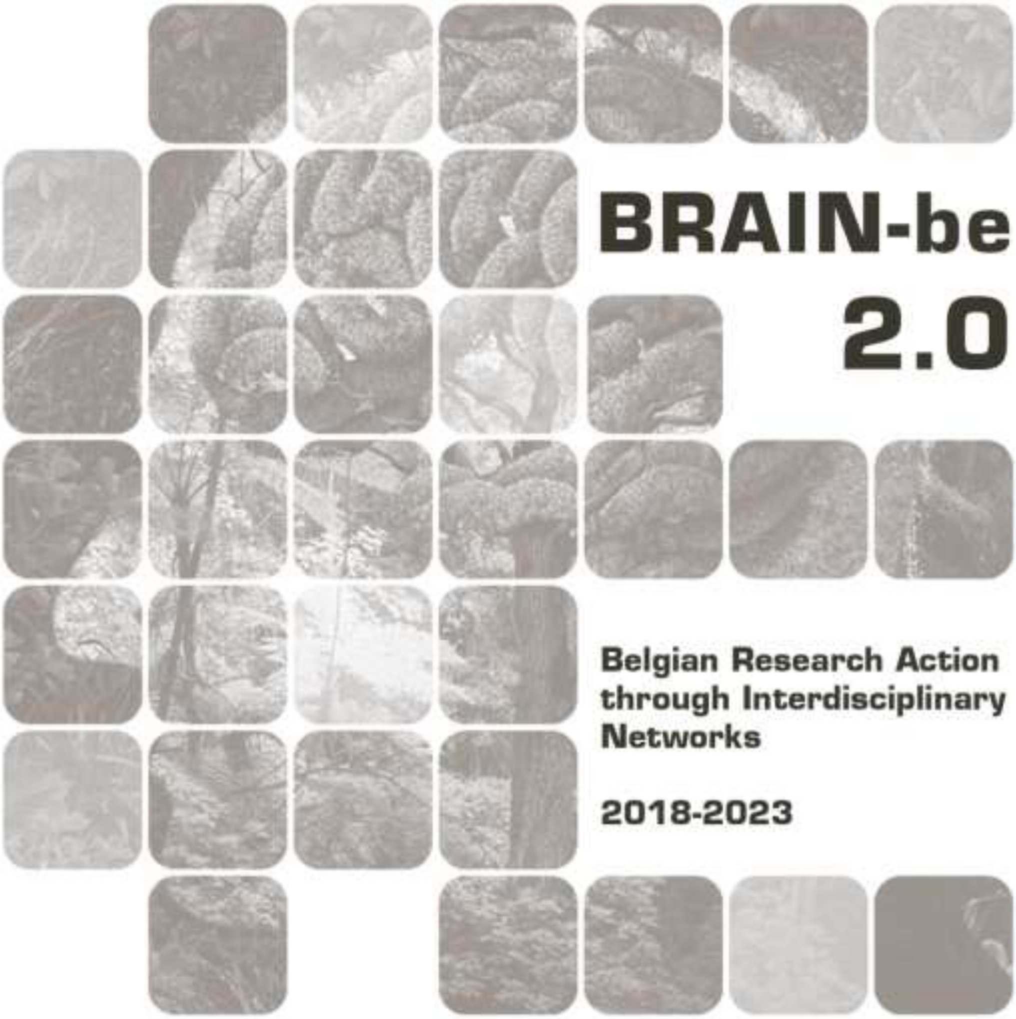

Princess

Peatland Rewetting In Nitrogen-Contaminated Environments: Synergies and trade-offs between biodiversity, climate, water quality and Society

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NETWORK PROJECT

PRINCESS

Peatland Rewetting In Nitrogen-Contaminated Environments: Synergies and trade-offs between biodiversity, climate, water quality and Society

Contract - B2/20E/P1/PRINCESS

FINAL REPORT

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ABSTRACT

Context

The PRINCESS project, funded by BiodivERsA, investigated how rewetting nitrogen-contaminated peatlands could simultaneously address biodiversity loss, climate change, and water quality issues. Drained peatlands in the EU had been significant sources of greenhouse gas (GHG) emissions, releasing around 200 million tons of CO_2-equivalents annually. Conventional agriculture on these lands had further exacerbated emissions and contributed to high nitrate levels, negatively impacting water quality and biodiversity.

Objectives

Focusing on temperate fens—groundwater-fed peatlands widespread across Europe—the project examined how rewetting affected biodiversity, GHG emissions, nitrate release, and biomass yield. Since these ecosystems had been largely drained for agricultural use, PRINCESS aimed to assess whether restoring water levels could reduce emissions while maintaining productive land use.

The research followed a multi-scale approach, incorporating controlled laboratory experiments, field studies, and modeling at catchment and EU levels. This methodology ensured robust findings, balancing scientific accuracy with practical applicability. The project brought together expertise from Austria, Belgium, Finland, Germany, Norway, and Poland—countries representing diverse peatland conditions and nitrogen load scenarios.

Conclusions

Key findings demonstrated that rewetting significantly reduced GHG emissions and nitrate leaching while promoting biodiversity recovery. However, the extent of benefits depended on site conditions, previous land use, and rewetting strategies. The project also highlighted the potential for paludiculture (wetland agriculture) to provide sustainable biomass production, offering economic opportunities while maintaining ecosystem functions.

Keywords: peatland rewetting, paludiculture, greenhouse gases, nitrogen pollution, biodiversity

1. INTRODUCTION

Europe faces three major environmental challenges: greenhouse gas (GHG) emissions, nitrogen (N) pollution, and biodiversity loss. Peatlands can play a vital role in addressing these challenges. Drained peatlands in the EU emit ~200 Mt CO_2eq a^{-1} (app. 5% of total EU emissions), mainly from conventional agriculture on drained peat soils (144 Mt CO_2eq a^{-1}). The latter make up only 2.5% of the total agricultural area but produce 25% of the total agricultural GHG emissions in the EU (incl. methane from enteric fermentation and nitrous oxide from fertilization), with an even larger contribution in peatland-rich countries, e.g. Finland (62%), Poland (42%), and Germany (37%, based on NIR 2019 data). Drained, agriculturally used peatlands in the EU are - through peat mineralization - also an annual source of 1-5 Mt of NO_3 (own estimates based on NIR 2019), with substantial impact on ground and surface water quality, drinking water provision, and biodiversity. Typical peatland biodiversity, in particular that of groundwater-fed fens in temperate Europe, has been devastated by drainage (Joosten et al. 2017). Consequently, all relevant EU policy objectives include rewetting of drained peatlands as an essential ecosystem-based solution to avoid peatland GHG emissions, reinstall carbon sequestration, reduce nitrogen mineralization, enhance nitrogen removal, and/or restore peatland-specific biodiversity.

These obvious synergies come, however, with **trade-offs**. Whereas peatland rewetting largely stops or even reverses carbon dioxide and nitrous oxide emissions, it also promotes **methane emissions** (Joosten et al. 2016). While the net effect on radiative forcing will - compared to drained peatlands - always be beneficial on the mid- and long-term (Günther et al. 2020), the balance may be strongly **determined by hitherto unquantified interactions with other environmental drivers, especially nitrogen**. Increased nitrogen availability may enhance methane emissions via increased production of easily decomposable organic substrates, accelerated anaerobic decomposition, and suppression of methanotrophs. On the other hand, nitrogen availability may lower methane emissions by simultaneous suppression of methanogenesis (Roy & Conrad 1999). Additionally, climate outcomes of peatland rewetting will be controlled by **site management**. Different land use leads to different vegetation - each with its own biodiversity and GHG emission characteristics - and to different depletion rates of soil nitrogen pools. Biomass use will in turn - via quantity and quality of the harvested biomass - feedback on economic returns and on acceptance by rural communities. Knowledge of these interactions is therefore crucial for estimating the practical feasibility, and optimizing the outcomes of rewetting peatlands under alternative land use scenarios.

Peatland rewetting in the EU can no longer focus on marginal or abandoned areas. It must also target highly fertilized and productive, deeply drained peatlands, because those have highest GHG emission, nitrate release rates, and biodiversity loss. A wide range of **alternative, wet land use options** have to be presented, which must include options that provide sufficient biomass yield for a fair income to farmers, thereby contributing to a healthy and vibrant relationship between urban and rural areas. The necessary variety can broadly be grouped into three main land use options for rewetted peatlands:

1. **<u>High-intensity paludiculture</u>**: the cultivation of deliberately established, selected wetland crops under intensive management with the goal to produce the highest quantity and/ or quality of targeted biomass;

2. **Low-intensity paludiculture**: the regular harvest from spontaneously established vegetation for biomass use;
3. **Wet wilderness**: the absence of biomass harvesting and other on-site management with the focus on the provision of regulating services and wilderness biodiversity values.

These three land use options can all be realised at rewetted peatlands of different nitrogen loads. Here, we define **nitrogen loads** as an increased nitrogen burden caused by atmospheric deposition, run-off from neighbouring agricultural sites, or mineralization of organic matter as a consequence of drainage. So far, rewetted peatlands have mainly been converted into wet wilderness or, to a limited extent, are being utilized as low-intensity paludiculture. High-intensity paludiculture has to date only been realised in a few pilot projects such as *Typha* farming for the production of building material at high nitrogen loads. At rewetted peatlands with lower nitrogen loads, *Sphagnum* farming for production of growing media or *Drosera* farming for medicinal purposes are being practised.
The **objective of PRINCESS is to evaluate the synergies and trade-offs between key EU policy objectives** such as (1) restoring biodiversity and healthy ecosystems, (2) keeping global warming below 2°C, (3) clean water and (4) guaranteeing a fair income to farmers **at rewetted peatlands under alternative land use options**. PRINCESS will explore **to what extent nitrogen loads can guide decision-making** with respect to land use that - under given circumstances - optimally contributes to these policy objectives. PRINCESS will test basic research hypotheses and deliver tools and guidelines for the sustainable use of rewetted peatlands in Europe.

The **main research questions** are:

- What are the effects of land use options of differing intensity (high-intensity paludiculture, low-intensity paludiculture, wet wilderness) for rewetted, formerly deeply drained peatlands on key EU biodiversity, climate, water and societal policy objectives? Are there synergies and trade-offs?
- How do nitrogen loads influence compliance with the policy objectives under different land use options?
- How do nitrogen loads determine which land use option optimizes between these policy objectives, are there thresholds or tipping-points for choosing between these land use options?

The hypothetical effects of different land use options for rewetted peatlands under a gradient of nitrogen loads on key policy objectives and related indicators are depicted in the table below. We hypothesize the effect of each land use option on each policy objective to be positive (green), neutral (yellow) or negative (red) relative to the other land use options, and *increasing nitrogen loads* to have a reinforcing (+), neutral (o) or weakening (-) effect on the policy objective indicators (considering nitrogen loads ranging from natural background to intensive agriculture on drained peatland with additional N deposition and inflow from the surroundings).

2. STATE OF THE ART AND OBJECTIVES

As agreed at the award stage, the objective of PRINCESS was to evaluate the synergies and trade-offs between key EU policy objectives such as (1) restoring biodiversity and healthy ecosystems, (2) keeping global warming below 2°C, (3) clean water, and (4) guaranteeing a fair income to farmers at rewetted fen peatlands under alternative land use options. PRINCESS aimed to explore to what extent nitrogen loads can guide decision-making with respect to land use that – under given circumstances – optimally contributes to these policy objectives. PRINCESS tested basic research hypotheses and delivered tools and guidelines for sustainable use of rewetted peatlands in Europe.

We have here re-structured the objectives of PRINCESS to better serve as a structure for this report:

1. Assess the impact of rewetting and paludiculture on **greenhouse gas (GHG) emissions**. PRINCESS aimed to quantify how rewetting nitrogen-contaminated temperate fens affected GHG emissions, particularly carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), to determine its effectiveness in mitigating climate change.

2. Evaluate changes in **water quality**, particularly nitrate leaching The project examined how rewetting influenced nitrate retention and release, with a focus on improving water quality and reducing nitrogen pollution in groundwater and surface water in temperate fen peatlands.

3. Analyze the effects of rewetting on **biodiversity** PRINCESS studied the response of plant and animal communities to rewetting and paludiculture in temperate fen peatlands, assessing whether restored water levels promoted the recovery of characteristic peatland species and enhanced overall biodiversity.

4. Develop **predictive models for peatland rewetting scenarios** Using field and experimental data, PRINCESS created models to predict the long-term environmental and economic impacts of rewetting at site, catchment, and EU-wide levels.

5. Support policy development and inform land management strategies PRINCESS provided **science-based recommendations** for policymakers, land managers, and farmers, ensuring that peatland restoration aligned with EU climate, biodiversity, and water protection policies.

The PRINCESS consortium infront of the high-intensity Cattail paludiculture site in NE Germany, September 2022.

Field workshop with foresters and other stakeholders in one of the study sites, Poland, 22.09.2021.

4. METHODOLOGY

Objective 1: Assessment of the impact of rewetting and paludiculture on GHG emissions

University of Antwerp: A controlled mesocosm experiment was set up, where three different types of vegetation were maintained on a standardized substrate. These were either amended or not with N, and GHG production was followed up over > 1 year. The effect of N and microbial community manipulation was specifically assessed. Selection and maintenance of the study sites (studied in WP4) in the Netherlands was supported.

University of Warsaw: Study sites in Poland (studied in WP4) were established and maintained, serving as project fieldwork locations. An attempt to predict total GHG emission reduction potential under different land use scenarios was made in the peatlands of the lower Narew catchment, Poland. To this end we compiled data on peat soil biogeochemistry, established plant species response models for groundwater levels in Polish peatlands to assess current and predicted GHG emissions, and calculated carbon footprint of various land-use options, including conventional farming, high- and low-intensity paludiculture, and rewilding.

University of Vienna: Greenhouse gas (GHG) fluxes (CO2, CH4,N2O) were quantified and analysed (diurnal and monthly observations) at the 14 project study sites over a two year period (September 2021 – August 2023) to determine the effect of nitrogen levels and paludiculture on GHG emissions, and to identify the drivers of GHG fluxes in rewetted fen peatlands.

NINA: High resolution GHG dynamics to target biogeochemical processes and their regulation were analysed from the start and end of the mesocosms experiments carried out at University of Anterp. Methodology for transcriptomics compined to critical points in the incubation were suggesfully tested prior the main experiments and samples were collected from the main experiment. Due to methodological and logistical difficulties analysis are pending.

Objective 2: Assessment of the impact of rewetting and paludiculture on water quality

University of Antwerp: Within the mesocosm experiment under objective 1, we particularly distinguished bare-soil and different vegetation types concerning their capacity to take-up N.

UW: We applied nutrient input and reduction data gathered in a previous project (CLEARANCE) to assess synergies and constraints of peatland rewetting between C and N reduction targets in the Narew catchment peatlands.

NINA: We targeted biogoechemincal processes and their regulation by different electron acceptors under the objective 1.

Objective 3: Assessment of the impact of rewetting and paludiculture on biodiversity

Universiy of Greifswald: Vegetation was assessed at the 14 project study sites over a 2.5 year period (April 2021 – September 2023). Biodiversity was studied at 6 + 1 study sites in Germany. We sampled data on birds, spiders, dragonflies, grasshoppers and ground beetles. We also studied above- and belowground production and decomposition using ingrowth cores and litter bags. This allows to make conclusions on the peat formation potential at the different study sites.

Objective 4: Develop predictive models for peatland rewetting scenarios

University of Greifswald: Building on the Global Peatland Databased hosted at P1/Greifswald Mire Centre, we collaborated within the PRINCESS consortium and additionally with a master student of Wageningen University (Q. Van Giersbergen) to add most recent datasets for EU peatlands and their land use to the database. We also worked on rewetting scenarios/trajectories for various countries.

Luke: Luke was responsible for the work to estimate the socio-economic effects of rewetting. For this, the Global Peatland Database was updated and the current GHG emissions of European countries estimated (van Giersbergen et al., in review). This was the basis of the EU rewetting scenario presented in the policy brief illustrating the benefits of peatland rewetting in the EU (see objective 4). For further calculation of a biomass potential, European catchments were divided in three classes based on nitrogen level. The potential of paludiculture to provide biomass for European industries was estimated based on a literature review of typical yields and the area of drained peatlands in agriculture (Temmink et al., in preparation). The same paper summarizes the benefits of rewetting for GHG emissions and biodiversity. Farm-scale estimates of three different subsidy schemes for compensating rewetting for land-owners were compiled.

Objective 5: Provide science-based recommendations

University of Greifswald (with subcontractors Ecologic): We organised three field days in Germany and exchanged with stakeholders, prepared three policy briefs (Carbon Removal Certification Framework, paludiculture and biodiversity, key results), facilitated the conference declaration of the “Power to the peatlands” conference, and contributed to a wide range of media output (e.g. short film about the PRINCESS project).

University of Antwerp: Team members were involved in the preparation of the “Power to the peatlands” conference in Antwerp and contributed to the PRINCESS policy brief on peatland rewetting for Belgium.

University of Warsaw: The PRINCESS team participated in peatland policy development in PL and at the EU level, including the preparation of PL Wetland Conservation Strategy, the development of EU carbon farming standard, the consultation of peatland protection policies under CAP, and others.

University of Vienna: This team contributed to the PRINCESS policy brief on peatland rewetting for Austria.

NINA: A Policy brief illustrating GHG emissions from drained peatlands in Norway was prepared. We organised a workshop in Trondheim (August 2024) on peatland restoration in Norway targeted to policy makers.

Luke: A policy brief illustrating the benefits of peatland rewetting in the EU was prepared. Also policy briefs with a rewetting scenario and country-specific messages were compiled for each partner country.

Table of deliverables

Deliverable			Lead partner (country and designation)	Date delivered (dd/mm/yyyy)	Comments
Work package	Deliverable or Milestone	Full name			
WP1	D1.1.1	Consortium agreement	P1	30.09.2022	Completed
WP1	D1.1.3	Internal progress report (1)	P1	01.06.2021	Completed
WP1	D1.1.4	Internal progress report (2)	P1	03.02.2022	Completed
WP1	D1.1.5	Internal progress report (3)	P1	01.09.2022	Completed
WP1	D.1.1.6	Internal progress report (4)	P1	01.03.2023	Completed
WP1	D1.1.7	Internal progress report (5)	P1	01.09.2023	Completed
WP1	D1.1.8	Internal progress report (6)	P1	01.03.2024	Completed
WP1	D.1.2.1	Financial and external report I	P1	31.12.2021	Completed
WP1	D1.2.2.	Financial and external report II	P1	31.12.2022	Completed
WP1	D1.2.3	Financial and external report III	P1	31.12.2023	Completed
WP1	D1.3.1	Data Management Plan	P1	21.09.2021	Completed
WP1	D1.3.2.	Interim dataset check report	P1	31.12.2022	Completed
WP1	D1.4.1	Literature Review	P1 + P4 + All	16.02.2023	Completed
WP1	D.1.5.1.	Description of sampling and experimental design in the project	P1	01.06.2021	Completed
WP1	D1.5.2	Interim workshop report	P1	02.09.2022	Completed
WP1	D1.5.3	Final workshop report	P1	30.06.2024	Completed
WP1	D1.6.1.	Conference proceedings	All	30.09.2022	Completed
WP1	D1.6.2.	Conference proceedings	All	30.09.2024	Completed
WP1	D1.6.3.	Manuscripts	All	pending	See list of publications for completed ones.
WP2	D2.1.2	Design for microcosm scale experiments	P5	31.12.2021	Completed
WP2	D2.2.2.	Description of most important factors regulating C & N mineralisation	P5	30.3.2022	Completed
WP2	D2.3.1	Analysis of changes in microbial community	P5	30.8.2024	Completed
WP2	D2.3.2.	Tool for predicting trends of C & N mineralisation	P5	30.8.2024	Completed
WP2	D2.4.2.	Description of critical microbial functions/ microbes responsible for phenotypic changes	P5	30.82024/Pending	Microbial functions completed/responsible microbes pending
WP3	D.3.1.2	Assessment of plant biomass production and NP content	P2	01.11.2024	Completed
WP3	D3.1.3.	Assessment of soil nutrient pools (NO3, NH4, P) and microbial communities involved in N cycling	P2	01.11.2024	Completed
WP3	D3.2.1.	Estimate of the direction (source/sink) and relative strength of GHG fluxes	P2	31.01.2025	Completed
WP3	D3.2.2	Description of relative importance of N levels, plant community type, and source of peat/biota on GHG balance	P2	31.01.2025	Completed

WP3	D3.3.1	Assessment of the relative and absolute abundance changes of CH4 producing and CH4 consuming micro-organisms	P2	31.01.2025 (modified)	Completed - this task has been modified, where instead of additional quantification of microbial taxa, we now additionally sequenced all fungi in samples
WP3	D3.3.2.	Assessment of the full bacterial community difference in response to peat source, N level, and plant functional type, with focus on N-cycling bacteria	P2	31.01.2025	Completed
WP4	D4.1.1.	Description of selected sites	P4	05.2021	Completed
WP4	D4.1.2.	Compilation of site data for year 1	P4	08.2022	Completed
WP4	D4.1.4.	Compilation of site data for year 2	P4	10.2023	Completed
WP4	D4.2.2.	Quantitative description of GHG fluxes at 14 plots over year 1	P4	12.2022	Completed
WP4	D4.2.3.	Quantitative description of GHG fluxes at 14 plots over year 2	P4	09.2023	Completed
WP4	D4.3.3.	Quantitative description of vegetation and key mire-specific faunal diversity	P1	12.2023	Completed
WP4	D4.3.4.	Assessment of above- and below-ground production and decomposition at 14 plots	P1	12.2024	Completed
WP4	D4.4.1	Description of limiting factors at 14 plots	P1	05.2022	Completed (implemented by P1 instead of P3)
WP4	D4.5.1	Description of microbial community at 14 plots	P2	12.2023	Completed
WP5	D5.1.1	GIS database structure	P3	30.06.2021	Completed
WP5	D5.2.3	GIS layer with geochemical peat characteristics	P3	30.11.2021	Completed
WP5	D.5.3.1	GIS layer with predicted NP loads after rewetting	P3	31.01.2025	Completed
WP5	D5.4.1.	GIS layers with vegetation response	P3	31.03.2025 (modified)	Modified after changing approach from vegetation to species-focused; completed as database of peatland species responses to groundwater levels; delayed due to difficulties with post-doc recruitment
WP5	D5.4.2.	Models representing GHG balance for three rewetting scenarios	P3	pending	Delayed due to difficulties with post-doc recruitment; will be delivered in May/June 2025
WP6	D6.1.1	EU 2050 rewetting scenario	P6	14.3.2025	The results will be published in the EU scale policy brief as soon as the Giersbergen et al. paper is published..
WP6	D6.1.2	National rewetting scenarios and GHG pathways for 5 countries	P6	31.12.2024	The scenarios are part of the policy briefs of each country.
WP6	D6.1.3	National communication and press releases	P6	04.2025 or pending	The policy briefs for Austria and Poland were published. The policy briefs of the other countries are pending because

					they utilise still unpublished data from the paper by Giersbergen et al.
WP6	D6.2.1	Calculation of the GHG balance for the rewetting scenario	P6	14.3.2025	The results will be published in the EU scale policy brief.
WP6	D6.2.2	Calculation of N balance for the rewetting scenario	P6	pending	Not achieved due to delays with the GIS work.
WP6	D6.2.3	Report on biodiversity effects of paludiculture;	P6	28.3.2025	This is included in the scientific manuscript "Agriculture on wet peatlands in Europe: the vast sustainability potential of paludiculture"
WP6	D6.2.4 D6.3.1	Analysis of environmental and socio-economic impacts of rewetting of cultivated peat soils in the EU	P6	28.3.2025	This is included in the scientific manuscript "Agriculture on wet peatlands in Europe: the vast sustainability potential of paludiculture". This deliverable was accidentally mentioned twice in the proposal.
WP7	D7.1.1.	Publication/press release of rewetting guidelines	P1	03.2025	Guidance provided to key DE publication, Ramsar global guidelines, through the policy briefs (see D6.1.3) and continuing in the global peatland breakthrough process (Working Group on targets and knowledge led by P1)
WP7	D7.1.2.	Webinar on rewetting guidelines hosted by FAO Mitigation of Climate Change in Agriculture programme MICCA	P1	•	In order to achieve a wider audience and create added value, the guidance will be incorporated in 2 global workshops co-organised by P1 and FAO in June 2025 in the framework of the global peatland breakthrough
WP7	D7.2.1	Outreach plan for policy communication	P1+Ecologic	31.03.2022	Completed
WP7	D.7.3.2.	Policy brief on opportunities and co-benefits of rewetting at EU level	P1+P6	04.2025 or pending	Policy brief on CRCF issued in 2022; policy brief on biodiversity issued in 2024; see D6.1.3. For 2025 policy briefs
WP7	D7.3.3.	Report on policy event	P1+Ecologic	31.12.2023	Completed, incl. Conference declaration of 'Power to the Peatlands' conference
WP7	D.7.4.1	Project website	P1	30.09.2021	Completed, missing policy briefs will be added once finalised

4. SCIENTIFIC RESULTS AND RECOMMENDATIONS

WP1 (University of Greifswald/All)

In WP1, we had included a literature review to create a common understanding. The deliverable was fulfilled by Darusman et al (2023)., who published a paper fulfilling excactly this deliverable without our previous knowledge. The full citation is: Darumsman, T., Muriyarso, D., Impron, Anas, I (2023): Effect of rewetting degraded peatlands on carbon fluxes: a meta-analysis. Mitig Adapt Strateg Glob Change 28 :10. https://doi.org/10.1007/s11027-023-10046-9. We made this paper available to all team members and discussed it in the consortium.

WP2 (NINA)

All set goals were achieved, excepting for transcriptiomics from critical points of incubation, which is pending due to methodological and logistical challenges, but is expected to be completed on the course of 2025. First we carried out a review targeting microbial processes controlling GHG emissions from rewetted peatlands, we carried out high-resolution GHG dynamics from start and end points of the mesocosm experiments of University of Antwerp. The project results were presented in multiple conferences, including EGU 2024. We expect one additional manuscript to be completed in 2025 in addition to the published review article.

Main results indicate the vulnerability of GHG production in restored peatlands for increased nitrogen loading (Fig. 1, 2). Exposing the mesocosm soils for long-term nitrogen loading lead to increase in the production potential of CO2 and N2O, with less pronounced impacts of vegetation (sedges) vs. Bare peat. Methane production potential, however, was slightly decreased as affected by nitrogen loading and sedge-dominated vegetation lead to highest increases in the production potential. We also showed that high iron contents in the soil can lead to high carbon mineralisation in anoxic condition.

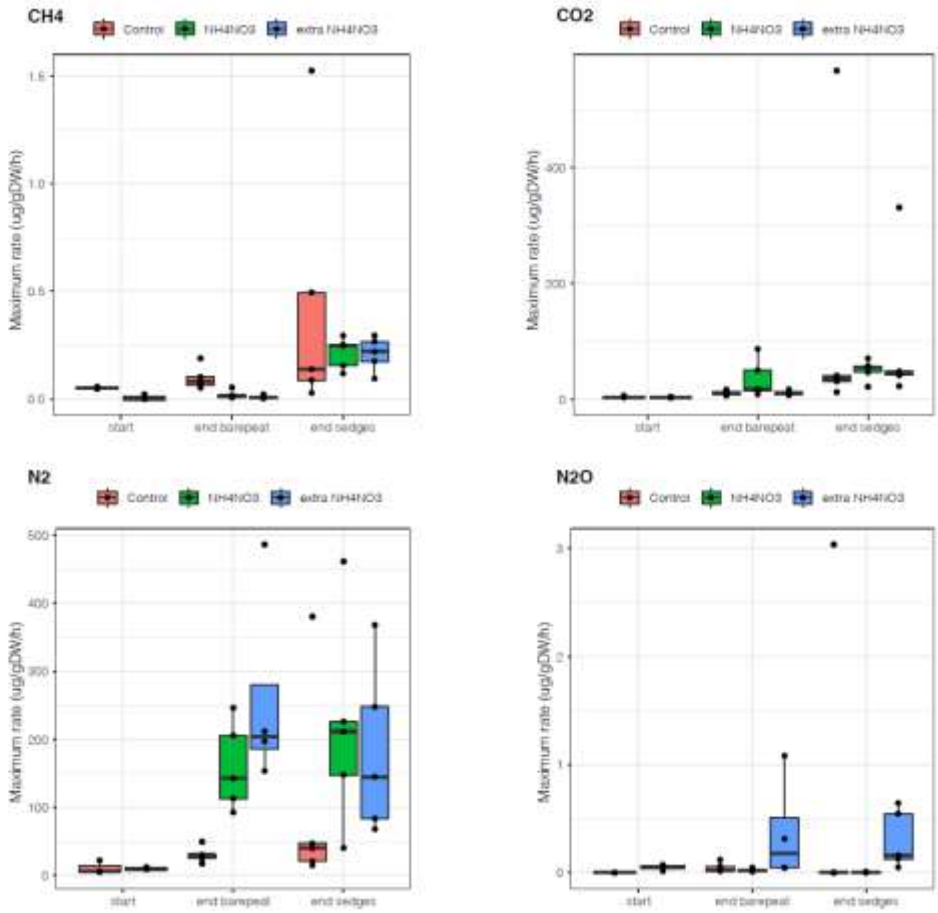

Fig. 1. Production potentials of GHG’s and N2 from start and end point incubations.

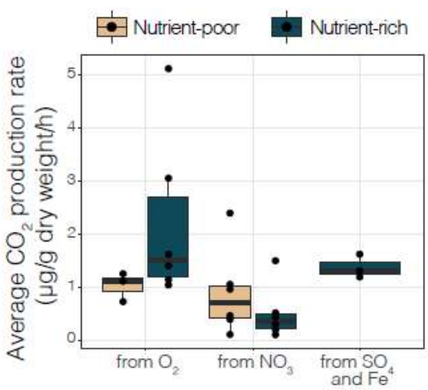

Fig. 2. Oxic and anoxic CO2 production potentials from nutrient.rich peat soils.

WP2 (University of Antwerp)

All set project goals (Mesocosm experiment, Greenhouse gas sampling, data compilation and analysis) were successfully completed. Data and results from WP2 were presented in several scientific conferences NAEM 2024, Netherlands, Power to the Peatlands 2023, Antwerp, Belgium). It is foreseen that the WP will result in multiple scientific publications. One is currently nearly ready to be submitted.

The major scientific findings of WP2 were that both the microbial community composition (as reprentend by source of microbial inoculum Arlon vs. Zwarte Beek, as well as vegetation (bare soil versus sedges) significantly impacted methane emission (Figure 3). The microbial community composition was primarily shaped by the initial microbiome inoculum, with a secondary impact from vegetation cover. Surprisingly, year-round simulated N deposition exhibited no discernible effects on GHG emissions or microbial community composition. However, it did stimulate or suppress vegetation biomass, depending on whether the inoculated microbiome was from a nutrient-rich or -poor peatland origin, respectively. Furthermore, we characterized the functional pathways of bacteria and functional guilds of fungi in the peatland soil microbiomes, and complemented this with annotation-free discovery of microbial functional groups. As can be seen in Figure 4, methane producing and consuming members of the microbial community only partly overlapped between microbes inoculated from the more oligotropic (Arlon) and eutrophic (Zwarte Beek) site, with more unique taxa originating from Arlon. Overall, our results underscore the significance of the peat microbiome (and its legacy) in shaping the biogeochemical processes that underlie the global warming potential of peatland soil, even under conditions of profoundly changed N levels and vegetation type.

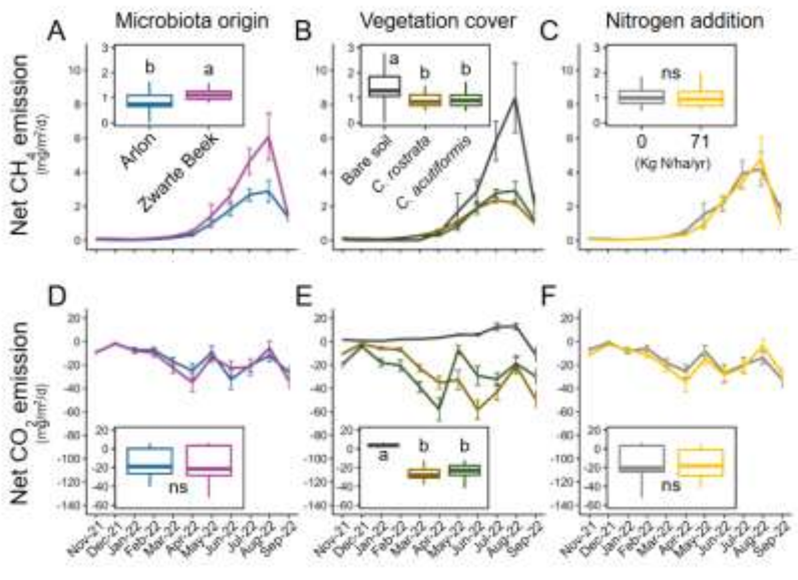

Fig. 3: Net CH4 and CO2 flux in mesocosm units depending on treatment (contrasting microbial origin, vegetation type, and nitrogen addition).

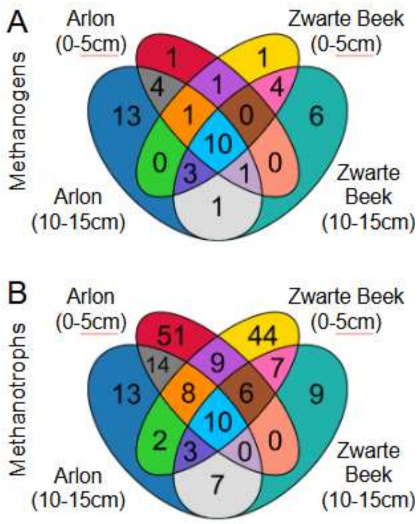

Fig. 4: Venn diagrams of the count of unique ASVs assigned to either “methanogens” (A) or “methanotrophs” (B) in two layers of the mesocosms of WP2.

WP4 (University of Vienna, University of Greifswald)

All set project goals (Greenhouse gas sampling, data compilation and analysis) were successfully completed. Data and results from WP4 were presented in several scientific conferences (EGU 2023,2024 in Vienna, Austria & Power to the Petlands 2023, Antwerp, Belgium). It is forseen that the WP will result in 3 scientific publications (2 currently in preparation (Q2/Q3 2025 respectively) and 1 planned (Q4 2025) in high impact (Q1) journals. Current (and planned) scientific journal publications are a collaborations between Uni Vienna (Lead) and Uni. Greifswald (paper planned for Q2 2025) and Uni. Antwerp/Greifswald (paper planned for Q3 2025) along with other potential project partners. Additionally it is forseen at least 2 more conference presentations on results from WP4 within 2025 (EGU 2025, Vienna, Austria & RRR 4th International conference 2025. Greifswald Germany). Two major scientific outputs/findings of WP4 were

1) The capturing of significant temporal (diurnal, monthly, seasonal) variability in GHG emissions is necessary to accurately determine GHG emissions from rewetted peatlands under different land management

2) The practice of paludiculture did not result in significant changes in total GHG emissions (measured as [CO2 eq]) from any of the sample countries / Nitrogen level treatments – compared to wet wilderness (no paludiculture/productive use of rewertted peatlands] , suggesting that paludiculture may allow for sustainable (in terms of GHG emissions) and productive use of rewetted peatlands.

We also achieved to implement all planned studies on biodiversity and peat formation.

Biodiversity was studies at our field sites in Germany and within 5 Bachelor and Master theses, which are summarised in an integrative paper (Martens et al. 2023). The paper thus presents a multi-taxon study investigating vegetation, breeding bird and arthropod diversity at six rewetted fen sites dominated by Carex or Typha species. Sites were either unharvested, low- or high-intensity managed, and were located in Mecklenburg-Vorpommern in northeastern Germany. Biodiversity was estimated across the range of Hill numbers using the iNEXT package, and species were checked for Red List status

(Fig. 5). Here we show that paludiculture sites can provide biodiversity value even while not reflecting historic fen conditions; managed sites had high plant diversity, as well as Red Listed arthropods and breeding birds. Our study demonstrates that paludiculture has the potential to provide valuable habitat for species even while productive management of the land continues. This is of big interest to all peatland-rich EU countries seeking to manage their peatlands more climate- and biodiversity-friendly. Together with other German research partners, we published an information paper using the PRINCESS and other results in both German and English languages in 2024 (see PRINCESS website).

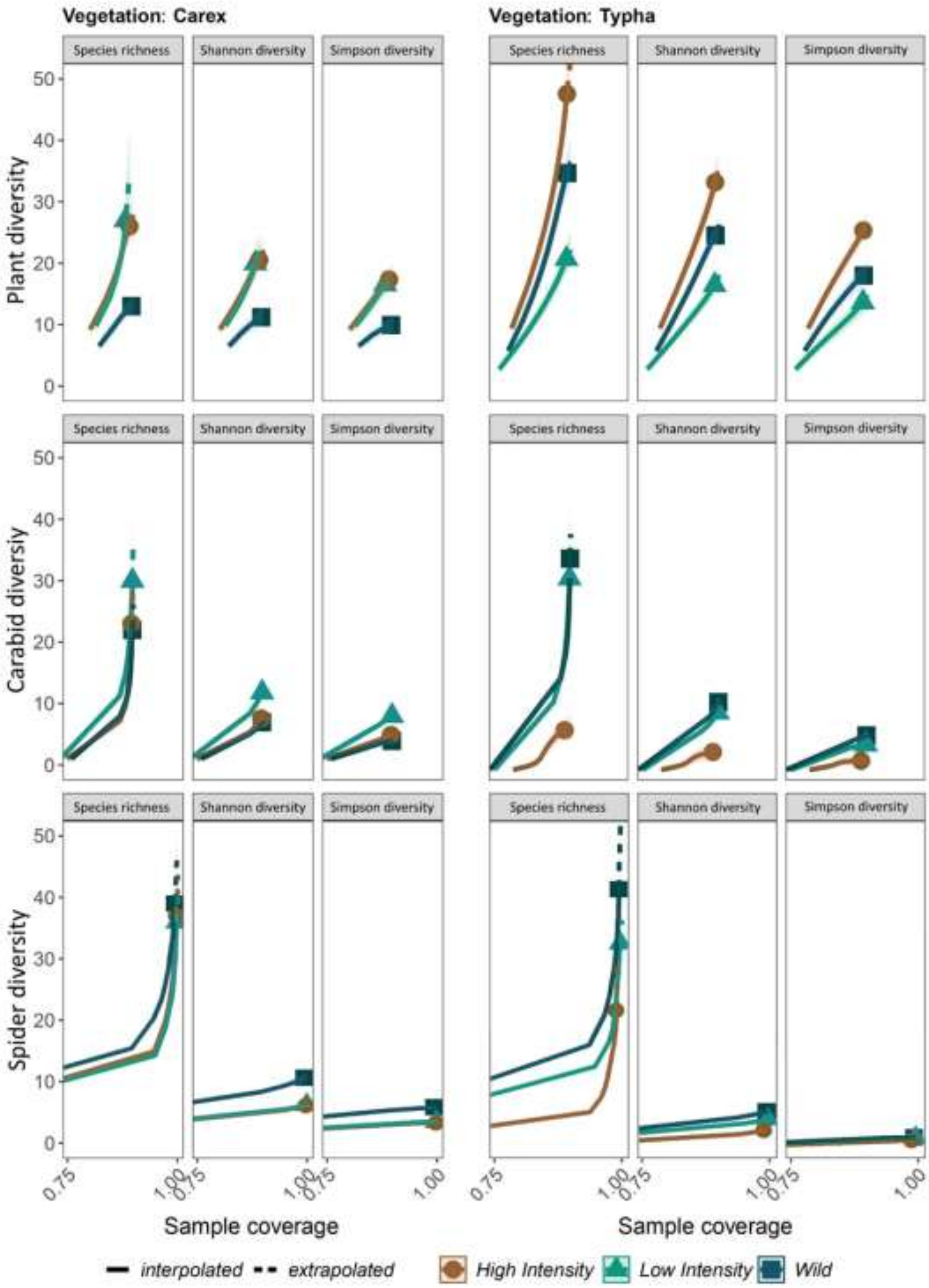

Fig. 5: Coverage based biodiversity extrapolations for different taxa comparing paludiculture intensities for Carex and Typha as target species. Estimate of sample completeness is given as sample coverage which is used to standardize samples according to the iNEXT.4 package. Diversity results are extrapolated and interpolated across the range of Hill numbers. Thus, diversity at each site is compared using species richness, which is biased towards rare species, Shannon diversity, biased towards common species, and Simpson's diversity, biased towards dominant species. Sites are compared at equal sample coverage, given as the coverage maximum (double the smallest sample size), where a sample coverage of 1.0 for Simpson's diversity indicates 100% of dominant species are predicted to have been found.

The peat formation potential was studied in rewetted fens differing in land use (wet wilderness, low-intensity and high-intensity paludiculture) and nutrient availability (Typha-dominated for high availability, Carex-dominated for low availability) across temperate Europe. It was quantified as the surplus between belowground production (ingrowth cores) and decomposition (litterbags). We showed for the first time that paludiculture in rewetted fens does not negatively affect the peat formation potential or its components (Fig. 6). Litter mass remaining from decomposition in sites with low nutrient availability was actually highest under high-intensity paludiculture. Belowground production was mainly linked to a long growing season. Belowground decomposition was lowest at medium to low nutrient availability. The peat formation potential increased with a long growing season, a high water table, and low nutrient availability in the studied rewetted fens. To maximize the peat formation potential in rewetted temperate fens, we recommend (1) applying paludiculture on highly degraded sites with high nutrient availability for maximizing aboveground production and nutrient removal and (2) actively secure stable and high water levels (Kreyling et al. submitted).

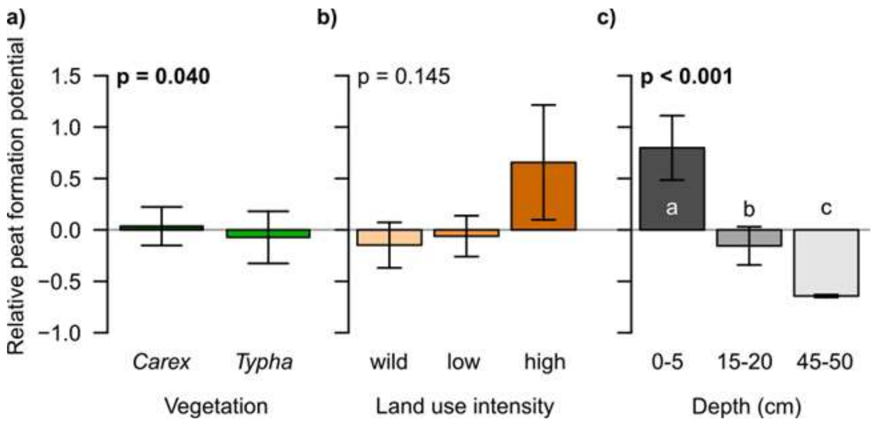

Fig. 6: Relative peat formation potential, expressed by multiplying annual belowground production by the share of belowground litter mass remaining after one year of exposition. Displayed are all main effects and all significant interactions and the significance of the effects based on a linear mixed model with vegetation type, land use intensity, depth and all their interaction as fixed effects and region (NL, DE, PL) as random effects. Shown are mean values and standard errors of the mean.

WP5 (University of Warsaw)

The synergies and tradeoffs between reduction of GHG emission and N/P pollution in fen restoration and paludiculture projects were analysed for the lower Narew catchment peatlands. Three drained fen peatlands were analysed with respect to Fe:P ratios, revealing spatial variation of post-rewetting PO43-remobilisation potential. N-input from agriculture was mapped using hydrological models and reduction of plant-available N in rewetted peat soil via microbial processes was calculated using empirical equations. GHG emissions prior- and post-rewetting were calculated in two ways: (1) using IPCC emission factors and (2) using published equations between GHG emissions and mean water levels in peat; which were indicated based on plant species composition using a newly-compiled database of species responses to groundwater levels in Polish peatlands (consisting of 211 records of phytosociological relevees matched with at least 1 year groundwater monitoring results ; Fig. 7). Post-rewetting emissions were calculated for several scenarios with different potential paludiculture plants, based on their affinity to mean water levels, revealed from the mentioned database. In addition, carbon footprint of mowing machinery and biomass transport was added to obtain full GHG balance of paludiculture establishment. We showed how this approach allows to plan peatlands rewetting at the landscape scale, where different types of paludiculture and wet wilderness form a spatially- and functionally-coherent system. The recommended landscape location of particular paludiculture crops was selected based on the potential for obtaining desired waterlevels, as well as the predicted N and P richness of the sites, whereas current refuges of rare species and more advanced successional stages indicate nature protection zones (Fig. 8). Two manuscripts describing this work are still under preparation: one about the landscape approach to maximise synergies from peatland rewetting and paludiculture (to be submitted to an agricultural sciences journal Q1-2) and another one about the new database of plants species responses to groundwater levels to be used as a proxy for GHG emissions from drained and rewetted peatlands (applied ecology journal Q1-2).

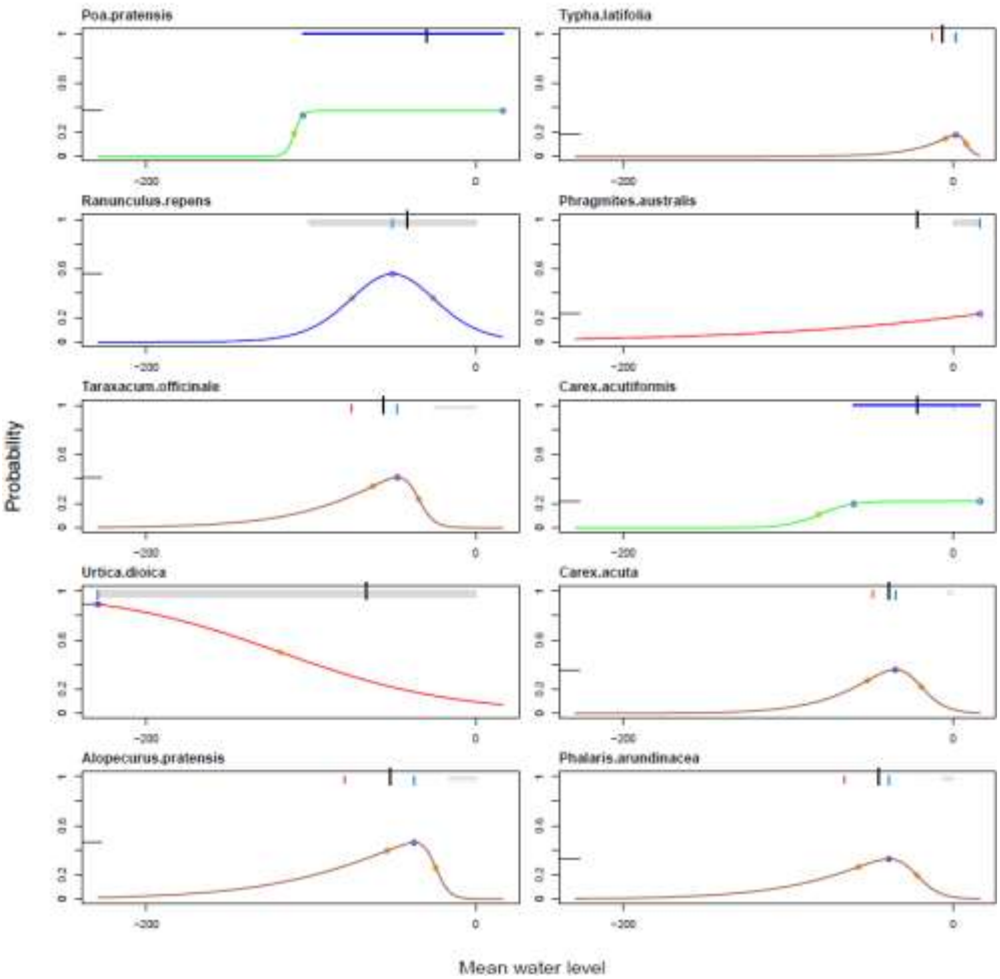

Fig. 7: Response curves of selected species to mean groundwater level in peatlands based on an analysis of 211 records, to be used in GHG emission predictions. Left column - drained grassland species, right column - potential paludiculture species.

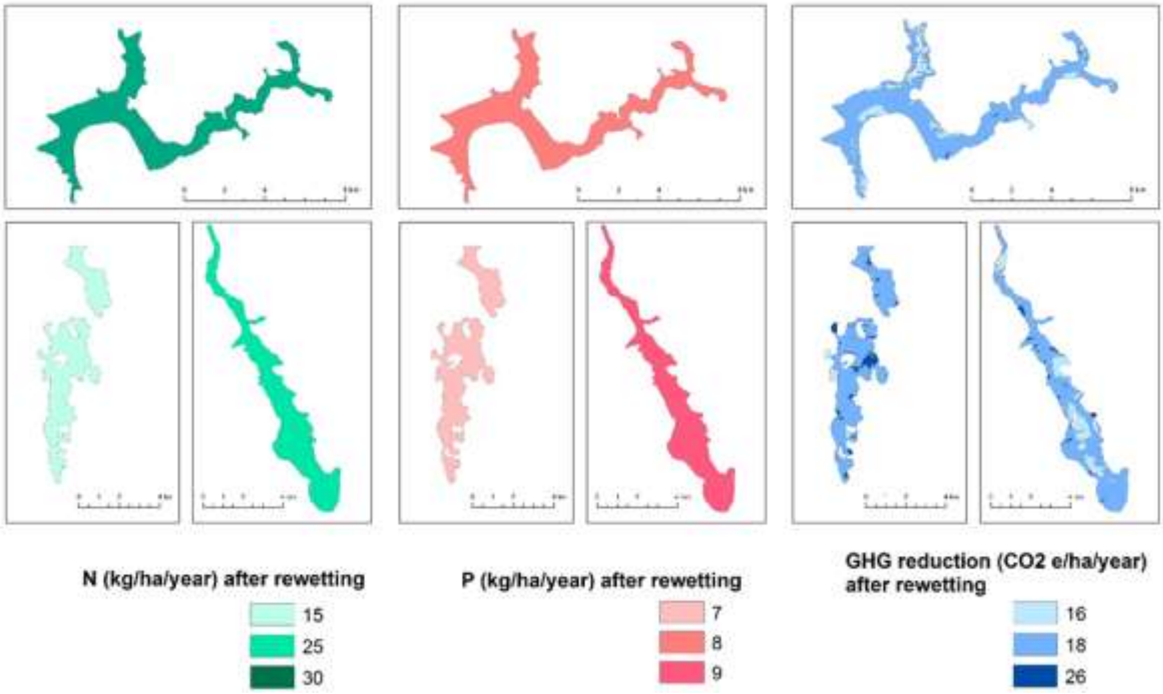

Fig. 8: Loads of bio-available nitrogen and phosphorous after rewetting and achievable GHG emission reductions (based on IPCC emission factors) in three Narew catchment peatlands.

WP6 (Luke)

We combined soil and land use data to provide detailed maps of land use, GHG emissions, and emission hotspots for EU+ peatlands (Giersbergen et al., in review). Based on peatland density and land use intensity, four main emission hotspots were identified, the North Sea region: south-eastern England, western Netherlands, and north-western Germany together accounting for 20% of EU+ peatland emissions on just 4% of the peatland area (Fig. 9). Also, E-Germany, the Baltics and E-Poland, and Central-Ireland contain important hotspots. This study highlights the potential and necessity to curb emissions from drained peatlands to meet EU climate targets. Furthermore, it reveals substantial under-reporting of emissions in current National Inventory Submissions to the UNFCCC, amounting to 59-113 Mt CO2e annually. Our findings provide a strong basis for policy-makers to prioritize peatland rewetting to reduce GHG emissions.

Seven policy briefs (EU, Germany, Finland, Belgium, Poland and Norway) were prepared to provide documents that illustrate the significance of drained peatlands in the GHG budgets and summarize the benefits from their rewetting.

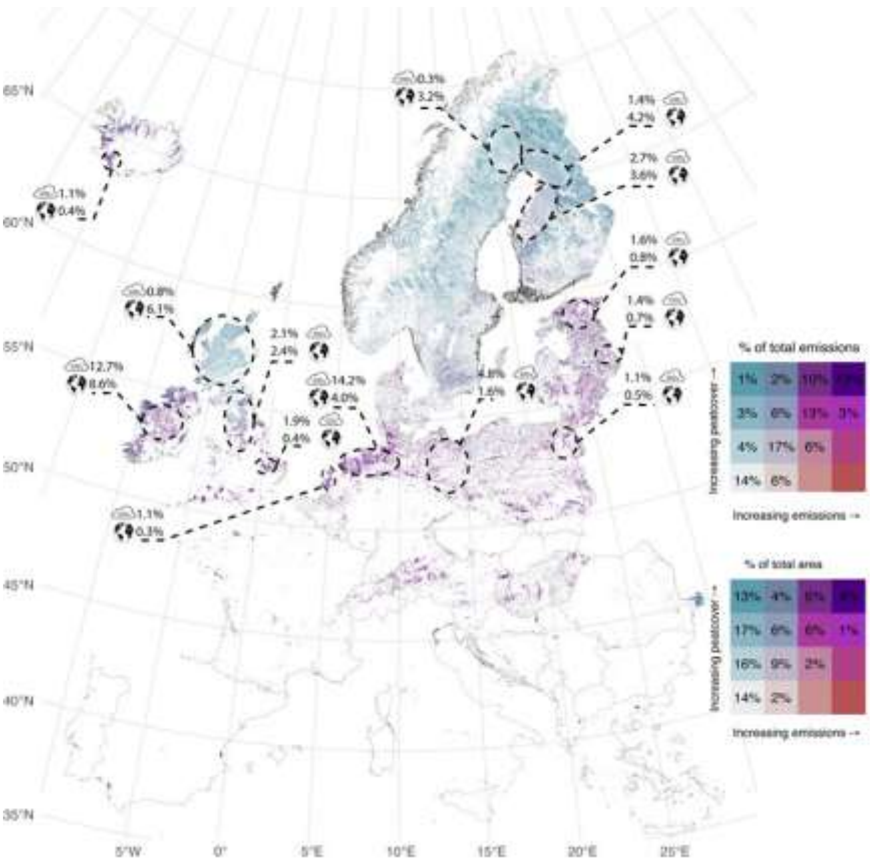

Fig. 9: Hotspot map of peatlands showing the contribution of regions to the total emissions or area of peatlands in Europe.

The review paper (Temminck et al., in prep.) showed that with typical yields of on average 8 ton dry matter ha-1 year-1, paludiculture has potential to increase the volume and diversity of sustainable biobased raw materials (e.g. for replacing fossil building materials or peat in growing media). The first EU-scale estimate of the biomass production potential in paludiculture was made. Europe has ca. 5.9 Mha of cropland and grassland on drained peatlands. The potential of biomass production on this area is 47 Mt dry matter (area × mean biomass yield of 7.9 t ha-1). The value of the alternative crops replacing conventional production would amount to ca. 3700 M€. The biomass yield would be 10.5% of the annual wood use of 446 Mt in the EU. This estimate suggests that the economic value of paludiculture and its potential to strengthen the carbon sink of the EU is significant and deserves further investigation.

The work on the economic performance of converting cultivated peatlands to paludiculture or wet wilderness consisted of analyzing how different subsidy systems (carbon tax, GHG flux-based subsidy and environmental subsidy) affect their financial feasibility. The study employed a comparative approach using data from economic reports and policy documents. We found break-even subsidy and tax levels, i.e. where the net present value of paludiculture equals that of the baseline. The results show that the required price for carbon tonne (22 €/t CO_2e) would be low compared to many other GHG mitigation measures.

5. DISSEMINATION AND VALORISATION

University of Greifswald (with subcontractors Ecologic): We organised three field days in Germany and exchanged with stakeholders, prepared three policy briefs (Carbon Removal Certification Framework, paludiculture and biodiversity, key results), facilitated the conference declaration of the "Power to the peatlands" conference, and contributed to a wide range of media output (e.g. short film about the PRINCESS project).

University of Antwerp: Team members were involved in the preparation of the "Power to the peatlands" conference in Antwerp and contributed to the PRINCESS policy brief on peatland rewetting for Belgium.

University of Warsaw: The PRINCESS team participated in peatland policy development in PL and at the EU level, including the preparation of PL Wetland Conservation Strategy, the development of EU carbon farming standard, the consultation of peatland protection policies under CAP, and others.

University of Vienna: This team contributed to the PRINCESS policy brief on peatland rewetting for Austria.

NINA: A Policy brief illustrating GHG emissions from drained peatlands in Norway was prepared. We organised a workshop in Trondheim (August 2024) on peatland restoration in Norway targeted to policy makers.

Luke: A policy brief illustrating the benefits of peatland rewetting in the EU was prepared. Also policy briefs with a rewetting scenario and country-specific messages were compiled for each partner country.

Transnational added value is the core of the project in all work packages. Either two or more partners collaborated and mutually supported each other within one WP, or a WP would not have been possible without sites in more than one country (e.g. field sites), or datasets from more than one country (e.g. Maps). This is most apparent in WP2-WP6 and of course in WP1 and WP7. WP6 may have been conducted within one country/funding organisation only, but benefitted substantially from the exchange of knowledge (methods, literature, experience in data analysis) within the consortium.

Follow up activities and plans for further exploitation of the results

There are various follow-up activities, clustered here according to the objectives:

1. Assessing the impacts on **GHG emissions**: the integration of findings (WP2-WP4) is ongoing, such as with Uni Vienna (concerning WP4) and with NINA (WP2).Collaboration between University of Vienna and University of Antwerp in investigating the role of microbial community composition on GHG emissions is ongoing. Results were presented at EGU 2025, Vienna, Austria (April 2025) and in a scientific paper (in preparation for submission in Q3 2025).

2. Assesing the impacts on **water quality** : See 3.

3. Assessing the impacts on **biodiversity**: The PRINCESS sites (WP4) will be included in a scheme of long-term biodiversity research sites by Greifswald University. With the start of a Collaborative

Research Center funded by Deutsche Forschungsgemeinschaft (WETSCAPES 2.0) in 2025, this is now planned for the coming 8-12 years.

4. Developing **predictive models for rewetting scenarios**: The database of plant species responses to groundwater levels (WP5) is proposed as a proxy for GHG emission estimates in PL peatland carbon offset schemes, a.o., by the Polish Wetland Conservation Centre.

5. Deriving **science-based policy recommendations**: The outputs will be integrated into various follow-up projects, e.g. In collaboration between University of Greifswald and Luke (Horizon Paludi4All project).

PRINCESS added to a sound database on the benefits of peatland rewetting and, for the first time, stratified between paludiculture intensities and nutrient loads. The outcome can thus be used to guide both national peatland protection/restoration work (e.g. to fulfill EU Climate Law objectives re. the LULUCF sector) and national restoration plans under the Nature Restoration Law. Key messages to guide policies in general have been formulated and published. In addition, further research will be necessary as peatlands are highly diverse and their response can be locally/regionally variable.

PRINCESS helped developing a proposal for a Horizon-Europe project on large-scale paludiculture demonstrations PALUWISE and its sister project Paludi4All.

In Poland, PRINCESS set scene for large-scale rewetting project in the area of project field study sites, i.e. Mazurian Lakeland, including a water retention project in >100 ha peatlands in State Forests and a Life-Climate project by an international consortium with Wetlands Conservation Centre planning c. 300 ha-rewetting with optional paludiculture and carbon offsets.

In Norway, PRINCESS lead into funding from the Research council of Norway for Norway's first paludiculture trials under the umbrella of the project PEATWAY.

Outcomes for the consortium / added value

	Rating (3=major outcome, 2=moderate outcome, 1=minor outcome, n/a= not applicable)
1. Increased research capacity	3
2. Improved scientific evidence base	3
3. New method, data or technology	2
4. New / improved product or service	2
5. New technical process	2
6. New organisational process	2
7. Better access to international networks / markets	3
8. Better understanding of other European cultures / issues	3
9. Enhanced research network to compete for future European project funding	3

10. Better understanding of stakeholder needs	2
11. Other(s) (specify):	

Stakeholder engagement before, during and after project's life

General Stakeholder engagement reporting

Please briefly describe how stakeholders have been involved overall (from before, to during and after the project) as relevant, following the five sections below. Consider also the planned engagement of stakeholders in follow-up activities as e.g. preparation of new research projects, of stakeholder-led projects resulting from this research, etc.

Stakeholders have not been involved systematically in project framing, which is also due to the novelty of the studied land use types. There are only very few land owners and farmers already involved in peatland rewetting and paludiculture. Those interested in research and strategic considerations have been consulted during project application, e.g. the Dutch-German cattail farmer Alder van Weeren.

The General Directorate for Environmental Protection (GDOŚ) in Poland expressed the interest in developing knowledge base for peatland restoration and paludiculture development in Poland (letter of support) and included these themes in the call for preparing the project of Wetlands Conservation Strategy for Poland (2021); later on GDOŚ organised a national conference on paludiculture (2022), with F. Tanneberger and W.Kotowski as a key-note speakers.

Provision of data by stakeholders; use of field / experiments allowed by stakeholders

In WP4, studies of greenhouse gas fluxes, diversity of the microbiome, vegetation and key peatland animals, as well as primary production, are carried out in two fertility and two land use variants at six study sites (BE/NL, DE, PL).

In WP2, sampling of inoculum soils for to be used in the mesocosm experiment was kindly allowed by the owners of the sites of "Zwarte Beek" and "Arlon".

The Dutch sites are part of Drentse Aa landscape park and owned largely by the State Forestry (Staatsbosbeheer), which is regularly contacted for conducting fieldwork. A local NGO is involved in greenhouse gas sample collection.

The German sites are set up largely on private land, and land owners have been consulted in this process. At one site (high intensity paludiculture, we provided all field research dates to the farmer in an online calendar. He regularly visited us and inquired about our work.They are also part of two nature parks, whose administration are involved, for permitting the research and identifying synergies with other ongoing works. We have also regularly contacted hunters using the sites and exchanged on their views of the peatlands and their condition. At the German sites, we held three field days and attracted large numbers of visitors (2021: 150 and 25 visitores, 2023: 100 visitors).

Two study sites, located in Poland, are on state-owned land: one on land managed by the State Forests (Maskulińskie Forest District), and the other on land of the Mazurian Landscape Park. Both the Maskulinskie Forest District and the Mazurian Landscape Park are important stakeholders in the project. They not only agreed to the location of the research plots on their land, but also declared their interest in the results obtained in the project and their willingness to cooperate in order to develop the best methods of peatland protection in their areas. At one of the sites, we held a workshop with ca. 15 participants from the local forestry administration.

In addition, the development of a Polish database of vegetation records and watertable data from peatlands, used for GHG emission calculations, was compiled from data donated by various scientists, national parks and NGOs.

Other meetings and activities

We organised or contributed to several events with the objective to inform about our results and to discuss them with stakeholders, namely:

– Field days at the PRINCESS study sites (WP4) in Germany in 2021 and 2022 (2021: 150 and 25 visitors, 2023: 100 visitors)

– A field day at the PRINCESS study site in (Poland) in 2021 (c. 30 visitors, mainly local foresters, nature protection administration and regional government)

– A workshop in Finland on 31.1.2024 to discuss the potential of paludiculture in textile and building industries and the challenges in logistics when delivering the biomass from scattered sites.

– Paludiculture Study Tour with c. 25 participants from Baltic countries, talk on outcomes of recent research, funded by European Climate Initiative, 09/2023

– Workshop “Peatland restoration and conservation – lessons from northern and central Europe”, 21.08.2023, Trondheim/Norway organised by NINA

PRINCESS also contributed to the organisation of various conferences with substantial numbers of academic and non-academic stakeholders as participants:

• Pact for Wetlands conference in Warsaw, Poland on the 4-7.02.2023

• World Wetlands Day in Warsaw, Poland on 2-3.02.2024

• Power to the Peatlands conference 2023 (P1)

• 19th conference of the Society of Wetlands Scientists (SWS), in 24-26.06.2024 in Goniądz, Poland, where sessions on fen restoration and paludiculture were held (P4)

• Field symposium of the International Mire Conservation Group (IMCG) 2024 in Germany (P1)

A very special and unexpected event with large stakeholder networking was the German Environmental Award 2024 ceremony in Mainz, Germany, with c. 300 guests and broad media coverage (incl. German News “Tagesschau”). The Award was handed over to two persons, one of them Dr Franziska Tanneberger, the project coordinator. During the ceremony, she presented roots of fen plants from one of the PRINCESS study sites and explained the role of peatlands for climate and biodiversity protection. With the Award, her role in shaping the concept and implementation of paludiculture, also in the course of the PRINCESS project, was acknowledged.

Follow-up activities with stakeholders

P1 is highly engaged in the toMOORow initiative (https://tomoorow.org) and working with an "Alliance of Pioneers" developing paludiculture products since 2024. The alliance unites 15 large Germany companies. We are actively including outcomes of PRINCESS in presentations at annual round tables and specific expert circles organised on highly relevant topics (e.g. CLA, CRCF, biodiversity and paluciulture etc.)

The PL-based Wetlands Conservation Centre co-ordinates the development of the national standard for carbon-offsetting schemes from peatlands rewetting, using part of the methodology developed by UW within the project.

Oral presentations

Biomass from peatlands (2022) - Warsaw, General Directorate for Environmental Protection in Poland. Oral presentation « Opportunities for paludiculture in EU policy; Pioneering scientific and implementation efforts in mono irrigation of degraded peatlands and paludiculture production » by Franziska Tanneberger (P1)

Biomass from peatlands (2022) - Warsaw, General Directorate for Environmental Protection in Poland. Oral presentation « Diagnosis of the state of peatlands and wetlands in Poland; Proposals for nature-based actions including peatlands and wetlands in climate protection, water resources protection, nature conservation and sustainable development in Poland» by Wiktor Kotowski (P3)

Netherlands Annual Ecological Meeting (NAEM) 2024 – Lunteren, Netherlands. Oral presentation on "Microbiome legacy influences the global warming potential of peatland soil" by Marco Cosme, Willem-Jan Emsens, Inge Van De Putte, Steven Jacobs, Emilie Gios, Hanna M. Silvennoinen, Ivan A. Janssens, Ruurd Van Diggelen, Erik Verbruggen (P2)

Power to the Peatlands (2023) – Antwerp, Belgium. Keynote presentation on "To rewet or not to rewet. Will the recent developments in policy environment safeguard EU peatlands" by Kristiina Lång (P6)

FAO Global Symposium of Soil Information and Data (2024) – Nanjing, China. Oral presentation on "Depth to water index as a tool to identify cultivated peat soils suitable for rewetting" by Hanna Kekkonen (P6)

Power to the Peatlands (2023) – Antwerp, Belgium. Oral presentation on "Greenhouse Gas fluxes and their drivers in re-wetted European peatlands" by Boodoo, K.S., Herbst, E., Niese, J., Fischer, K., Glatzel, S. (P4)

European Geoscience Union (EGU) 2023 – Vienna, Austria. Oral presentation on "Seasonal and diurnal patterns in Greenhouse Gas fluxes from re-wetted European peatlands" by Boodoo, K.S., Herbst, E., Niese, J., Fischer, K., Glatzel, S. (P4)

Power to the Peatlands (2023) – Antwerp, Belgium. Oral presentation "What determines the peat forming potential of rich fens" by Wiktor Kotowski (P3)

SWS conference (2024) – Goniądz, Poland. Oral presentation “Learning to think like the landscape: How to avoid trade-offs and maximize synergies in wetland restoration” by Wiktor Kotowski (P3)

Amerian Geosciences Union (AGU) Annual meeting, Wetland Session, 12/2023, “Paludiculture in temperate fens to combat eutrophication, biodiversity loss, and climate change”, Oral presentation by Franziska Tanneberger & Jürgen Kreyling (P1)

Pact for Wetlands (2025) - Poznań, Poland, Oral keynote presentation “Peatlands in Europe – status, threats and future perspectives” by Franziska Tanneberger (P1)

Pact for Wetlands (2025) - Poznań, Poland, Oral keynote presentation “Back to the future? In search of viable strategies for peatland nature” by Wiktor Kotowski (P3)

Bavarian Academy of Sciences, peatland conference, Munich, 04/2025, “Verbreitung und Zustand der Moore in Deutschland, Europa und weltweit”, oral presentation by Franziska Tanneberger (P1)

Power to the Peatlands (2023) – Antwerp, Belgium. Controls of soil functions and greenhouse gas emissions in rewetted peatlands, oral presentation by Emilie Gios (P5).

Poster presentations

European Geoscience Union (EGU) 2025 - Vienna, Austria. Poster presentation on “The influence of paludiculture intensity on peat microbial community composition and resulting greenhouse gas emissions from fen peatlands” by Boodoo, K.S., Emsens W-J., Verbruggen, E., Glatzel S. (P2/P4)

European Geoscience Union (EGU) 2024 - Vienna, Austria. Poster presentation on “Drivers of CH4 flux quantity and variability in re-wetted European peatlands” by Boodoo, K.S., Glatzel S. (P2)

ECEM 2023 - European Conference on Ecological Modelling, Leipzig, Germany. Poster presentation “Comparison of estimated reduction in GHG emissions after re-wetting of peatlands depending on the method of estimating emissions and the diversity of vegetation before and after re-wetting” by Ewa Jabłońska (P3)

European Geoscience Union (EGU) 2024**.** Controls of soil functions and greenhouse gas emissions in rewetted peatlands, by Emilie Gios (P5)

Scientific events

Pact for Wetlands (2023): with c. 400 participants, a first in Poland conference on wetlands and peatlands bringing together scientists, NGOs, decision makers, foresters, farmers and hydrotechnical engineers. Organised by UW; PRINCESS contributted to organisation.

Power to the peatlands conference (2023): With more than 500 participants, this was the largest conference ever in the EU on peatlands. University of Greifswald/GMC (P1) was part of the organising team and scientific team. Additionally, together with the subcontractor Ecologic we facilitated the drafting, discussion and approval of the conference declaration.

Society of Wetland Scientists (SWS) conference (2024) “Wetlands across timescales” - hosted and organised by University of Warsaw with partners.

Session “Peatland restoration and management”, European Geosciences Union (EGU), co-organised by NINA, Warsaw University and Greifswald University in 2023-2025

Interactions with other BiodivERsA projects

We have interacted with to BiodivERsA funded projects, ReVersal and MiDiPeat.

The connection with ReVersal is mainly via a German peatland scientist (Klaus-Holger Knorr). To explore links and synergies, we organised 2 online meetings and invited him to join our Steering Committee meeting in 09/2022 in NE Germany.

We are also connected to MiDiPeat. Franziska Tanneberger joined the Advisory Board in 2025.

Outreach to stakeholders, the general public and Education project

The partners in the PRINCESS consortium have been involved in a large number of stakeholder-oriented activities, and often it is difficult to assign them specifically to a project. Here, we list only a selection of most important ones.

Germany:

• Meeting with the regional farmers’s organisation (Bauernverband) MV, 2023 - 70 persons (farmers)

• Presentation on paludiculture in a hearing in German Parliament (Bundestag), 04/2023

• 3 field days (see above)

Poland:

• Field workshop with foresters, 09/2021 - 30 participants (foresters, administration, decision makers);

• Meeting with governmental representatives (5 ministers) on World Wetlands Day, 02/2024 (discussion of Wetland Strategy for Poland);

• Involvement in “Biomass from Peatlands” conference with decision makers in Poland 09/2022.

Austria: Reporting and discussion of Austrian paludiculture options in the 2024 meeting of the National Ramsar Comittee and within the Ministry of Agriculture and the LIFE-AMooRe project.

Finland: Workshop on paludiculture for industry and administration representatives 01/2024: textile and construction industries/engineering, logistics company and an official responsible for regulation in construction industries.

Global Impact assessment indicators

Impact statement

The PRINCESS project made a strong contribution to the objectives of the BiodivERsA call by addressing key environmental challenges at the interface of biodiversity loss, climate change, and ecosystem services. Specifically, it advanced research in the following areas:

Biodiversity and ecosystem functioning: PRINCESS provided robust, empirical evidence on how rewetting improves biodiversity in nitrogen-polluted peatlands. It showed that restoring water levels can significantly enhance species richness and the return of typical fen communities, supporting biodiversity recovery in degraded ecosystems.

Climate change mitigation and adaptation: The project confirmed that rewetting substantially reduces greenhouse gas emissions, particularly CO_2 and N_2O, thereby contributing to climate mitigation. It also assessed methane dynamics to ensure a realistic understanding of the trade-offs involved. These findings are directly relevant to climate goals under the EU Green Deal and the Paris Agreement.

Water quality and nutrient retention:: By evaluating how rewetting impacts nitrate leaching, the project addressed critical concerns related to nutrient pollution and water quality. This contributes to the EU Water Framework Directive and provides actionable insights for land use planning.

Sustainable land management and socio-economic relevance: PRINCESS examined paludiculture as a viable post-rewetting land use, balancing ecological restoration with the economic needs of landowners. This approach supports sustainable agriculture and aligns with the Common Agricultural Policy (CAP).

PRINCESS demonstrated clear transnational added value by bringing together expertise and case studies from six European countries—Germany, Poland, Austria, Belgium, Norway, and Finland—representing a range of peatland types, land use histories, and nitrogen loads. This diversity allowed for cross-country comparison of rewetting effects, increasing the generalizability of findings across Europe.

It also allowed for shared methodologies and data harmonization, improving scientific robustness and comparability. The integrated policy insights are relevant to both national and EU-wide governance frameworks. The project's collaborative design ensured that results were not only scientifically sound but also applicable across different geographic and socio-economic contexts, strengthening the collective capacity to manage and restore peatlands in Europe.

6. PUBLICATIONS

Submitted/published

Hanna Kekkonen, Aura Salmivaara , Henri Honkanen , Sanna Saarnio , Aleksi Lehtonen, Mikko Peltoniemi , Hannu Ojanen , Kristiina Lång (2025) "Explorative analysis of depth-to-water index in identifying rewettable agricultural peat soils" Journal of Environmental Management 383 125443 doi.org/10.1016/j.jenvman.2025.1254438

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