Indicators for successful carbon sequestration and greenhouse gas mitigation by rewetting cultivated peat soils (INSURE) project

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Background

- Drainage triggers the microbial processes that decompose peat → GHG emissions and water pollution
- Annual GHG emissions from drained peat soils are >200 million tonnes CO_2equivalent in the EU
- Raising the ground water table is the only measure that can stop peat loss
- Rewetting can aim at restoration close to natural conditions or to paludiculture: cultivation of wet-tolerant crops with raised ground water level
- Rewetting has a high GHG mitigation potential per area
- The mitigation potential of peat soils has been poorly used
- Side-effects of of rewetting are not well understood
- Decision makers benefit from information that helps to target rewetting with the most benefits and the least side-effects

Paludiculture of willow, forage and extensive grassland in Finland; photo M. Kurki

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Potential to mitigate GHG emissions by rewetting

No peat policies / No new drainage / No drainage+60% restored

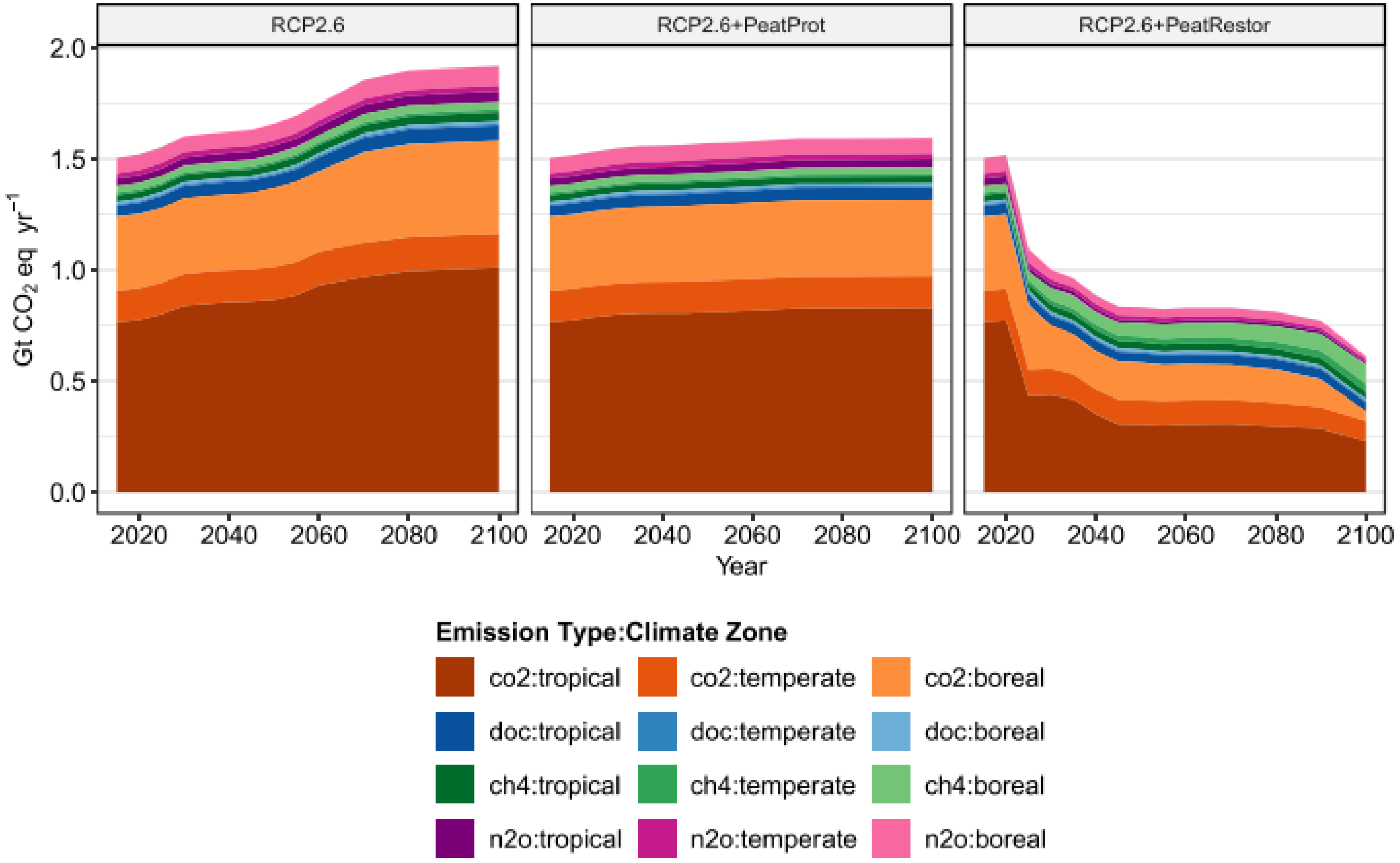


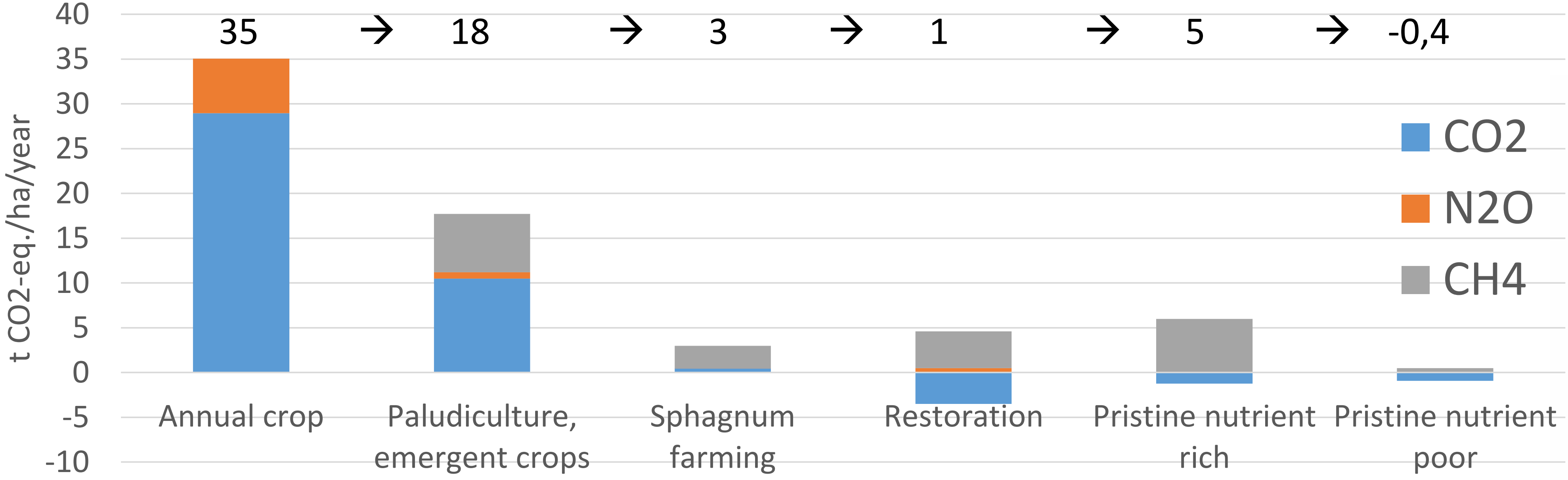
Figure 4. Annual GHG emissions (CO_2, CH_4 and N_2O) and off-site CO_2 emissions (DOC) from degraded and rewetted peatlands between 2015 and 2100 for three scenarios (left, middle, right) in tropical, temperate and boreal climate zones. Emission types are indicated by colour, climate zones are indicated by corresponding colour gradients.

- Without restoration the emissions will last for centuries
- Significant global mitigation potential by protecting intact peatlands and restoring 60% of drained peatland

- Source: Humpenöder et al. 2020 https://doi.org/10.1088/1748-9326/abae2a

Typical GHG emission rates from peat soils CO_2 eq./ha/year

Significant reduction in total emissions with a raise in ground water level.
CO_2 and N_2O emissions decrease, CH_4 emissions increase.
Restoration of cultivated soils can reach similar total emissions as pristine sites.



Sources: IPCC 2014, Bianchi et al. 2021, Ojanen et al. 2021

Factors affecting GHG emissions from rewetted peat soils (monitored by INSURE project)

Soil

- Origin and decomposition status of the peat affect its chemical and physical properties: soil element content, ash content, quality of carbon (oxidation state), pH, porosity, bulk density,…
- Biodegradability of the leached dissolved organic matter

Hydrology/Climate

- Ground water level and temperature are the main controllers of both CO_2 and CH_4
- Fluctuations in water level→ frequency of anoxia

Management

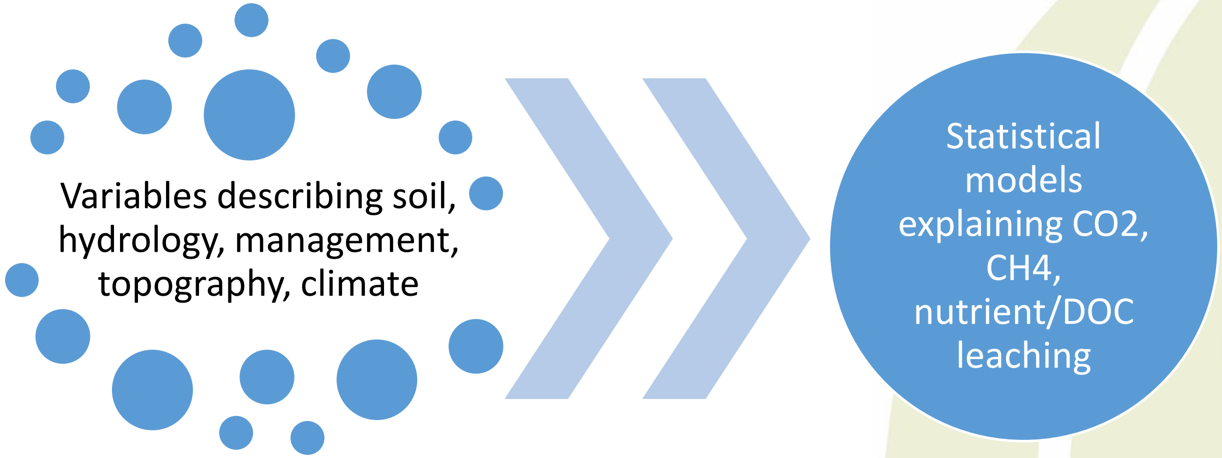
- Crop type, yield, fertiliser rate, type of fertiliser, timing of operations
- Actions preceding rewetting
- Rewetting strategy

Measurements and statistical modelling

- Measurements at wet peat sites in FI, DK, NL, IR (LUKE, AU, WR, Teagasc) in 2021-2023
  - GHG emissions, water quality, basic peat properties and advanced analysis of the molecular composition of peat (pyrolysis-GCMS)

Zegveld measurement site in the Netherlands

Experimental site on a poorly drained fen peatland in the Nørreå stream valley, Denmark



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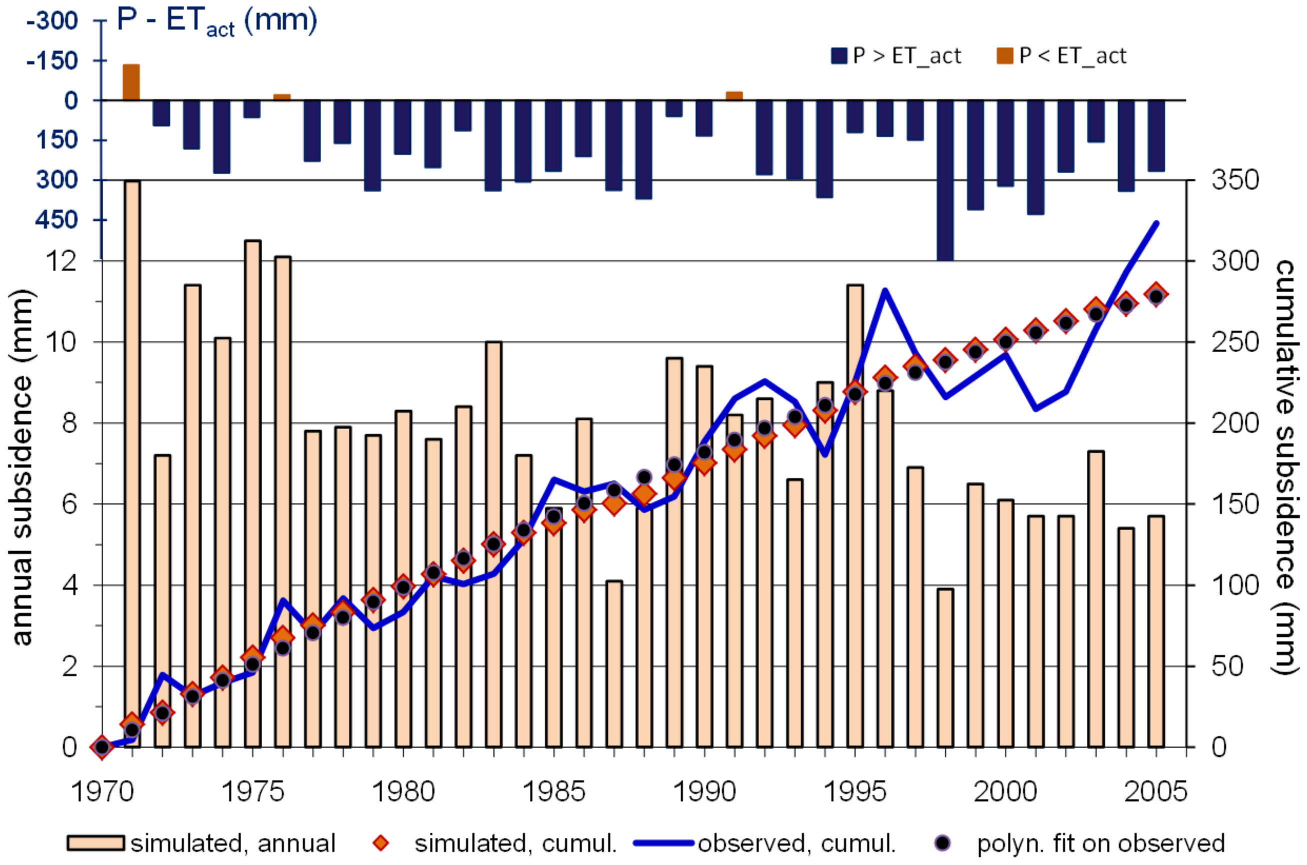
Biogeochemical and hydrological modelling

- INSURE will demonstrate long-term impacts of wet agricultural management by scenarios made using the combined hydrology and biogeochemical SWAP-ANIMO model.

- The scenarios will illustrate the impact of climate change and different water management strategies on emissions from the INSURE research sites until 2100.

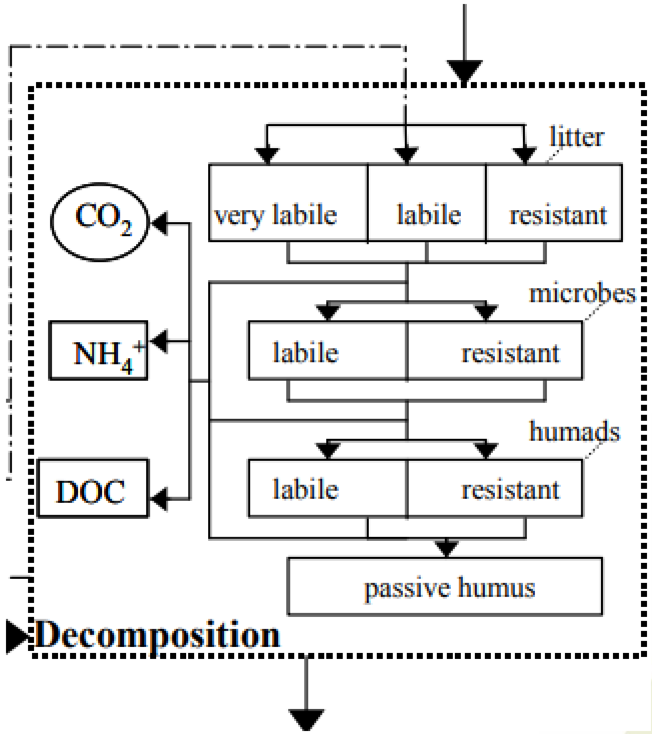


Example of measured and modelled land subsidence (predictor of CO_2 emissions)

Development of soil carbon modelling

The performance of soil carbon models can be improved by comparison of model results and measurements:

1. Soil respiration measurement data will be used to calibrate the initial distribution of soil organic carbon pools in the DNDC and ECOSSE models
2. Molar concentrations of carbon, hydrogen, nitrogen, oxygen, sulphur and phosphorus in peat can be used to derive an indicator of peat decomposition rate → comparison to model results



Example: the DNDC model divides C to labile, resistant and passive conceptual pools which are not easily measured. We will study if the measured chemical composition can be related to these pools.

Expected outcomes

Site selection criteria for rewetting

- Information for funders (governments, voluntary C markets) for selecting the most beneficial sites for rewetting
- Guidance for land use planning and GHG mitigation

Guidance for site management in rewetting

- Fertilizer rates, harvest, water table management...

Scientific understanding on element cycling in peat

- Improved understanding on element cycling and regulatory factors of GHG emissions and nutrient/C losses to watercourses
- Better modelling tools

Thank you!

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