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Powerful peatlands

Since the 17th century, vast areas of peatlands were drained in the name of progress and expanding agriculture. Today we know that this endeavour has turned a major carbon sink into a carbon source. To fight climate change, we now need to restore peatlands and develop sustainable land use including paludiculture. **Michael Gross** reports.

The last ice age left Europe and other northern continents with a legacy of wetlands. In the millennia since, many of these developed a layer of peat, defined as dead plant material with a high content of fixed carbon that has accumulated under water-saturated conditions that leave decomposition incomplete. On average, the peat deposits are three to four metres deep with maximum depths of up to 12 metres. Undrained wetlands that are still actively forming new peat are known as mires. Their image has changed repeatedly in European history.

Historically, there were multiple ways of gaining livelihoods out of the natural resources of active mires, including eel fishing, hunting of waterfowl, harvesting of reeds and use of peat as fuel. The dangers of the terrain gave these landscapes a bad name, with multiple myths and legends referring to people disappearing in the moors in one way or another. Numerous victims of ritual killings reappeared centuries later as well-preserved bog bodies.

Thus, the case for progress, law and order, and expanding agricultural production was to drain the swamps and use the land for agriculture instead. This requires large-scale infrastructure such as channels, dykes and pumps. In the 16th century, the Dutch started a business model that spread across Europe — to encourage investors to pay for the infrastructure in exchange for a part of the agricultural land gained.

This appealed to the rulers of the rising nation states across Europe. In France, Henry of Navarre (1553–1610) sent a request for expert help to the Netherlands in 1596. In England, the conversion of the Fens in Cambridgeshire met opposition from a local MP called Oliver Cromwell (1599–1658) as well as from militant residents known as the Fen Tigers, but proceeded regardless, even under Cromwell's rule as Lord Protector. Frederick the Great (1712–1786) of Prussia arranged for the wetlands of the river Oder (Oderbruch) to be drained.

The history of draining in the name of progress and reclaiming land for agriculture continued well into the 20th century. From 1933, political prisoners held in Nazi labour camps were forced to work in drainage projects in the Emsland area in today's Lower Saxony. A ban on singing existing political song led to the creation of the famous protest song *Die Moorsoldaten* (Peat bog soldiers). Even as late as the 1970s, Finland conducted one of the biggest conversion programmes draining 300,000 hectares per year and destroying 60% of its peatland area.

The awakening environmental consciousness then recognised wetlands as habitat of disappearing species, which led to some areas being protected, although industrial removal of peat for gardening and agriculture continued elsewhere.

Only in recent years have the surviving peatlands found recognition in a new role that may save their survival and the planet. As peatlands are known to store more carbon per surface area than tropical rainforests, they are now celebrated as climate guardians.

Peatland policy

In September 2023, more than 500 participants gathered for a conference in Antwerp, Belgium, with the programmatic title 'Power to the peatlands'. Senior researchers present all agreed it was the biggest peatlands gathering they had seen, not even counting the online participants following the proceedings from afar.

Climate change is the main reason why interest in the field is spreading beyond the group of people who enjoy putting on their Wellington boots to wallow in the mires. Peatlands still store 600 billion tons of carbon worldwide, more than forests or grasslands, while taking up much less space. Converting active peatlands to agricultural land is a major contributor to carbon dioxide emissions from land-use change. Draining the land allows oxygen into the incompletely decayed plant material and thereby leads to carbon dioxide emissions. Therefore, protecting and

Low lands: Population pressure and generous investments made the Netherlands a pioneer in draining wetlands to create new land for agriculture. The iconic windmills now admired by tourists often served as pumps to remove water from low-lying areas. (Photo: R Boed/Flickr (CC BY 2.0 DEED).)

Wet again: Wetlands once drained in the name of progress now urgently need to be rewetted, to curb their emissions of greenhouse gases. The photo shows a peatland rewetting site in Moscow Province, Russia. (Photo: Tatiana Kitain/Flickr.)

restoring them can make a major contribution to the fight against climate change.

Thus, topics like monitoring greenhouse gas emissions from various types of peatlands, along with the challenges and climate benefits of peatland restoration were main subject areas of the two days of presentations at the Antwerp conference. As the focus lay on the long-suffering peatlands of Europe, case studies from across the continent and beyond were presented, and participants had the choice between six different peatland ecosystems in Belgium and the Netherlands to visit on the final day of the meeting, ranging from the ambitious restoration project at Valley of the Zwarte Beek to a degraded bog at De Nol that has been exploited since the 14th century.

Considering the relatively new emphasis on the nexus between peatlands and climate change, experts in the field are also learning how to interact with climate policy and make decision-makers listen. A final declaration of the conference addresses the European Union and calls to preserve all natural peatlands, accelerate rewetting of drained ones, and to include ambitious peatland restoration targets in the EU's Nature Restoration Law currently under deliberation.

To achieve these policy goals, communication will be a key requirement. Politicians and voters will have to be pulled away from the historically entrenched view of moors as the opposite of progress. Even the more recent appreciation as a nice ecosystem to have for birdwatchers is not good enough. It is vital that decision-makers and the general population at large understand that at this point, with climate targets wobbling under the assault of right-wing populists, the conservation and restoration of peatlands is both a cost-effective and a scaleable way of fighting climate change.

As part of the necessary communications offensive, the Michael Succow Foundation, partner in the Greifswald Mire Centre, together with BUND (Bund für Umwelt und Naturschutz Deutschland) and the Heinrich Böll foundation, all in Germany, supported by the UNEP-led Global Peatlands Initiative launched at the conference their Peatland Atlas, a 60-page brochure presenting the essential facts in accessible form (https://www.greifswaldmoor.de/peatland-atlas.html). Among other things the Atlas highlights the very different situations of peatlands around the globe. Compared with the historic destruction across Europe, North America's vast boreal and arctic peatlands have suffered smaller proportional losses due to the lower population pressure, whereas the temperate ones were drained to a similar extent. Some Northern areas have been lost due to resource extraction, however, and even the small fraction of peatlands degrading in Canada still produces significant greenhouse gas emissions.

Ecologically different but equally important peatlands can also be found around the tropics. In Indonesia, large-scale losses due to development as well as peatland fires have recently given way to progress in restoration projects. In South America, where areas like the Pantanal are in danger (Curr. Biol. (2022) *32*, R495–R497), very little is known about their distribution or specifics, making it harder to protect them. Africa has some of the largest peatland areas, e.g. in the Congo Basin, in East Africa as well as in South Africa and Madagascar. Their degradation produces an estimated 130 million tonnes of CO_2 equivalent per year, with more than a tenth of the amount coming from Madagascar.

Given the large emissions quietly seeping out of decaying peatlands, it is of utmost importance to have comprehensive information about them from the local to the global level. The United Nations Environment Programme (UNEP) published a Global Peatlands Assessment in November 2022 with a global peatlands map (https://tinyurl.com/yc5vybb2). The Greifswald Mire Centre maintains a global peatland database that is updated regularly (https://tinyurl.com/2z8j2vbc).

It is even more challenging to quantify the changes over time. Etienne Fluet-Chouinard from Stanford University, USA, and colleagues recently attempted to pin down the proportion of wetlands lost since 1700 around the globe (Nature (2023) *614*, 281–286). They arrived at a global loss of 21% but much higher figures for Europe, China and the USA. The authors call for continuous monitoring of the state of the world's wetlands in order to extend their assessment in real time and help protect the remaining ecosystems.

Restoration and rewetting

Where peatlands have been drained but the area is still available for restoration, a path to be considered is allowing the water back in to its natural level, a process called rewetting. Depending on the circumstances, it is not a given that this measure will restore the natural state and restart carbon sequestration. While rewetting often stops carbon

dioxide emissions, it may lead to the release of methane. A lot of research in recent years has gone into the questions around if, where, and how to rewet drained peatlands.

Anke Günther from the University of Rostock, Germany, and colleagues modelled the likely climate effects of peatland managing practices, including rewetting projects, based on the Global Peatland Database (Nat. Commun. (2020) *11*, 1644). The researchers conclude that the expected methane release does not undermine the overall positive climate contribution of rewetting. As drained peatlands continuously release large quantities of carbon dioxide from degradation of the peat, the biggest benefit can be gained from the earliest possible rewetting and the carbon dioxide emissions it avoids. As a bonus, the restored ecosystem may later resume its function as a net carbon sink. To reach the Paris goal of climate neutrality by 2050, the authors conclude, "CO_2 emissions from (almost) all drained peatlands have to be stopped by rewetting".

But can rewetting turn back time? Jürgen Kreyling from the University of Greifswald and colleagues assessed 320 rewetted fen peatland sites in comparison with 243 near-natural peatland sites of similar origin across temperate Europe (Nat. Commun. (2021) *12*, 5693). The authors found that some rewetted sites return to a near-natural state, but many others display significant differences in biodiversity and ecosystem functions, possibly because of the duration and intensity of their drainage. The authors caution that existing knowledge of natural peatlands may not be adequate to describe these novel ecosystems and their development.

Most recently, Curtis J. Richardson, Neal E. Flanagan and Mengchi Ho from Duke University at Durham, USA, published a case study detailing the carbon balance of Pocosin Lakes National Wildlife Refuge and adjacent peatland sites in coastal North Carolina (Ecol. Engineer. (2023) DOI: 10.1016/j.ecoleng.2023.107011). A characteristic type of shrub bog known as pocosin peatlands is found along the Atlantic coast from Virginia to northern Florida. These peatlands have deep peat soils and are covered by woody shrubs rather than the low-growing *Sphagnum* moss found in more northern peatlands. Left undisturbed, their organic soil can keep carbon locked in for millennia.

Peat moss: *Sphagnum* species are among the plants that can be cultivated in wetlands for commercial gain as well as for ecosystem restoration. (Photo: Patrick Alexander/Flickr.)

Based on their analyses of data from nearly 20 years of long-term monitoring and research in this area, the authors conclude that rewetting those areas of drained pocosin peatlands that are no longer economically used in agriculture or forestry could make a significant contribution to the US climate targets while also generating carbon credit income for the landowners.

Cultivated swamps

Beyond carbon credits, there are other ways to make a living from wet peatlands. The Peatland Atlas specifies 30 examples of plant product types that can be obtained from wet peatland management that preserves peat, so-called paludiculture. Reed (*Phragmites australis*), for instance, can be used in construction (as thatch or boards) or as fuel or for biogas production. Peat moss (genus *Sphagnum*) and bulrush (genus *Typha*) can be harvested as a growing medium for gardening to substitute for peat. Gipsywort (*Lycopus europaeus*), sundew (*Drosera rotundifolia*) and bogbean (*Menyanthes trifoliata*) are of pharmaceutical interest, whereas cranberries (subgenus *Oxycoccus* of the genus *Vaccinium*) are an example of a suitable food crop.

Franziska Tanneberger from the University of Greifswald and colleagues have used examples from Germany to assess the climate balance and economic viability of various types of paludiculture in typical European peatlands (Reg. Environ. Change (2022) *22*, 69). The authors note that expanding the rewetting and restoration to deeply drained peatlands currently under cultivation will produce opportunity costs. These could be compensated at least partially by implementation of paludiculture. This fundamental change in how the land is used will at first require public incentives and investments. The authors also recommend to "initiate the establishment of the pilot and best practice demonstration sites with special attention to decentralised solutions to address the large variety of environmental and socio-economic conditions" and also "to strengthen research into paludiculture crops, water tables and management options to optimise climate and other environmental effects and economic consequence".

In recent years, we have learned that the historically maligned mires, swamps, peat bogs, and such like don't have to be the opposite of progress and civilisation. On the contrary, they can be the foundation for substantial progress in fighting the climate catastrophe, the biggest problem now facing our civilisation.

Michael Gross is a science writer based at Oxford. He can be contacted via his web page at www.michaelgross.co.uk