key messages

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RRR2021 *virtual conference*

Renewable Resources from Wet and Rewetted Peatlands

March 09th - 11th 2021

The 3rd international conference on paludiculture (RRR – Renewable Resources from Wet and Rewetted Peatlands) took virtually place on March 9th-11th 2021. The following summary provides key points of presentations and discussion outcomes within 10 session topics.

Yield, water and nutrient dynamics

- Paludiculture works - we have a wide array of options in terms of species and usages.
- They all require basic ecological and biogeochemical knowledge in order to optimize their management.
- Knowledge on these issues is quickly increasing, but we still need to work on getting the overall picture (i.e. the net ecosystem service gain, clear from all the great bits and pieces known by now).

Harvesting techniques

- The success of paludiculture will depend on the availability of the right technology to harvest the biomass according to
  - the wet soil conditions respectively low bearing capacity,
  - the biomass to be harvested and
  - the intended processing.
- There is a wide variety of adapted special machinery with low soil pressure (<< 100 g cm^{-2}) available on the market. Various solutions were presented. However, these machines are still not built in large series. Therefore, they are comparatively expensive.
- Large scale implementation of paludiculture will strongly increase the demand for special machines and thus make them available on the market at a lower price.
- Some things need to be developed further
  - Increasing the area output during harvesting,
  - Optimization regarding the division of the partial steps (mowing, preprocessing like chopping, transport from the area),
  - Development of new power sources (hydraulic/electric, hydrogen cell),
  - Training of staff (drivers of harvesting machines).

Biomass to product:

- There is a potential demand of about 10.000 ha of reedbeds to cover thatching material supply in Germany.
- The demand for regional reed could be increased through better communication between thatcher and reed cutter. Workers are sought-for to do the reed cutting.
- Also guidelines or a handbook on reedbed establishment and management for thatching is needed, for interested practitioners to establish reed for thatching.
- There are a number of utilisation options for wet peatlands (bog/fen), some with high potential, some near or in the market. Large question always: Is it possible to establish the product in the market?
- Wood is a strong competitor to a range of paludi-biomass products (concerning the prize).

- Cranberry farming seems to be able to compete with dairy farming revenue, competitive plants are surpressed over time through water tables above soil surface.
- Reed canary grass seems to have good potential for phytomining.

Sphagnum farming/restoration/propagules

- 18 out of 61 talks (~ 30%) + 4 from 8 virtual excursions at this conference were related to *Sphagnum* → shows importance, progress and dynamics of this topic.
- Studies from Germany, UK, Sweden, The Netherlands were presented.
- *Sphagnum* production fields are GHG sinks (without harvest → carbon farming).
- Application of *Sphagnum* founder material is important for fast establishment (for both Sphagnum farming and *Sphagnum* vegetation restoration).
- Irrigation is important → different types were successfully tested: ditches, sprinkling, drip irrigation.
- Topsoil removal on grassland sites promotes *Sphagnum* establishment, but only in combination with the application of founder material.
- Mass propagation of founder material is possible in bioreactor (axenic in-vitro culture) and in glasshouse.
- Selection of productive *Sphagnum* proveniences have successfully started.
- Sphagnum farming sites can also be used for sundew cultivation.
- 4th Sphagnum farming workshop for continued exchange and discussion was suggested.

Biomass for energy

- As with other energy sources, using wetland biomass requires careful consideration of sources, harvesting, processing, and combustion methods to be economic and comply with regulations on emissions and ash disposal.
- Different species have different properties, in terms of productivity, physical structure and chemical composition, which may also vary intraspecifically according to genotype, growth form, habitat, local climate and age at harvest. These parameters will affect processing for biogas, bales, briquettes or pellets.
- It is important to consider scale in terms of biomass availability, processing capacity and combustion power (for example, industrial boilers of ≥ 300 kW consume biomass more efficiently than domestic ones of 30 or 40 kW).

Greenhouse gas (GHG) emissions

- Insight in long-term effects and long-term monitoring data on GHG emissions only become available now. There are still too few long-term monitoring sites.
- CO_2 emissions from drained peatlands strongly depend on the carbon (and N & P?) available in the oxic zone. Shallow peat soils and peaty soils can have very high emissions, often higher than similarly drained 'pure' peat soils.

- Whereas rising the water table will always reduce CO_2 emissions, subsidence can only be stopped by full rewetting.
- Questions remain on some peculiar observations, yet the majority of new data fits in the existing data cloud and can be understood from the existing explanatory framework.
- Still, research into processes underlying correlations is needed and data on some issues are still scarce, like e.g. relation between P-content and CO_2 emissions.
- Knowledge on methane emissions should become specific for specific types of paludiculture / vegetation cover.

Factors determining methane emissions from rewetted peatlands:

- Quality of the substrate:
  - Flooding unadapted plants lead to high emissions → remove before rewetting,
  - Removal of the root mat before rewetting can substantially reduce emissions,
  - Quality of the soil and water (brackish water, SO_4^{2-}, Cl^-) also play a role.
- Water table and water table dynamics:
  - Already short periods of lowered water table and thus induced oxic conditions can considerably reduce methane emissions (but increase CO_2?) through changes in microbiome and redox,
  - Drought years can push succession towards emergent plants (see below).
- Vegetation:
  - Floating, non-emergent vegetation (e.g. *Azolla*) has lower emissions than emergent vegetation (e.g. *Typha*), which has (much) lower emissions than submerged vegetation (e.g. *Ceratophyllum*),
  - Different species have different emission, e.g. *T. angustifolia* is more effective in oxygenating its root zone compared to *T. latifolia* resulting in lower methane emissions.
- Harvest may affect emissions, e.g. when not all stalks are harvested and photosynthesis in unmown stalks drives emissions from mown stalks.

Or, shorter:

  - factors affecting CH_4 from rewetted sites are rather well understood,
  - science driven management options result, focusing on nutrients, water table (fluctuations), plant species and mowing regimes,
  - the dry year 2018 has initiated plant succession in new directions, away from high methane emissions.

- We understand GHG behaviour of Sphagnum farming, we know what a Sphagnum cultivation plot should look like. Yet, we need to look into GHGs from dams and ditches and develop optimal ways of designing cultivation sites.
- Vegetation development of both *Sphagnum* and vascular plants strongly influences GHG exchange and depends on hydrological conditions, peat properties and protective cover → longer time series than just the usual two years needed.
- To derive robust estimates of GHG balances for the entire Sphagnum farming system, data on dams, irrigation infrastructure and biomass harvest are needed.
- And, evidently, the ratio of actual farming area to dams + irrigation system should be as large as possible.

With respect to GHGs future research should focus on:

- Adjusting management to avoid or undo unfavorable GHG budgets, including:
  - Optimal water management to reduce methane emissions (short dry pulses help, but how feasible are they from a management perspective?),
  - Optimal crop choices and the development of cultivars to reduce methane emissions (cf. rice),
  - Optimal harvesting techniques and timing to minimize GHG emissions.
- Monitoring options are needed to recognize potential high methane emissions (e.g. mobile eddy-covariance devices mounted on drones) to be able to react and adjust management.
- Explore options for remote sensing of water tables, vegetation changes and emissions.
- In the second half of this century at the latest, we need a net CO_2 sink.
- Rewetting and establishment of adapted vegetation on current agriculturally used peatlands will result in a *one-off* CO_2 sink in vegetation, litter and proto-peat of, in the EU, ~450 Mt CO_2; the long term sink through peat formation may be about ~25 Mt CO_2 *per year* (14 Mt more than the current ~11 Mt).
- There may be a potential for carbon caption and storage using paludiculture crops (Harvested Wetland Products). As future sinks will be very important and highly sought-after, research into possibilities and potentials is opportune.

Biodiversity at ecosystem level

- Paludiculture can easily re-establish habitats and shelter various biodiversity (from arthropods to birds), so peatland conservation and paludiculture should not be seen as confronting, but rather complementing each other.
- However, for the sake of biodiversity some paludiculture benefits may be sacrificed.
- We need more insight in different biodiversity groups in regard to paludiculture, how they interact with new habitats and management, as most of paludiculture plots are quit new, small etc.
- Some evolving databases aim to collect and underpin knowledge on paludiculture and biodiversity, let's contribute!
- Rules and regulations are needed to secure biodiversity values in paludiculture sites, but also the other way around: to secure paludicultures when biodiversity values arise because of the creation of wetlands with their inherent nature conservation values.

Worldwide developments of paludiculture

- Paludiculture may involve multiple goals and multiple uses.
- Paludiculture is about peat conserving site conditions, not merely about crop types or products.
- Next to the concept "paludiculture" (which is about biomass production) it might be useful to use the wider concept "wet livelihoods", which also includes livelihood support based on wider payments for ecosystem services.

- Indonesia teaches us how to proceed: necessity is the mother of invention. >80 plant species in Indonesia can be used economically in paludiculture.
- The Baltic countries have big potential for paludiculture (with some exciting pilot studies and sites) but the social and administrative framework does not fully support the re-wetting of drained peat soils. In fact, still more drainage is going on than re-wetting.
- The paludi-inquiry learned that 32% of projects dealing with paludiculture are based on traditional use forms of wet peatland use. Innovation combined with tradition.
- Paludiculture can only be a small part in a very large solution. Rewetting peatlands means rewetting landscapes and reorganizing land use, incl. water management.
- Land use should adapt to climate restrictions, changes in diet for an ever larger population and most of all to the land and the soil.

Financing/economics/policy

- Landscape finance is a rapidly growing industry that offers an opportunity to design peatland solutions - including paludiculture, where needed - at much larger scale, with longer term funding and allowing for more precisely measurable impact.
- To engage in landscape finance requires partners willing to work at landscape scale, clear business cases with sustainable value chains, seed funding and credible finance partners.
- To engage in landscape finance for peatland requires partners willing to work together, at the landscape scale, showcasing clear business cases, combining funding sources, including for seed funding and credible finance partners.
- We need more circular bioeconomics with paludibiomass in the market. This can be stimulated by mandatory demand by public authorities, e.g. the use of paludiculture construction material in public construction, renovation and insulation projects.
- In the light of the ongoing climate change, policy instruments have to be strong and radical, not incremental. Incremental change might help to reduce fears in the short view, but in the end, it is too expensive and confuses the stakeholders too much. Nevertheless, policy instruments need testing fields, like paludiculture do.

Excursions

- First day's virtual excursions lead us to bog peatlands in NW Germany and the United Kingdom.
  - Different cultivation methods for Sphagnum as an intensive crop are tested in the UK, e.g. with spray irrigation leading to high growth rates,
  - Impressive progress in upscaling and optimising Sphagnum farming as sustainable land use option on degraded bogs was shown for NW Germany,
  - Adapted machinery still needs to be developed for Sphagnum farming, both for more efficient weed-management and for on-site harvesting, which would allow the reduction of causeways and increase the share of productive land.
- Second day's virtual excursions focussed on fen paludiculture in NE Germany:
  - Typha farming site set up on 10 ha former grassland in 2019, where lots of experience have been made in large scale site establishment,
  - Long term rewetted grassland delivers biomass for district heating plant,
  - Product range of typha and potential for building insualtion was shown,
  - A visit of the paludi-tiny house, built 2020 with products from wet meadow, reed cattail and alder biomass for roofing, insulation and interiors.

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