaud, L.V., Roelsma, J. (2005) Prediction of nitrogen and phosphorus leaching to groundwater and surface waters. Process descriptions of the ANIMO 4.0 model. Alterra-rapport 983, Wageningen.

[6] van der Wiel, K., Beersma, J., van den Brink, H., Krikken, F., Selten, F., Severijns, C., ... van Dorland, R. (2024) KNMI'23 Climate Scenarios for the Netherlands: Storyline Scenarios of Regional Climate Change. Earth's Future, 12(2), e2023EF003983.

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