Final project report
Reporting template

Project acronym		REPEAT
Project title		REstoration and prognosis of PEAT formation in fens linking diversity in plant functional traits to soil biological and biogeochemical processes
Project coordinator	Person (Title, Full Name)	Dr hab. Wiktor Kotowski
	Entity (Company/organization)	University of Warsaw
Project period (Start date – End date)		14.02.2017-14.02.2020
Project website, if applicable		www.project-REPEAT.com

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List of partners involved in the project (company/organization and principal investigator). Please use partner numbers to specify the tasks, work packages and inputs of each partner in sections 4.3, 5 and 6.2 to 6.4.	Partner 1: University of Warsaw (UW), dr hab. Wiktor Kotowski Partner 2: Danube Delta National Institute for Research and Development (DDNI), Dr Jenica Hangau Partner 3: University of Greifswald (UG), Prof. Dr. Hans Joosten Partner 3.1 (subcontractor of #3): Wetlands International – European Association (WI-EuA), Cy Griffin. Partner 4: Norwegian Institute of Bioeconomy Research (NIBIO), Dr Bente Foereid Partner 5: University of Antwerp (UA), Prof. Dr. Ruurd van Diggelen Partner 5.1 (subcontractor of #5): Charles University (CU), prof. dr Jan Frouz

1. Short description for publicity

The REPEAT project analysed the mechanisms contributing to peat formation in fen peatlands. In Europe most fen peatlands have been severely degraded by drainage, which has turned them from carbon sinks into significant sources of greenhouse gases. Peat formation is a precondition to re-install the vital ecosystem services provided by the fen ecosystem, however, whether it can be reinstalled in rewetted fens, and under which conditions, remained largely unknown. REPEAT targeted this question, collecting abiotic and biotic data from almost 100 localities in undrained, drained and rewetted fens in 6 countries and conducting ex-situ growth experiments and laboratory analyses. We found that 10-20 years after rewetting abiotic conditions were similar to those in undrained fens, which was often followed by a substantial recovery of microbial communities, vegetation and soil fauna. However, the positive effect depended on a relatively low degree of peat decomposition and relatively stable water levels. High water level fluctuations in rewetted fens increase decomposition and the availability of labile carbon, which in turn enhances the methane production. We found that rewetted fens may develop new layers of detritus potentially returning to peat-accumulating ecosystems. Analyses of undrained fens revealed that production and decomposition patterns are significantly controlled by water level amplitude. Growth experiments with sedges and bryophytes revealed that also nutrient levels significantly impact production and biomass allocation and thereby control peat production potentials. We further found that low-intensity mowing had no detectable effects on neither production nor decomposition in fens, suggesting that paludiculture may support peat-forming ecosystems.

Photo 1. Natural fens of the Biebrza Valley (NE Poland)

Photo 2. Mesocosm experiment testing response of fen sedges (Carex sp.) to nutrient level gradients.

2. Summary

Fen peatlands are important carbon stocks, biodiversity hotspots and regulators of catchment hydrology but these functions have widely deteriorated due to agricultural drainage. While rewetting is an accepted method to restore fens, it is unclear whether it can reinstall peat accumulation – the key process responsible for carbon sequestration and long-term stability of mire ecosystems. The REPEAT project targeted this question, aiming also at clarifying the mechanisms of peat formation in reference (undrained) fen ecosystems by linking biogeochemical

processes to soil community structure and biodiversity, and to plant belowground litter quality. We monitored almost 100 localities in undrained, drained and rewetted fens in six European countries across the climatic gradient and conducted ex-situ growth experiments and numerous laboratory analyses. We found that fens rewetted 10-20 years ago are similar to undrained ones in terms of hydrology but are more sensitive to extreme meteorological conditions. The regeneration potential of microbial communities depended on the degree of peat decomposition: the higher the organic matter content, the higher was the chance of microbial recovery. Water level stability controlled the availability of easily decomposable carbon, which turned out to be the main regulator of methane production. Vegetation and soil mesofauna also point to a significant degree of fen recovery after restoration. Multi-proxy palaeo-ecological studies revealed that rewetted fens may develop new layers of detritus ("proto-peat") at high rates potentially turning them again to peat-accumulating ecosystems. We further analysed production and decomposition rates of roots of vascular plants, which are main constituents of fen peat. In the field, root productivity was most affected by water levels, against root decomposition by multiple variables. Analysis of undrained reference fens revealed that production and decomposition patterns are significantly controlled by water level amplitude, whereas ex-situ experiments with sedges and bryophytes revealed that also nutrient levels significantly impact biomass production and allocation and thereby peat production potential. Results from rewetted fens in Central Europe, as well as highly-productive fens of the Danube Delta, indicate that eutrophic systems may have high capacity of peat formation. We further found that low-intensity mowing had no detectable effects on neither production nor decomposition in fens. Our findings advance the knowledge of fen restoration and paludiculture (i.e. productive agricultural use of wet and rewetted peatlands), showing that restoration of peat accumulation is possible both in managed and unmanaged systems and indicating factors that may impede or enhance this process.

3. Objectives of the research

The overall objective of the project was to describe how environmental factors and human management interact with soil biodiversity in determining rates of peat accumulation in undrained and rewetted fens.

Specific objectives were to:

#1 Assess the effects of soil biodiversity and its changes due to peatland degradation and restoration on peat formation and decomposition and how these processes control the delivery of ecosystem services via peat sequestration/decomposition rates (e.g. climate change mitigation, nutrient/pollutant retention) and peat structure (e.g. flood control, evaporation cooling, baseflow provision).
#2 Clarify the role of climate and human activities (draining, rewetting, mowing) on taxonomical and functional soil biodiversity in fen peatlands, the associated ecosystem processes and the impact these have on greenhouse gas fluxes. More specifically: identify whether drainage and climate change may irreversibly shift ecosystem functioning into a state with higher decomposition rates and GHG production; and further whether the interactive effects of these multiple drivers can be modified by management (incl. rewetting and mowing).
#3 Enhance the knowledge base with respect to the key processes (and their indicators) associated with rewetting (as innovative management of soils hitherto used under drained conditions). Special attention was paid to paludiculture as an innovative strategy to deliver sustainable, climate friendly provisioning services in synergy with the provision of other ecosystem services associated with peat formation.

4. Project activities and achievements

4.1. General description of activities over the duration of the project

The project objectives were addressed by descriptive and experimental research, as well as by practical outreach and networking. Field investigations focused on analysing biodiversity at taxonomic and functional levels in microbial, plant and faunal communities in natural, drained and rewetted fen peatlands – in relation to measured environmental variables and peat accumulation and decomposition processes. This scope of studies reflects the Objective #1. Following project meetings, the field set-up was established, including three main components: (1) "triplets" of undrained, drained and rewetted fens distributed along the climatic gradient (Wales, Belgium, Netherlands, Germany, Poland), (2) transects of 5 plots in undrained fens distributed along trophic and hydrological gradients in NE Poland and Romania and (3) pairs of plots with differing mowing status in Germany and Poland. Altogether, >80 plots were established in six countries. Such a lay-out, along with specific investigations dedicated to various aspects of fen functioning, from species composition and functional trait analysis, through production-decomposition measurements, to greenhouse gases production potential, fulfilled Objective #2, regarding the relative impact of climate and human impact on fen biodiversity and peat (trans)formation processes. In addition, nutrient enrichment effects, as an important aspect of human impact, were studied in a mesocosm experiment, whereas a modelling exercise integrated various processes contributing to peat formation. Objective #3, i.e. enhancing the knowledge base with respect to key processes associated with rewetting drained fens, has been addressed in numerous conference papers and manuscripts of scientific publications, Ramsar guidelines on peatland restoration, as well as media coverage, regional workshops and special events.

The project was organized in eight workpackages:

WP1 – Project management (partner 1). Several project consortium meetings were carried out, as dedicated seminars (Antwerp, February, 2018, an on-line seminar (December 2018), to discuss joint fieldwork (2016, 2017) and conferences (2019, 2020). External reporting was carried out timely, project representatives participated in the kick-off and mid-term Biodiversa conferences.

WP2 – State variables (co-ordination partner 1, analysis partners 1, 4, 5, sampling all partners)
Task 2.1 Hydrological status: water levels were measured in all sites with automatic loggers (1 h interval 07.2017-10.2019). The originally planned measurement period of 1 year was extended to check whether the extremely dry summer of 2017 did affect the overall picture.
Task 2.2 Hydrochemical status: soil water samples were taken anaerobically and analysed for pH, EC25, Ca, Mg, Na, K, Fe, alkalinity, SO_4, Cl, NO_3, NO_2, NH_3, PO_4.
Task 2.3 Greenhouse gases: soil water samples were taken and analysed for CO_2, CH_4 and N_2O.
Task 2.4 Peat decomposability: peat samples obtained from triplets and transects were analysed for lignin and cellulose content by standard laboratory methods (Van Soest extractions) and FTIR spectrometry.
Task 2.5. Nutrient stoichiometry: NPK content of above-ground plant biomass was analysed for all plots.
Task 2.6 Management status: the management status (mowing, grazing) was recorded in all study sites. Almost all triplet sites were mown, many of the transect sites unmown. In a subset of undrained and rewetted triplet sites (8), an additional unmown plot was established to study mowing effects. In addition, at four undrained fen sites pairs of unmown and mown plots were established to enlarge the dataset of the 'mowing study'.

WP3 – Peat accumulation rates (co-ordination partner 3, contribution partners 1 and 5 in T.3.2 and 3.3)
Task 3.1. Subrecent peat formation. Two triplets of undrained, drained and rewetted fens were sampled for palaeo-ecological research: the Recknitz and Trebel valley in NE Germany and the surroundings of the Rospuda valley in NE Poland. Of each site, one peat core was taken for analysis. Cores of the drained and rewetted sites in NE Germany were analysed in a high-resolution multi-proxy approach (analysed for micro- and macrofossils, physical properties, chemical components and the microbial assemblage). The other cores were exclusively analysed palaeo-ecologically.
Task 3.2 Production rates. Below-ground biomass annual production (roots) at different depths was assessed using ingrowth cores filled with standard material at all triplet and transect sites and in the additional mowing study sites. Plant growth in the standard material was tested against root-free peat in 30 additional cores.
Above-ground biomass was assessed both as standing crop (year 1) and as annual production (year 1 – year 2).
Moss productivity was measured in the field by two methods: marking moss shoots by oil paint followed by measuring yearly increments, and measuring one-year changes in fresh mass and length increments of within-site moss transplants (new method developed within the project).
T3.3 Decomposition rates. Above-ground and below-ground decomposition was studied using the litter bag method with autochthonous material (mosses, leaf litter and roots) for comparison within sites and allochthonous material (standard tea, cellulose and lignin, as well as the standard moss *Calliergonella cuspidata* for mossy sites) for comparison between sites at all triplet and transect sites and in the additional mowing study sites. As in T3.2, the material was exposed at three different depths (0-5 cm, 15-20 cm, 45-50 cm) over one year.

WP4 – Decomposers diversity (coordination partner 5, contribution partners 1, 4 and 5.1)
Task 4.1 Functional analysis of soil mesofaunal diversity. Samples were taken from the top layer of in total 51 sites and classified in three groups with a different functional profile (Collembola, Oribatida, other Acari).
Task 4.2 Quantitative analysis of soil microbial communities. PLFAs, ergosterol and qPCRs (16S –bacteria, 18S – fungi, and a set of functional genes) have been performed on all triplets at three soil depths, and in representative sites for the transects. PLFAs give an abundance estimate of fungi and bacteria, qPCR as well, and ergosterol quantifies fungal abundance. Together these data have given a robust indication of microbial abundances.
Task 4.3 Soil microbial taxonomic and functional diversity. From each of the triplet sites at three depths and a selection of the transects DNA has been isolated, which was subsequently subjected to amplicon sequencing. We sequenced two genes: a portion of the 16S rRNA (bacteria), and the full ITS1 operon (fungi). These sequences were subsequently sorted into functional groups (fungi) or genes were predicted based on known genomes (bacteria)
Task 4.4 Physiological profiling of soil microbial communities. From all triplets and a selection of transects we measured substrate induced respiration (SIR) by adding various organic compounds as substrates and following the respiration it induces in peat microbes. This way, we have characterized the substrate use of the various peats.

Task 4.5 Greenhouse gas production potentials and microbial regulation. Anaerobic production potentials of carbon dioxide, methane and nitrous oxide of the restored and undrained sites were measured by making root-free soil samples anoxic and measuring the gas concentrations in high temporal resolution over five days.

WP5 – Producers belowground diversity (coordination partner 3, contribution partner 1)
Task 5.1 Compilation of database of root traits from literature. A root data base has been prepared containing functional traits and features for identification, on the basis of literature research and recent and subfossil plant material.
Task 5.2. Root porosity. Root porosity was measured in two samples from the freshly harvested roots at c. 5 cm depth from all 108 mesocosms in September 2018 using the pycnometer method.
Task 5.3. Root growth and decomposition. Root growth and decomposition of five sedge species from three origins (Netherlands, Germany, Poland) was studied in a mesocosm experiment in 108 pots over the period May-September 2018. All pots were frequently watered to keep the water table close to soil surface and simulate natural conditions. In total 12 different fertilisation levels were applied to the pots, from extremely nutrient-poor to extremely nutrient-rich conditions. The total amount of above- and below-ground biomass was washed out and weighted after the experiment. Decomposition was studied with above-ground biomass and root biomass as well as standard tea material (the latter in two different depths). Root recalcitrance of different sedge species was also assessed by means of FTIR spectrometry, as well as by extraction of lignin and cellulose.
Task 5.4. Bryophyte growth and decomposition. Two bryophyte growth experiments were carried out. Following a pilot study in a climate-chamber, a full-size experiment with eight species and ten trophic levels was executed in a greenhouse allowing to compare responses of growth and chlorophyll content to nitrogen levels between different species. Moss decomposition was studied by incubating samples of different species in-situ within transect plots in Poland.
Task 5.5. Mycorrhizal status. A database of the mycorrhizal status of all plants species from the research areas has been prepared based on literature, taking also the most recent approaches into account. Analysis of appropriate replicates of all plant species from the research areas turned out to be unfeasible due to very high number of samples required. Therefore we alternatively analysed mixed samples to estimate overall mycorrhizal colonization on the level of the plant community at the given plot. Five mixed samples of roots were collected per plot, washed, conserved in ethanol and stored at 4ºC. The analyses are delayed but will be finalized within 6 months after the project's end.

WP6 Modelling (partner 4)
Task 6.1 Integration of root processes in existing peat formation models. A literature review and expert interviews have been conducted on limitations and shortcomings of existing peat formation models, and modelling approaches that better reflect the peculiarities of displacement peat formation have been discussed.
Task 6.2 Adaptation and parameterisation of MIMICS microbial model. The MIMICS model was adapted for waterlogged conditions using data from UA, UW and UG. The model was also tested using literature data.
Task 6.3 Comparison of impact of rewetting on microbial processes in project areas. The modified MIMICS model was run with drainage and rewetting with climate data from project areas and provide reasonable results, in line with experimental results.

WP7 Scientific integration (coordination partner 1, contribution all partners in T7.1, partner 2 in T2.2)
Task 7.1. Multidisciplinary scientific publications – reported in the dedicated table.
Task 7.2. Scientific conference. The REPEAT project conference was organised in June 2019 in the Danube Delta (Tulcea).

WP8. Outreach to climate and biodiversity policy (coordination partner 3, contribution partner 3.1)
Task 8.1. Visualisation of fen land-use scenarios and related ecosystem services. Maps of the study regions including study sites and peat cover have been produced. Awareness raising with stakeholders used key figures on peatland ecosystems services from literature.
Task 8.2. Practical guidelines for restoration managers. Outcomes from REPEAT have been used in the draft report of the new Ramsar Convention Global Restoration Guidelines (lead author: Hans Joosten, submitted to Ramsar Convention in May 2020). A draft manuscript on a decision-tree for fen restoration has been prepared.
Task 8.3. Stakeholder workshops in focal countries. Workshops and 'field days' with stakeholders and media invited to join international sampling campaigns have been organised (see in #6 – Dissemination of the results).
Task 8.4. Mainstreaming fen restoration benefits and principles among policy-makers. Events including outcomes of REPEAT have been organised in 2018 at UNFCCC COP 24 in Katowice (PL). The side event "The trace of haze: Peat fires as local and global challenges" took place 06.12.2018 in the German pavilion and was co-organised with partners from the Global Peatlands Initiative network (UN Environment, government of Indonesia, Russian Academy of Sciences, Newcastle University, see here: https://www.moorwissen.de/doc/moore/tools/projekte/repeat/SAVE%20THE%20DATE%20UNFCCC%20COP24,%206.12.2018%20(Peat%20fires).pdf). On 11.12.2018, a 'peat-free lunch' event was organised at the ClimateHub during UNFCCC COP24 together with Wetlands International and CMoK (https://www.moorwissen.de/doc/moore/tools/projekte/repeat/Food%20and%20Peat%202.pdf).

The international workshop “Exploring Synergies for Peatlands – Detecting and enhancing the global importance of peatlands in achieving the Sustainable Development Goals” was conducted at the International Academy for Nature Conservation, Isle of Vilm, 21th-25th May 2019. It was jointly organised by the German Federal Agency for Nature Conservation, the Global Peatlands Initiative, the Secretariat of the Ramsar Convention, the Greifswald Mire Centre, and Wetlands International, and co-financed by REPEAT. (The full workshop report).
The workshop "Exchange of views on post 2020 Common Agricultural Policy (CAP) and its effect on farming on organic (peat) soils" was conducted 09.04.2019 in Brussels, Belgium. It was co-organised by Wetlands International European Association and Greifswald Mire Centre, and co-financed by REPEAT. (The workshop report).
A policy brief on greenhouse gas emissions from degraded peatlands, reporting of organic soils in national inventories and Common Agricultural Policy has been prepared in Romanian language in autumn 2019 and can be accessed here: https://www.moorwissen.de/doc/moore/tools/projekte/repeat/Brosura_Repeat_A5_ebook.pdf
Task 8.5. Project webpage maintenance. The project website www.repeat-project.com has been set-up in 2017 and maintained throughout the project. Key project activities (field campaigns, events, publications) have been communicated via twitter @greifswaldmoor (c. 780 followers in May 2020).

4.2. Table of deliverables

Deliverable and Milestone Name			**Lead partner (country and designation)**	**Date of delivery (mm/yyyy)**		**Comments**
				Initially planned	**Delivered**	
Work Package	***Deliverable or Milestone***	***Full Name***				
WP1	M.1.1.1.	Consortium agreement signed	**Partner 1, Poland, UW**	3.2017	9.2018	achieved with delay, due to prolonged administrative and legal procedures
	D.1.1.1.	Consortium agreement		3.2017	6.2018	delivered with delay; as above.
	M.1.1.2.	Kick-off meeting		3.2017	2.2017	achieved ahead of deadline
	M.1.1.3.	Internal progress reports (1) obtained from WP leaders		8.2017	X	internal progress report 1 skipped
	D.1.1.3.	Internal progress report (1)		8.2017	X	internal progress report 1 skipped
	M.1.1.4.	Internal progress reports (2) obtained from WP leaders		2.2018	3.2018	achieved
	D.1.1.4.	Internal progress report (2)		2.2018	3.2018	delivered
	M.1.2.1.	Financial report I prepared		3.2018	3.2018	financial reports prepared and submitted according to national rules
	D.1.2.1.	Financial report I		3.2018	3.2018	financial reports prepared and submitted according to national rules

Deliverable and Milestone Name			Lead partner (country and designation)	Date of delivery (mm/yyyy)		Comments
				Initially planned	Delivered	
	M.1.3.1.	External progress report I prepared		3.2018	9.2018	Achieved
	D.1.3.1.	External progress report I		3.2018	9.2018	external progress report deadline set up on 01.10.2018
	M.1.1.5.	Internal progress reports (3) obtained from WP leaders		8.2018	9.2018	achieved as input to external progress report
	D.1.1.5.	Internal progress report (3)		8.2018	9.2018	delivered as input to external progress report
	M.1.1.6.	Internal progress reports obtained from WP leaders		02.2019	x	Skipped
	D.1.1.6.	Internal progress report (4)		02.2019	x	Skipped
	M.1.2.2.	Financial report II prepared		03.2019	03.2019	Achieved
	D.1.2.2.	Financial report II		03.2019	03.2019	Delivered in accordance with national reporting rules [PL]
	M.1.3.2.	External progress report II prepared		03.2019	x	Merged with M1.3.3.
	D.1.3.2.	External progress report II		03.2019	x	Merged with D.1.3.3.
	M.1.1.7.	Internal progress reports (5) obtained from WP leaders		08.2019	x	Skipped
	D.1.1.7.	Internal progress report (5)		08.2019	x	Skipped
	M.1.1.8.	Internal progress reports (6) obtained from WP leaders		02.2020	06.2020	Achieved with delay due to prolongation of the project
	D.1.1.8.	Internal progress report (6)		02.2020	06.2020	Delivered as input to external report
	M.1.2.3.	Financial report III prepared		03.2020	04.2020	Achieved
	D.1.2.3.	Financial report III		03.2020	04.2020	Delivered in accordance with national rules [PL]

Deliverable and Milestone Name			Lead partner (country and designation)	Date of delivery (mm/yyyy)		Comments
				Initially planned	Delivered	
	M.1.3.3.	External progress report III prepared		02.2020	05.2020	Achieved later due to project prolongation
	D.1.3.3.	External progress report III		02.2020	05.2020	Delivered at the end of the project.
WP2	M.2.1.1.	Loggers installed, soil samples for laboratory analyses collected	**Partner 5, Belgium, UA**	9.2017	9.2017	achieved, no deviation
	M.2.2.1.	Macro-rhizons installed		9.2017	9.2017	achieved, no deviation
	M.2.2.2.	Samples for laboratory analyses collected		9.2017	9.2017	achieved, no deviation
	M.2.3.1.	First season samples for laboratory analyses collected		9.2017	9.2017	achieved, no deviation
	M.2.4.1.	Soil samples for laboratory analyses collected, tea bags installed		9.2017	9.2017	achieved, no deviation
	M.2.5.1.	Plant material for laboratory analyses collected		9.2017	9.2017	achieved, no deviation
	M.2.6.1.	Management study transects localised in each research area		9.2017	9.2017	24 pairs of unmown and mown plots in Netherlands, Germany and Poland.
	M.2.2.3.	Data from laboratory analyses obtained		12.2017	12.2017	achieved, no deviation
	M.2.4.2.	Data from laboratory analyses (including analyses of tea bags) obtained		2.2018	5.2018	Delivered with delay
	D.2.2.3.	Description of the hydrochemical and redox stratification per profile		2.2018	3.2018	Delivered; redox measurements skipped after revision of project plan
	M.2.5.2.	Data from laboratory analyses obtained		3.2018	07.2018	achieved

Deliverable and Milestone Name			Lead partner (country and designation)	Date of delivery (mm/yyyy)		Comments
				Initially planned	Delivered	
	D.2.4.2.	Description of decomposability of plant material		4.2018	4.2018	delivered
	D.2.5.2.	Assessment of the factors limiting primary production at each site		5.2018	5.2018	achieved
	M.2.1.2.	Data from loggers and laboratory analyses obtained		07.2019	1.2020	data acquisition prolonged until autumn 2019
	D.2.1.2.	Description of the distribution of permanent aerobic, alternating aerobic/ anaerobic and permanent anaerobic horizons		08.2019	02.2020	delivered with delay
	M.2.3.2.	Last season samples for laboratory analyses collected		06.2019	06.2019	achieved, no delay
	M.2.3.3.	Last data from laboratory analyses obtained		08.2019	08.2019	achieved, no delay
	D.2.3.3.	Quantitative comparison of sites for soil water GHG content		10.2019	10.2019	achieved, no delay
	M.2.6.2.	Relevant data from WP2, WP3 and WP5 obtained		08.2019	6.2019	achieved
	D.2.6.2.	Description of effects of mowing on peat accumulation rates		11.2019	6.2019	achieved
WP3	M.3.2.4.	Moss productivity plots established - pilot study	**Partner 3, Germany, UG**	8.2017	4.2017	achieved ahead of deadline
	M.3.1.1.	Peat samples collected		9.2017	11.2017	achieved with delay
	M.3.2.1.	Ingrowth bags installed, peat cores taken		9.2017	9.2017	achieved, no deviation

Deliverable and Milestone Name			Lead partner (country and designation)	Date of delivery (mm/yyyy)		Comments
				Initially planned	Delivered	
	M.3.2.5.	Assessment of the results of the pilot study on moss productivity		12.2017	5.2017	achieved ahead of deadline; combined with T 5.4.; method approved for main study
	M.3.3.1.	Litter bags prepared and installed, peat cores taken		12.2017	10.2017	achieved ahead of deadline
	M.3.2.6.	Moss productivity plots established		5. 2018	9.2017	achieved ahead of deadline
	M.3.1.2.	Peat samples analysed and dated		8.2018	5.2020	achieved
	M.3.2.2.	Ingrowth bags collected		8.2018	10.2018	achieved
	D.3.1.2.	Assessment of subrecent peat formation of two peat profiles (upper 50 cm) per study area		10.2018	5.2020	achieved
	M.3.2.3.	Ingrowth bags analyzed		02.2019	12.2019	achieved
	D.3.2.3.	Assessment of below-ground biomass production rates and of below-ground bio- and necromass stocks at each study site		08.2019	12.2019	Achieved, bio- and necromass stocks not separated; instead dataset for production rates strongly extended (98 plots with 3 replicates)
	M.3.2.7.	Moss productivity analyzed		08.2019	06.2019	Achieved ahead of deadline
	D.3.2.7.	Assessment of moss productivity		09.2019	06.2019	delivered as seminar presentation and input to manuscript
	M.3.3.2.	Litter bags collected		01.2019	10.2018	achieved ahead of deadline
	M.3.3.3.	Litter bags analyzed		06.2019	12.2019	achieved, delay due to large amount of samples
	D.3.3.3.	Assessment of below-ground biomass decomposition rates at each study site		09.2019	05.2020	achieved
WP4	M.4.1.1.	First samples collected	**Partner 5, Belgium,**	7.2017	7.2017	achieved, no delay

Deliverable and Milestone Name			Lead partner (country and designation)	Date of delivery (mm/yyyy)		Comments
				Initially planned	Delivered	
	M.4.5.1.	Samples collected	UA	9.2017	9.2017	achieved with delay
	M.4.1.2.	All samples collected		12.2017	7.2017	achieved ahead of deadline
	M.4.1.3.	Samples analysed		12.2018	12.2018	achieved, no delay
	D.4.1.3.	Assessment of soil invertebrate diversity		02.2019	02.2019	achieved, no delay
	M.4.2.2.	Samples analyzed		08.2019	08.2019	achieved, no delay
	D.4.2.1.	Biomass estimates of (all) main groups of soil microbes, and assessment of fungi:bacteria ratio		10.2019	10.2019	achieved, no delay
	M.4.3.2.	Samples analyzed		08.2019	08.2019	achieved, no delay
	D.4.3.2a.	Assessment of soil fungal diversity, including division into functional groups (e.g. saprotrophs, mycorrhizal, pathogens, etc.)		09.2019	09.2019	achieved, no delay
	D.4.3.2b.	Diversity estimates of soil prokaryotes producing key enzymes in fen geochemical cycles, and abundance estimates/quantification of genes encoding these enzymes		09.2019	09.2019	achieved, paper published in ISME journal
	M.4.4.2.	Samples analysed		08.2019	08.2019	achieved, no delay
	D.4.4.1.	Description of decomposition potential of total soil microbial communities expressed as physiological profiles		10.2019	10.2019	achieved, no delay
	D.4.5.2a.	Quantitative information on GHG production potential of soil microbial communities		10.2018	10.2018	achieved, no delay

Deliverable and Milestone Name			Lead partner (country and designation)	Date of delivery (mm/yyyy)		Comments
				Initially planned	Delivered	
	D.4.5.2b.	Description of linkage of most remarkable production potentials to functional genes		12.2018	No	deliverable had to be omitted due to10% reduction of funding by BELSPO
WP5	M.5.3.1.	Root growth and decomposition pilot experiment established	**Partner 3, Germany, UG**	8.2017	4.2018	achieved; 6 sedge species (2 species from 3 countries) grown in containers from April till September 2018
	M.5.5.1.	Roots collected		9.2017	9.2017	achieved, no deviation
	M.5.4.1.	Bryophyte growth and decomposition pilot experiment established		11.2017	4.2017	achieved, ahead of deadline, combined with T3.2.
	M.5.2.1.	Roots collected		12.2017	10.2017	achieved ahead of timeline; reduced number of plants because of logistical constraints
	M.5.3.2.	Assessment of the results of the pilot experiment on root growth and decomposition		12.2017	09.2018	experiment conducted and finished in 2018, all data collected as planned
	M.5.1.1.	Root traits gathered from literature		2.2018	12.2019	achieved
	D.5.1.1.	Root traits database, ready for adding supplementary information from own measurements		2.2018	(partly achieved) 12.2019	Database on macrofossil traits (including roots) prepared as input to a published article; the remaining work will be finished shortly after the project end
	M.5.3.3.	Root growth and decomposition experiment established		3.2018	3.2018	achieved
	M.5.4.2.	Assessment of the results of the pilot experiment on bryophyte growth and decomposition		4.2018	4.2018	delivered timely

Deliverable and Milestone Name			Lead partner (country and designation)	Date of delivery (mm/yyyy)		Comments
				Initially planned	Delivered	
	M.5.4.3.	Bryophyte growth and decomposition experiment established		5.2018	2.2018	achieved ahead of the deadline
	M.5.2.2.	Roots analyzed		02.2019	02.2019	achieved
	D.5.2.2.	Root traits with database with added data from own meaasurements of root porosity		02.2019	02.2019	Achieved
	M.5.3.4.	Root growth and decomposition traits analyzed		09.2019	09.2019	achieved
	D.5.3.4.	Root traits database with added data from own measurements of root trait values and plasticity re. growth rates and decomposability		09.2019	09.2019	Achieved
	M.5.4.4.	Bryophyte growth and decomposition traits analyzed		02.2019	02.2019	achieved
	D.5.4.4.	Database with bryophyte growth and decomposition traits values and plasticity		02.2019	02.2019	delivered on time, based on nutrient gradient experiment.
	M.5.5.2.	Species mycorrhizal status analyzed		02.2019	11.2020	delayed, will be delivered within 6 months after the project's end; methods modified
	D.5.5.2.	Root traits with database with added data from own mesurements of mycorrhizal status of species		02.2019	12.2020	partly achieved - literature database on mycorrhization completed and ready for supplementation with empirical data; methods modified
WP6	M.6.1.1.	Input data to the model from all relevant WPs obtained	**Partner 4, Norway, NIBIO**	09.2019	09.2019	data has been received and formatted.
	D.6.1.1.	Microbial model for carbon turnover in fens		02.2020	04.2020	Model has been developed and documented

Deliverable and Milestone Name			Lead partner (country and designation)	Date of delivery (mm/yyyy)		Comments
				Initially planned	Delivered	
	M.6.2.1.	Publication prepared and submitted to per-rewieved journal		02.2020	Delayed	paper is in preparation
	M. 6.3.1.	Existing peat formation models reviewed and boundary conditions for integration of root processes assessed		08.2019	02.2020	Achieved with delay, continued discussion with WETSCAPES project studying peat formation in NE-German fens
	D.6.3.1.	Report on integration of root processes in exisiting peat formation models		08.2019	posponed	In progress, will be delivered as input for a joint paper with WETSCAPES, which will be prepared in 2021
WP7	M.7.1.1.	Sampling and experimental protocols cross-reviewed for all WPs	**Partner 1, Poland, UW**	5.2017	5.2017	achieved, no deviation
	D.7.1.1.	Description of sampling and experimental design in the project		5.2017	5.2017	achieved, no deviation
	M.7.2.1.	Conference registration opened		3.2018	01.2019	achieved after postponing to 2019
	M.7.2.1.	Conference organized		9.2018	05.2019	achieved (postponed)
	D.7.2.2.	International scientific conference		9.2018	06.2019	achieved (postponed)
	M.7.1.2. /D.7.1.2.	Manuscript on types peat formation in fens (review)		02.2020	02.2020	topic slightly changed: published article on types of macrofossil remnants in fen peat (Michaelis et al. 2020)
	M.7.1.3. / D.7.1.3.	Manuscript linking all WP (balance of production & decomposition + microbial processes) in natural and rewetted fens		02.2020	Partly delivered 03.2020	Split: published article on microbial processes (Emsens et al. 2020); remaining work in progress, will be delivered after project end.

Deliverable and Milestone Name			Lead partner (country and designation)	Date of delivery (mm/yyyy)		Comments
				Initially planned	Delivered	
	M.7.1.4. / D7.1.4.	Manuscript on mowing impact on fen peat accumulation		02.2020	Delayed	in progress, will be delivered within 6 months after project end, some conclusions reported in Tanneberger et al. 2019
	M.7.1.5. / D7.1.5.	Manuscript on plant traits, to be combined with replacement peat formation		02.2020	05.2020	two manuscripts (based on mesocosm experiments) prepared for submission (Hinzke et al., Jaszczuk et al.)
	M.7.1.6. / D7.1.6.	Manuscript on recommendations for restoration (directed towards restoration targets)		02.2020	delayed	work in progress, will be delivered by the end of 2020
	M.7.1.6.	Manuscript on simulation of microbial processes in fen rewetting		02.2020	Not delivered	in progress, will be achieved after the project
WP8	M.8.2.1.	Leaflet prepared & printed	Partner 3, Germany, UG	7.2017	skipped	desision has been made that project outcomes are better communicated as part of the Ramsar Global Restoration Guidlines (submitted 05.2020)
	D.8.2.1.	Leaflet about fen restoration		7.2017	skipped	see above
	M.8.5.1.	Project website created		8.2017	8.2017	achieved
	D.8.5.1.	Project website		8.2017	8.2017	delivered - website established and maintained
	M.8.3.1.	Five stakeholders workshops prepared		11.2017	06.2019	achieved with delay, stakeholder workshops organised partly later than planned to achieve synergies with other events

Deliverable and Milestone Name			Lead partner (country and designation)	Date of delivery (mm/yyyy)		Comments
				Initially planned	Delivered	
	D.8.3.1.	Five stakeholders workshops, documentary movie		11.2017	06.2019	achieved with delay ; stakeholder workshops organised in Belgium, Germany, Poland, Romania and Norway documentary movie made as video-reportage from REPEAT field campaign (available on REPEAT webpage) + TV spots
	M.8.1.1.	Maps prepared		02.2020	05.2020	achieved
	M.8.4.1.	Workshop/side events for policy makers prepared		02.2019	05.2019	achieved with delay; side events at COP24 in 12/2018, Workshop in Brussels in 04/2019 and workshop with UNFCCC, CBD and other conventions in 05/2019
	D.8.4.1.	Workshop in Brussels and side events to UNFCCC COP23 (2018) and CBD COP14 (2018)		02.2019	05.2019	events/workshops conducted and reports published at project website
	D.8.1.1.	Set of maps for each project area		02.2020	05.2020	Achieved
	M.8.2.2.	Guidelines prepared		02.2020	05.2020	Achieved as input to Ramsar Convention Global Restoration Guidelines
	D.8.2.2.	Guidelines for restoration managers published online		02.2020	Delayed	After review by Ramsar secretariat/reviewers

4.3. Scientific outcomes

All scientific objectives of the project have been achieved. The processes associated with degradation and formation of fen peat have been quantified (e.g. decomposition and accumulation rates, greenhouse gas production, peat physical and chemical properties, hydrological regimes of the sites) and linked with (changes in) biodiversity at various levels (Objective #1). Further, we considered how climate affects these relations (Objective #2) by investigating a cross-European transect of sites extending from NW Europe (Wales, Benelux) to Central Europe (Germany, Poland), to SE Europe (Romania). We also considered the impact of vegetation management on peat accumulation and decomposition processes (further in Objective #2). All results create a new knowledge base for the restoration of mires and implementation of the paludiculture concept - as an innovative strategy to deliver sustainable, climate friendly provisioning services in synergy with regulating and supporting ecosystem services associated with peat formation (Objective #3). Whereas the project has produced a large amount of data, not all analyses have finished, so far and only a smaller part has been published. Some work is still in progress and results will be published during the coming months. Below we briefly describe the main scientific achievements of the project, indicating how they refer to hypotheses stated in the proposal.

1. Restored fens are becoming similar to the undrained ones in terms of hydrology but are more sensitive to extreme meteorological conditions (lead partner 5)

Although rewetting (e.g. by ditch blocking) is a basic method of fen restoration and a precondition for re-establishing mire processes, rewetted fens differ from the undrained reference sites in various aspects. Our analyses showed that the values of many variables relevant to the recovery of drained peatlands are close to those of undrained fens one to two decades after rewetting. However, rewetted fens appeared to be less buffered and more sensitive to extreme meteorological conditions such as dry years, meaning that water levels drop sooner and deeper than in undrained sites. Furthermore, we showed that water level stability is tightly linked to the availability of easily decomposable carbon, which in turn is the main regulator of methane production by the methanogenic microbial community. A paper describing these outcomes is in preparation.

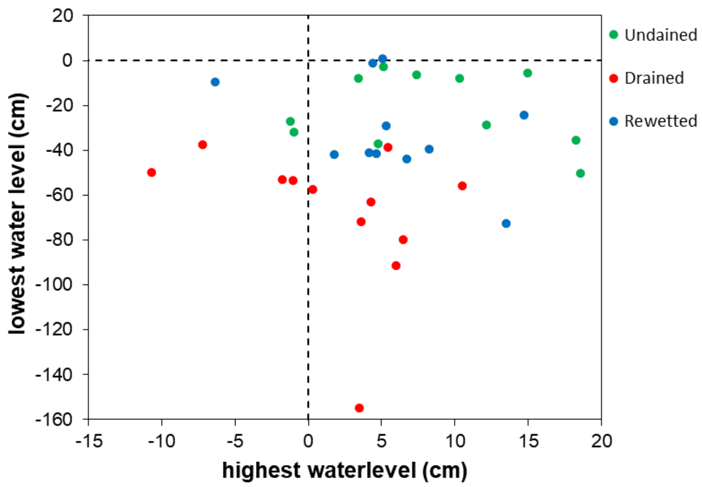

Figure 1. Lowest and highest phreatic water level relative to soil surface for undrained, drained and rewetted triplet sites. Lowest water level is the 0.05 percentile and highest water level the 0.95 percentile of measurements in the period 15-09-2017 to 16-09-2018. Green = undrained, red = drained, blue = rewetted.

2. Rewetting of drained fens allows for significant recovery of microbial communities, vegetation and soil mesofauna (lead partner 5 + partners 5.1 & 1)

A cross-European comparison of undrained, drained, and rewetted fens (13 localities) re. microbial communities, vegetation composition and soil mesofauna was carried out.
With respect to microbial communities (lead partner 5), their composition, key functional genes, abundances of fungi and bacteria, and substrate use capacity as dependent on soil depth and peat drainage status was analysed. There was a clear difference in microbial communities between drained and undrained fens, regardless of location (figure 1). It was found that in particular key peatland microbes are able to return after rewetting. This return was however contingent on the prior drainage state of the peats, as reflected by the quantity and quality of the organic matter (figure 2). We estimate

that a minimum organic matter content of ca. 70% is required to enable microbial recovery. Results of the micriobial analyses were published by Emsens et al. (2020).
Analysis of vegetation (lead partner 1) and soil mesofauna (lead partner 5.1) revealed that while pristine and drained fens formed distinct clusters, the rewetted fens were much more diverse. While most of the rewetted fens seemed to regain typical fen vegetation and mesofauna assemblages, others remained more related to the degraded, drained ones. Publications including the vegetation and mesofauna data are in preparation.

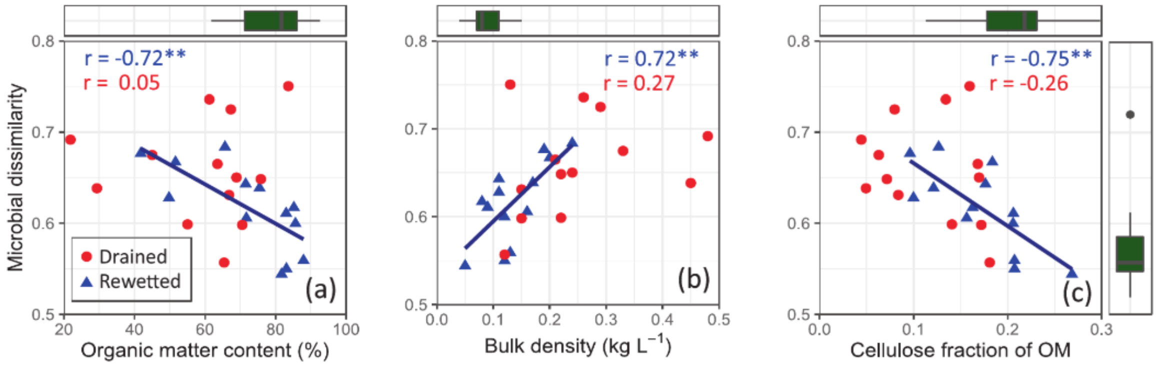

Figure 2. Environmental variables in drained (red dots) and rewetted (blue triangles) fens in relation to microbial community dissimilarity to undrained fens. Microbial community dissimilarities are based on Bray–Curtis dissimilarity results (after 16S rRNA sequencing and 97% OTU clustering) from each individual (drained or rewetted) sample of the top peat layer (0–5 cm) to all the samples collected in the top layer of undrained fens: the larger the dissimilarity, the more the microbial community deviates from communities in undrained fens. The horizontal boxplots represent the range of the environmental values in undrained fens, the vertical boxplotrepresents the range of microbial community dissimilarities undrained fens only. Pearson's correlation coefficients (r) are given in each plot; significance is indicated with **P < 0.01. Emsens et al. 2020.

3. Multi-proxy methods were developed for palaeo-ecological study of drained and rewetted fens. Rewetted fens start to develop new layers of detritus ("proto-peat") at high rates (lead partner 3)

To verify whether rewetted fens return to previous peat-forming conditions, we have analysed peat profiles from reference, drained and rewetted sites in two percolation fen systems (Recknitz and Trebel valley in NE Germany and vicinities of the Rospuda valley in NE Poland). Our study belongs to the first multi-proxy palaeo-ecological studies of rewetted fens. Due to the selection of one of the earliest rewetting projects, we could show on the one hand the development from a drained and degrading peat grassland to a carbon-sequestering mire and on the other hand from the living vegetation via a stage of rawhumus to a kind of "proto-peat" during a time span of about 20 years (Michaelis et al. 2020). Furthermore, we could calculate the accumulation of new material and the loss of carbon due to drainage for two sites of the Mecklenburg-Vorpommern site complex (Mrotzek et al. 2020). Alongside this work, a data base of root macrofossils traits has been compiled for improved analyses of peat from drained and rewetted fens. A catalogue of widespread subfossil root types with detailed descriptions and microscopic photographs is published in Michaelis et al. (2020).

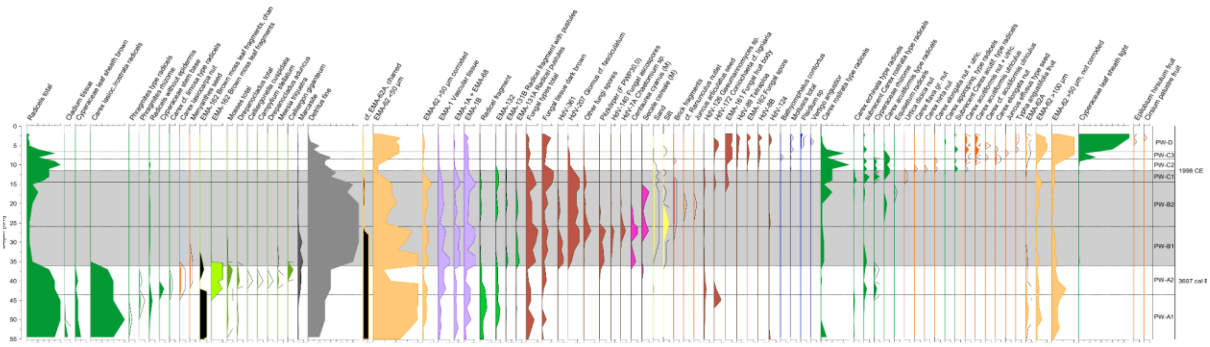

Fig. 3. Selected curves of macro- and micro-remain analyses of rewetted fen in Trebel valley (PW). Curves show percentages [%] or number [N] of macro-remains as indicated, or otherwise concentrations [101 N cm^{-3}] of micro-remains. Michaelis et al. (2020).

4. Root productivity in fens is mostly affected by water levels, while root decomposition is controlled by multiple variables (lead partner 3)

In-situ measurements of root productivity (by means of ingrowth cores) and root decomposition (by litter bags) were conducted in drained, rewetted and undrained fens in the gradient across Europe. Total root productivity appeared to be only affected by water level with highest productivity at intermediate water levels. In contrast, root decomposition was affected by a wider range of variables: water level (positive), bacterial biomass (negative), pore water phosphorous content (positive), pore water Cl content (negative), above ground standing crop, herb cover and moss cover (all positive), and aboveground biomass C:P and K:P ratios (both negative). Generally, explanatory variables had a weak effect on productivity and decomposition. The analyses of this dataset are in progress.

5. No effect of mowing on production and decomposition in fens (lead partner 3)

Comparing mown and unmown wet (undrained/rewetted) fens, we could not detect any difference in above- and below-ground production or decomposition. Also a comparison of root porosity in two sedge species and of enzyme activity (in collaboration with Bangor University) did not show differences. The plots differed, however, in vegetation composition, number of plant species, and soil density (measured with a penetrologger). Preparation of an article is in progress.

6. Depth is the strongest predictor of organic matter decomposition in undrained fens (lead partner 1)

Samples of organic soil material, including fossil peat and fresh biomass (living and dead roots, fragments of mosses) taken from three depths were incubated for one year in their original depths on 35 sites in natural fens of the Biebrza and Rospuda valleys. None of the chemical or hydrological variables measured was a good predictor of mass loss, which was most strongly determined by depth (decomposition in the uppermost 5 cm was 2,5 higher than at 25-30 cm, which was only slightly higher than at 45-50 cm depth. Mass loss at the surficial layer was positively correlated to the percentage cover of bryophytes. A manuscript based on these data is under preparation.

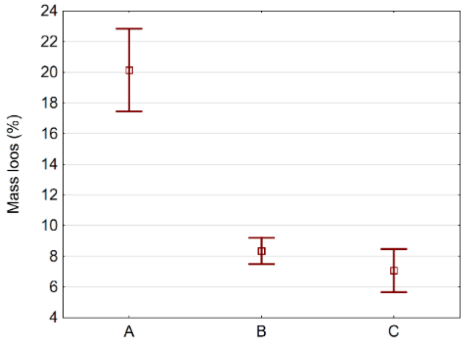

Fig. 4. Mean mass loss of autochthonous organic matter incubated at three depths, 0-5 cm (A), 25-30 (B) and 45-50 (C), in 35 undrained fen sites of the Biebrza and Rospuda valleys (NE Poland).

7. Growth rates of fen bryophyte species differ in response to nutrient levels (lead partner 1)

A greenhouse experiment was carried out to examine how the growth rate of eight brown moss species dominant in natural fens is influenced by the available nitrogen and phosphorus. Mosses were grown in the gradient of N and P, with constant potassium level, similar to conditions occuring in natural fens. All examined moss species achieved a maximum growth rate and chlorophyll content with the availability of N and P higher than in their natural habitats, indicating their likely displacement from physiological optima by competition for light with vascular plants. However, clear interspecific differences occurred, with some species showing a unimodal response, whereas others had

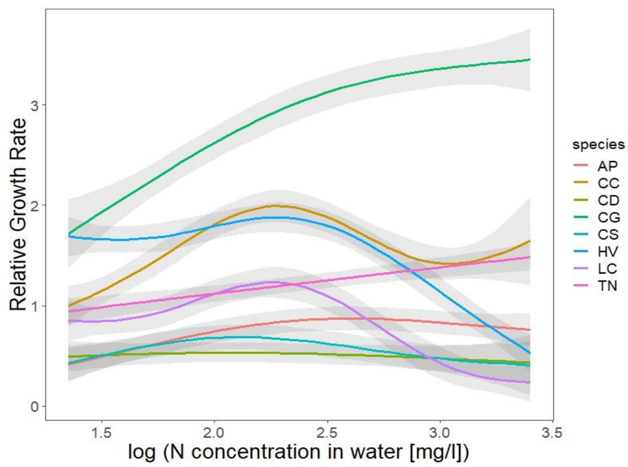

Fig. 5. Relative growth rates of *Aulacomum palustre* (AP), *Calliergon giganteum* (CG), *Calliergonella cuspidata* (CC), *Campylium stellatum* (CS), *Climacium dendroides* (CD), Hamatocaulis vernicosus (HV), *Limprichtia cossoni* (LC), and *Tomentypnum nitens* (TN) under an experimentally controlled nitrogen availability gradient.

increasing response curves. The results of the experiment will allow a better understanding of the processes responsible for the functioning of fens, which is important for the restoration of these valuable ecosystems. The manuscript is in a final stage before submission.

8. Nutrient levels affect production but not decomposition in fen sedges (lead partners 3 & 1)

We investigated above- and below-ground biomass production and decomposition of five fen sedges (*Carex* spp.) grown under different nutrient (N+P) levels in a mesocosm experiment. Our study indicated that, generally, higher *Carex* biomass production at higher nutrient levels was not offset by a comparable increase in decomposition. Increase of above- and below-ground biomass with higher nutrient levels was species-specific. Decomposition of *Carex* standard plant material in mesocosms was not dependent on the species growing in the mesocosms and showed only slight, if any, variations with differing nutrient levels. Decomposition of roots grown under different nutrient levels was mainly correlated with species-specific traits. Our results suggest that *Carex* peat formation potential increases with increasing nutrient levels, due to higher biomass growth, which is not balanced or counteracted by comparable increases in decomposition. With regard to restoration efforts of degraded fens, our results indicate that drained, eutrophied peatlands could quickly be peat-forming again upon rewetting. The manuscript is in a final stage before submission.

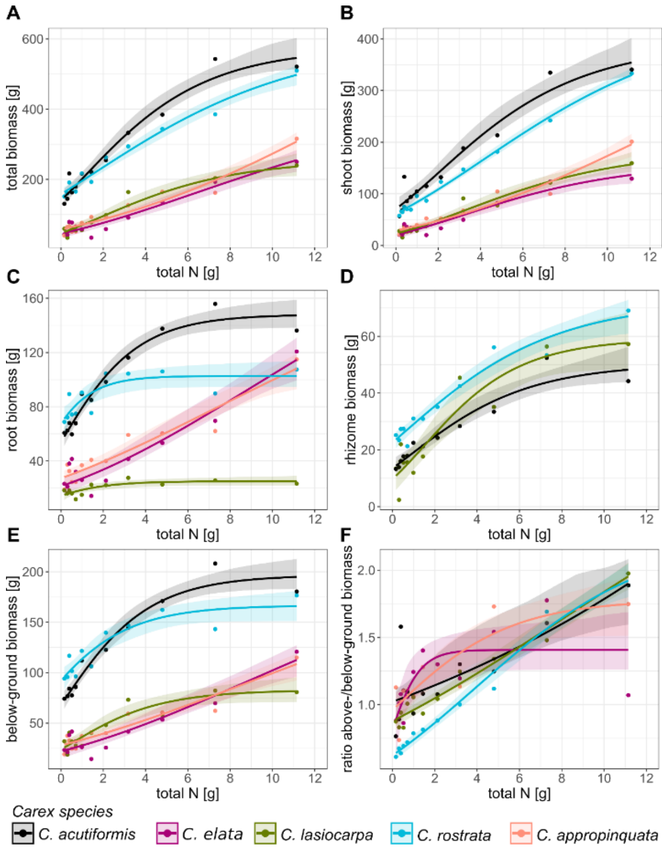

Fig. 6. Biomass production and non-linear model fit for the five Carex species grown under different nutrient levels in mesocosms. (A) Total biomass, (B) shoot biomass, (C) root biomass, (D) rhizome biomass, (E) below-ground biomass (i.e., root + rhizome biomass), (F) ratio between above-ground and below-ground biomass. Biomass data were fit using Gompertz growth models, above:below-ground ratio was fit using a logistic growth model. Shown are mean estimates (solid lines) and 95% confidence bands (semitransparent ribbons) based on bootstrapping of residuals.

9. Primary production shifts from bryophytes to vascular plants and from belowground to aboveground along the water level amplitude gradient (lead partner 1)

Yearly net primary production (NPP) of bryophytes (increment of in-situ transplants), aboveground parts of vascular plants (standing crop harvested 1 year after clipping vegetation to ground level) and roots (roots present in ingrowth cores incubated for 1 year) were compared along transects in natural fen valleys of Biebrza and Rospuda rivers. Although different methods of biomass quantification do not allow for making complete balances, between-zone comparisons are justified. Bryophytes make a substantial part of NPP in outer zones, likely equalling or surpassing total NPP of vascular plants, and sharply decline towards the riverside zones of fen systems. Vascular plants shift biomass allocation from mostly belowground in hydrologically stable groundwater-fed zones towards predominantly aboveground in riverside zones. In other words, fractions of recalcitrant organic matter (bryophytes, roots) decline and easily decomposable fraction (leaves, shoots) increase with river proximity and water level amplitude. These data are still being analysed and a manuscript shall be submitted by the end of 2020.

10. Eutrophic floating fens in Danube Delta (Romania) have distinct microbial decomposer communities dominated by bacteria (lead partners 2 and 1).

Depth is the strongest environmental factor, with surficial layer having the highest biomass, activity and diversity of decomposers. However, some important groups of e.g. fungi showed clear preference towards deeper layers and substantial diversity was also found there, altogether probably contributing to relatively high decomposition rates recorded in deep “peat”. The data are still being analysed and a manuscript shall be submitted by the end of 2020.

11. Methane production in fens increases with percentage of easily decomposable organic matter in peat and fluctuation of water level, whereas its concentrations are controlled by the availability of iron, sulphate and nitrogen (lead partner 4, with contribution of partners 5 & 1).

Analysis of pore water methane concentrations in 39 Central European fens with different drainage history confirmed that drained sites had significantly lower methane concentrations compared to undrained sites, whereas the methane concentrations at restored and undrained sites did not differ. From various control variables, CH_4 production responded strongest to pore water iron (positive) and sulphate (negative) concentrations. In addition, CH_4 concentration increased also with increase in porewater ammonium concentration, but its effect size was negligible compared to those of iron and sulphate. However, when only undrained fens of the Biebrza and Rospuda valleys (NE Poland) were taken into account, ammonium was the strongest control of methane pore water concentration.

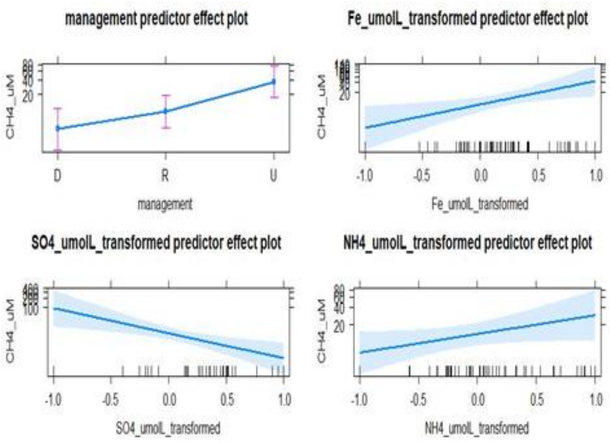

Fig. 7. Predictor effect plots from the used linear mixed effect model for management, iron, sulphate and ammonium concentrations

In addition, methane production potential was analysed experimentally in peat samples from undrained and rewetted fens. It turned out that drainage history has little effect on methane production potential when water level stability and carbon availability are similar. Main control for methane production potential was carbon availability. Both carbon availability and methane production potential were larger for peats that had been the longest above the water level, presumably due to enhanced decomposition releasing nutrients and the larger quantity of roots under better oxygen availability. The relative number of methanogens and the vegetation cover also correlated with the methane production potential, but to a significantly smaller degree. Manuscripts describing these results are in their final stage before submission.

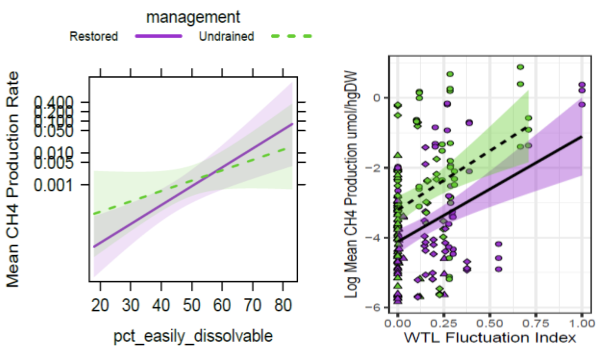

Fig. 8. Methane production potential in relation to peat labile carbon content and water level fluctuation of the sampled fen site. The higher the index the longer the sampled peat was above the water level during the year before sampling. Dotted line with green shade represents the undrained and solid line with lilac shade the restored peatlands.

12. The MIcrobial-MIneral Carbon Stabilization (MIMICS) model (Wieder et al 2015)l has been modified to take waterlogging into account (lead partner 4).

The microbial data analysis indicated a lower microbial abundance and a higher fungi:bacteria ratio in drained fens as compared to the waterlogged ones. It is also known that waterlogging affects structural litter more than the metabolic litter, at least lignin degradation requires oxygen. The model was therefore modified so that the moisture modifier affected microbial utilization of structural litter which also reduces the fraction of chemically protected carbon becoming active, and death rate of K strategist microbes only. The model predicted the evolution of soil carbon after drainage and rewetting realistically. Carbon flux was high just after drainage, and it remained above that of the undrained for a long time. Carbon content decreased quickly after drainage and rose more slowly after re-wetting. The model can be included in larger land surface models, to make them take into account the effect of waterlogging and draining and re-wetting on carbon sequestration and global warming potential. Publication of the results of modelling study is foreseen after the results used (microbial analysis) are published.

13. New knowledge base was created advancing restoration ecology of fens and the concept of paludiculture and communicated during several conferences and events.

Most of the above-described findings translate to new practical knowledge advancing restoration of fens; the main conclusions are: (1) rewetting does lead to a substantial recovery of fen systems, (2) the degree of recovery depends on the advancement of peat decomposition processes prior to rewetting, (3) low-intensity paludiculture, i.e. mowing of seminatural fens, seems to have no effect on peat-forming processes, (4) eutrophic rewetted fens may support peat-forming communities, (5) the intensity of methane production after rewetting depends on the fraction of labile carbon and pore water S, Fe and N content. The findings were communicated at several special sessions (see under dissemination) and a dedicated Repeat conference in Tulcaea, Romania (2019). Outcomes from REPEAT have been used in the draft report of the new Ramsar Convention Global Restoration Guidelines.

4.4. List of project meetings

Date	Place	Participating partners	Meeting title and object
22-24.11.2016	Warsaw	1, 2, 3, 3.1, 4, 5	REPEAT kick-off meeting. The meeting or the whole consortium was organised after confirmation of project financing, however before official start of the project. The meeting was financed by external sources.
23-24.01.2017	Berlin	3, 5	Meeting REPEAT UG – UA re. WP3. The aim was to discuss and specify methods and plans regarding field measurements of production and decomposition rates.
17.05.2017	Greifswald	1, 3	Meeting REPEAT re. WP 3 & 5. The aim was to develop methodology and define details of collaboration re. decomposition measurements and functional diversity of plants.
20-21.02.2018	Antwerp	1, 2, 3, 4, 5	Mid-term meeting 1. The aim was to assess progress in all WPs and define strategy of results dissemination.
17.12.2018	online	1, 2, 3, 4, 5	Mid-term meeting 2. The aim was to assess progress in elaborating results and manuscript preparation.
05-08.06.2019	Tulcea	1, 2, 3, 4, 5	Final project conference and partner meeting aimed and presenting results to international audience and setting final publication strategy.

4.5 Follow up activities and plans for further exploitation of the results

- WETSCAPES project, funded in 2017, compliments REPEAT with additional measured variables (University of Greifswald, University of Rostock).
- CLEARANCE project (WaterWorks 2016-2020) complimented REPEAT by focusing on riparian wetlands, including fluviogenic fens, and their role in water purification (coord. University of Warsaw).
- NCN (National Science Centre Poland) project “Bryophyte nutrient limitation along productivity gradient” (2019), University of Warsaw.

- NCN (National Science Centre Poland) project “Superficial beauty? Does mowing of fen peatlands affected by tree- and shrub encroachment restore belowground communities of mycorrhizal and saprotrophic fungi?” (funded 2020); (2019/35/D/NZ9/03212), University of Warsaw.
- NCN (National Science Centre Poland) project “Preconditions of stability and vegetation dynamics in Polesie peatlands (funded 2020). University of Warsaw.
- Project proposal submitted to Beethoven call (2019, not funded) launched by NCN (National Science Centre Poland) and DFG (Deutche Forschungsgemeinschaft).
- Project proposal submitted to Mozart call (2019, awaiting decsion) launched by NCN (National Science Centre Poland) and FWF (Austrian Science Fund).
- Project proposal submitted in the GRIEG call launched by the National Science Centre under the Norway Grants (2019; not funded).
- Project proposal submitted in the Biodiv-Clim call (2020; awaiting decision) - submitted by consortium including 4 partners of REPEAT (lead by University of Greifswald).

5. Stakeholder engagement in the project

5.1 Before the project’s start

Prior the application, the proposal was consulted and supported by:

1) International Union for Nature Conservation (IUCN) – European Regional Office
2) Ministry of Agriculture, Environment and Consumer Protection - Mecklenburg Vorpommern (Germany)
3) Ministry of Environment, Waters and Forests, Danube Delta Biosphere Reserve Authority (Romania)
4) General Directorate for Environmental Protection (Poland)
5) Federal Agency for Nature Conservation (Germany)
6) Agency for Nature and Forests (Belgium)
7) Biebrzański National Park (Poland)
8) Nature Park “Flusslandschaft Peenetal” (Germany)
9) Natuurpunt – Organisation for Nature Conservation and Management in Flanders (Belgium)
10) Centre for Wetlands Conservation (Poland)

5.2 During the project

Within the project, stakeholder engagement at international level is secured by Wetlands International – European Association (WI-EuA), a sub-contractor of Partner#3. WI-EuA was responsible for the review of peatland conservation and restoration status in EU policies (under elaboration) and organisation of a public event dedicated to peatland carbon sequestration during 24 COP of UNFCCC in Katowice, in December 2018 (co-organised by partners 1, 3, 3.1).

In 2019, together with Wetlands International, we prepared and conducted the workshop "Exchange of views on post 2020 Common Agricultural Policy (CAP) and its effect on farming on organic (peat) soils" in Brussels. As we succeeded in inviting several senior staff from the Directorate-General for Agriculture of the European Commission (DG AGRI) as well as peatland rewetting and paludiculture practitioners from Poland and the Netherlands/Germany, we could discuss up-to-date policy decisions and reflect on implications for peatlands and farmers in the EU (partners: 3, 1, 3.1).

In 2019, together with German Federal Agency for Nature Conservation, the Global Peatlands Initiative, the Secretariat of the Ramsar Convention, the Greifswald Mire Centre, and Wetlands International, we prepared and conducted the workshop "Exploring Synergies for Peatlands - Detecting and enhancing the global importance of peatlands in achieving the Sustainable

Development Goals". With direct video links to several convention secretariats, we discussed opportunities for mainstreaming peatland policies (partners 3, 3.1).

Project partners are in frequent operational contact with stakeholders responsible for carrying out nature conservation on project study sites. Permits for carrying out fieldwork have been obtained from:

- Ministry of Environment, Waters and Forests, Danube Delta Biosphere Reserve Authority (Romania, partner 4)
- General Directorate for Environmental Protection (Poland, partner 1)
- Agency for Nature and Forests (Belgium, partner 5)
- Biebrzański National Park (Poland, partners 1, 3, 4, 5)
- State Forests (Poland, partner 1)
- Nature Park "Flusslandschaft Peenetal" (Germany, partner 3)
- Natuurpunt – Organisation for Nature Conservation and Management in Flanders (Belgium, partner 5).

5.3 Foreseen after the project's end

As a direct results of the workshop in Brussels, several meetings and interactions of REPEAT project staff with EU institutions followed, which will have consequences on the development of policies related to peatland restoration; the most important ones and their outcomes being:

- 09./10.10.2019 DG AGRI and IUCN round table on CAP reform: Roundtable dialogue, working group and policy lab on peatland management (F. Tanneberger)
- 18.10.2019 DG AGRI (deputy director, heads of units), DG CLIMA: Awareness, CAP amendments discussed and proposals made (H. Joosten)
- 07./08.11.2019 European Parliament, MEPs from AGRI and ENVI committees (eg Jahr, Liese, Wiezik): Awareness, CAP amendments discussed and proposals made, event on peatlands in Eur. Parl. Agreed (F. Tanneberger)
- 04./05.12.2019: European Council/Member States workshop with DG AGRI on CAP Strategic Plans: Presenting results, scientific facts and policy recommendations (F. Tanneberger)
- 03.06.2020 Webinar on CAP and launch of a policy brief: high-level attendance with video messages on peatlands by 5 MEPs and 2 MEPs joining the webinar (F. Tanneberger, W. Kotowski) https://www.youtube.com/watch?v=VEUDh2PznHc

Also the workshop with multi-lateral environmental agreements (MEAs) on peatlands in May 2019 led to direct results. The roadmap for upcoming peatland-related events agree during the workshop has been further discussed and shaped at a workshop on European peatland strategies (https://www.bfn.de/fileadmin/BfN/internationalernaturschutz/Dokumente/Peatland_Workshop_2019/Policy_brief_peatland_strategies_bf.pdf) Several events planned had to be cancelled/delayed due to the Corona pandemic. The roadmap will be further followed-up by the partners in the Global Peatlands Initiative.

Two members of Polish REPEAT team (W. Kotowski, Ł. Kozub) joined the newly established Ramsar Convention Committee in Poland enforcing fen restoration and paludiculture in national policies.

A LIFE project proposal on fen restoration is currently (2020) being prepared by the Wetland Conservation Centre (Poland) in collaboration with the State Forests holding and the society 'Bocian' with involvement of REPEAT team members (E. Jabłońska, Ł. Kozub, W. Kotowski).

Insights and guidelines arising from REPEAT will be used in the management plan for Biebrza National Park; new proposals of hydrological restoration will be prepared as response to peatland fires in Spring 2020 (involvement of W. Kotowski).

Assessment of the condition of Polish peatlands in relation to greenhouse gas emissions has been prepared by WWF-Poland and the Wetland Conservation Centre (2020; led by W. Kotowski) as part of recommendations for Poland's climate change mitigation strategy.

6. Dissemination of results

6.1 List of scientific publications

Michaelis D, Mrotzek A, Couwenberg J (2020) Roots, tissues, cells and fragments — how to characterize peat from drained and rewetted fens. SoilSystems, 4, 12, doi: 10.3390/soilsystems4010012

Emsens W-J, van Diggelen R, Aggenbach C, Cajthaml T, Frouz J, Klimkowska A, Kotowski, Kozub L, Liczner Y, Seeber E, Silvennoinen H, Tanneberger F, Vicena J, Wilk M & Verbruggen E (2020):Recovery of fen peatland microbiomes and predicted functional profiles after rewetting. The ISME Journal. doi: 10.1038/s41396-020-0639-x

6.2. Dissemination of results to scientists and scientific organisations (1-page max)

Oral presentations:

- Klimkowska A., Kotowski, W.: Microbial communities in the soils in natural and restored fen peatlands and relevance for restoration. International Mire Conservation Group Symposium, August 2018, Texel, Netherlands.
- Hanganu, J. et al.: Floating fens of the Danube Delta - formation and succession. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania
- Aggenbach, C. et al.: Can rewetting of peatlands restore water level regime and hydrochemistry of undrained fens? REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Klimkowska, A. et al.: Pattern of decomposition potential in European fens. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Verbruggen, E. et al.: Responses of microbial functional gene abundances in response to fen rewetting. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Emsens, W.-J. et al.: Microbiome recovery in rewetted fens. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Wilk, M. et al.: Peat fungal communities of natural, drained, and rewetted fen mires. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Michaelis, D. et al.: A paleo-approach to drained and rewetted fens in Mecklenburg-Vorpomern. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Foereid, B. et al.: Modelling carbon cycling in wetlands. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Michaelis, D. & Joosten, H.: Towards a root trait data base for fen plants. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Tanneberger, F. et al.: Peat formation under pressure? Effects of machine mowing on soil and below-ground plant properties in wet temperate fens. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Pronin, E. et al.: Evaluation of the decomposition rates in fens using FTIR spectra of peat and litter bags methods. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Izabela, J. et al.: Bryophytes productivity and decomposition in trophy gradient. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Kotowski, W.: Fen production (and decomposition) along gradients. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Li, G. & Kotowski, W.: The prediction of recalcitrance of belowground biomass of fen sedges. REPEAT conference: Fens across ecological gradients. June 2019, Tulcea, Romania.
- Emsens, W.-J. et al.: Microbiome recovery in rewetted fens. General Assembly 2019 of the European Geosciences Union (EGU), Vienna, April 2019.

- Michaelis, D.: A focus on displacement peat, peat losses, and new peat accumulation in a rewetted, former drained fen. Wetscapes Conference, Rostock, September 2019.
- Mrotzek, A., et al. Roots, tissues, cells and fragments – how to characterize peat from drained and rewetted fens. Wetscapes Conference, Rostock, September 2019.
- Davey M, et al.: Methane productionin Central Europeanfens is linkedto edaphicproperties, not large scale climatic gradients. WETSCAPES conference, Rostock, September 2019.
- Gribbe, S., et al.: Digital visualisation techniques of roots in peat. Wetscapes Conference, Rostock, September 2019.
- Tanneberger F, et al.: Peat formation under pressure? Effects of machine mowing on soil and below-ground plant properties in temperate fens. WETSCAPES conference, Rostock, September 2019
- Blume-Werry, G. et al.: Root growth phenology of common sedge species in response to increasing levels of nutrient availability. WETSCAPES conference, Rostock, September 2019
- Kotowski, W.: Productivity gradients, vegetation processes, and ecosystem functions in fens. What's known and what's still hidden? WETSCAPES Conference, Rostock, September 2019 (key-note lecture).
- Verbruggen, E. et al.: Microbiome recovery in rewetted fens. WETSCAPES Conference, Rostock, September 2019.
- Kotowski, W. et al.: Can we enhance nutrient removal in wetland buffer zones by biomass harvesting? A comparison of restored (Danish) and natural (Polish) sites. 8th International Symposium on Wetland Pollutant Dynamics and Control (WETPOL), Aarhus, Denmark, June 2019.

Poster presentations:

- Mrotzek, A. et al.: Non-pollen palynomorphs from drained and rewetted fens. NPP-Workshop Dublin 2018.
- Michaelis, D. et al.: Peat loss and renewed accumulation in a rewetted, former drained fen. INQUA Conference Dublin 2019
- Tanneberger F, et al.:Peat formation under pressure? Effects of machine mowing on soil and below-ground plant properties in temperate fens. EGU conference, Vienna, April 2019
- Jaszczuk, I. et al.: Bryophytes' productivity and decomposition in fens along the environmental gradients. WETSCAPES Conference, Rostock, September 2019.
- Davey, M. et al.: Methane production in Central European fen peatlands is primarily linked to edaphic properties, not large scale climatic gradients. Geophysical Research Abstracts Vol. 21, EGU2019-19087, 2019 EGU General Assembly 2019

6.3 List of dissemination activities with stakeholders

- Project website (http://repeat-project.com/) linked to the platform Moorwissen (https://www.moorwissen.de) guarantees the outreach to restoration practitioners and other tsakeholders (maintained by partner 3);
- A short film about the REPEAT project (in Polish) in Polish TV: http://bialystok.tvp.pl/37649500/bagna-pod-lupa (partner 1);
- A short film showcasing peatland restoration with Antwerp and Greifswald team members at WDR5: https://www1.wdr.de/mediathek/audio/wdr5/quarks/hintergrund/audio-moore-sind-wichtig-fuer-den-artenschutz-100.html (partners 3 & 5)
- Nature Microbiology Community, April 2020. Behind the paper blogpost by W.-J. Emsens: Rewetting the wasteland - Do microbes find their way back? Nature Microbiology Community: https://naturemicrobiologycommunity.nature.com/channels/346-behind-the-paper/posts/64878-rewetting-the-wasteland-do-microbes-find-their-way-back (partner 5);
- Video podcast "Why do we need mires" by W. Kotowski (in Polish) (02/2020) (https://www.youtube.com/watch?v=RvT53EXPY1Q), (partner 1);
- Exchange of views on post 2020 CAP and its effect on farming on organic (peat) soils. Workshop report: https://www.moorwissen.de/doc/moore/tools/projekte/repeat/Report%20on%20Paludiculture%20workshop_Brussels.pdf. (partner 3);

- Brochure for stakeholders ‘Information on the importance of conserving organic soils to reduce greenhouse gas emissions‘ in Romanian: https://www.moorwissen.de/doc/moore/tools/projekte/repeat/Brosura_Repeat_A5_ebook.pdf (partners 2 and 3);
- Exploring Synergies for Peatlands – Detecting and enhancing the global importance of peatlands in achieving the Sustainable Development Goals International Academy for Nature Conservation Isle of Vilm, 21th – 25th May 2019 - Workshop report: https://www.moorwissen.de/doc/moore/tools/projekte/repeat/MEA%20synergies%20for%20peatlands_workshop_report_final.pdf (partners 3 and 3.1)
- Report “Herstelbaarheid van verdroogde beekdaltrilvenen. Status van Nederlandse veenterreinen in een Europese context” for Dutch and Flemish nature managers (https://www.natuurkennis.nl/Uploaded_files/Publicaties/herstelbaarheid-van-verdroogde-beekdaltrilvenen.66c1eb.pdf) – 23 pp. (partner 5);
- Lay man’s article on peatland restoration in the Zwarte Beek area *Laagveenherstel door vernatting. Terug naar oernatuur in de vallei van de Zwarte Beek* in the journal “Natuur.focus” 2019: 60-65 (Emsens, Aggenbach, Verbruggen, Van Diggelen) (partner 5);

Presentations at conferences:

- Conference of the Landeslehrstätte für Naturschutz und nachhaltige Entwicklung, oral presentation: Michaelis, D.: Moore – wie sie entstanden und waren. Güstrow, June 2018; information event for co-workers of the administration of forestry and nature conservation (partner 3)
- Wetscapes evaluation conference, poster presentation: Michaelis, D.: An den Wurzeln der Torfbildung. Rostock 2019; information event for funders of the Wetscapes project (partner 3)
- Presentation of W. Kotowski „Local, regional and global importance of mires conservation”. Conference “Kampinos wetlands” May 2019.
- Oral presentation by W. Kotowski “Priorities in mire conservation in Poland” in the Conference “It started in the Tatra Mountains. Protection of Polish nature in 150 years since the introduction of species protection of goats and marmots, 100 years since the establishment of the State Commission for Nature Conservation” , Kraków, Poland, November 2019.

6.4 Dissemination of results to stakeholders (1-page max)

- **Dissemination of results to stakeholders**:

- 13-14/02/2017 (Belgium, partner 5) - advice and field visit in the Arlon region with representatives of the Belgian nature conservation organisation Natagora (http://www.natagora.be) regarding the LIFE project on restoration projects of alkaline fens there (Van Diggelen);
- 8/04/2017 (Poland, partner 1) – workshop about ecosystem services of rivers and wetlands, Warsaw; organised by the initiative ‘Nauka dla Przyrody’ (Science for Nature), Polish Hydrobiological Society and Centre of Biological and Chemical Sciences of Warsaw University; c 50 participants – scientists and practitioners involved in science transfer to society (Kotowski);
- 23/11/2017 (EU, partner 5) – advice to the European Habitat Forum (representatives of the large international nature conservation organisations at the European Commission, DG Environment) on possibilities to implement paludiculture in degraded fen areas (Van Diggelen);
- 28/02-01/03/2018 (Germany, partner 3) - stakeholder workshop in Bad Bevensen with ~35 peatland restoration scientists and practitioners from all peatland-rich German federal states about assessing restoration success and monitoring approaches (Joosten & Tanneberger);
- 03/2018 (Germany, partner 3) - meetings with landowners, farmers, conservation authorities in March 2018 in Recknitz Valley sites (joint meetings with WETSCAPES project; Tanneberger);

- 03/08/2018 (Germany, partner 3) - meeting with Indonesian ambassador H.E. Dr. Arif Havas Oegroseno in Western Pomerania following an invitation of the Greifswald Mire Centre - environmental and socio-economic benefits of peatland rewetting and paludiculture (Joosten);
- 14/03/2018 (Belgium, partner 5) – advice and field visit on restoration activities to regional decision makers of the Flemish organisations Natuurpunt (https://www.natuurpunt.be/) and Agentschap Natuur en Bos (https://www.natuurenbos.be/) in the fen area Zwarte Beek near Beringen (Van Diggelen);
- 20/03/2018 (Belgium, partner 5) – stakeholder workshop with lectures and a field visit about restoration prospects of degraded fens for 25 Flemish and Dutch nature conservation experts (Aggenbach&Van Diggelen);
- 12/04/2018 (Belgium, partner 5) – workshop and field visit of 2 UA REPEAT members with Conservatoire d'espaces Naturels Picardie (http://conservatoirepicardie.org/) on restoration prospects of degraded peatlands in the region around Amiens (Fr). This workshop was held together with representatives of the Belgian Nature Conservation organisation Natagora (http://www.natagora.be), who supplies field sites to the REPEAT project (Van Diggelen & Emsens);
- 27/05/2018 (Belarus, partners 1, 3 & 5) – workshop on restoration prospects of Zvanec mire in Belarus - land owners, managers (Kotowski, Aggenbach, Tanneberger, Joosten);
- 06/09/2018 (Poland, partner 1) – invited presentation about Biebrza fens on 25th Anniversary of the Biebrza National Park – attended by Park's staff members and associated experts (Kotowski);
- 26/09/2019 (Belgium, partner 5) – invited presentation in Best (NL) on water conservation and soil restoration in a changing climate in a workshop on nature conservation of the 21th century – attended by c. 100 practitioners and regional decision makers from the border region of Belgium and the Netherlands (Van Diggelen)
- 4/09/2018 (Belgium, partner 5) - workshop ('Field workshop") with lectures and field visit for Flemish and Dutch practitioners and decision makers in biodiversity conservation. 3 oral key note presentations by Repeat members (Van Diggelen, Aggenbach, Emsens). Koersel, (https://www.veldwerkplaatsen.nl/veldwerkplaats/herstel-beekdalvenen-internationaal; https://www.circonomist.com/general/herstel-beekdalvenen-internationaal-zwarte-beek-kennisblad-veldwerkplaats-obn/;
- 08/02/2020 (Belgium, partner 5) – invited lecture in Antwerp for c. 300 amateurs on peatland restoration (Van Diggelen)
- 23/05/2019 (Poland, partner 1) – workshop about functioning and restoration of fens organised for the Mazovian Landscape Park (Otwock), attended by 20 nature conservation managers; (Kotowski, Kozub, Jabłońska).
- 22/07/2019 (Poland, partner 1) – workshop on fen ecology and restoration for the State Forestry organised by the Repeat project, Szczebra, attended by c. 50 foresters (Kotowski, Jabłońska).
- Presentation and discussion on mowing effects on peat formation ("Auswirkungen von maschineller Mahd auf Vegetation, Bodenphysik, Wurzelporosität und Zersetzungsraten in Niedermooren") by F. Tanneberger and F. Närmann with staff of the regional nature conservation authority (StALU Vorpommern) responsible for peatland management and N2000 plans.
- 02/2020 (Poland, partner 1) - Presentation about wetland and water management in the Polish Parliament (Senat), attended by c. 30 parliament members and politicians (Kotowski).

Outreach to the general public

- Presentations on mire ecology, restoration and climate change by Wiktor Kotowski and Łukasz Kozub during Biebrza Academia (Wszechnica Biebrzańska) meeting (October 2019)

- Over 20 media interviews and radio programs with W. Kotowski about the role of wetland restoration for climate change mitigation (2018-2020).
- Several lectures in secondary schools dealing with mire conservation / restoration and climate change by W. Kotowski (2018-2020)
- World Wetland Day organisation in Warsaw (2017-2020) – each year >100 participants in lecture room and media coverage in press and radio.

7 Global Impact assessment indicators

7.1 Impact statement

REPEAT has enabled substantial progress with respect to peatlands in the EU CAP reform process, starting from the workshop in April 2019 where trustful relationships were established with DG AGRI. From there, a chain of follow-up events followed, culminating the webinar of 03.06.2020 where MEPs committed in public to support eligibility of paludiculture in EU direct payments etc. See above.

On a global scale the REPEAT results are being incorporated in the Global Guidelines for Peatland Rewetting & Restoration, which are prepared for the Ramsar Convention by Partner 3 (University of Greifswald, Joosten).

On the local and regional scale, REPEAT will enable better management and decision making in several peatland conservation areas, including Zwarte Beek nature reserve, Danube Delta Biosphere Reserve, Biebrzański National Park, Rospuda Valley (Augustów Forest), Nature Park “Flusslandschaft Peenetal.

7.2 Synthetic figures for the project publications (including interactions with stakeholders)

Two published papers (only those acknowledging Biodiversa funding are counted), plus 15 in preparation (listed in the publication list template, but not taken into account in the following table).

Analysis of the *project* publications:

Scientific Journal	*Number*	*Impact (2018)*	*Factor*
The ISME Journal	1	9.493	
Soil Systems	1	-	

International dimension and multi-partnership for publications

		Number of publications
Multi-partner publications	**Peer-reviewed journals**	1
	Books or chapters in books	
	Communications (conferences)	15
Single-partner publications	**Peer-reviewed journals**	1
	Books or chapters in books	
	Communications (conferences)	15
Outreach initiatives including interactions with stakeholders	**Popularization articles**	2
	Popularization conferences	5
	Others	>40

7.3. Other scientific outputs

	Number, years and comments (Actual or likely outputs)
International patents obtained	0
International patents pending	0
National patents obtained	0
National patents pending	0
Operating licences (obtained / transferred)	0
Software and any other prototype	0
Company creations or spin-offs	0
New collaborative projects	5 new projects funded
Scientific symposiums	1 conference organised, special sessions organised in three symposia, communications presented in 5 symposia
Others (please specify)	Guidelines prepared for the Ramsar Convention Committee

7.4. Assessment and follow-up of personnel recruited on fixed-term contracts (excluding interns)

Identification			Before recruitment for the project			Recruitment for the project				After the project			
Surname and first name	Sex M/F	E-mail address	Last diploma obtained at time of recruitment	Country of studies	Prior professional experience, including post-docs (years)	Partner who hired the person (Organisation and Country)	Position in the project (1)	Duration of missions (months) (2)	End date of mission on project	Professional future (3)	Type of employer (4)	Type of employment (5)	Promotion of professional experience (6)
Jaszczuk Izabela	F	izabela.m.jaszczuk@gmail.com	M.Sc.	Poland	0	University of Warsaw, Poland	Ph.D. student	35 months	14.05.2020	Still a Ph.D. student	Teaching and public research	Ph.D.	yes
Li Guixiang	F	guixiang.li@biol.uw.edu.pl	M.Sc.	China	1	University of Warsaw, Poland	Ph.D. student	29 months	14.05.2020	Fixed-term contract	Teaching and public research	Technician	yes
Wilk Mateusz	M	mattzwilk@gmail.com	Ph.D.	Poland	7 years	University of Warsaw, Poland	Post-doctoral	36 months	14.05.2020	Fixed-term contract; NCN	Teaching and public research	researcher	yes
Pronin Eugeniusz	M	e.pronin@uw.edu.pl	Ph.D.	Poland	6	University of Warsaw, Poland	Post-doctoral	28 months	30.11.2019	Fixed-term contract; NCN	Teaching and public research	researcher	yes
Klimkowska Agata	F	agataecorecover@gmail.com	Ph.D.	Netherlands	13 years	University of Antwerp, Belgium	Post-doctoral	26 months part-time, in total 10 months full time	01-03-2020	Conservation organization	NGO	Expert	yes
Emsens Willem-Jan	M	w.emsens@gmail.com	Ph.D	Belgium	7 years	University of Antwerp, Belgium	Post-doctoral	12 months 0.8	01-01-2019	Fixed-term contract FWO	Science Foudation	researcher	yes
Aggenbach Camiel	M	paludosa.research@telfort.nl	M.Sc.	Netherlands	25 years	University of Antwerp, Belgium	Researcher	3 months full time	01-02-2018	Permanent position research Institute	Applied Research Institute	researcher	yes
Liczner Yvonne	F	Yvonne.Liczner@hotmail.com	M.Sc.	Germany	7 years	University of Antwerp, Belgium	Microbial laboratory expert	12 months	31-12-2019	Fixed-term contract; working on similar projects	Teaching and public research	Microbial laboratory expert	yes
Michaelis Dierk	M	michaelisd@uni-greifswald.de	Ph.D.	Germany	16 years	University of Greifswald, Germany	Postdoctoral	36 months	28.02.2020	Fixed-term contract	Teaching and public research	researcher	yes
Seeber Elke	F	elke.seeber@uni-greifswald.de	Ph.D.	Germany	8 years	University of Greifswald, Germany	Post-doctoral, technician	36 month, part-time	14-02-2020	Permanent position	Teaching and public research with collections	Collection Manager Custos of Herbarium collection	Yes
olvåg	F	Astrid.solvag.ness	MSc	Norway	1	NIBIO	Pre-	12 months,	31.12.201	Fixed term	Research	researcher	yes

Nesse, Astrid		e@nmbu.no					doctoral	part time	8	contract and hourly paid	Institute		
Maria Dietrich	F	diemaria@posteo.at	MSc	Switzerland	4	NIBIO	Pre-doctoral	17 months, part time	31.12.2020	Hourly paid	Research Institute	researcher	yes

7.5. Data Management and timeline for open access

New data on vegetation composition, peat and plant biomass chemistry have been acquired during this project using a software generating standard file formats to facilitate exchange/availability. Qualitative (e.g. species lists), quantitative (e.g. chemical parameters of peat), and image data (e.g. vegetation maps) were generated. Novel data were obtained and stored as original files and reports (pdf) from the completed task. Most data has been collected and stored in easily readable and harmonized data exchange file format (xls). All project administration data has been collected and stored in acceptable standard file formats (docx, pdf). Storing and exchange of data between partners has been organised via an internet drive, hosted at University of Antwerp. Open-access publication are prioritized and where possible source data are made openly accessible via dedicated services. All DNA sequences obtained in this project are accessible in thee NCBI sequence read archive (SRA) under project number PRJNA595701 (currently, no future date). Raw sequences from Illumina MiSeq sequencing of fungal samples will be deposited in SRA (https://www.ncbi.nlm.nih.gov/sra) on the submission of manuscripts using this data – timeline: 2020.

Mycorrhizal status database will be deposited as supplementary material to the publication using the data, and stored on the publisher's website/repository – timeline: 2021.