Wetland buffer zones for nutrients retention and cleaner waters

Factsheet 01/2021

Background

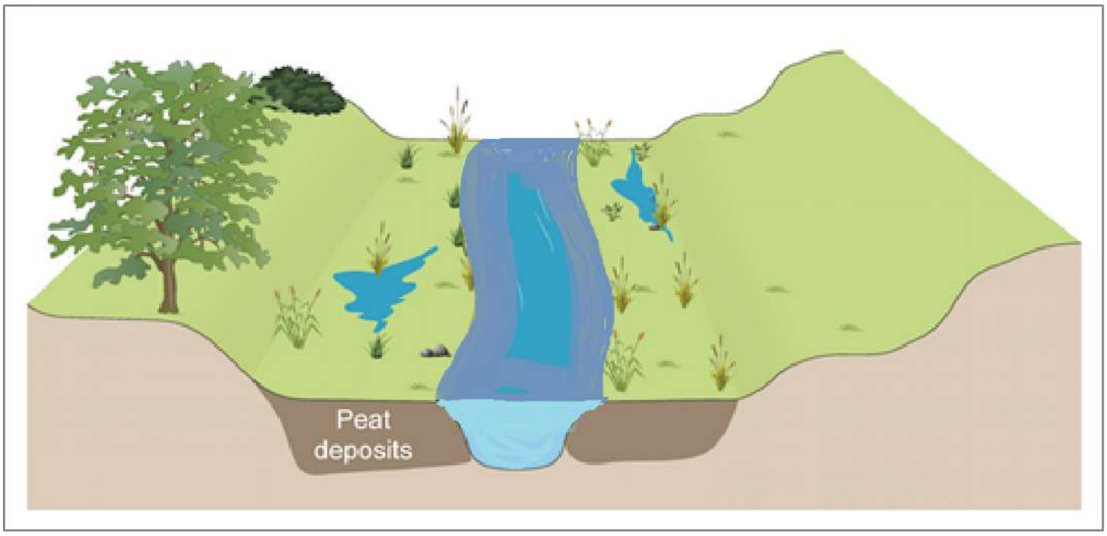
The aim of this factsheet is to present concise and science-based information on nutrient retention, peat conservation, and paludiculture as benefits of peatland protection and restoration. Intact and successfully restored wetlands - swamps, marshland, and fens - serve as "kidneys of the landscape" by filtering nutrients from ground- and surface water that flows through them. Furthermore, wetlands can accumulate carbon by transforming dead plant biomass into peat under waterlogged soil conditions. However, around 20% of the global peatland area and 90% of peatlands in the European Union are degraded due to human activities. Drainage and intensive, large scale agricultural use of peatlands lead to multiple ecological as well as economic problems, which can extend far beyond the peatland area. Mineralization of drained organic soils and excess use of fertilizers lead to pollution of adjacent surface waters (rivers, lakes), groundwater, and seas with nutrients (mainly nitrogen and phosphorus). Consequently, surface waters suffer from cyanobacteria blooming, formation of micro- and macroalgae mats and oxygen deficiency. As a result, living conditions for fish and other aquatic organisms are deteriorated, which has negative impacts on aquatic biodiversity, as well as on fishery, tourism industries, and local people's livelihoods. Further drawbacks of drainage are soil degradation and land subsidence, which increase the risk of flooding, drought and fires. These processes not only affect rural, but also urban areas. Moreover, drained peatlands are globally one of the primary sources of greenhouse gas emissions (mainly CO_2) and contribute to climate change. To restore important ecosystem services and meet the goals of climate protection, it is necessary to rewet drained peatlands, but first of all to protect the intact ones.

Riparian wetland in the Neman catchment area, Poland (J. Peters).

Efficiency of wetland buffer zones to remove nutrients

The projects DESIRE and CLEARANCE[1] have reviewed 82 studies from 51 publications on the removal efficiency of nitrogen (N) and phosphorus (P) by wetland buffer zones in temperate regions (Northern and Central Europe, Northern USA). A 'wetland buffer zone' (WBZ) is the transitional riparian area between terrestrial (e.g. agricultural land) and aquatic environments. WBZs purify waters by removal or retention of nutrients present in waters moving from terrestrial to riverine ecosystems, for instance, from agricultural fields to rivers. Various types of wetland buffer zones were included in the review: e.g., fens (ground- and surface-water fed peatlands), and floodplains with mineral soils "- wet lands" along streams or rivers. Wetland buffer zones may significantly improve water quality by filtering out agricultural nutrients such as nitrogen (N) and phosphorus (P).

[1] www.clearance-project.com, https://getidos.uni-greifswald.de/en/projects/current/clearance/



Schematic illustration of a riparian wetland buffer zone with fen peat deposits (changed after Walton et al., 2020).

Main results of the study of Walton et al. (2020) are:

- WBZs work as **effective barriers** for diffuse nutrient pollution from agriculture and ought to be recognized in large-scale, long-term pollution management.
- **Biological, chemical and physical** processes allow a WBZ to act as a nutrient sink.
- WBZs with organic soils (peatlands) and mineral soils have similar nitrate retention efficiency (53±28%; mean ± sd and 50%±32).
- When peatlands are **mineralizing and degrading,** they **release** large amounts of mobile dissolved N and soluble reactive phosphorus.
- Mean **removal efficiency** of both organic and mineral soils is **80%** for total nitrogen (TN) and **70%** for nitrate (at a load of < 160 kg N*ha*year).
- **Higher loads** of nitrogen in the catchment area (> 160 kg N*ha*year) **reduce TN removal efficiency** of WBZs **from 80 to 31%**, thus restoration of WBZs has to be integrated with reduction of nutrient inputs from the catchment area.
- **The longer water resides** within a WBZ, **the more efficient** nutrient removal and retention are.
- Vegetated land is generally more efficient in nutrient retention than bare soil, but nutrients are remobilized by decomposition after the plants die off. Trees store nutrients reliably and long-term, but they grow slower than herbs and grasses. Forest age also affects nutrient uptake: young trees have a higher nutrient requirement.
- Mowing and removal of plant biomass from a wetland can remove nutrients from the WBZs. Harvested biomass of reeds and sedges can be used as e.g. building material or for bioenergy. Such cultivation on wet organic soils is called *paludiculture*.
- Large-scale WBZ restoration is necessary to improve water quality and meet Water Framework Directive requirements.

Overall, WBZs can efficiently remove nutrients from water flowing to surface- and groundwaters, thus helping to maintain a better water quality.
However, many factors determine their nutrient removal efficiency, for instance, hydrology, soil characteristics, vegetation cover, nutrient input and agricultural use. Thus, each wetland restoration needs to be assessed individually in order to evaluate its potential for nutrient removal.

The peat forming potential of sedge species – results of an experimental study

The projects DESIRE and REPEAT had set up an experimental study to investigate if the peat-forming potential of sedge (*Carex*) species varies with nutrient availability. Sedges form peat under waterlogged conditions when biomass production is higher than decomposition. For the experiment, individuals of five different sedge species were collected from natural peatlands in Poland and cultivated into peat-filled pots for one vegetation period. For each of the five species, twelve different nutrient levels were simulated, all under water-logged conditions. The lowest nutrient level resembled nutrient-poor conditions of intact natural peatlands (3.6 kg N/ha/year), while the highest nutrient level corresponded to the annual N input in agricultural West European grasslands or Dutch floodplains (>400 kg N/ha/year).

Main results of the study (Hinzke et al. under review) are:

- **Biomass increase:** All sedges produced more root and shoot biomass (340-780%) with higher nutrient levels, with almost no saturation even at the highest nutrient level.
- **Biomass increase was species-specific**, i.e., some species grew more under higher provision of nutients than others. Species in the experiment with highest total biomass production were *Carex acutiformis* (19.7 t/ha) and *Carex rostrata* (19.3 t/ha), whereas the other three species produced a total biomass between 9 and 12 t/ha.
- **Decomposition** increased for plant material grown at higher nutrient levels, but root decomposition increase was smaller over increasing nutrient levels than root biomass increase: Highest root mass loss was seen for *C. elata* roots (62-74%), lowest for *C. lasiocarpa* and *C. appropinquata* (21-39% of initial root mass)
- **Peat forming potential:** Based on these results it can be concluded that *Carex* species can form peat even at high nutrient levels.
  For restoration projects on nutrient-rich peatlands, *Carex* species (particularly *C. acutiformis* and *C. rostrata*) contribute to peat formation, therefore, rewetting should facilitate optimum water levels for their growth.

Left and centre: Set up of pots for the trial on peat forming potential of sedges. Right: Carex appropinquata *whole plant (above and below ground biomass) Photos: Jürgen Kreyling, Franziska Tanneberger, Wiktor Kotowski.*

Lessons learned - recommendations derived from our studies

WBZs, including wet peatlands, efficiently remove N and P from waters. Additionally, peatland rewetting leads to benefits such as reduction of greenhouse gas emissions, higher biodiversity of wetland species, and possibilities for bio-economy.

→ Wherever possible, drainage of peatlands must be stopped, and drained peatlands must be rewetted to reduce nutrient discharge. The establishment of wetland buffer zones is an effective large-scale and long-term method for water quality improvement.

The nutrient removal capacity of wet peatlands and wetlands on mineral soils is limited but can be enhanced by taking nutrients from the system with biomass harvest.

→ Restoration measures need to be combined with good agricultural practice: fertilizer use must be reduced in the entire catchment. Additionally, harvesting of nutrient-rich vegetation (paludiculture) in WBZs should be considered as a measure for the additional removal of nutrients.

The nutrient removal efficiency depends on many factors and can vary among wetlands.

→ The efficiency can be improved by tailoring restoration measures to chemical properties and nutrient loads of inflowing waters, soil characteristics, water retention time, size of the area, and vegetation cover (Carstensen et al. 2020).

Paludiculture and wet agriculture

Paludiculture is the sustainable agricultural and forestry use of wet and rewetted peatlands (wet organic soils). Biomass harvesting and productive use of wet mineral soils is accordingly. Both paludiculture and agriculture on wet mineral soils are suitable management approaches in wetland buffer zones (WBZs). Typical wetland plants, such as cattail (*Typha* spp.) or common reed (*Phragmites australis*), grow well on nutrient-rich soils with a water table level of up to one meter above ground. Depending on species and biomass quality, the harvested biomass can be used as building material (e.g., insulation, roof thatching), or for bioenergy. In this way, paludiculture represents a win-win-situation of restoring degraded peatlands and continuing to use the land in an environmentally friendly manner. In addition, harvesting of biomass helps to remove nutrients (including agricultural pollutants) from WBZs, which prevents them from being discharged into surface- and groundwaters. Studies in fens (ground- and surface-water-fed peatlands) in the Netherlands involving biomass harvest showed nitrogen retention efficiencies of up to 93-99% (Koerselmann 1989, Wassen & Olde Venterink 2009). Other types of paludiculture are currently tested: Growing of *Sphagnum* mosses on rewetted bogs might substitute peat in horticulture and grazing with water buffalos can be a sustainable way to produce meat and dairy products in wetlands.



Left: Typha harvest in Kamp, Germany (Photo: W. Wichtmann). Centre and right: Energy pellets and construction plates made of common reed and cattail, respectively. (Photos: www.wetland-products.com).

Introduction (or promotion) of wetland plants and harvesting biomass can restore the peat forming potential and significantly increase the amount of nutrients removed by the peatland. Additionally, this is the prerequisite for sustainable land use on peatlands.

→ Implementation of paludiculture should be considered when aiming at restoring a peatland, especially when the main aim is the reduction of nutrient leaching.

Looking further – benefits and challenges of rewetting and paludi-culture

Rewetting and the sustainable use of peatlands provide a wide range of ecosystem services to society. At the same time, but require some challenges solved.

Benefits:

- **Reduction of catastrophes:** Restoring peatlands prevents flooding, continued soil subsidence, peat fires, and desertification.
- **Water quality and wildlife:** Restoring wetlands reduces nutrient discharge into adjacent water bodies and algal blooms and therewith helps to restore biodiversity and habitats in watercourses.
- **Climate change mitigation:** Rewetting peatlands reduces greenhouse gas emissions and contributes to climate change mitigation.
- **Sustainable land use and renewable raw materials:** Paludiculture and wet agriculture allow a shift from drainage based, land degrading site management to sustainable land use practices, which provide multiple ecosystem services and produce renewable fossil-free products, e.g., bio-energy, insulating boards, or other construction materials. By using such products, additional climate protection effects can be achieved.

Challenges:

- **Changes in the agricultural policy framework:** The aim of the European Common Agricultural Policy (CAP) must be to eliminate subsidies that are harmful to the environment. Supporting schemes (subsidies, direct payments) must be redesigned according to the principle of "public money only for public goods". An agricultural policy adapted to peatland requirements would also increase planning security for farmers.
- **Yield potential and demand:** The potentials of paludiculture are determined by the biomass yield and the demand for paludiculture raw materials. New value chains and innovative networks need to be established by stakeholders.
- **Alternative for unsustainable land use** (abandonment, peat extraction, drained forestry): Rewetting and implementation of wet utilization schemes provide sustainable solutions and give perspectives for foresters and farmers.
- **Changes in attitude**: Presently only biodiversity policies (habitat and bird directives) acknowledge the benefits of peatland restoration while unsustainable use of peatlands is still accepted by society. A change in attitudes and policies is required to acknowledge the full ecosystem services of wetlands, including water purification and climate change mitigation.
- **Conflicting goals between nature conservation and paludiculture:** If nature conservation aspects prevail, a different rewetting, planting and harvesting approach may be required in terms of timing, extent, species selection and techniques than in a more production-based approach.
- **Policy objectives and land use**: After all, the aim is to achieve specific climate and water protection targets. A paradigm shift from conventional use to paludiculture is needed.

Literature

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Find out more:
https://projects.interreg-baltic.eu/projects/desire-183.html
https://www.moorwissen.de/en/paludikultur/projekte/desire/index.php
www.neman-peatlands.eu