The Deurnese Peel peatland, the Netherlands, one year after the fire. Photo: Hans Joosten.

IMCG Bulletin 2021-3: May – June 2021

The international peatland news that matters

INTERNATIONAL MIRE CONSERVATION GROUP

www.imcg.net

Contents of this Bulletin

IMCG issues

Word from the Secretary-General

Dear mire friends,

Again a densely packed Bulletin illustrating the dynamics and urgency of peatland conservation all over the world. A reminder in this Bulletin is the information on the IMCG Field Symposium, Congress and General Assembly in South Africa and the Kingdom of Eswatini in December 2021. Please inform the organizers quickly about your possible participation in person, so that they can proceed with the complex organization.
Furthermore a call for nominations for the new IMCG Board. Election will – like former times – be organized via email enabling all members to participate and acquiring a fully representative new Main Board. Please consider nominating yourself and contribute to promoting the cause of international mire conservation.
Keep sending news, photographs, papers and other contributions for the next July-August IMCG Bulletin **by September 1, 2021** to Hans Joosten at joosten@uni-greifswald.de.

IMCG Field Symposium, Congress and General Assembly, 5 – 15 December 2021O

The 2021 IMCG Field Symposium with an online General Assembly will take place in December 2021. The idea is to have a somewhat shorter than normal genuine field symposium in South Africa and the Kingdom of Eswatini from 5 to 13 December, followed by a scientific Conference (hybrid, i.e. in person and online) on 14 December and our IMCG General Assembly (only online) on 15 December 2021, both hosted by the University of Eswatini. Additionally "virtual" excursions and field discussions on Southern African peatlands and their management problems will be offered in the format of digital "story maps". After these meetings, three post-symposium field trips will be offered from 15 to 22 December 2021. More information you can find in the March-April Bulletin.
The in person costs of the Field Symposium and Conference are €950 (all in, excl. your trip to and fro South-Africa), those of the post symposium tours €400 - 600 (implementation will depend on the level of interest).
Please express your interest in participating in the genuine field symposium and post-symposium field trips as soon as possible, so that our colleagues can proceed with organization and bookings.

Please use https://docs.google.com/forms/d/e/1FAIpQLSffYEjz63N6buBv6Y2O35tqvmq-HMOEyH-2oMJN7tVwN1kJYg/viewform to register. The local organization can be reached under imcg2020sa@gmail.com

IMCG General Assembly 14 December 2021

On the IMCG General Assembly 2021 in the Kingdom of Eswatini only a limited number of IMCG members will be present in person, and only limited time will be available. Therefore we will arrange the discussions and decisions largely beforehand and by internet and email. The IMCG Bulletin 2021-2 (March-April) contained the preliminary agenda for this Assembly and in the beginning of November 2021 we will produce a Bulletin containing the documents for the Assembly and all information on how the voting per email will be done. We will furthermore open a special place on the website where discussion papers can be made available. Therefore: provide the IMCG secretariat with additional agenda points and submit your background papers, concrete proposals, draft resolutions, contributions for discussion, nominations for the IMCG Main Board and for Honorary Life membership, etc. until 31 October 2021. Send the material in as soon as possible to joosten@uni-greifswald.de – the sooner the better – so that we can arrange the democratic procedures in a smooth way.

Main Board nominations

At the 2021 IMCG General Assembly we will elect a new IMCG Main Board and we invite your nominations. Don't hesitate to run for MB member: we need 15 members for a full Main Board and we should again strive for a fair

representation with respect to geography, expertise, gender, and age. Please send in your nomination with some information on your person, your involvement in mire conservation and your ideas on how you envisage that IMCG should function and your possible roll in that. Examples of nominations you can find in the IMCG Bulletins of 2018:

http://www.imcg.net/modules/download_gallery/dlc.php?file=290&id=1552072916 pp. 2 – 3
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Olivia Bragg

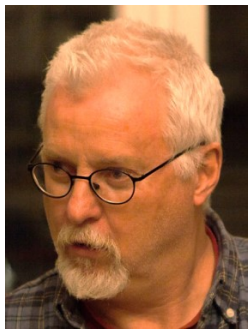

Zhao-Jun Bu


Ab Grootjans


Samantha Grover


Piet-Louis Grundling


Rodolfo Iturraspe


Hans Joosten


Wiktor Kotowski


Tapio Lindholm


Tatiana Minayeva


Francis Muller


Faizal Parish


Line Rochefort


Rob Stoneman


Franziska Tanneberger

The current IMCG Main Board. Try to be part of it next time ;-)

Mires and Peat

In May - June 2021 the following papers were published in Mires and Peat:

- Peat swamp biodiversity in the Qizimei Mountain National Nature Reserve, China. [H. Wang, T.T. Li, N. Ran, M.Y. He, H.Q. Jiang & Z.X. Wang] Volume 27: Article 17 http://mires-and-peat.net/pages/volumes/map27/map2717.php
- A baseline soil survey of two peatlands associated with a lithium-rich salt flat in the Argentine Puna: physico-chemical characteristics, carbon storage and biota. [M.F. Chiappero, M.V. Vaieretti & A.E. Izquierdo] Volume 27: Article 16 http://mires-and-peat.net/pages/volumes/map27/map2716.php

- Seed germination and seedling survival of *Drosera rotundifolia* (L.) cultivated on *Sphagnum*: Influence of cultivation methods and conditions, seed density, *Sphagnum* species and vascular plant cover. [B. Baranyai, M. Krebs, C. Oehmke & H. Joosten]. Volume 27: Article 15 http://mires-and-peat.net/pages/volumes/map27/map2715.php
- Degradation legacy and current water levels as predictors of carbon emissions from two fen sites. [W.-J. Emsens, E. Verbruggen, P. Shenk, Y. Liczner, M. van Roie & R. van Diggelen] Volume 27: Article 14 http://mires-and-peat.net/pages/volumes/map27/map2714.php
- Soil CO_2 emissions and net primary production of an oil palm plantation established on tropical peat. [N. Wakhid & T. Hirano] Volume 27: Article 13 http://mires-and-peat.net/pages/volumes/map27/map2713.php
- On the hydrological relationship between petrifying-springs, alkaline-fens, and calcareous-spring-mires in the lowlands of North-West and Central Europe; consequences for restoration. [A.P. Grootjans, L. Wolejko, H. de Mars, A.J.P. Smolders & G. van Dijk] Volume 27: Article 12 http://mires-and-peat.net/pages/volumes/map27/map2712.php
- Assessment of using state of the art unmanned ground vehicles for operations on peat fields. [R. Kägo, P. Vellak, E. Karofeld, M. Noorma & J. Olt] Volume 27: Article 11 http://mires-and-peat.net/pages/volumes/map27/map2711.php
- Analysis of the effect of composite peat-based hydrophobically-modifying additives on the properties of Portland cement and cement mortar. [O. Misnikov] Volume 27: Article 10 http://mires-and-peat.net/pages/volumes/map27/map2710.php

Find the journal online at http://mires-and-peat.net/ Electronic submission is required using our dedicated electronic submission system. If you experience any problems please contact the Editor-in-Chief Olivia Bragg (o.m.bragg@dundee.ac.uk) who can offer alternative routes for electronic submission.

***Mires and Peat*: the 2020 impact factors**

Olivia Bragg (o.m.bragg@dundee.ac.uk)

The latest Journal Impact Factors (JIFs) and other citation statistics were published on 30 June 2021. These are called the '2020 impact factors' because they tell us how many times the articles we published up to the end of 2019 were cited (i.e. referred to) by authors publishing during 2020. For *Mires and Peat*, the (two-year) JIF has increased by 7.2 % (from 1.328 to 1.425) since last year. The underlying calculation is that 87 articles published between 01 Jan 2018 and 31 Dec 2019 were cited 124 times during 2020 across all journals in the *Web of Science* database. The top ten articles attracted 32 citations (4 or 3 each), meaning that the remaining 92 citations were shared amongst 77 articles with 3 or fewer citations apiece. Our 2020 five-year impact factor shows an improvement of 30.7 % over last year, telling us that each qualifying article we published during the five-year period 2015–2019 was cited, on average, 2.434 times during 2020. Possible conclusions are that a substantial proportion of our articles have been immediately useful to other authors, and that items published previously have continued to be relevant for several years after the two-year JIF window passed over them. The latter impression is reinforced by a visit to the current Citation Report in *Web of Science*, which shows that our most recent 284 articles have now received 1,904 citations in total, giving an average of 6.71 citations per item.

More generally, the official 2020 statistics (Table 1) are encouraging in that total citations and the JIF have been trending mostly upwards since 2014. However, it is possible that JIFs calculated prior to 2020 are not accurate because the Clarivate (formerly Thomson Reuters) system did not correctly navigate the publication schedules of all volumes of the journal. We hope the problem will disappear with our new focus (from 2020) on producing just one 'standard' volume of *Mires and Peat* per calendar year - as was intended when the journal was originally conceived.

Although the parallel series of special volumes has now been discontinued, we remain receptive to occasional suggestions for 'very special' additional volumes, as well as to the submission of single articles distilled from proceedings/discussions at workshops and conferences (Volume 20, Article 13 is a splendid example). And of course we retain our flexibility on everything else including the peaty topics covered by your manuscripts and the disciplines from which they are drawn, the use of colour illustrations and the variety of supplementary materials that can be added. Some recent mind-broadening contributions that spring to mind are Articles 15 and

22 in Volume 26; and Articles 12 and 17 in Volume 24. Article 16 of Volume 19 remains a firm favourite although you may need to download/enable to see its full glory. In other words, *Mires and Peat* welcomes creativity within the constraints of journal format and may be able to publish elements that other journals cannot accommodate; but of course, please still send us your regular manuscripts as well.

Table 1. Mires and Peat *citation statistics 2014–2020 (source: Clarivate, July 2021). Note the discrepancies between 'No. citable items' logged by Clarivate and the numbers of peer reviewed articles that we actually published (in parentheses) in most years; indeed, it is not totally clear which data from this Table were actually used to calculate any of the impact factors.*

Year	No. citable items	Total citations	2-year Impact Factor (JIF)	5-Year Impact Factor
2020	30 (30)	745	1.425	2.434
2019	56 (52)	508	1.328	1.862
2018	31 (40)	437	1.868	1.802
2017	20 (32)	347	1.326	1.638
2016	32 (34)	261	1.129	1.956
2015	11 (22)	227	1.095	n/a
2014	7 (20)	190	0.806	n/a

Drained peatland in Iceland. Photo: Hans Joosten.

Papers

The fluvial landscape of lower Mesopotamia: an overview of geomorphology and human impact

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Hans Joosten (Greifswald University/Greifswald Mire Centre, joosten@uni-greifswald.de)

Introduction

It is well-known that Mesopotamia means "between the rivers" (from the Greek μέσος – mesos: middle - and ποταμός – potamos: river, see Finkelstein 1962). Indeed, eastern/southeastern Iraq consists predominantly of fluvial landscapes of the rivers Tigris and Euphrates, whereas in adjacent southwestern Iran - directly north of the Persian Gulf – landforms have been shaped by the Karun River. Anthropogenic impact on the landscape has been intensive since the early/middle Holocene. Numerous wars and social instability have hampered earth-scientific and archaeological survey in the region since the 1980s, and consequently relevant knowledge is not at the present-day international standard. During the last two decades, however, research could be intensified greatly, and numerous gaps are now being closed (Master & Woldai 2004, 2007; UNEP 2009; Hritz et al. 2012a; Adamo & Al-Ansari 2020m), despite that field survey still is not safe.

Recently, we initiated a research program on the perception of mires/peatlands/wetlands by ancient cultures (De Klerk & Joosten 2019), and the various Mesopotamian societies play an important role in this respect. Reconstructing the wetland perception of these ancient cultures requires a thorough understanding of the landscape, its development, and the human interaction with that landscape. Earlier studies have dealt with the geology and geomorphology of Iraq and adjacent areas, but none of these suffices completely for our purposes because of their different research contexts.

For that reason, we studied various geological/geomorphological publications of the relevant regions and made a compilation geomorphological map (Fig. 1) that focusses on fluvial landscape types relevant for an understanding of the human-wetland interaction. Most processed studies base on satellite imagery (mostly Landsat and CORONA; cf. Walstra et al. 2010a/b, 2011; Jotheri & Allen 2020; Nadali 2021) for which groundtruthing was hardly possible because of safety considerations. Transliterated spelling of geographical names in this paper is standardised after the English edition of GoogleEarth (version of May 2021), historical topographical names are standardised after Bryce & Birkett-Rees (2016).

Around the rivers

The western part of Iraq consists of deserts and rocky plateaus consisting of or underlain by Tertiary limestone, marl, gypsum, and dolomite deposits (Sissakian & Fouad 2015). In the desert, many wadis only transport water during rare high precipitation events. Various wadis run to the dry lake of the Al-Nukhib depression that, consequently, contains water only incidentally; other wadis run to the Mesopotamian floodplain (Aqrawi et al. 2006). The Zagros mountains lie to the east and northeast of the floodplain, and extensive foothills – which are also underlain by calcareous deposits (Saleh et al. 2020) – lay between the mountains and the Tigris River. Various alluvial fans in front of the foothills were predominantly formed during the Pleistocene (Aqrawi et al. 2006; Yacoub 2011a/b; Sissakian et al. 2020a/b). Extensive fans ("megafans") along the lower Karun River in the Iranian part of lower Mesopotamia originate from the mid or late Holocene (Heyvaert et al. 2013). The alluvial fan east of Razazza Lake – actually a wadi fan – dates to the Pleistocene (Yacoub 2011b). The fan of the Wadi Al Batin stretches to the coast and also covers part of Kuwait (Morozova 2005; Sissakian et al. 2014), but in papers on the geology of Kuwait its extension does not fit that as indicated in geo(morpho)logical data from Iraq (see Gunatilaka 1986; Al-Sulaimi & Mukhopadhyay 2000). Most research indicates along the Tigris River in the northern part of the fluvial landscape an area of river incision with prominent terraces (dark-green areal in Fig. 1). Yacoub (2011a/b), however, identified these terraces as a large alluvial fan from early and middle Pleistocene age (see Yacoub 2011a who discusses the different opinions and underlying thoughts).

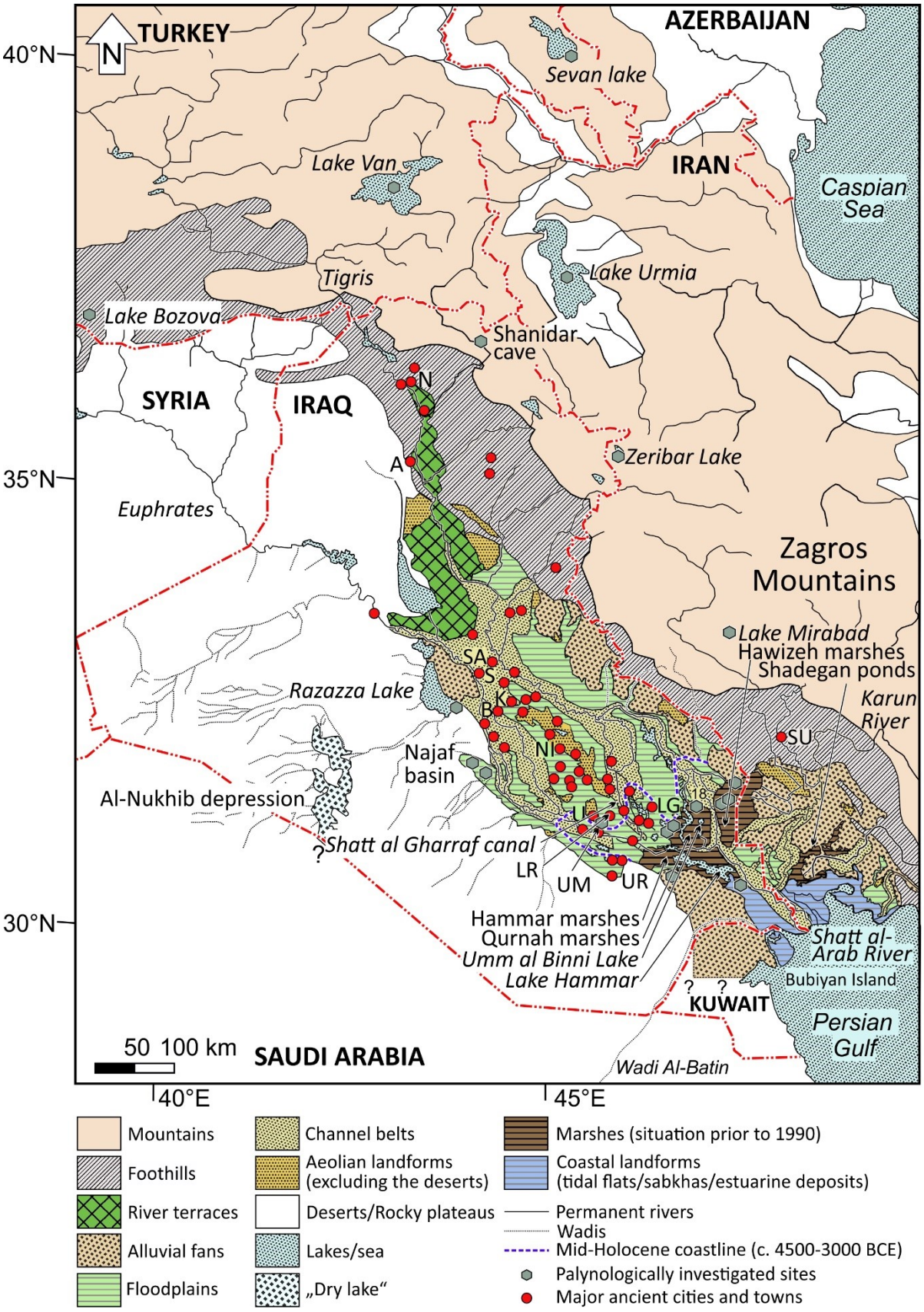

Fig. 1: Geomorphology of Mesopotamia and the location of major settlements. *Compiled after: Aqrawi (1997), Al-Sulaimi & Mukhopadhyay (2000), Pournelle (2003, 2017), Morozova (2005), Aqrawi et al. (2006), Heyvaert & Baeteman (2007), Walstra et al. (2010a), Yacoub (2011b), Heyvaert et al. (2013), Sissakian & Fouad (2015), Azhdari & Bironro (2018), Sissakian et al. (2020a/b/e), counterchecked with satellite images from GoogleEarth (2020-edition). Locations of major settlements compiled after Morozova (2005) and Frahm (2013): A: Ashur; K: Kish; LG: Lagash; LR: Larsa; N: Nineveh; NI: Nippur; S: Sippar; SA: Sippar Amnanum; SU: Susa; UM: Tel Umm al-Aqrab.*

The southern Mesopotamian fluvial landscape

Total thickness of Holocene sediments in lower Mesopotamia is around 15-20 m (Yacoub 2011b; Jotheri 2016; Sissakian et al. 2020). The early and mid-Holocene development of the landscape was predominantly ruled by sea level rise (Al–Sheikhly et al. 2017; Pournelle 2017). Sissakian et al. (2020d) discussed various theories from the 20th and early 21st centuries CE on sea level changes and note that there is absolutely no consensus. To us, the scenario that the highest sea level - and thus the maximum inland extent of the Persian Gulf - was reached around 4500 BCE appears the most likely. The extent of the Gulf changed only minimally by alluvial infill along its northwestern shore until a larger relative marine regression after c. 3000 BCE allowed the progradation of the alluvial landscape (cf. Pournelle 2017; Sissakian et al. 2020d). Apart from fluvial and sea level dynamics, also tectonic subsidence influenced the elevation of the landscape (Sissakian et al. 2020c).

Channel belts

Various sandy belts across Mesopotamia reflect different river courses, which were partly synchronously active. Widening of the belts will relate to lateral fluvial extension. The large volumes of sediments transported by the rivers caused a rapid filling-in of the channels, which resulted in a continuous rise of the riverbeds up to several meters above the surrounding floodbasins (Verhoeven 1998; Adamo & Al-Ansari 2000c).

The higher position of the river level led to regular breaches of the levees and a diversion of a part of the water stream that resulted – on small scales – in crevasse channels and crevasse splays running into the floodbasins (Fig. 2; see Makaske 2001) and – on a large scale – in avulsions. The consequent formation of new parallel channels formed an anastomosing fluvial pattern (cf. Makaske 2001). In lower Iraq five major channel belts occur next to each-other, three belts occur in the Kuran river fans (Fig. 1), and a single belt in front of these leads to the sea. It is likely that various river avulsions were anthropogenically caused, either intentionally or unintentionally (Cole & Gasche 1998; Heyvaert & Baeteman 2008; Heyvaert et al. 2013; Sissakian et al. 2020d). Sissakian et al. (2020c) posed that avulsion may furthermore have been induced by tectonic processes(see also Stouthamer & Berendsen 2000).

Figure 2: Satellite image displaying fan-like crevasse splays with many active and inactive channels leading water from the River Tigris into its western floodbasins. The curved channels appear natural, the straight channels have been anthropogenically modified.

Most belts contain – next to still active river branches – numerous fossil channels (Cole & Gasche 1998; Heyvaert & Baeteman 2008; Jotheri et al. 2016). Verhoeven (1998) speculated that the rivers changed to meandering in the second part of the Holocene by building-out the channel belts of the previously anastomosing river branches. The channel belts of the various branches of the Euphrates River terminate far before the present-day coast of the Persian Gulf (Jotheri 2016, see Fig. 1): fluvial energy will have been too low to build the belts further and slow-flowing water allowed the development of the southeastern marshes. The Tigris had considerably more energy and sediment load because of its steeper gradient (Jotheri 2016) and, thus, was able to build a sandy channel belt through the marshes. A detailed chronology of the various river courses that would allow the reconstruction of the sequence of belts development does not yet exist, but a basis for such a fluvial chronology has been laid by Cole & Gasche (1998) and Jotheri et al. (2016) by comparing written records of various courses.

Floodbasins

The floodbasins lay several metres deeper than the rivers and their levees (see previous text-section). The natural floodbasins will have comprised marshes, lakes and pools.

A dense system of up to several thousand small channels crosses the Mesopotamian floodplains. The channels mostly terminate in the floodbasins, and many will have been natural mire-streams or crevasse channels (Fig. 2). Many channels, however, will have been artificially dug for agriculture to allow irrigation, drainage and transport (see text-section "human impact"; see also Verhoeven 1998; Hritz 2010; Yacoub 2011b; Jotheri 2016, 2018; Wilkinson 2017; Sissakian et al. 2020a/b). By breaching the levees, humans may also have artificially initiated crevasse splay development in order to lead water streams into the floodbasins (Fig. 2).

Floodbasin deposits - for which numerous core data scattered over lower Mesopotamia are available - consist predominantly of clay and silt. Although luxurious reed beds will have grown in the floodbasins (see text-section "vegetation history"), peat is very rare, even in the southeastern marshes (cf. Baeteman 1980; Aqrawi 1997; Verhoeven 1998; Aqrawi et al. 2006; Heyvaert & Baeteman 2007, 2008; Issa 2010; Walstra et al. 2010a; Benni & Al-Tawah 2011; Hritz et al. 2012b; Heyvaert et al. 2013; Jotherti 2016; Jotheri et al. 2016, 2018; Al–Sheikhly et al. 2017; Altaweel et al. 2019; Albadran 2021). Few cm thin layers of dark-coloured mud dominated by remains of *Phragmites* and *Typha* (Aqrawi 1997; Aqrawi et al. 2006) have regularly been erroneously described as peat (Aqrawi 1997). Aqrawi (1997) and Aqrawi et al. (2006) noted that at deeper levels more organic matter occurs: in northeastern Kuwait under Bubiyan Island, for example, peat occurs between 24.5 and 20 m below the present surface and dates to c. 7500-6700 BCE (Gunatilaka 1986 quoting a conference abstract by A.Z. Al-Zamel). In warm and precipitation-poor Mesopotamia, rapid decay of organic matter will have hampered the formation of peat. Furthermore, continuing river sedimentation and intensive agriculture will have frustrated the formation of peat layers. It is not yet known which parts of Mesopotamia were cultivated during which periods, and to what extent natural vegetation types were common.

The southeastern marshes

In front of the rivers, a marsh landscape with vast reeds developed after the retreat of the sea (Fig. 3). This landscape included the large Hammar, Qurna, and Hawizeh marshes, which gradually expanded seaward (Al-Ansari et al. 2012; Jotheri 2016). The precise timing and causes of marsh progradation are a matter of discussion, but it seems that the process started around 3000 BCE (see Aqrawi 1997; Pournelle 2017; Jotheri 2016). This date corresponds with a shift to a drier climate (Altaweel et al. 2019), which may have contributed to decreased river discharge and increased terrestrialisation along the palaeocoast. The name "Sealand" for the marsh region is attested since the mid 2nd millennium BCE (Bagg 2020), which implies that around this time marsh formation had progressed to such extent that a separate landscape was recognisable. The Shadegan marshes in the Iranian part of southeastern Mesopotamia were formed not later than the 10th century CE after the development of a new alluvial ridge had blocked the discharge of water (Walstra et al. 2011).

In contrast to the Tigris, the Euphrates had insufficient energy and suspended matter (cf. Jotheri 2016) to build up sandy belts in the marshes: the water probably flew dispersed through the fens. Adamo & Al-Amsari (2020g) note that in the Sassanid period, i.e. around 600 CE, the marshes reached their largest extent. After 1991 CE the Saddam Hussein regime drained almost the complete marsh area (see text-section "human impact"). Whereas

also the marshes do not contain significant amounts of peat (see text-section “floodbasin”), they have a surficial layer of dark organic-rich sandy silt of 10-50 cm thick (Yacoub 2011b; Albadran 2021).

Figure 3: Reed marshes in the undrained remnant of the Al Hawizeh marsh, with a pathway for boat navigation. Photograph: Curtis J. Richardson (Duke University Wetland Center).

The estuary

Near the coast, the Euphrates, Tigris and Karun rivers join and continue to flow in a single channel – known as the Shatt al-Arab river that partly forms the border between Iraq and Iran - through an estuary into the Persian Gulf. In and around the estuary the landscape consists predominantly of tidal flats, tidal channels and marine sabkhas (salt flats) (Yacoub 2011a/b).

Desertification and salinization

A major geomorphological process in the Mesopotamian fluvial area with its dry and hot climate is desertification with wind easily blowing sand and dust into the basins (Yacoub 2011b). After the channel belt in the central part of Mesopotamia (with the ancient city of Nippur) became inactive, the sandy deposits were reactivated by wind that modified the belt (Al-Ameri & Jassim 2011; Yacoub 2011b; Sissakian et al. 2020e). Some aeolian landforms also developed on the alluvial fans along the Iraqi/Iranian border.

Evaporation results in salinization and the formation of salt flats (inland-sabkha; not displayed in Fig. 1) in the lakes and the floodbasins, and also in an increasing salt content of the groundwater (Adams 1981; Jabbar et al. 2010; Yacoub 2011b; Adamo & Al-Ansari 2020c; Abdullah et al. 2020c; Sissakian et al. 2020e). For example, the Najaf basin - indicated as a part of the floodplain in Fig. 1 - in recent times changed to an inland sabkha (Benni & Al-Tawah 2011). Minor salt crusts occur frequently in the landscape. A decrease of the already rare precipitation as a result of ongoing global warming will increase desertification and salinization in the future (Sissakian et al. 2020e).

Vegetation history

High-resolution palaeoecological data are available from lakes in the mountains surrounding the Mesopotamian lowland, including from Lakes Mirabad (Van Zeist & Bottema 1977), Zeribar (e.g. Van Zeist & Bottema 1977) and Urmia (e.g. Bottema 1986; Djamali et al. 2008) in Iran, from Sevan Lake in Armenia (Leroy et al. 2016; Robles et al. 2020), and from Lakes Van (e.g. Van Zeist & Woldring 1978; Wick et al. 2003) and Bozova (S. Bottema in the European Pollen Database) in Turkey. In the northeastern Iraqian mountains palaeoecological studies were

carried-out in the Shanidar cave, a well-known site with remains of Neanderthals (Solecki & Leroi-Gourhan 1961; Al-Ameri et al. 2011). These studies provide detailed information on the palaeoenvironment of the Near East in general but are hardly relevant for reconstructing the wetland vegetation in lower Mesopotamia.
Various pollen diagrams from the Iraqian lowlands exist but their low temporal resolution, few identified pollen types and methodological uncertainties provide only crude insights in the vegetation development of the fluvial landscape. Data from Razazza Lake indicate how a Weichselian steppe vegetation (represented by high amounts of pollen attributable to Chenopodiaceae) was succeeded by a vegetation of Poaceae (grasses), *Quercus* (oak) and *Polypodium* (polypody) (Alrawi et al. 2005). The pollen diagram from "Core 18" in the north of the southeastern mires shows a marked decrease of pollen attributable to Chenopodiaceae also, corresponding to rises in pollen attributable to grasses and palm trees (Al-Ameri et al. 2001; Al-Ameri & Jassim 2011) that were interpreted as the Pleistocene-Holocene transition (Al-Ameri et al. 2001; Al-Ameri & Jassim 2011). In the present-day inland sabkha of the Najaf basin, the lower parts of two cores contain mainly pollen attributable to pine (*Pinus*) and grasses (Benni & Al-Tawah 2011) which were interpreted as indicating a somewhat moister climate. Various 1-m cores from the marshes show predominantly pollen attributable to grasses, *Crinum* and *Tofieldia* with incidental occurrences of pollen attributable to Typhaceae (cattail family) and *Isonandra* (Al-Ameri & Jassim 2011). A profile from an ancient river channel at the Tel Umm al-Aqrab site dating back to c. 3000 BCE shows much pollen attributable to *Typha* and grasses, which may reflect reedbeds along the river, whereas furthermore a dryland (levee?) vegetation can be inferred with palms and date palms, and in earlier times *Carpinus* (hornbeam). Phytolith analyses at various sites indicate for the early and mid-Holocene the presence of grasses, sedges and reeds. *Arundo donax* (giant cane/elephant grass/wild cane/giant reed) could be identified as a reed species, while oak (*Quercus*) and date palm (*Phoenix dactylifera*) were important tree species in the earlier Holocene (Altaweel et al. 2019). Whereas oak disappeared in the early Holocene (Altaweel et al. 2019), date palm remained and was important as a food resource (Bouchaud et al. 2012; Fig. 4).

Figure 4: Date palm plantation along the Euphrates River. Photograph: Curtis J. Richardson (Duke University Wetland Center).

Archaeobotanical studies near Sippar demonstrated the past presence of date palm, poplar (*Populus*) and Tamarisk (*Tamarix*) (Van Zeist 1984). The genus *Populus* includes various typically riverine tree species that may have grown on the river levees and whose wood was frequently used for construction (Van Zeist 1984; Ghazanfar & McDaniel 2016). The genus *Tamarix* includes many species that occur predominantly in dry desert/steppe habitats but also along riverbanks (Ghazanfar & McDaniel 2016): the plants can tolerate the rather salty soils, which are currently widespread (Ohrtman & Lair 2013). Furthermore, charcoal of *Pinus halepenis*-type was found, which probably derives from *P. brutia* (Turkish pine), the only pine species native in Iraq (Van Zeist 1984; Ghazanfar & McDaniel 2016). For former levee forests along the Tigris and Euphrates Willcox (1992) named *Salix* (willow), *Populus euphratica* (Euphrates poplar), *Fraxinus syriaca* (Syrian ash), *Platanus orientalis* (old world sycamore), *Juglans regia* (walnut tree), *Vitex agnus-castus* (chaste tree), and *Tamarix aphylla* (athel tamarisk).

Wetland plants identified in archaeobotanical studies from the Sippar and Abu Tbeirah areas that will have grown in the reedbeds include *Arundo donax*, *Bolboschoenus maritimus* (sea clubrush), *Cyperus* (e.g. *C. rotundus*), and *Typha angustifolia* (Van Zeist 1984; Romano et al. 2021). Probably these species were used as raw material for the construction of utilities (see Romano et al. 2021). Crop plants remains found at Sippar, Kish and Ur include *Hordeum* (barley), *Triticum dicoccum* (emmer wheat), *T. durum/aestivum* (i.e. common wheat or durum), *Lens culinaris* (lentil), *Pisum sativum* (pea), *Coriandrum sativum* (coriander), *Cuminum cyminum* (cumin), *Allium sativum* (garlic), *Pistacia* cf. *atlantica* (pystachio) and *Pyrus malus* (apple tree) (Field 1932; Ellison et al. 1978; Van Zeist 1984). Not all these plants will have occurred in ancient Mesopotamia: various of their products will have been imported from abroad (Van Zeist 1984).

Wetland fauna

Inherent to wetlands, animal live consists of numerous mollusc, fish, fowl, turtle, and small mammal species (Veldhuis 2004; Bagg 2020; Albadran 2021; Esmaeili 2021; Jawad 2021a; Salim et al. 2021). Wild (i.e., not-domesticated) large mammal species include grey wolf, long-fingered bat, smooth-coated otter, honey badger, striped hyena, jungle cat (also known as reed or swamp cat), wild boar, lion, goitered gazelle, crested porcupine, and roe deer, which all have been attested to thrive until recently (Bagg 2020; Jawad 2021a).

Human impact

Agriculture in the Fertile Crescent, including Mesopotamia, started around 11000 BCE (Haywood 2005; Bryce & Birkett-Reese 2016). Not later than the 7th millennium BCE the lower Tigris and Euphrates floodplains started to be inhabited by people of the so-called Ubaid culture (Bryce & Birkett-Reese 2016; Radner 2017; Adamo & Al-Ansari 2020b). During the Ubaid 2 period (4880-4500 BCE) numerous artificial canals were constructed that must have supported irrigation-based agriculture (Adamo & Al-Ansari 2020b). Rapid urbanisation – following the increase of agricultural production– is inferred for the Ubaid 3 period (4500-4000 BCE) and continued in the subsequent Uruk and Jemdet Nasr periods (4000-2900 BCE). During these latter periods, the various Sumerian city states developed (Adamo & Al-Ansari 2020b), including Ur and Uruk, which were located along the coast of that time (Fig. 1). A centralised authority must have developed in the city states of the 4th millennium BCE to coordinate regional canal construction and maintenance (Frahm 2013; Adamo & Al-Ansari 2020b; Nadali 2021), which may have triggered the development of writing around 3400-3200 BCE (Haywood 2005; Haarmann 2017). Simultaneously, geometry and trigonometry and tools for land measurement developed in order to calculate areas of agricultural fields and volumes of harvested products (Adamo & Al-Ansari 2020c). Frequent floods required protection works such as dikes and overflow areas (Cole & Gasche 1998; Heyvaert & Baeteman 2008; Abdullah et al. 2020b; Adamo & Al-Ansari 2020c). This incited many conflicts and wars between the city states, which all put their own interests above those of their neighbours (Adamo & Al-Ansari 2020c; Nadali 2021).

The state of Akkad (2350-2150 BCE) unified the lower Mesopotamian peoples in a single empire (Adamo & Al-Ansari 2020c), which made large-scale hydrological regulation more efficient. The climate anomaly of c. 2200-2000 BCE – the so-called 4.2 ka event that in the Near East was characterised by severe drought (Riehl 2008, 2017; Höflmayer 2017; Kaniewski et al. 2018; Robles et al. 2020) - may have aided in the collapse of the Akkadian empire (Cullen et al. 2000; Bar-Matthews & Ayalon 2011; Weiss 2017). Subsequently, the Sumerian state of the Ur III dynasty (c. 2150-2000 BCE) ruled major parts of lower Mesopotamia (Adamo & Al-Ansari 2020c). Gradual immigration of the Amorite people out of Canaan resulted in an increasing Semitic population, which eventually took-over the rule of Mesopotamia (Burke 2017). Although Sumerian culture was preserved, the Sumerian language was replaced with the Semitic Babylonian language (Adamo & Al-Ansari 2020d). King Hammurabi (c. 1810-1750 BCE) developed the legal "Hammurabi code", which included many articles on agriculture and hydrological management (Adamo & Al-Ansari 2020d) and, thus, gave land-use a jurisdictional basis. At this time, the Old Assyrian empire flanked the Tigris and Euphrates Rivers upstream of Babylonia (Bryce & Birkett-Reese 2016; Adamo & Al-Ansari 2020b). Kassite people – which had immigrated from the Zagros mountains (Haywood 2005) – subsequently provided the ruling class of Babylonia (Bryce & Birkett-Reese 2016; Adamo & Al-Ansari 2020d). Being located at some distance from the Mediterranean coast, Mesopotamia did not suffer directly from the mysterious Sea Peoples - which ransacked the eastern Mediterranean coasts in the first half of the 12th

century BCE - but was subject to the subsequent general societal unrest in the Near East (Haywood 2005; Bryce & Birkett-Reese 2016). Elamite people - from the western ranges of the Zagros mountains and its foothills - took-over the rule of the Babylonian country around 1150 BCE (Haywood 2005; Adamo & Al-Ansari 2020d), after which the armies of the Neo-Assyrian empire conquered lower Mesopotamia (Adamo & Al-Ansari 2020d/e/f). Starting in the 9th century BCE the Semitic Chaldean people from the Western Levant immigrated into the southeastern marshes (Adamo & Al-Ansari 2020f) and overtook Babylonia from the Assyrians in 626 BCE to rule the so-called Neo-Babylonian empire. In 539 BCE the Persian Achaemenids annexed Babylonia. Adamo & Al-Ansari (2020f) remarked that the Neo-Babylonian and Achaemenid periods were characterised by growth of wealth and the resettlement and cultivation of long-abandoned areas. The armies of Alexander the Great invaded in 336 BCE (Haywood 2005; Adamo & Al-Ansari 2020f) and after the division of his empire under his military commanders, general Seleucus integrated Babylonia in the Seleucid empire (Adamo & Al-Ansari 2020g). Regional military instability resulted in tensions and wars, and Mesopotamia became part of the Parthian empire in 141 BCE and of the Sasanian empire in 224 CE (Adamo & Al-Ansari 2020g). This empire perished in 652 CE after which Islamic empires controlled the Mesopotamian area following immigration from Arabia (Adamo & Al-Ansari 2020g/h/i). The new ruling class introduced the name Iraq, which may have been derived from the city-name Uruk (Adamo & Al-Ansari 2020h). A cultural decline took place in the late 1st millennium CE because of social and economic instability, rapid change of rulers, and frequent wars (Adamo & Al-Ansari 2020l). The situation even worsened after the Mongolian invasion of 1258 CE resulting in an ever declining economic and agricultural system and numerous invasions. Only after the defeat of the Ottoman empire in 1918 and the establishment of the modern state Iraq in 1920 the country became sufficiently stable to provide its inhabitants again with some prosperity until new wars and social unrests started in the 1980s (Adamo & Al-Ansari 2020m).

Although the rulers and the ruling class changed frequently, agricultural techniques remained rather similar over the millennia. The new rulers primarily wanted a share in the prosperity of the country and were not hostile towards the lower Mesopotamian cultures in which they assimilated (Haywood 2005). One remarkable technical change was the introduction of animal power to move water in the first millennium BCE (Ahram 2021).

Settlements in the riverine landscape were primarily erected on river levees or connected crevasse splays (Adams 1981; Morozova 2005; Yacoub 2011b; Sissakian & Fouad 2015; Jotheri et al. 2016, 2018). In addition to being positioned at these higher landscape elements, various cities were built on artificial hillocks ('tells'), which increased their height even further (Yacoub 2011a; Alhawi et al. 2017; Altaweel et al. 2019; Sissakian et al. 2020a). Settlements were predominantly oriented towards the branches of the Euphrates, which had a smaller discharge and a lower flow velocity than the Tigris: the latter also had less predictable and more violent floods (Adams 1981; Verhoeven 1998; Morozova 2005; Adamo & Al-Ansari 2020c). Furthermore, the general east-west slope of the lower Mesopotamian plain made drainage and irrigation more effective in the western regions (Adamo & Al-Ansari 2020c). In the southeastern marshes settlements were erected on artificial floating islands that sustained a solid habitation (Al-Ansari et al. 2012) with a lifestyle that persisted among the Marsh Arabs up to the destruction of the marshes in the 1990s (see Thesiger 1964; Young 1977; Al-Ansari et al. 2012; Jawad 2021b).

Hydrological works were indispensable to make the floodbasins suitable for agriculture. Using remote sensing, Hritz (2010) identified some 5000 archaeological sites, whereas Jotheri (2016) found even 8000 sites along the numerous minor channels crossing the floodbasins (although various of these sites post-date the ancient societies relevant for our study). Irrigation was in general gravity based, meaning that the canals run from the higher alluvial belts into the lower floodbasins (Adamo & Al-Ansari 2020h). Whereas remote sensing reveals a dense network of irrigation canals in the floodbasins, it is unknown which canals date to which period, and which were active simultaneously. The extent of agriculture and population structures during specific cultural periods is, therefore, unknown (see Cole & Gasche 1998). It can be expected that - although techniques remained similar - expanding population and thus a greater need for food resulted in the increase of canals and agricultural fields in the course of time, and in canals becoming increasingly longer and wider (Adamo & Al-Ansari 2020e/f). By creating levee breaches humans may have artificially initiated crevasse channels/splays in the floodbasins as inception for irrigation canals (see Fig. 2). Furthermore, canals possibly also developed from preferred travel routes with boats (Fig. 3) or by water buffalo herding (so-called "hollow ways", see Jotheri et al. 2019). A major

achievement among the hydrological works was the Lumna-gimdug canal – the present-day Shatt Al Gharraf River – which runs over almost 200 km, connects Tigris with the Euphrates, and was first incepted in the mid-3rd century CE after which it was gradually enlarged (Adamo & Al-Ansari 2020c). The hydrological techniques were so successful that the Assyrian rulers imported them in their own core territory around Ashur and Nineveh to supply the cities more effectively with water (Adamo & Al-Ansari 2020e). After a flood around 629/627 BCE the Tigris was cut-off from its main branch and re-directed into the Lumna-gimdug irrigation canal that subsequently became its principal course (Adamo & Al-Ansari 2020c/h). The damage could not be repaired, and the eastern floodbasins lost their water supply (Adamo & Al-Ansari 2020h).

According to Adamo & Al-Ansari (2020g), neglect of the southern Tigris dikes in the 6th century CE resulted in breaks, and inflow of the Tigris water in the surrounding floodbasins triggered a further expansion of the southeastern marshes. After the start of the Islamic period in 652 CE irrigation works reached their maximum pre-industrial extent (Adamo & Al-Ansari 2020h), and exotic crops like rice, sugarcane or cotton flourished. Afterwards, canals continued to be constructed and became increasingly larger in size (Adamo & Al-Ansari 2020i/j/k).

After the cultural decline in the late 1st millennium CE the landscape became neglected, and canals and their maintenance deteriorated (Adamo & Al-Ansare 2020l; Ahram 2021). It was not until the 20th century that the country started to prosper again, and new barrages and dams were constructed for hydrological regulation (Abdullah et al. 2019a/b, 2020a/b). The lower marshes were widely destroyed by hydrological projects, especially in the 1990s, to facilitate agriculture, urban expansion, and oil exploration (Richardson & Hussain 2006; UNEP 2009; Jabbar et al. 2010; Al-Ansari & Knuttson 2011; Yacoub 2011a; Lonergan 2012; Jawad 2021a; Ahram 2021). But there were military reasons for this destruction as well: after the 'Battle of the marshes' in 1984 CE during the first Gulf war, violent campaigns against the Marsh Arabs started in 1991 during the second Gulf war (Al-Ansari et al. 2012; Lonergan 2012; Bagg 2020; Ahram 2021). Consequently, the former marsh area became highly contaminated with munition and poison gas (Al-Ansari & Knutsson 2011; Al-Ansari et al. 2012; Fig. 5). Due to the drainage, the aeolian input caused an expansion of dune areas, and the drying-out facilitated expansion of inland sabkhas (Jabbar et al. 2010; Yacoub 2011b). Since 2003 projects are in progress to restore the areas as much as possible (Richardson & Hussain 2006; UNEP 2009; Jabbar et al. 2010; Yacoub 2011a/b; Al-Ansari et al. 2012; Lonergan 2012; Jawad 2021c).

Figure 5: The dried-out Al Hawizeh marsh (near the Iraqi/Iranian border) with tank treads remaining from warfare. Photograph: Curtis J. Richardson (Duke University Wetland Center).

Dating of vegetation phases, river activity and human impact

The scarcity of organic matter makes radiocarbon-dating – which could provide a chronology for landscape developmental phases - a challenge. Until now in most cases shell remains have been dated (e.g. Aqrawi 1993,

1995; Jotheri et al. 2016, 2018; Bogemans et al. 2017a/b), which may be subject to an aging hardwater effect (Bogemans et al. 2017). Although various calcareous deposits persist in the deeper underground of the regions around the Mesopotamian floodplain (Saleh et al. 2020), these were assumed to be too far away to have any effect on the carbonates in the shells, and therefore a hardwater effect would be negligible (e.g. Hritz et al. 2012b). This hypothesis is in contrast with the studies of Maulood & Hassan (2021) and Salman et al. (2021) who found that the water in the southeastern marshes was very calcareous in the 1980s which it will also have been in the past. Bogemans et al. (2017a/b) also dated root material that – penetrating from a higher younger level – may also provide unreliable results (Törnqvist et al. 1992). Some organic-rich sediment layers have also been dated (Aqrawi 1995; Heyvaert & Baeteman 2007; Hritz et al. 2012b; Bogemans 2017a/b), but without knowledge what precisely makes-up the amorphous organic matter the reliability of the dates remains unknown. The alternative could be to date pollen concentrates (see Regnell 1992), although this method is also subject to possible errors of which the causes are still unknown (Kilian et al. 2002; De Klerk & Brumlich 2018).
For the time being, thus, the precise dates of vegetation phases and river activity are still only roughly known, but numerous archaeological remains in the floodplain sediments allow dating specific periods rather accurately.

Possible meteor impact

The Umm al Binni lake in the Qurna marshes has – because of its near circular basin with an elevated rim and a c. 500 m wide ring around the lake – been proposed to be a meteor crater, tentatively dated to between c. 3000-2000 BCE (Master 2001; Master & Woldai 2004, 2007). It has even more tentatively been correlated to c. 2350 BCE ash layers found in Syria and in a marine sediment core near Oman (Master & Woldai 2004). The impact – if the assumption is correct – must have had a large effect on the contemporaneous landscape and population. The spot was in the 3rd millennium BCE still covered by the Persian Gulf in front of the expanding alluvial landscape: if it would have triggered a tsunami that reached far into the Mesopotamian lands, it may have been the event on which the Great Flood stories of the 'Gilgamesh-epic' – according to Foster (2019) first conceived around 2100 BCE – and the 'Atra-hasis' – from the early 2nd millennium BCE (Dalley 2008) - are modelled (Master & Woldai 2004). Indeed, the 11th tablet of the Gilgamesh epos has the deluge story start with a reference to a large cloud and a thundering sound (Foster 2019).
The evidence of Umm al Binni being an impact crater is, however, scant and ambiguous, which Master & Woldai (2004, 2007) stressed themselves. They expressed their regret that because of ongoing political instability the necessary field investigations were impossible in the 2000s. Sissakian & Al-Bahadily (2018) and Sissakian et al. (2020c) evaluated the theory with help of satellite imagery and noted that many surface structures that should have occurred at an impact crater are absent. They posed that tectonic activities and human impact shaped the lake, but they could also not visit the structure in the field because of safety concerns. Indeed, there are some indications that a meteorite impacted in the Near East around 2360-2340 BCE that influenced or even destructed human societies (Baillie & McAneney 2015; see Courty 1998), but it is at present only a matter of speculation where the impact took place.

Concluding remarks

In the course of time, starting in the early or mid-Holocene, the land "between the rivers" lost its natural character and was transformed into an increasingly cultural landscape with an intensive interaction of human and fluvial processes. Already early in the Holocene the landscape will have been mainly cultural. When and to what extent natural floodbasin marshes still existed is unknown, but they will have gradually decreased as a consequence of increasing population and expanding agriculture.

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References

Adullah, M., Al-Ansari, N. & Laue, J. (2019a): Water resources projects in Iraq: reservoirs in the natural depressions. Journal of Earth Sciences and Geotechnical Engineering 9,4: 137-152.

Adullah, M., Al-Ansari, N. & Laue, J. (2019b): Water resources projects in Iraq: irrigation projects on Euphrates. Journal of Earth Sciences and Geotechnical Engineering 9,4: 169-199.

Abdullah, M., Al-Ansari, N., Adamo, N., Sissakian, V.K. & Laue, J. (2020a): Floods and flood protection in Mesopotamia. Journal of Earth Sciences and Geotechnical Engineering 10,4: 155-173.

Abdullah, M., Al-Ansari, N., Adamo, N., Sissakian, V.K. & Laue, J. (2020b): Major irrigation systems on Tigris River within Mesopotamia. Journal of Earth Sciences and Geotechnical Engineering 10,4: 175-198.

Abdullah, M., Al-Ansari, N., Adamo, N., Sissakian, V.K. & Laue, J. (2020c): Soil salinity of Mesopotamia and the main drains. Journal of Earth Sciences and Geotechnical Engineering 10,4: 175-198.

Adamo, N. & An-Ansari, N. (2020a): Prelude. Journal of Earth Sciences and Geotechnical Engineering 10,3: 1-3.

Adamo, N. & An-Ansari, N. (2020b): Man's first strides (the Prehistoric Era). Journal of Earth Sciences and Geotechnical Engineering 10,3: 5-16.

Adamo, N. & An-Ansari, N. (2020c): The Sumerians and the Akkadians: the forerunners of the first civilization (2900-2003BC). Journal of Earth Sciences and Geotechnical Engineering 10,3: 17-39.

Adamo, N. & An-Ansari, N. (2020d): In Old Babylonia: irrigation and agriculture flourished under the Code of Hammurabi (2000-1600 BC). Journal of Earth Sciences and Geotechnical Engineering 10,3: 41-57.

Adamo, N. & An-Ansari, N. (2020e): The Neo-Assyrians: warriors and canal builders under Sennacherib (911-609BC). Journal of Earth Sciences and Geotechnical Engineering 10,3: 59-86.

Adamo, N. & An-Ansari, N. (2020f): Babylon in a new era: the Chaldean and Achaemenid empires (330-612 BC). Journal of Earth Sciences and Geotechnical Engineering 10,3: 87-111.

Adamo, N. & An-Ansari, N. (2020g): The Greeks and the Sassanids - a new glorious era for agriculture (330-625 AD). Journal of Earth Sciences and Geotechnical Engineering 10,3: 113-135.

Adamo, N. & An-Ansari, N. (2020h): The first century of Islam and the question of land and its cultivation (636-750 AD). Journal of Earth Sciences and Geotechnical Engineering 10,3: 137-158.

Adamo, N. & An-Ansari, N. (2020i): Agriculture and irrigation of Al-Sawad during the Early Islamic Period and Baghdad irrigation: the booming period. Journal of Earth Sciences and Geotechnical Engineering 10,3: 159-181.

Adamo, N. & An-Ansari, N. (2020j): The Abbasids and Tigris irrigation canals: The Nahrawan. Journal of Earth Sciences and Geotechnical Engineering 10,3: 183-222.

Adamo, N. & An-Ansari, N. (2020k): Sammara and its canals. Journal of Earth Sciences and Geotechnical Engineering 10,3: 223-251.

Adamo, N. & An-Ansari, N. (2020l): The decline. Journal of Earth Sciences and Geotechnical Engineering 10,3: 253-281.

Adamo, N. & An-Ansari, N. (2020m): Epilogue. Journal of Earth Sciences and Geotechnical Engineering 10,3: 283-285.

Adams, R. McC. (1981): Heartland of cities. Surveys of ancient settlement and land use on the central floodplain of the Euphrates. The University of Chicago Press, Chicago / London, 384 pp.

Ahram, A.I. (2021): Human ecology of the marshes. In Jawad, L.A. (ed.): Southern Iraq's marshes. Their environment and conservation. Coastal Research Library 36. Springer, Cham: 55-76.

Al-Ameri, T.K. & Jassim, S.I. (2011): Environmental changes in the wetlands of Southern Iraq based on palynological studies. Arabian Journal of Geosciences 4: 443–461.

Al-Ameri, T.K., Al-Jubouri, B.S. & Al-Dolayni, A.S. (2001): Palynological evidences for events of the historical deluge on Mesopotamian peoples and the future climatic changes. In Youssef, E.A.A. (ed.): Geology of the Arab world. Proceedings of the fifth international conference on the geology of the Arab world, Cairo University, February 2000. Volume III. Geology Department, Faculty of Science, Cairo University, Giza: 1575-1584.

Al-Ameri, T.K., Jasim, S.Y. & Al-Khafaji, A.J.S. (2011): Middle Paleolithic to Neolithic cultural history of North Iraq. Arabian Journal of Geosciences 4: 945-972.

Al-Ansari, N. & Knutsson, S. (2011): Possibilities of restoring the Iraqi marshes known as the Garden of Eden. Water and climate change in the MENA-Region. Adaptation, Mitigation, and Best Practices. International Conference, April 28-29, 2011 in Berlin, Germany, not paginated.

Al-Ansari, N., Knutsson, S. & Ali, A.A. (2012): Restoring the garden of Eden, Iraq. Journal of Earth Sciences and Geotechnical Engineering 2,1: 53-88.

Albadran, B.N. (2021): Sedimentology and mineralogy of Quaternary sediments of marshes, south of Iraq. In Jawad, L.A. (ed.): Southern Iraq's marshes. Their environment and conservation. Coastal Research Library 36. Springer, Cham: 201-214.

Alhawi, N.A., Albadran, B.N. & Pournelle, J.R. (2017): The archaeological sites along the ancient course of Euphrates River. American Scientific Research Journal for Engeneering, Technology, and Sciences: 29(1): 1-20.

Al-Rawi, Y.T., Al-Tawash, B.S. & Al-Ameri, T.K. (2005): Pollen evidence of late Quaternary vegetation and inferred climatic changes of Lake Razzaza, western Iraqi desert. Iraqi Bulletin of Geology and Mining 1,2: 1-13.

Al–Sheikhly, S.S., Al–Jumaily, W.A., Al-Ka'abi, F.S., Al–Shehmany, Z. Kh. & Owen, M.A. (2017): Late Pleistocene - Holocene paleoecology of Southern Mesopotamia, Iraq. Journal of Science 58: 1856-1873.

Al-Sulaimi, J. & Mukhopadhyay, A. (2000): An overview of the surface and near-surface geology, geomorphology and natural resources of Kuwait. Earth-Science Reviews 50: 227–267.

Altaweel, M., Marsh, A., Jotheri, J., Hritz, C., Fleitmann, D., Rost, S., Lintner, S.F, Gibson, M., Bosomworth, M., Jacobson, M., Garzanti, E., Limonta, M. & Radeff, G. (2019): New insights on the role of environmental dynamics shaping southern Mesopotamia: from the pre-Ubaid to the early Islamic period. Iraq 81: 23-46.

Alwan, N. (2013): Euphrates River. In Howarth, R.W. (ed.): Biomes and Ecosystems. Salem Press, Ipswich: 20-23.

Aqrawi, A.A.M. (1993): Implications of sea-level fluctuations, sedimentation and neotectonics for the evolution of the marshlands (ahwar) of Southern Mesopotamia. Quaternary Proceedings 3: 21-31.

Aqrawi, A.A.M. (1995): Correction of Holocene sedimentation rates for mechanical compaction: the Tigris-Euphrates Delta, Lower Mesopotamia. Marine and Petroleum Geology 12: 409-416.

Aqrawi, A.A.M. (1997): The nature and preservation of organic matter in Holocene lacustrine/deltaic sediments of lower Mesopotamia, SE Iraq. Journal of Petroleum Geology 20: 69-90.

Aqrawi, A.A.M., Domas, J. & Jassim, S.Z. (2006): Quaternary deposits. In Jassim, S.Z. & Goff, J.C. (eds.): Geology of Iraq. Dolin, Prague / Moravian Museum, Brno: 185-198.

Azhdari, A. & Bironro, M. (eds.) (2018): Geological map of Khozestan proviance. Geological Survey of iran South west Teritory (Ahvaz), Ahvaz.

Baeteman, C. (1980): Geomorphological features in the area of Abū Ḥabbah and Tell ed-Dēr. In De Meyer, L. (ed.): Tell ed-Dēr. Sounding at Abū Ḥabbah (Sippar). Peeters, Leuven: 15-21.

Bagg, A.M. (2020): The unconquerable country: the Babylonian marshes in the Neo-Assyrian sources. Water History 12: 57-73.

Baillie, M. & McAneney, J. (2015): Why we should not ignore the mid-24th century BC when discussing the 2200–2000 BC climate anomaly. In Meller, H., Arz, H.W., Jung, R. & Risch, R.: 2200 BC – Ein Klimasturz als Ursache für den Zerfall der Alten Welt? 2200 BC – A climatic breakdown as a cause for the collapse of the old world? 7. Mitteldeutscher Archäologentag vom 23. bis 26. Oktober 2014 in Halle (Saale), 7th Archaeological Conference of Central Germany October 23–26, 2014 in Halle (Saale). Tagungen des Landesmuseums für Vorgeschichte Halle 12/II: 833-844.

Bar-Matthews, M. & Ayalon, A. (2011): Mid-Holocene climate variations revealed by high-resolution speleothem records from Soreq Cave, Israel and their correlation with cultural changes. The Holocene 21: 163-171.

Benni, T.J. & Al-Tawash, B.S. (2011): Palynological evidences on paleoclimate and paleoenvironmental changes during Late Quaternary of Bahr Al-Najaf depression, Central Iraq. Iraqi Journal of Geology and Mining 7/2: 1-28.

Bogemans, F., Boudin, M., Janssens, R., & Baeteman, C. (2017a): New data on the sedimentary processes and timing of the initial inundation of Lower Khuzestan (SW Iran) by the Persian Gulf. The Holocene 27: 613-620.

Bogemans, F., Janssens, R. & Baeteman, C. (2017b): Depositional evolution of the Lower Khuzestan plain (SW Iran) since the end of the Late Pleistocene. Quaternary Science Reviews 171: 154-165.

Bottema, S. (1986): A late Quaternary pollen diagram from Lake Urmia (Northwestern Iran). Review of Palaeobotany and Palynology 47: 241-261.

Bouchaud, C., Thomas, R. & Tengberg, M. (2012): Optimal use of the date palm (*Phoenix dactylifera* L.) during Antiquity: anatomical identification of plant remains from Madâ'in Sâlih (Saudi Arabia). Sagvntvm extra-13: 173-186.

Bryce, T. & Birkett-Rees, J. (2016): Atlas of the ancient Near East from prehistoric times to the Roman Imperial period. Routledge, New York / London, 318 pp.

Burke, A.A. (2017): Amorites, climate change, and the negotiation of identity at the end of the third millennium B.C. In Höflmayer, F. (ed.): The late third millennium in the ancient Near East. Chronology, C14, and climate change. The Oriental Institute of the University of Chicago, Oriental Institute Seminars 11, Chicago: 261-307.

Cole, S.W. & Gasche, H. (1998): Second- and first-millennium BC rivers in northern Babylonia. In Gasche, H. & Tanret, M. (eds.): Changing watercourses in Babylonia. Towards a reconstruction of the ancient environment in Lower Mesopotamia. Volume 1. Mesopotamian history and environment Series II Memoirs V: 1-64.

Courty, M.-A. (1998): The soil record of an exceptional event at 4000 B.P. in the Middle East. In Peiser, B.J., Palmer, T. & Bailey, M.E. (eds.): Natural catastrophes during Bronze Age civilisations. Archaeological, geological, astronomical and cultural perspectives. BAR International Series 728: 93-108.

Cullen, H.M., deMenocal, P.B., Hemming, S., Hemming, G., Brown, F.H., Guilderson, T. & Sirocko, F. (2000): Climate change and the collapse of the Akkadian empire: evidence from the deep sea. Geology 28: 379-382.

Dalley, S. (2008): Myths from Mesopotamia. Creation, the flood, Gilgamesh, and others. Oxford University Press, Oxford, 342 pp.

De Klerk, P. & Brumlich, M. (2018): Pollenanalysen an Sedimenten aus dem Rangsdorfer See zur Rekonstruktion der Vegetations- und Siedlungsgeschichte im Umfeld der Glienicker Platte mit einer hohen zeitlichen Auflösung der mittleren Bronze- bis frühen römischen Kaiserzeit (ca. 1500 BC – 200 AD). In Brumlich, M.: Frühe Eisenverhüttung bei Glienick. Siedlungs- und wirtschaftsarchäologische Forschungen zur vorrömischen Eisen- und römischen Kaiserzeit in Brandenburg. Berliner archäologische Forschungen 17: 629-651.

De Klerk, P. & Joosten, H. (2019): How ancient cultures perceived mires and wetlands (3000 BCE – 500 CE): an introduction. IMCG Bulletin 2019-04 (May-July 2019): 4-15.

Djamali, D., de Beaulieu, J.-L., Shah-hosseini, M., Andrieu-Ponel, V., Ponel, P., Amini, A., Akhani, H., Leroy, S.A.G., Stevens, L., Lahijani, H. & Brewer, S. (2008): A late Pleistocene long pollen record from Lake Urmia, NW Iran. Quaternary Research 69: 413-420.

Djamali, M., de Beaulieu, J.-L., Andrieu-Ponel, V., Berberian, M., Miller, N.F., Gandouin, E., Lahijani, H., Shah-Hosseini, M., Ponel, P., Salimian, M. & Guiter, F. (2009): A late Holocene pollen record from Lake Almalou in NW Iran: evidence for changing land-use in relation to some historical events during the last 3700 years. Journal of Archaeological Science 36: 1364–1375.

Esmaeili, H.R. (2021): Checklist of freshwater fishes of southwestern wetlands of Iran. In Jawad, L.A. (ed.): Southern Iraq's marshes. Their environment and conservation. Coastal Research Library 36. Springer, Cham: 295-318.

Field, H. (1932): Ancient wheat and barley from Kish, Mesopotamia. American Anthropologist, new series 34: 303-309.

Finkelstein, J.J. (1962): "Mesopotamia". Journal of Near Eastern Studies 21: 73-92.

Foster, B.R. (2019): The epic of Gilgamesh. A new translation, analogues, criticism and response. W.W. Norton & Company, New York / London, 246 pp.

Frahm, E. (2013): Geschichte des alten Mesopotamien. Reclam, Stuttgart, 296 pp.

Ghazanfar, S.A. & McDaniel, T. (2016): Floras of the Middle East: a quantitative analysis and biogeography of the flora of Iraq. Edinburgh Journal of Botany 73: 1-24.

Gunatilaka, A. (1986): Kuwait and the northern Arabian Gulf: a study in Quaternary sedimentation. Episodes 9: 223-231.

Haarmann, H. (2017): Geschichte der Schrift. Verlag C.H. Beck, München, 128 pp.

Haywood, J. (2005): The Penguin historical atlas of ancient civilizations. Penguin Books, London etc., 144 pp.

Heyvaert, V.M.A. & Baeteman, C. (2007): Holocene sedimentary evolution and palaeocoastlines of the Lower Khuzestan plain (southwest Iran). Marine Geology 242: 83-108.

Heyvaert, V.M.A. & Baeteman, C. (2008): A middle to late Holocene avulsion history of the Euphrates river: a case study from Tell ed-Dēr, Iraq, Lower Mesopotamia. Quaternary Science Reviews 27: 2401-2410.

Heyvaert, V.M.A., Verkinderen, P. & Walstra, J. (2013): Geoarchaeological research in lower Khuzestan: state of the art. In De Graef, K. & Tavernier, J. (eds.): Susa and Elam. Archaeological, philological, historical and geographical perspectives. Proceedings of the international congress held at Ghent University, December 14-17, 2009. Koninklijke Brill NV, Leiden / Boston: 493-534.

Höflmayer, F. (2017): The late third millennium B.C. in the ancient Near East and eastern Mediterranean: a time of collapse and transformation. In Höflmayer, F. (ed.): The late third millennium in the ancient Near East. Chronology, C14, and climate change. The Oriental Institute of the University of Chicago, Oriental Institute Seminars 11, Chicago: 1-28.

Hritz, C. (2010): Tracing settlement patterns and channel systems in southern Mesopotamia using remote sensing. Journal of Field Archaeology 35: 184-203.

Hritz, C., Pournelle, J. & Smith, J. (2012a): Revisiting the Sealands: report of preliminary ground reconnaissance in the Hammar district, Dhi Qar and Basra governorates, Iraq. Iraq 74: 37-49.

Hritz, C., Pournelle, J., Smith, J., Albadran, B., Issa, B.M. & Al-Handal, A. (2012b): Mid-Holocene dates for organic-rich sediment, palustrine shell, and charcoal from southern Iraq. Radiocarbon 54: 65-79.

Issa, B.M. (2010): Depositional environments and biofacies of selected sediments, north Basrah. Journal of Basrah Researches ((Sciences)) 36 A/5: 1-14.

Jabbar, M.F.A., Al-Ma'ar, A.F. & Shehab, A.T. (2010): Change detections in marsh areas, south Iraq, using remote sensing and GIS applications. Iraqi Bulletin of Geology and Mining 6(2): 17-39.

Jawad, L.A. (2021a): Introduction. In Jawad, L.A. (ed.): Southern Iraq's marshes. Their environment and conservation. Coastal Research Library 36. Springer, Cham: 1-12.

Jawad, L.A. (2021c): The daily life of the Marsh Arab of the southern marshes of Iraq through a camera lens. In Jawad, L.A. (ed.): Southern Iraq's marshes. Their environment and conservation. Coastal Research Library 36. Springer, Cham: 641-807.

Jawad, L.A. (2021c): Co-management scheme to protect the southern marshes of Iraq: a proposal. In Jawad, L.A. (ed.): Southern Iraq's marshes. Their environment and conservation. Coastal Research Library 36. Springer, Cham: 591-597.

Jotheri, J.H.A. (2016): Holocene avulsion history of the Euphrates and Tigris rivers in the Mesopotamian floodplain. PhD-thesis, Durham University, 208 pp.

Jotheri, J. (2018): Recognition criteria for canals and rivers in the Mesopotamian floodplain. In Zhuang, Y. & Altaweel, M. (eds.): Water societies and technologies from the past and present. UCL Press, London: 111-126.

Jotheri, J. & Allen, M.B. (2020): Recognition of ancient channels and archaeological sites in the Mesopotamian floodplain using satellite imagery and digital topography. In Lawrence, D., Altaweel, M. & Philip, G. (eds.): New agendas in remote sensing and landscape archaeology in the Near East, studies in honour of Tony J. Wilkinson. Archaeopress, Oxford: 283-305.

Jotheri, J., Allen, M.B. & Wilkinson, T.J. (2016): Holocene avulsions of the Euphrates River in the Najaf area of western Mesopotamia: impacts on human settlement patterns. Geoarchaeology 31: 175–193.

Jotheri, J., Altaweel, M., Tuji, A., Anma, R., Pennington, B., Rost, S. & Watanabe, C. (2018): Holocene fluvial and anthropogenic processes in the region of Uruk in southern Mesopotamia. Quaternary International 483: 57-69.

Jotheri, J., de Gruchy, M.W., Almaliki, R. & Feadha, M. (2019): Remote sensing the archaeological traces of boat movement in the marshes of southern Mesopotamia. Remote Sensing 11: article 2474.

Kaniewski, D., Marriner, N., Cheddadi, R., Guiot, J. & Van Campo, E. (2018): The 4.2 kaBP event in the Levant. Climate of the Past 14: 1529-1542.

Kilian, M.R., Van der Plicht, J., Van Geel, B., & Goslar, T. (2002): Problematic ^{14}C-AMS dates of pollen concentrates from Lake Gosciaz (Poland). Quaternary International 88: 21–26.

Leroyer, C., Joannin, S., Aoustin, D., Ali, A.A., Peyron, O., Ollivier, V., Tozalakyan, P., Karakhanyan, A. & Jude, F. (2016): Mid Holocene vegetation reconstruction from Vanevan peat (south-eastern shore of Lake Sevan, Armenia). Quaternary International 395: 5-18.

Lonergan, S. (2012): Ecological restoration and peacebuilding: the case of the Iraqi marshes. In Jensen, D. & Lonergan, S. (eds.): Assessing and restoring natural resources in post-conflict peacebuilding. Earthscan, London: 223-239.

Makaske, B. (2001): Anastomosing rivers: a review of their classification, origin and sedimentary products. Earth-Science Reviews 53: 149–196.

Master, S. (2001): A possible Holocene impact structure in the Al'Amarah marshes, near the Tigris-Euphrates confluence, southern Iraq. Meteoritics & Planetary Science 36, supplement: A124.

Master, S. & Woldai, T. (2004): The Umm al Binni structure, in the Mesopotamian marshlands of southern Iraq, as a postulated late Holocene meteorite impact crater: geological setting and new landsat etm+ and aster satellite imagery. Economic Geology Research Institute Information circular no. 382, University of Witwatersrand, Johannesburg, 21 pp.

Master, S. & Woldai, T. (2007): Umm al Binni structure, southern Iraq, as a postulated Late Holocene meteorite impact crater. In Bobrowsky, P.T. & Rickman, H. (eds.): Comet/Asteroid Impacts and Human Society: an interdisciplinary approach. Springer, Berlin / Heidelberg / New York: 89-103.

Maulood, B.K. & Hassan, F.M. (2021): Physical and chemical characters of Mesopotamian marshes: a short review. In Jawad, L.A. (ed.): Southern Iraq's marshes. Their environment and conservation. Coastal Research Library 36. Springer, Cham: 95-112.

Morozova, G.S. (2005): A review of Holocene avulsions of the Tigris and Euphrates Rivers and possible effects on the evolution of civilizations in lower Mesopotamia. Geoarchaeology 20: 401-423.

Nadali, D. (2021): Cities in the water: waterscape and evolution of urban civilisation in Southern Mesopotamia as seen from Tell Zurghul, Iraq. In Jawad, L.A. (ed.): Southern Iraq's marshes. Their environment and conservation. Coastal Research Library 36. Springer, Cham: 1-31.

Ohrtman, M.K. & Lair, K.D. (2013): Tamarix and salinity: an overview. In Sher, A. & Quigley, M.F. (eds.): Tamarix: a case study of ecological change in the American west. Oxford University Press, Oxford: 123-145.

Owen, M.A., Al-Sheikhly, S.S. & Al-Ameri, T.K. (2000): Palaeoecology of Mandli / Kut area during the Quaternary period. 1st national symposium on scientific and technical support for archaeological studies, 15-17 May 2000, Baghdad-Iraq: 571-580.

Pournelle, J. (2003): Marshland of cities: deltaic landscapes and the evolution of Early Mesopotamian civilization. PhD-thesis, University of California, San Diego, 315 pp.

Pournelle, J.R. (2017): Physical geography. In Crawford, H. (ed.): The Sumerian world. Routledge, London / New York: 13-32.

Radner, K. (2017). Mesopotamien. Die frühen Hochkulturen an Euphrat und Tigris. Verlag C.H. Beck, München, 128 pp.

Regnell, J. (1992): Preparing pollen concentrates for AMS dating — a methodological study from a hard-water lake in southern Sweden. Boreas 21: 373–377.

Richardson, C.J. & Hussain, N.A. (2006): Restoring the Garden of Eden: An ecological assessment of the marshes of Iraq. BioScience 56: 477-489.

Riehl, S. (2008): Climate and agriculture in the ancient Near East: a synthesis of the archaeobotanical and stable carbon isotope evidence. Vegetation History and Archaeobotany 17 (suppl 1): S43-S51.

Riehl, S. (2017): Regional environments and human perception: the two most important variables in adaptation to climate change. In Höflmayer, F. (ed.): The late third millennium in the ancient Near East. Chronology, C14, and climate change. The Oriental Institute of the University of Chicago, Oriental Institute seminars 11: 237-260.

Robles, M., Peyron, O., Ménot, G., Brugiapaglia, E., Ollivier, V., Tozalakyan, P., Meliksetian, K., Sahakyan, L. & Joannin, S. (2020): Impact of climate change on steppe environments around Lake Sevan in Armenia during the Holocene. EGU2020-21402.

Romano, L., Celant, A. & Montorfani, M.V. (2021): Reed-swamps in the Sumerian material culture: archaeological, archaeobotanical and experimental insights from the Abu Tbeirah excavations. In Jawad, L.A. (ed.): Southern Iraq's marshes. Their environment and conservation. Coastal Research Library 36. Springer, Cham: 33-54.

Saleh, S.S., Al-Ansari, N. & Abdullah, T. (2020): Groundwater hydrology in Iraq. Journal of Earth Sciences and Geotechnical Engineering 10,1: 155-197.

Salim, M.A., Abed, S.A. & Porter, R.F. (2021): The ornithological importance of the southern marshes of Iraq. In Jawad, L.A. (ed.): Southern Iraq's marshes. Their environment and conservation. Coastal Research Library 36. Springer, Cham: 351-375.

Salman, N.A., Al-Saas, H.T. & Al-Imarah, F.J. (2021): The status of pollution in the southern marshes of Iraq: a short review. In Jawad, L.A. (ed.): Southern Iraq's marshes. Their environment and conservation. Coastal Research Library 36. Springer, Cham: 505-516.

Sissakian, V.K. & Al-Bahadily, H.A. (2018): The geological origin of the Umm Al-Binni Lake within the Ahwar of southern Mesopotamia, Iraq. Arabian Journal of Geosciences 11, article 669.

Sissakian, V.K., Shilab, A.T., Al-Ansari, N. & Knutsson, S. (2014): Al-Batin alluvial fan, southeastern Iraq. Engineering 6: 699-711.

Sissakian, V.K. & Fouad, S.F.A. (2015): Geological map of Iraq, scale 1:1000000, 4th edition, 2012. Iraqi Bulletin of Geology and Mining 11: 9-16.

Sissakian, V.K., Al-Ansari, N., Adamo, N., Al-Azzawi, M.K., Abdullah, M. & Laue, J. (2020a): Geomorphology of the Mesopotamian plain: a critical review. Journal of Earth Sciences and Geotechnical Engineering 10,4: 1-25.

Sissakian, V.K., Al-Ansari, N., Adamo, N., Abdullah, M. & Laue, J. (2020b): Stratigraphy of the Mesopotamian plain: a critical review. Journal of Earth Sciences and Geotechnical Engineering 10,4: 27-56.

Sissakian, V.K., Al-Ansari, N., Adamo, N., Zainy, M.T., Abdullah, M. & Laue, J. (2020c): Tectonics and neotectonics of the Mesopotamian plain: a critical review. Journal of Earth Sciences and Geotechnical Engineering 10,4: 57-86.

Sissakian, V.K., Adamo, N., Al-Ansari, N., Abdullah, M. & Laue, J. (2020d): Sea level changes in the Mesopotamian plain and limits of the Arabian Gulf: a critical review. Journal of Earth Sciences and Geotechnical Engineering 10,4: 87-110.

Sissakian, V.K., Al-Ansari, N., Adamo, N., Abdullah, M. & Laue, J. (2020e): Desertification and salinization of the Mesopotamian plain: a critical review. Earth Sciences and Geotechnical Engineering 10,4: 125-142.

Solecki, R.S. & Leroi-Gourhan, A. (1961): Palaeoclimatology and archaeology in the Near East. Annals New York Academy of Sciences 95: 729-739.

Stouthamer, E. & Berendsen, H.J.A. (2000): Factors controlling the Holocene avulsion history of the Rhine-Meuse Delta (The Netherlands). Journal of Sedimentary Research 70: 1051-1064.

Thesiger, W. (1964): The Marsh Arabs. Longmans, London, 242 p.

Törnqvist, T.E., De Jong, A.F.M., Oosterbaan, W.A. & Van der Borg, K. (1992): Accurate dating of organic deposits by AMS ^{14}C measurement of macrofossils. Radiocarbon 34: 566-577.

UNEP (2009): Support for environmental management of the Iraqi marshlands 2004-2009. United Nations Environment Programme, Osaka / Shiga, 100 pp.

Van Zeist, W. (1984): Palaeobotanical investigations of Tell ed-Dēr. In De Meyer, L. (ed.): Tell ed-Dēr IV progress reports (second series). Uitgeverij Peeters, Leuven: 119-133.

Van Zeist, W. & Bottema, S. (1977): Palynological investigations in western Iran. Palaeohistoria 19: 19-85.

Van Zeist, W. & Woldring, H. (1978): A postglacial pollen diagram from Lake Van in East Anatolia. Review of Palaeobotany and Palynology 26: 249-276.

Veldhuis, N. (2004): Religion, literature, and scholarship: the Sumerian composition of 'Nanše and the birds'. Brill, Leiden / Styx, Boston, 405 pp.

Verhoeven, K. (1998): Geomorphological research in the Mesopotamian flood plain. In Gasche, H. & Tanret, M. (eds.): Changing watercourses in Babylonia. Towards a reconstruction of the ancient environment in Lower Mesopotamia. Volume 1. Mesopotamian history and environment Series II Memoirs V: 159-245.

Walstra, J., Verkinderen, P. & Heyvaert, M.A. (2010a): Reconstructing landscape evolution in the Lower Khuzestan plain (SW Iran): integrating imagery, historical and sedimentary archives. In Cowley, D.C., Standring, R.A. & Abicht, M.J. (eds.): Landscapes through the lens. Aerial photographs and historic environment. Oxbow Books, Oxford / Oakville: 111-128.

Walstra, J., Heyvaert, V.M.A. & Verkinderen, P. (2010b): Assessing human impact on alluvial fan development: a multidisciplinary case-study from Lower Khuzestan (SW Iran). Geodinamica Acta 23: 267-285.

Walstra, J., Heyvaert, V.M.A. & Verkindern, P. (2011): Mapping Late Holocene landscape evolution and human impact - a case study from lower Khuzestan (SW Iran). In Smith, M.J., Paron, P. & Griffiths, J.S. (eds.): Geomorphological mapping. Methods and Applications. Developments in Earth Surface Processes 15. Elsevier, Amsterdam etc: 551-575.

Weiss, H. (2017): "Seventeen kings who lived in tents". In Höflmayer, F. (ed.): The late third millennium in the ancient Near East. Chronology, C14, and climate change. The Oriental Institute of the University of Chicago, Oriental Institute Seminars 11. Chicago: 131-162.

Wick, L., Lemcke, G. & Sturm, M. (2003): Evidence of Lateglacial and Holocene climatic change and human impact in eastern Anatolia: high-resolution pollen, charcoal, isotopic and geochemical records from the laminated sediments of Lake Van, Turkey. The Holocene 13: 665-675.

Willcox, G. (1992): Timber and trees: ancient exploitation in the Middle East: evidence from plant remains. Bulletin on Sumerian Agriculture 6: 1-31.

Wilkinson, T.J. (2017): Hydraulic landscapes and irrigation systems of Sumer. In Crawford, H. (ed.): The Sumerian world. Routledge, London / New York: 33-54.

Yacoub, S.Y. (2011a): Geomorphology of the Mesopotamia plain. Iraqi Bulletin of Geology and Mining Special issue 4, 2011: 7-32.

Yacoub, S.Y. (2011b): Stratigraphy of the Mesopotamia plain. Iraqi Bulletin of Geology and Mining Special issue 4, 2011: 47-82.

Young, G. (1977): Return to the marshes: Life with the Marsh Arabs of Iraq. Collins, London, 224 p.

A note on the definition, identification and delineation of peatland

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Over the last months, various countries and institutions have been revisiting the definition of 'peatland' as a basis for mapping. Evidently, there is a clear relation between the definition (where are we talking about?) and the mapping (where do we find it?). C.A. Weber, the factual founder of peatland science, already observed in 1903 that without clear definition you cannot map the resource reliably nor collect accurate statistics. However, peatland mapping inevitably runs into the problem that no globally accepted pragmatic definition of 'peatland' exists. How to choose or construct the 'right' definition among all existing and possible definitions, which are often not mutually compatible?

For general use the definitions in the 2021 Ramsar Global Guidelines for Peatland Restoration may be sufficient:

Organic matter: Carbon-hydrogen based material of botanical, faunal, fungal and microbial origin
Peat: Substance largely consisting of dead organic matter, with macroscopic plant remains, that after its production has not been relocated by water or ice or wind (compare sediments, which result from relocation)
Organic soil: Soil with a substantial layer of organic matter at or near the surface
Peatland: Area with a spontaneously accumulated layer of peat at the surface
If you want to make it even simpler, you merge the concepts of 'peat' and 'organic matter' and you call a peatland: "an area with a substantial[1)] layer of spontaneously accumulated organic matter at/near the surface"
[1)] This 'substantial' must be added to prevent that every tree leaf falling on the ground immediately creates a 'peatland'.

If you want to *map* peatlands - for whatever purpose -, you must be more concrete: you have to give a *quantitative* definition of 'peat' and of its minimum thickness for land to be called a 'peatland'. There is where the definitions diverge, often for very pragmatic reasons. Some examples:

- The FAO (2006/7) partial definition of organic soils (Histosols) as "Soils having organic material …10 cm or more thick starting at the soil surface and immediately overlying ice, continuous rock, or fragmental materials,…" is clearly inspired by the impracticality of coring or digging in rocks or ice.
- The common peat depth threshold in the temperate and boreal zones of 30/40cm (or 60cm in case of hardly humified moss peat) is clearly informed by agricultural (and forestry) purposes (deeper than normal plough and crop rooting depth). Development of land techniques over time is reflected in the adjustment of the 'peatland' limit in Germany, which in former times was 20 cm, for a short period also 25 cm and later 30 cm.
- The threshold of 0.7 m for the area of 'peat resources' in Russia has been chosen because peat cannot economically be extracted from shallower peatlands.

- And also the thresholds between ‘non-peat’ (0-50 cm peat), ‘shallow peat’ (50-300 cm) and ‘deep peat’ (> 300 cm) in Indonesia clearly have an agricultural background.

The commonly applied definitions are thus mainly informed by agriculture and peat extraction, i.e. on climate damaging, peatland destroying ‘provisioning services’, not for the regulating ecosystem services for which peatlands nowadays have to be mapped. The most important current reason for peatland mapping is climate change mitigation, i.e. the conservation of the peatland peat carbon stock (and the maintenance of peatland carbon sequestration capacity). How can this purpose guide us to a practical definition?

The 2015 Paris Agreement implies that in 2050 global CO_2 emissions should be net zero, meaning that *no net loss* of peat and peatland should take place anymore. After 2050 we even require *net sinks* meaning that we should not only have stopped carbon losses from degrading peatlands, but preferably should have restored these to newly peat accumulating systems. So in fact we should protect every layer of peat, how thin it might be….

This is, however, not pragmatic. For climate change mitigation we do not protect every single tree (which eventually anyhow will turn into CO_2 again), but we must take care that concrete forest carbon stocks are increasing, conserved in a dynamic steady-state (‘prevent deforestation’) or not reducing (‘prevent forest degradation’). In the deforestation debate, pragmatic thresholds of carbon are discussed above which concrete forest stands should not be subjected to deforestation and degradation: the so-called High Carbon Stock (HCS) forests. These thresholds lay from 30 to 75 tons of C in the above-ground biomass (AGB).

The High Carbon Stock+ study of the oil palm Manifesto Group defined 75 tons C per hectare as the AGB carbon threshold for HCS forests. This study furthermore argued correctly that if HCS tropical rainforests should be spared for climate change mitigation, also soils with an equivalent (or higher) content of easily mobilized carbon should be protected (independent of the biomass the land may hold). After all, CO_2 from soil carbon heats the climate in the same way as CO_2 from wood carbon.

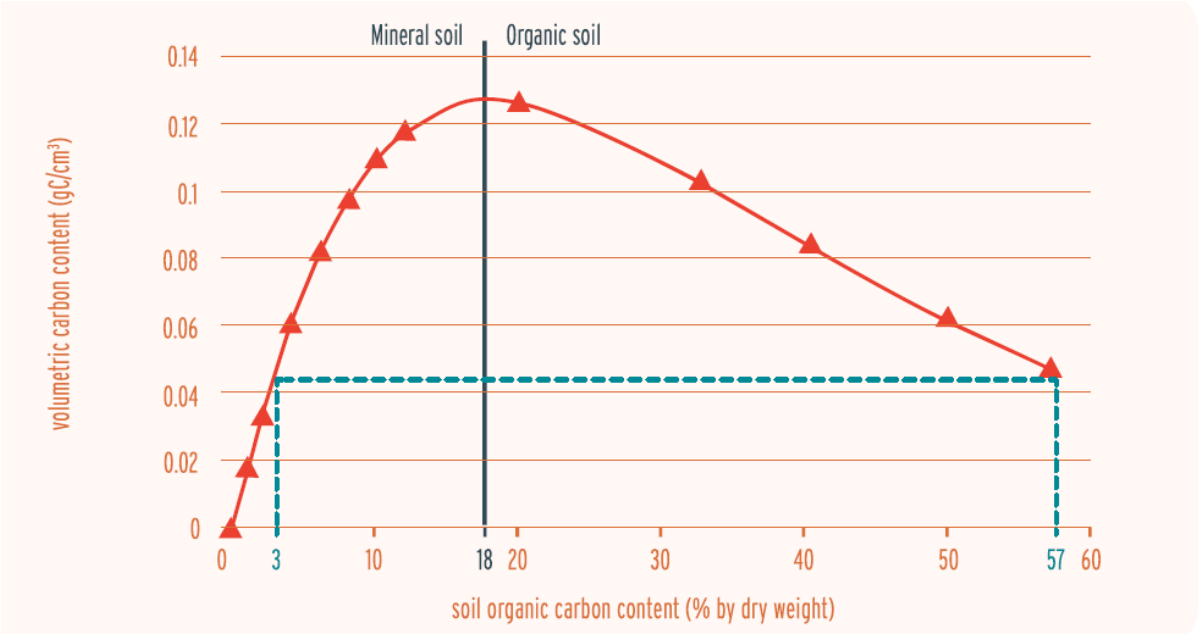
Per hectare, a typical tropical peatland (i.e. the peat domes of Southeast Asia consisting for almost 100% of organic matter) has a carbon stock of about 6 tonnes of carbon per cm of peat depth, i.e. a layer of 13 cm of peat would already comply with the 75 tons threshold. The Manifesto Group study thus concluded: “No development on organic soils (peat and other) where the organic layer exceeds 15 cm in depth”. This is the background of the NDPE commitments (No Deforestation, No Peat, No Exploitation) various companies and standards have meanwhile adopted.

Peat, however, not only exist of organic matter, but may also contain mineral components. From a climate point of view it is thus also relevant to determine how much organic carbon a soil layer should minimally contain to call it ‘peat’. Varying with country and sector, peat has been defined as requiring a minimal content by dry weight of 5, 15, 30, 50, 60, or 65% of organic material.

A threshold of 30% is often encountered in definitions of peats and organic soils in European literature. This 30% is a practical criterion, because between 8% and 30% it is impossible to assess the proportion of organic matter in the soil manually. Because clastic materials (sand, silt, clay) and organic matter have particle densities of 2.2–2.9 g cm^{-3} and 1.0–1.5 g cm^{-3}, respectively, 30% dry mass of organic material (= ~18 % of carbon) means that – apart from the water – more than half of the soil volume consists of organic matter.

Also here we meet the problem that conventional definitions have been informed by agricultural, not by climate considerations. Conventionally in soil science the organic matter content is expressed as a percentage of total dry mass. This convention leads to the counterintuitive situation that peat with a lower percentage of organic matter (and the rest sand or clay) may have a higher density of organic matter (mass per volume) than pure peat (~100 % of organic matter). Pure peat has a high percentage of carbon by weight (44 - 58 %, depending on the degree of decomposition), but – also because it is often loosely stacked - a low volumetric carbon content. In comparison, mineral soil weighs much more and with just 3 % of carbon by weight has just as much carbon per volume as a pure organic soil with 57 % (see graph below). All soils with an intermediate percentage of carbon contain more carbon per volume (see graph) and may emit more CO_2 upon drainage. And at the percentage value

where currently the border is drawn between mineral and organic soils (18 %) the carbon density and thus the potential CO_2 emissions are even the largest. From a climate point of view the carbon content threshold should thus better lay at 3% of (organic) carbon, not at (12 -) 18 %.



From a climate change mitigation point of view, a 'peatland' definition should thus comprise all areas with a ≥ 15 cm layer of 'peat' (with ≥ 5% of organic matter). This '≥ 15 cm ≥ 5%' definition would cover all lands with carbon rich soils, including peat swamp forests, papyrus swamps, dambos in savannahs, cloud forests in the mountains, various coastal mangroves, etc.

Humid forest near Mouila (Gabon) with 10 cm thick organic soil layer. Photo: Hans Joosten.

The ‘no net loss’ implication of the Paris Agreement means that these ‘≥ 15 cm ≥ 5%’ thresholds are merely a minimum requirement: a thicker layer has more climate importance - ‘more is better’. A further subdivision of peatlands could therefore be guided by areal carbon content (tons of carbon per ha) but because ‘carbon content’ (and its indicator ‘peat depth’) is a continuous variable, the delineation of classes is subjective.
In the field a ‘≥ 15 cm ≥ 5%’ peat soil can easily be identified: you do not need sophisticated instruments, you only have to look at the uppermost layer of soil.
Whereas detection of a ‘soil with climate relevance’ is thus easy in the field, it is impossible to detect such shallow layers of peat with remote sensing, because in general “peat cannot be seen from space”. Remote sensing is, however, necessary to rapidly map large and difficultly accessible peat occurrences. Various remotely sensed features –often related to vegetation and water - may give a fair indication of the presence of peatlands, and this precision may be expected to improve with the increase of ground truthing points. But also then it will remain difficult to distinguish areas with only a shallow peat layer, because their vegetation differs less from that of mineral soils.
A climate wise mapping of soils must thus follow a two-stage approach: 1) acquire an overview of peatland occurrence using remote sensing. Such overview will allow identifying larger and clear occurrences of peatland and will be sufficient for major land use planning; and 2) use field mapping for fine scale identification and planning.

Further reading:

Raison, J., Atkinson, P., Chave, J., DeFries, R., Goh, K.J., Joosten, H., Navratil, P. & Siegert, F. 2015. HCS+: A new pathway to sustainable oil palm development. The High Carbon Stock Science Study, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwii77Sd9-vxAhVhMOwKHRheBmUQFjADegQICRAD&url=https%3A%2F%2Fwww.simedarbyplantation.com%2Fsites%2Fdefault%2Ffiles%2Fsustainability%2Fhigh-carbon-stock%2Fhcs-iIndependent-report-technical-committee.pdf&usg=AOvVaw1b2vLu2RDyVTytNm4WS8sD

Vernimmen, R., Hooijer, A., Joosten, H., Ballhorn, U., Nuutinen, M. & Tata, H. 2020. Peatland mapping. In: FAO: Peatlands mapping and monitoring – Recommendations and technical overview, FAO, Rome, pp. 7 – 18.

Peatland news

Global

Nominate authors for Global Peatlands Assessment

Raising awareness and strengthening knowledge and data to inform policies, priorities and practice is part of the core work of the Global Peatlands Initiative (GPI https://www.globalpeatlands.org/). The Global Peatlands Assessment (GPA) is one of GPI’s flagship products which aims to establish the State of the World's Peatlands, answering questions on peatland distribution, status, trends and pressures through gathering the best available science. In February 2021, the GPI Steering Committee met and approved the GPA concept and process. The GPA, led by UNEP for the GPI, will be coordinated by the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC). The Greifswald Mire Centre (GMC) and the Food and Agriculture Organization of the UN (FAO) have helped to shape the GPA concept, in consultation with other GPI partners.
We kindly invite you to nominate Contributing Authors (CAs) to participate in the Assessment, describing how their expertise is relevant to one or more chapters of the assessment (letter attached). Nominated authors can be affiliated with your institution or can be independent experts. We would appreciate it if you could respond by Monday 26th July. Authors will contribute to specific parts of or themes within a chapter, working with the chapter's Coordinating Lead Authors (CLAs). We anticipate that three author meetings will be organized starting in September 2021 and throughout 2022 for the development of the Assessment. Please join us as we work together to communicate the State of the World's Peatlands: raquel.agra@unep-wcmc.org

U.N. declares decade of ecosystem restoration to 'make peace with nature'

8 June 2021 marked the launch of the United Nations Decade on Ecosystem Restoration led by the U.N. Environment Programme (UNEP) and the Food and Agriculture Organization (FAO). The goal: to prevent, halt and reverse ecosystem degradation worldwide. A new report released alongside the decade launch presents evidence on the state of global ecosystem destruction and explains why restoration is critical for the economy, food security, clean water, health, climate change mitigation, security, and biodiversity. "Degradation is already affecting the well-being of an estimated 3.2 billion people — that is 40 percent of the world's population," UNEP executive director Inger Andersen and FAO director-general Qu Dongyu, wrote in the forward to the report. "Every single year we lose ecosystem services worth more than 10 percent of our global economic output."

The report calls on the world to restore at least 1 billion hectares (of degraded land in the next decade — an area larger than China. Restoring nature at such an ambitious scale will require systemic changes, and will be costly, but the cost of inaction could be greater. Roughly half of global GDP depends on nature, and if ecosystem services decline at a steady rate, an estimated $10 trillion in global GDP may be lost by 2050. Restoration is also a good investment. For every dollar that goes into restoration, up to $30 in economic benefits are created. According to the report, humanity is using nearly 1.6 times the amount of services nature sustainably provides. "In short," the report states, "we need more nature than we have." Ecosystem restoration has also been recognized as a critical part of achieving the Paris Agreement climate targets, Aichi biodiversity targets, and many of the Sustainable Development Goals, including clean water, health, peace and security.

There is no formula for restoring nature on a global scale. The effort will require many methods, including landscape restoration, regenerative agriculture, and rewilding. These efforts will be aided by advances in remote monitoring, better methods for sharing knowledge, and improved on-the-ground practices.

While no methods are universal, the UNEP and FAO do offer a set of guiding principles. These principles include aiming for the highest level of well-being for people and ecosystems, addressing the drivers of degradation, promoting inclusive and participatory governance, tailoring approaches to local contexts, including plans for monitoring, and integrating policies for longevity.

Monitoring is a key guiding principle of the U.N. Decade. And to that end, the FAO and UNEP have also launched a digital hub, which includes a framework that countries and communities can use to measure progress.

Time and again, successful restoration projects have demonstrated the importance of involving all stakeholders and communities throughout the process. And this inclusivity must extend to youth and women. Depending on the culture, men and women hold different knowledge about the environment and have different restoration priorities. Plans that ensure women and men can benefit equally from and fully participate in are often more sustainable. The leadership and traditional knowledge of Indigenous people is also paramount. An estimated 37% of all remaining natural lands (28% of the world's land surface) are managed by Indigenous peoples, and these lands protect a majority of intact forests and 80% of global biodiversity.

A key message of the report is that nature is not something that is "nice to have" — it is essential to our survival. Restoring the planet will take a massive global effort, and that effort can happen at all scales, from a backyard to a country. "Making peace with nature is the defining task of the 21st century," António Guterres, the U.N. secretary-general, said in a statement. "It must be the top, top priority for everyone, everywhere."

- https://www.unep.org/resources/ecosystem-restoration-people-nature-climate
- https://news.mongabay.com/2021/06/u-n-declares-decade-of-ecosystem-restoration-to-make-peace-with-nature/

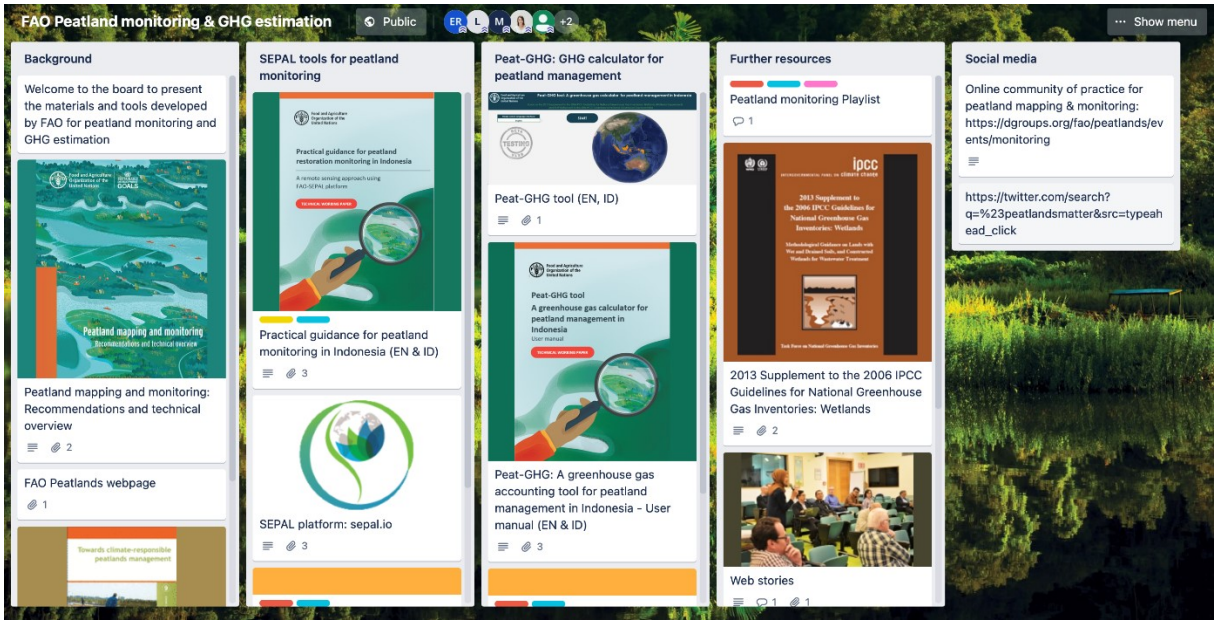
Peatland partners welcome the UN Decade of Ecosystem Restoration

Peatland conservation organisations and experts from across the world have joined together with the United Nations Environment Programme's Global Peatlands Initiative (GPI) to pledge their collective commitment to tacking climate change, protecting nature and forging ahead for the health of our planet.

The network of organisations is beginning a press and social media collaboration to share experiences and celebrate the successes of ongoing work. The joint effort will highlight the importance of peatlands to the planet and focus on the different ways that organisations are working towards their conservation, restoration and sustainable management across the world. The relay of stories from peatland projects worldwide starts with the UK as the host of the United Nations climate change conference, COP26, taking place in Glasgow in November.
Restoring and conserving peatlands is the most effective way to naturally capture carbon and lock it away. The global network is working together to share the importance and value of peatlands as a nature-based way to accelerate climate action as we enter into the UN Decade of Ecosystem Restoration. The Decade of Ecosystem Restoration aims to prevent, halt and reverse the degradation of ecosystems on every continent and in every ocean.

Global consultation on restoration principles

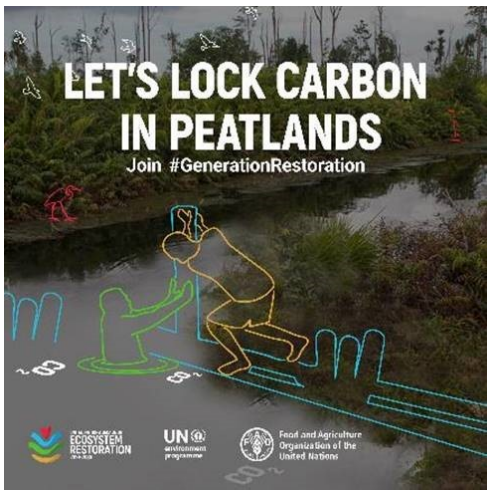
In the context of the UN Decade on Ecosystem Restoration, the FAO-led Task Force on Best Practices partnered with the IUCN´s Commission on Ecosystem Management and the Society for Ecological Restoration to jointly develop nine principles for ecosystem restoration. We are now soliciting feedback from the global restoration community on the proposed principles. The global consultation will be open until 19 July 2021. We kindly invite you to complete the survey: https://www.decadeonrestoration.org/global-consultation-restoration-principles



To celebrate the launch of the UN Decade on Ecosystem Restoration, FAO have compiled all materials associated with their joint project with the Indonesian BRGM (Peatlands Restoration Agency) and UNOPS. On a comprehensive Trello board, the latest peatlands mapping methodologies, best practices on climate- responsible management of peatlands and the most recent Peat-GHG and SEPAL tools for peatland restoration monitoring in Indonesia are showcased. Peat-GHG tool training videos and real case-studies exercises are also available together with useful social media links to join the ever-growing online community to facilitate collaboration and exchanges on peatland monitoring and mapping. FAO Peatland monitoring & GHG estimation | Trello
Join us - share, learn, inspire, experience and act for peatlands, people and the planet. Follow and share using #PeatlandsMatter and #GenerationRestoration.

A media campaign to promote the UN Decade on Ecosystem Restoration (2021-2030) and toward the UNFCCC COP 26, the Global Peat Press Project (GP3) campaign brings together international partners to highlight the importance of peatlands as vulnerable but valuable ecosystems. The aim of the campaign is to demonstrate the role that peatlands play in the fight against climate change and the importance to restore degraded peatlands into healthy ecosystems. The campaign will give site managers the opportunity to showcase their restoration work and successes so that others can learn and be inspired to do more. The campaign kicked off following the launch of the UN Decade on June 8th and will run until the UNFCCC COP26 in November 2021. It is by GPI member North Pennines AONB Partnership. If you are interested in being a part of GP3 please contact Paul Leadbitter at North Pennines AONB Partnership, Jelke Brandehof at Eurosite, or Dianna Kopansky at UNEP-GPI and and follow @Eurosite, @NorthPennAONB and @DiannaKopansky on Twitter !

- http://www.globalpeatlands.org/global-peat-pres...ampaign-kick-off/
- https://www.decadeonrestoration.org/stories/global-peat-press-project-gp3-campaign-kick
- https://www.northpennines.org.uk/peatland-welcome-for-decade-of-ecosystem-restoration/



TEN MORE YEARS TO RESTORE THE PLANET

There has never been a more urgent need to revive damaged ecosystems than now.

Ecosystems support all life on Earth. The healthier our ecosystems are, the healthier the planet - and its people. The UN Decade on Ecosystem Restoration aims to prevent, halt and reverse the degradation of ecosystems on every continent and in every ocean. It can help to end poverty, combat climate change and prevent a mass extinction. It will only succeed if everyone plays a part. https://www.decadeonrestoration.org/

In support to the UN Decade FAO launched a new monitoring platform – the Framework for Ecosystem Restoration Monitoring (FERM). Entry are either through http://www.fao.org/national-forest-monitoring/ferm or directly: https://data.apps.fao.org/ferm/ A web story for the FERM launch can be found here: http://www.fao.org/national-forest-monitoring/news/detail/en/c/1403620/ And a link to the launch event at GLF Africa can be found here: https://www.youtube.com/watch?v=8J3k2Xq80fk
The Launch Gala event of the Un Decade on Ecosystem Restoration 2021-2030 broadcasted online Friday 4 June

is available under: https://www.youtube.com/watch?v=3X_Dz0vD6cE Two new publications recently launched: Becoming #GenerationRestoration: https://www.unep.org/resources/ecosystem-restoration-people-nature-climate and Ecosystem Restoration Playbook: https://www.worldenvironmentday.global/get-involved/ecosystem-restoration-playbook

Bog Day videos

Take part in the IUCN UK initiative Bog Day "Peatlands are.." video series to commemorate the brilliance of bogs on the 25th of July this year! In the lead up to the event, we want to celebrate with you and raise awareness on peatlands, reflecting over the benefits they provide, the threats they face, and the ways we can help to protect them. How can you let the world know what peatlands mean to you? Record yourself in a 10-15 sec videoclip (feel free to extend it if inspired!) and finish the sentence "Peatlands are..." then share your clip on Twitter with #BogDay #PeatlandsMatter @IUCNpeat @UNEP. Please refer to this short videoclip for inspiration https://www.youtube.com/watch?v=vpx7xZ8curM and let us know what peatlands mean to you. Remember…let your heart speak ☺ Looking forward to seeing your videos!

Save the date for the next GPI training session!

Don't forget to mark your calendar for the next GPI training session "How to write and use policy briefs" on Friday 30th July 2021, 10:00-11:30AM BST (UTC+1). The session will be run by Jan Peters (Greifswald Mire Centre) and Prof. Mark Reed (SRUC). Link to register: https://www.eventbrite.co.uk/e/how-to-write-a-policy-brief-tickets-156263491309https:/www.eventbrite.co.uk/e/how-to-write-a-policy-brief-tickets-156263491309

In this session you will learn how to write and use policy briefs, considering different types of policy audience, the benefits and risks of co-producing briefs with policy networks and different ways of using your brief to influence policy. Both trainers have extensive experience developing and using policy briefs with national governments and international policy processes such as on the EU and UN level, and will present case studies of their own work in peatland policy. As a preparation for the day, please choose (only) one policy product from https://www.dropbox.com/sh/yrgsd8icbril25r/AAAVx7Stf8_o2PQ0dkJwPnIxa?dl=0 to read and critique before the training. You can choose a policy brief, an infographic or a presentation (note that presentations consist of both a PowerPoint file and a notes file in Word with the same title and one has a video of the slides being presented). You will be asked to discuss the product you chose in small groups, explaining what you liked or disliked about it, and why. The next GPI training session will be on Wednesday 11th August 14:00-15:30PM BST (UTC+1) on "Engaging with the creative sector and public engagement' and will be led by Roxane Andersen (University of the Highlands & Islands) and Richard Lindsay (University of East London).

To find out about future sessions as they are advertised, check the Research Working Group webpage regularly: http://www.globalpeatlands.org/global-peatlands-initiatives-research-working-group/.

All training resources, slides and videos of the GPI Research Working Group trainings can be found here: https://clicks.eventbrite.com/f/a/jIeSBGTgk2NzZ-erYarG5A~~/AAQxAQA~/RgRisdE1P0RSaHR0cHM6Ly9kcml2ZS5nb29nbGUuY29tL2ZpbGUvZC8xLWdVUkNLMFNTZi0zOWY5Sm5ReGJuS2ZsVlpLY01yVmEvdmlldz91c3A9c2hhcmluZ1cDc3BjQgpgyLWd0GDhoCwqUhdlbGVvbm9yYS5taW5lbGxpQHVuLm9yZ1gEAAAAAA~~

BES response to IPBES/IPCC report on biodiversity and climate change

On 10 June IPBES and IPCC released a report on the twin crises of biodiversity loss and climate change. It details how neither can be successfully resolved unless both are tackled together. The report is the product of a four-day virtual workshop assembled by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC) – the first-ever collaboration between these two intergovernmental bodies. The report recognizes that restoration and protection of habitats, can play a significant role in reducing atmospheric carbon and boosting biodiversity

The authors of the report warn that narrowly-focused actions to combat climate change can directly and indirectly harm nature and vice-versa, but many measures exist that can make significant positive contributions in both areas. These include stopping the loss and degradation of carbon- and species-rich ecosystems, increasing

sustainable agricultural and forestry practice and eliminating subsidies that support activities harmful to biodiversity – such as overfishing.

Prof Rick Stafford, Bournemouth University, Policy Committee Chair for British Ecological Society and lead author of the BES Nature-based solutions report said: "It's very important to see the two major environmental crises we currently face, of climate change and biodiversity loss, being considered together. Both do need to be addressed simultaneously and urgently. "This report clearly highlights the negative effects of ecological habitat destruction on both biodiversity and climate change. Equally, it recognises findings, such as those in the British Ecological Society's recent report into Nature-based solutions, that restoration and protection of these habitats, can play a significant role in reducing atmospheric carbon, boosting biodiversity and providing adaptation responses to climate change effects, such as flooding. "A joined-up approach to these environmental crises is important. For example, some carbon reduction technologies, such as electric cars, may have unintended negative consequences for biodiversity through pollution caused by mining necessary metals such as lithium. As some of our recent research has demonstrated, relying on technological solutions alone is unlikely to provide large carbon reduction benefits, and can even negatively affect biodiversity. "However, progressive moves to reduce carbon, including technological solutions, alongside carbon taxation and removal of fossil fuel subsidies (as recommended by many comprehensive Green New Deal plans), especially when coupled with nature-based solutions, can have positive and highly significant climate and biodiversity benefits."

Dr Christian Dunn, Bangor University, chapter author of the BES Nature-based solutions report said: "It's good to see this report state one of the most vital actions is better protection and management of our peatlands. These habitats are our most important terrestrial store of carbon on the planet and their influence cannot be over emphasized. If we're serious about climate change and biodiversity we have to get serious about our peatlands. "Peatlands are the perfect demonstration of the report's statement that climate and biodiversity are inextricably connected with each other and with human futures. If we don't look after our peatlands we will lose biodiversity, irreparably damage our climate through loss of stored carbon from these ecosystems and ultimately destroy our own future. "Worryingly, the report also indicated that if temperatures do continue to rise then the ability of peatlands to act as a global carbon sink may be put at risk. So there really is no time to delay in tackling the issue."

You can read the full report here: https://www.ipbes.net/biodiversityclimatescience

- https://www.miragenews.com/bes-response-to-ipbesipcc-report-on-576409/

Peatland Pavilion proposal for COP26 programme

The UNEP Global Peatlands Initiative team is working together with the IUCN UK Peatlands Programme and others, on a Peatlands Pavilion proposal for the UNFCCC COP26. The Peatlands Pavilion will provide a hub for networking and the creation of new ideas, commitments, and collaboration. The Pavilion will also be a hub where Ministers, climate negotiators, peatlands experts and enthusiasts from around the world come together to exchange their knowledge and experiences on peatlands policy, practice, research, and innovation at COP26 and virtually in a Peatlands Virtual Pavilion.

The Pavilion will host a broad range of side events and daily networking events to stimulate discussion and urgent action around key thematic areas linked to the negotiations and advocating the importance of peatlands as a key nature-based solution. Events will aim to facilitate multi-sectoral dialogue by emphasizing inclusive networking and participation of audiences including: party delegates, observers, scientists, business, civil society, youth groups and other participants.

- Peatland Pavilion Concept note
- Virtual Peatland Pavilion cheat sheet – a summary of possibilities

There is opportunity for organisations and individuals to contribute to the developing Peatland Pavilion proposal and we welcome you to submit collaborative, innovative, impactful and dynamic ideas, resources or session plans via the online Pavilion Application form.

At the moment, we are planning for a hybrid approach with a plan for a physical pavilion and a connected and complementary virtual pavilion. If the COVID-19 situation doesn't allow us to meet in person at all, we will put all efforts into bringing everyone together with this dynamic virtual pavilion beautifully designed by Richard Lindsay and his colleagues at University of East London (UEL). Take a virtual tour and feel free to provide any insights and contributions as we build this one of a kind Peatlands PavilionPlease note that we are at the development stage and cannot guarantee to accommodate any proposal at this stage. For information: info@iucn.org.uk. For sponsoring: dianna.kopansky@un.org and sbrooks@nts.org.uk.

- https://www.iucn-uk-peatlandprogramme.org/news/peatland-pavilion-proposal-cop26-programme

Please find cases of sustainable management practices on wet peatlands, published since 2015 by FAO in this link: https://drive.google.com/drive/folders/1znxgdG9dR6Rf7zWUfhapDOy2gv1b9Uqk?usp=sharing In case you would like to submit a case, please share a short summary of the practice. The FAO team will be available to guide you throughout the entire process of submitting and publishing the best practice case example: contact maria.nuutinen@fao.org ; laura.villegas@fao.org ; eva.ntara@fao.org

On May 29, the youth-led Re-Peat collective "pushing for a peatland paradigm shift through collaboration, education and re-imagining" ran its second 24 hours online peat event: https://www.re-peat.earth/

With the Covid situation becoming locally a bit more open, several meetings related to wetlands are forthcoming:

- WETPOL 2021, Vienna 15-17 September, wetpol.com
- INTECOL Wetland Conference Christchurch, 10-15 October, www.intecol2021.com
- SWS Europe 2022, Arles June 2022
- INTECOL world congress, Geneva August 28- September 2, 2022 www.intecol2022.org

The WETPOL meeting will be completely virtual. The INTECOL wetland conference in New Zealand could be difficult for most if not all of us to attend in person, if that will be allowed. The next annual meeting of SWS Europe is scheduled for June 2022 in the Camargue, France, as a hybrid meeting.

Better peatland management could cut half a billion tons of CO_2

Half a billion tonnes of carbon emissions could be cut from Earth's atmosphere by improved management of peatlands. A team of scientists, led by the UK Centre for Ecology and Hydrology (UKCEH), estimated the potential reduction of around 500 million tonnes in greenhouse gas (GHG) emissions by restoring all global agricultural peatlands. Peatlands cover just 3% of the global land surface, but store around 650 billion tonnes of carbon, around 100 billion tonnes more than all of the world's vegetation combined.

Professor Sue Page from the University of Leicester's School of Geography, Geology and the Environment, one of the co-authors of the study published in *Nature*, said: "Our results present a challenge but also a great opportunity. Better water management in peatlands offers a potential 'win-win' - lower greenhouse gas emissions, improved soil health, extended agricultural lifetimes and reduced flood risk. "For agricultural peatlands, the balance is between climate security, and livelihood and food security. Our study indicates that raising peatland water levels could allow peatland farmers to both reduce the climate impact of their activities and extend the usage of these very fertile organic soils through modified land management. "However, this will not be possible in all locations, and will need to be considered alongside other options, including complete rewetting and ecosystem restoration."

In their natural state, peatlands can mitigate climate change by continuously removing the GHG carbon dioxide (CO2) from the atmosphere and storing it securely under waterlogged conditions. But many peatland areas have been substantially modified by human activity, including drainage for agriculture and forest plantations. This results in the release of around 1.5 billion tonnes of CO2 into the atmosphere each year - which equates to three per cent of all global GHG emissions caused by human activities. However, because large populations rely on these peatlands for their livelihoods, it may not be realistic to expect all agricultural peatlands to be fully returned to their natural condition in the near future. The team therefore also analysed the impact of halving current drainage depths in croplands and grasslands on peat - which cover over 250,000km^2 globally - and showed that this could still bring significant, realistic benefits for climate change mitigation. The study estimates this could cut emissions by around 500 million tonnes of CO_2 a year, which equates to one per cent of all global GHG emissions caused by human activities.

Professor Chris Evans of UKCEH, who led the research, said: "Widespread peatland degradation will need to be addressed if the UK and other countries are to achieve their goal of net zero greenhouse gas emissions by 2050, as part of their contribution to the Paris climate agreement targets. "Concerns over the economic and social consequences of rewetting agricultural peatlands have prevented large-scale restoration, but our study shows the development of locally appropriate mitigation measures could still deliver substantial reductions in emissions."

The scientists say potential reductions in GHG emissions from halving the drainage depth in agricultural peatlands are likely to be greater than estimated, given they did not include changes in emissions of the potent GHG nitrous oxide (N_2O) which, like levels of CO_2, are also likely to be higher in deep-drained agricultural peatlands.

The study in *Nature*, 'Overriding water table control on managed peatland greenhouse gas emissions', involved authors from UKCEH, the Swedish University of Agricultural Sciences, the University of Leeds, The James Hutton Institute, Bangor University, Durham University, Queen Mary University of London, University of Birmingham, University of Leicester, Rothamsted Research and Frankfurt University.

- https://www.eurekalert.org/pub_releases/2021-05/uol-bpm052621.php
- https://phys.org/news/2021-05-peatland-billion-tons-carbon.html

Global peatland dry-out could release 860 million tons of carbon dioxide per year

New research published in Nature Climate Change found drying peatlands could release an additional 860 million tons of CO_2 into the atmosphere every year by around 2100. To put this into perspective, Australia emitted 539 million tons in 2019. To stop this from happening, we need to urgently preserve and restore healthy, water-logged conditions in peatlands.

An international team of scientists across Australia, France, Germany, Netherlands, Switzerland, the US and China collected and analyzed a large dataset from carefully designed and controlled experiments across 130 peatlands all over the world. In these experiments, water levels were lowered under different climate, soil and environmental conditions to disentangle the greenhouse gas responses, using machine learning algorithms. The results showed that lower water levels greatly enhanced the loss of peat as carbon dioxide, with only a mild reduction of methane emissions. The net effect—carbon dioxide vs methane—would make the climate warmer. This suggests that without restoration drying peatlands would add the equivalent of 860 million tons of carbon dioxide to the atmosphere every year by 2100. This projection is for a "high emissions scenario", which assumes global greenhouse gas emissions aren't cut any further.

- Substantial carbon dioxide emissions from northern peatlands drained for crop cultiva
- https://phys.org/news/2021-06-global-peatland-dry-out-million-tons.html

Greenhouse gas measurements in Burns Bog, Canada. Photo: Hans Joosten.

Researchers reveal complex ecosystem changes cause more greenhouse gases to be emitted from peatlands

A research team from Florida State University (FSU) and Georgia Institute of Technology found that the warming Earth is stimulating complex ecosystem changes in peatlands with the end result of more greenhouse gases being released into the air. The team's findings were published in the Proceedings of the National Academy of Sciences. FSU environmental chemist Rachel Wilson, the study's lead author, said that warming causes more greenhouse gases to be emitted into the atmosphere because of a cascading effect and those higher emissions, if unabated, are likely to continue long-term. "First, the plant community responds to warming and produces more sugars," Wilson said. "Those sugars are then fuel for the anaerobic microorganisms that produce carbon dioxide and methane as their respiration products. This suggests that the increase in methane production at higher

temperatures is not a transient effect but is likely to persist over time, worsening the climate crisis by adding greenhouse gases to the atmosphere."

Researchers are particularly concerned about feedback loops through which a warming climate accelerates greenhouse gas production from peatlands, which then warms the climate further. Peatlands are among the largest carbon banks on Earth's surface, holding as much carbon dioxide as the pre-industrial atmosphere. The peatland stored carbon is climate vulnerable.

"As peatlands warm, more of the carbon stored there becomes susceptible to decomposition by microorganisms, which then gets released as carbon dioxide and, even more troubling, methane," Wilson said. Jeff Chanton, a world-renowned expert on methane, directs FSU's part of the project and has been involved since 2012. "Methane currently drives about 25 percent of the 'climate forcing,' or influence on the atmosphere that traps heat and warms the earth, compared to carbon dioxide, which drives most of the rest," Chanton said. "But methane is a stronger greenhouse gas than CO_2 by a factor of 30. The research shows that with warming conditions, the peatland carbon cycle will change from one of sequestration to emissions with an increasing methane effect. It's doubly bad." Georgia Tech microbiologist Joel Kostka, who co-led the study, said that this unpleasant outcome is attenuated by the extreme conditions found in peatlands around the world. "Although most peatlands are in northern regions, which are undergoing some of the most rapid warming on the planet, we're talking about generally cold, acidic soils where there's no oxygen," Kostka said. "Methanogens grow really slowly under these extreme conditions. We do see their activity increasing with warming, but they're not yet growing that fast."

The FSU and Georgia Tech research is one part of the much larger Spruce and Peatland Responses Under Changing Environments experiment, or SPRUCE, to study peatland climate feedbacks. Overseen and directed by ORNL's Hanson, a peatland in the northern Minnesota Marcell Experimental Forest is experimentally warmed to various temperatures inside of large enclosures. Both the air and peat are warmed to temperatures that simulate warmer climates. Scientists from several DOE national laboratories including ORNL, the U.S. Department of Agriculture's U.S. Forest Service, and a number of U.S. and international universities are collaborating to determine changes in vegetation, physical characteristics of the peat, and refining climate models to better capture how these climate-critical ecosystems respond to warming conditions.

- https://news.fsu.edu/news/science-technology/2021/06/15/researchers-reveal-complex-ecosystem-changes-cause-more-greenhouse-gases-to-be-emitted-from-peatlands/
- https://rh.gatech.edu/news/648107/temperate-glimpse-warming-world
- https://www.pnas.org/content/118/25/e2004192118

Historical climate effects of permafrost peatland surprise researchers

Peatlands are an important ecosystem that contribute to the regulation of the atmospheric carbon cycle. A multidisciplinary group of researchers, led by the University of Helsinki, investigated the climate response of a permafrost peatland located in Russia. Unexpectedly, the group found that a cool climate period during the past 3,000 years, which resulted in the formation of permafrost in northern peatlands, had a positive, or warming, effect on the climate. The climate-related effect of permafrost formation was investigated particularly by analysing the ancient plant communities of the peatland, using similarly analysed peatland data from elsewhere in Russia, Finland and Sweden as a comparison.

"Our studies demonstrated that the effect of permafrost peatlands on the climate can be difficult to predict. Studies encompassing longer periods of time are valuable, as they help us to understand future change," says researcher Minna Väliranta from the Faculty of Biological and Environmental Sciences, University of Helsinki.

The study linked data on ancient plant communities with information about how rapidly contemporary northern peatlands bind and sequester carbon, or how rapidly peat accumulates. In addition, data on carbon emissions to the atmosphere were utilised. These factors constitute what is known as the peatland's radiative forcing, which has either a warming effect on the climate when the peatland emits more carbon into the atmosphere than it binds from it, or a cooling effect when the peatland serves as a carbon sink and binds more carbon from the atmosphere than it releases into it.

Rather unexpectedly, the researchers found that a cool climate period, which resulted in the formation of permafrost in northern peatlands, had a warming effect on the climate. This was caused by the habitats of the

plant communities living in the permafrost peatlands drying up, after which they no longer bound carbon from the atmosphere very effectively. In fact, a reverse process took place in which previously formed peat, which used to store carbon, was released back into the atmosphere as a result of accelerated decomposition and degradation.

Moreover, the permafrost processes even created bare peat surfaces entirely devoid of vegetation in the peatlands. Such surfaces emit, in addition to carbon dioxide, also nitrous oxide, a potent greenhouse gas, into the air. These emissions clearly increased the peatland's warming effect on the atmosphere.

Other typical peatland surfaces do not emit significant quantities of nitrous oxide into the atmosphere, which is why such emissions have been considered insignificant. The study demonstrated that such bare peat surfaces have previously been much more prevalent. However, it appears that this type of surfaces have regained their plant cover over time, consequently reducing the extent of bare surfaces.

"This was the first study in which the long-term development of bare peat surfaces was investigated. Consequently, further research is needed in order to better forecast the fate of such surfaces typical of permafrost peatland and the future development of permafrost peatlands in general," says Väliranta.

The climate effects of the greenhouse gas emissions of the peatlands studied were associated with changes in plant life, which, in turn, are determined by the peatland's hydrological balance. The researchers predict that the thawing of the permafrost may lead to rising peatland water levels and, therefore, substantial methane emissions that will warm the climate further. At the same time, global warming is thought to accelerate carbon intake from the atmosphere due to the intensification of the basic production processes of plants. In other words, photosynthesis is binding carbon dioxide from the air with increasing efficiency.

- https://www.sciencedaily.com/releases/2021/06/210617133751.htm

Bare palsa surfaces in Komi, Russia. Photo: Hans Joosten.

Leaders urge prioritization of wetland restoration to fight climate change and biodiversity loss

"While it's important to look at all ecosystems, wetlands are particularly important," said Elizabeth Maruma Mrema, Executive Secretary of the United Nations Convention on Biological Diversity. "Particularly for the ecosystem functions and services they provide, such as recycling and moderation of water for freshwater ecosystems to thrive and as essential habitats for migratory species."

Peatlands are particularly crucial in the fight against climate change. They are powerful carbon sinks - estimates suggest that peatlands store the same amount of carbon that is contained in all terrestrial biomass and twice as much as in all the world's forest biomass. And, when degraded, they emit vast quantities of greenhouse gases. While peatlands can and are being restored, it is a long-term, not a short-term process. "We need to be sure our restoration action takes special care and notice of irrecoverable carbon – these are vast stores of carbon that could be released due to human activity and, if lost, cannot be restored by 2050," said Dianna Kopansky, Coordinator of UNEP-led Global Peatlands Initiative. Ms. Kopansky and Ms. Mrema were speaking on a high-level plenary panel at SER2021 titled 'UN Decade on Restoration: Responding to climate destabilization and wetland/biodiversity Loss', June 22, 2021, in Washington DC, alongside Professor Brendan Mackey of Griffith University, Professor William Moomaw of Tufts University and Jane Madwick, CEO of Wetlands International.

The panel highlighted the proven benefits of restoring wetlands for biodiversity conservation, food and water security, climate change mitigation and adaptation, and disaster prevention. "Wetlands are the standout ecosystems in terms of biodiversity and in their contribution to Earth's life support," said Jane Madgwick, CEO of Wetlands International. "Looking to the future, it seems undeniable that we must safeguard the remaining more-or-less intact wetlands and their resilience, plus regenerate others on a big scale for a safe, biodiverse and liveable planet."

Approximately 25% of all wetland species currently face extinction. And there are proven economic benefits of wetland restoration. The World Resources Institute estimates that for each $1 USD invested, restoration can generate up to $30 USD in economic benefits over time, and halting the decline of ecosystem services could prevent losses of $10 trillion in global income by 2050.

Bethanie Walder, Executive Director of SER, said of the findings: "Not only are the climate change and biodiversity crises two sides of the same coin, but ecological restoration can no longer be thought of as separate from the vital work needed to address these two issues in order to protect human health and societal wellbeing."

- https://www.ser.org/news/570501/Leaders-Urge-Prioritization-of-Wetland-Restoration-to-Fight-Climate-Change-and-Biodiversity-Loss.htm

Marches Mosses BogLIFE Project and Australian Wetlands Collaboration puts Arts Council England Funding to Work

The changing environments of two of the world's internationally recognised wetlands are under the microscope in an exciting collaboration between artists, land managers and environmental specialists in the UK and Australia. The project, called 'Mosses and Marshes' has newly been awarded a grant from Arts Council England. It questions how we think about – and value – natural environments through works centred on the raised peat bogs of the Fenn's Bettisfield and Whixall Mosses NNR on the border between England and Wales and the iconic Macquarie Marshes in New South Wales, Australia. Combined with funding secured in Australia, the UK funding will allow the artists involved to create artworks and run events and exhibitions in their respective local communities, as well as nationally and internationally. The project was launched via social media and project websites on World Wetlands Day, 2nd February 2021.

Andrew Howe (UK) and Kim V. Goldsmith (Australia) are co-leading the project exploring each unique site and environmental challenges we face on opposing sides of the planet. Andrew Howe is partnering with Shropshire Wildlife Trust and Natural England as they carry out their peatbog conservation projects, including habitat restoration on the former scrapyard on the Mosses. Kim has been partnering with the Macquarie Wetlands Association, as well as tapping into the knowledge of various wetland and water management specialists to explore elements of the Macquarie Marshes.

The first phase includes new artworks for public exhibition, workshops, walks and talks, and a project publication due for release prior to the first exhibition at Qube Gallery, Oswestry, in October. Australian exhibitions will follow in 2022.

- https://ofthemosses.com/2021/02/26/mosses-and-marshes-project-comes-to-life/
- https://www.iucn-uk-peatlandprogramme.org/news/marches-mosses-boglife-project-and-australian-wetlands-collaboration-puts-arts-council-england

U.N. report: Protected areas now cover nearly 17% of Earth's surface

The area of protected land on Earth has increased to seven times the size of India since 2010, according to a report released May 19 by the United Nations Environmental Programme (UNEP) and the International Union for Conservation of Nature (IUCN). The addition of 2 million square kilometers brings the world tantalizingly close to meeting one of the goals set at the 2010 Convention on Biological Diversity conference held in Japan's Aichi prefecture. Inger Andersen, executive director of UNEP, called those gains "impressive." "We do need to congratulate the national governments for stretching and for getting so far," Andersen said at a press conference. "But we also need to understand that there's more to be done."

The Protected Planet Report 2020 takes stock of measures taken to meet what's known as Aichi Target 11, which called for protecting 17% of Earth's land and 10% its marine environments by 2020. The report also lays the groundwork for a new framework aimed at protecting nature, which will be decided upon at the U.N. Biodiversity Conference, scheduled for October 2021 in Kunming, China.

The raw numbers tabulated in the report revealed that parks, preserves and other conservation-focused areas cover 16.64% of all land. The report's authors say ongoing efforts to identify all of the land that's currently conserved or managed privately or by Indigenous and local communities will almost certainly be enough to push that proportion past the 17% goal in Aichi Target 11. But although protected area coverage in the oceans has more than tripled since 2010, the 28.1 million square kilometers falls short of safeguarding 10% of marine environments worldwide.

The report also notes that some protected areas do a better job of protecting biodiversity and critical ecological regions than others. "It's not enough putting up a fence," Andersen said. "We also need to ensure that the quality is up to standard." She noted that protected areas are crucial pieces in the global climate puzzle, given that they hold about a fifth of the land's sequestered carbon. And a 2019 report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services has shown that, even as progress was made toward the goal of increasing protected area coverage, biodiversity has continued to decline worldwide, with around 1 million species threatened with extinction.

"The headline message here is that the quality elements of the target have made much slower progress than the quantity elements," Neville Ash, the director of UNEP World Conservation Monitoring Centre, said during the press conference. "Not all protected and conserved areas are effective."

On land, links between conserved areas are rare, with less than 8% of Earth's surface qualifying as "protected and connected." Research for the report also surfaced concerns about the data used to assess the effective management of protected areas and "other effective area-based conservation measures," or OECMs. The report also reveals that conservation measures need to be more inclusive and to place less of a disproportionate burden on poor communities. This remains the case, despite decades of research showing that management by Indigenous and local communities often helps maintain healthier ecosystems than traditional protected areas.

"We must ensure that protected and conserved areas are at the right places, well-managed and equitably governed," Bruno Oberle, director-general of the IUCN, said at the press conference.

Elizabeth Maruma Mrema, executive secretary of the U.N.'s Convention on Biological Diversity, said the past decade has revealed there aren't adequate monitoring mechanisms for assessing protections for land and water. The panel also acknowledged that none of the 20 Aichi targets were met in full. But Mrema said getting to 17% protection coverage on land should be encouraging, even if it was only part of the Target 11 goal. "A key lesson coming from the strategic plan is that, if we take action, then we deliver," she said. "We can do it, and we've done it."

- https://news.mongabay.com/2021/05/protected-areas-now-cover-nearly-17-of-earths-surface-u-n-report/

Titles of papers available under https://ipc2021.publicon.ee/extended-abstract-form/confirmed-oral-presentations/
Titles of posters available under https://ipc2021.publicon.ee/extended-abstract-form/confirmed-poster-presentations/

'Zombie fires' are already smoldering in the Arctic. They could become more common as the planet warms

As global temperatures rise, the once reliably frozen Arctic has seen a rash of massive wildfires in recent years. And while biting winter cold and heavy snow are enough to eventually suppress most blazes, scientists say the right conditions can create fires that just will not die. Like their undead namesakes, these so-called 'zombie fires' are tough to kill. Fed by fuel-rich soils in the Northern Hemisphere and subsisting on the meager oxygen available beneath the snow, zombie fires can smolder for months, long after flames above ground have been extinguished. And sometimes, fires that have burned all winter long can ignite new blazes the following year after the snow has melted.

Sander Veraverbeke, an associate professor at Vrije Universiteit Amsterdam, first suspected this phenomenon was sparking wildfires several years ago. Scanning satellite images for an earlier study that examined the role of lightning in triggering Arctic fires, Veraverbeke noticed new fires were igniting near land that had burned the previous year. 'I saw that on the edges of the fire scars from the year before, flames were popping up again in spring and new forest fires were starting on the edge. And to me, that was really intriguing,' he said. Veraverbeke said that local fire managers confirmed that they too had observed fires that seemed to survive the winter.

Still, it was unclear how widespread these zombie fires were -- and whether they were becoming more frequent. In a new study published in the journal Nature, lead author Rebecca Scholten of Vrije Universiteit Amsterdam, along with Veraverbeke and other co-authors, attempt to answer these questions. Overall, they found that zombie fires are responsible for just a fraction of the land burned by fire in most years. However, they warn that they could become a force for firefighters to reckon with, as human-caused climate change loads the dice in favor of the hot, dry conditions that can trigger large wildfires. 'We will have more of these extreme fire seasons, which also means that we will likely have more zombie fires,' Veraverbeke said. 'So even though it's a relatively small percentage now, it's likely that it may become more in the future.'

Using field observations and satellite monitoring, the study surveyed forests in Alaska and Canada's Northwest Territories during the years between 2002 and 2018. During the years examined, the study found zombie fires were responsible for just 0.8% of the total land burned and 0.5% of the total carbon emissions released by fires in Alaska and the Northwest Territories. However, there were some years when they made up a much more significant piece of the overall fire picture. In 2007, 2008 and 2010, zombie fires were responsible for more than 5% of the land burned and carbon emissions generated by fires in Alaska. In 2008, a single zombie fire in Alaska scorched more than 33,000 acres as it simmered all winter, an area equal to 38% of the total land burned in the state by fires that year, the authors found. Both regions are home to extensive boreal forests containing huge stocks of pine, spruce, fir and some deciduous tree species, as well as soils rich in the flammable mixture of decaying vegetation known as peat. When peat burns, that carbon is released into the atmosphere, where it stays and contributes to global warming. The researchers found that years that featured large fires and above-average temperatures were strongly correlated with a higher prevalence of zombie fires.

Zombie fires were observed during all six winters following the six hottest summers in the Northwest Territories, while none were observed after the seven coolest summers over the study time frame.
Since 2000, the Arctic has warmed more than twice as fast as the rest of the planet. Average temperatures in Alaska are now between 3 and 4 degrees Fahrenheit warmer than they were in the early 20th century. And though these fires that can survive winter remain rare, the researchers argue that we should continue to monitor their occurrence, along with the other changes that are transforming these high-latitude forests. 'I think the sheer fact that this is happening really shows that this region is changing so, so quickly,' Veraverbeke said. 'it's really a testimony of the rapid warming in the Arctic and boreal (forests).'

- https://www.waaytv.com/content/news/574453122.html

Post-burning landscape in Alaska. Photo: Hans Joosten.

Africa

Democratic Republic of Congo

Meeting on the definition of peatlands in Kinshasa

Delegates from national and international structures interested in the theme related to peatlands met on Friday, June 18, in a video conference, in order to share preliminary ideas on the definition of peatlands as well as possible typologies. Organized by the Peatland Management Unit of the Ministry of Environment and Sustainable Development, this meeting is part of a preliminary meeting on the definition and identification of peatland typologies. According to the head of this unit, Jean Jacques Bambuta, who confided in the ACP, the DRC, needing multisectoral data including mapping, is called upon to develop a definition of the peatland and to identify the possible typologies. The meeting will take into account, in the inventory, the mapping of peatlands and the possible typologies existing in the country.

Mr. Bambuta recalled that the DRC has launched its country dynamic dedicated to the valuation of peatlands, in response to one of the recommendations of the third meeting of the Global Peatland Initiative which was held in March 2018 in Brazzaville.

The Ministers of Environment of DRC, Indonesia and Rep. of Congo signing the Brazzaville Declaration. On the background the then UNEP Secretary-General Erik Solheim. Photo: Hans Joosten.

The first national information workshop on peatlands held in Kinshasa in July 2019 resulted in a roadmap for the preparatory phase for peatland management, while the Ministry of Environment and Sustainable Development presented the national vision on this ecosystem during the round table in December 2020. The Ministry of Environment and Sustainable Development has data on the legal framework conducive to peatland management as well as a picture of national competencies in this ecosystem.

- https://acpcongo.com/index.php/2021/06/19/meeting-on-the-definition-of-peatlands-in-kinshasa/

Republic of Congo

Congolese peatlands, a lethal weapon

Since 2017, it has been official that the Congo holds a real treasure for humanity in its subsoil... as well as a time bomb. Work carried out over three years by British researcher Simon Lewis and his team from the University of Leeds (UK), published in January 2017 in the scientific journal Nature, has confirmed the existence of the largest area of tropical peatlands on the planet, along with those in Brazil and Indonesia. "NASA had identified these peat bogs as early as the 1960s, but we had to wait for the results of the scientists to really acknowledge their existence," explains Arlette Soudan-Nonault, the Congolese Minister of Tourism and the Environment. The country alone holds a third of the 150 000 km^2 of this marshy ecosystem located on the border between the two Congos. The huge carbon sink discovered in the swampy bowels of the Congo and DRC is estimated to contain more than 30 billion tonnes of CO_2, equivalent to three years of global emissions (or 20 years of US emissions). The United Nations considers that protecting this peatland area and preventing its drying up, already envisaged on the DRC side by some oil and forestry predators, is an absolute ecological priority.

Located in remote areas, the Congolese peat bogs have so far been spared human activity. Their balance has not been disturbed for food production, mining or oil extraction, unlike Indonesian peatlands, which have been deforested and drained for palm oil and pulpwood cultivation. This has resulted in massive carbon dioxide emissions and the ignition of peat, triggering large-scale fires in Sumatra and Borneo, making Indonesia to one of the world's largest emitter of CO_2. In order to learn how to avoid such a catastrophe, in March 2018, Congo and the DRC jointly signed the Brazzaville Declaration with Indonesia, for better management and conservation of Congolese peatlands. The challenge is therefore to limit the damage that could be caused by local populations, who are called upon to respect their environment, in the Congo Basin even more than elsewhere, by promoting "economically sustainable and responsible practices".

For its part, the Congolese government seems to want to assume its responsibilities. Where Kinshasa has authorised some twenty forestry concessions, Brazzaville has been content to issue a single prospecting permit, in 2019, to the Congolese company Petroleum Exploration and Production Africa (Pepa) on the Ngoki block, on the edge of the peat bogs... Like a warning to the international community which, despite its promises, is slow to put its hand in its pocket.

In other words: Congo intends to protect this peatland complex to "serve humanity", but this must not be at the expense of its "right to development". In September 2019, Paris and Berlin did sign a letter of intent committing $65 million to the Central African Forest Initiative (CAFI), but no money has yet been disbursed.

There is no doubt that Congo will put the issue back on the table at COP26 in Glasgow in November, so that the international community will also assume its responsibilities. In the name of preserving the peat bogs and all the biodiversity of the Congo Basin.

- https://www.jeuneafrique.com/1117775/societe/serie-green-congo-3-3-les-tourbieres-congolaises-une-arme-fatale/

Peat swamp forest (background) and open peatland in the Republic of Congo. Photo: Hans Joosten.

Asia

Efforts to restore tropical peatlands need fire-free plantations

Come dry season every year, fires flare up across Indonesia, including in protected forest areas. Not only do these endanger the plant and animal wildlife in these forests, but they also spew clouds of toxic smoke that choke up cities and lungs, affecting 50 million people across Southeast Asia. Officials struggle to extinguish these fires, in part because the areas burning are peatlands.

In Southeast Asia, especially in Indonesia and Malaysia, peatlands have been extensively drained and cleared using fire for agricultural purposes (mostly for oil palm, rubber, paper and pulp plantations). Since 2000, more than 90% of global land area expansion for oil palm production has taken place in Indonesia and Malaysia. As a result, there has been a dramatic increase in the frequency, intensity and extent of peatland fires. In Indonesia, peat fire hotspots include Sumatra and Kalimantan, where around 13 million ha of peatlands have burnt up over the last few decades. These peat fires and haze events have been increasing in intensity and scale of destruction. The 2015-16 fires are thought to have caused 100,000 premature deaths, large-scale deforestation, massive GHG emissions and economic losses amounting to over $16 billion USD in Indonesia alone. To address the issue, a peatland restoration agency was formed, and the Directorate of Peatland Degradation Control within Indonesia's Ministry of Environment and Forestry was established in 2015. Yet, forest and peatland fires remain a major challenge, with over a million ha burning again in 2019, half of which were peatlands.

So what can we do to reverse course? One important step would be to transition to fire-free sustainable peatland management in plantations. This could include implementing zero-burning techniques of land preparation, developing peatland-adapted livelihoods, and encouraging financially viable agribusiness options for peatland fire risk reduction. As part of the International Fund for Agricultural Development (IFAD) supported ASEAN Peatland Forests Project (APFP) funded by the Global Environment Facility (GEF), communities in Indonesia were trained to manage and control fires. Community fire groups and brigades were also established, and innovative community regulations to prevent fires supported these measures.

Rehabilitating and restoring degraded peatland areas is also crucial. The U Minh Thuong National Park in Vietnam, where APFP supported on-the-ground community-based restoration, was designated as an ASEAN Heritage Park and officially recognized as a Ramsar site in 2015. Key to this success was raising awareness of the importance and value of the peatland ecosystem within the local community. Developing alternative livelihoods in the buffer zone was also critical. The 51 households living in the buffer zone were issued "green contracts" to better manage the buffer zone and to adopt alternative income-generation activities such as fruit and vegetable growing, fish farming, and livestock and poultry management. This integrated approach has meant that the national park has seen no forest fires or illegal activities since 2009, while household incomes have increased to $5,000 USD per year. The native vegetation and wetland habitats and the biodiversity in the park have all seen an uptick.

Another scheme that took a microfinance approach to engage local people in reforestation activities in Indonesia, the "Buying Living Tree System", hinges on the community being involved in seedlings aftercare and maintenance instead of just planting predetermined number of seedlings, and thus has a longer scope in operation. This was so successful that the Philippines is replicating it on a national scale.

Restoration of peatlands also requires a behavioral change by everyone involved at the landscape level – including government institutions, large-scale private sector plantations, smallholder farmers, NGOs, etc. The National Action Plans on Peatlands developed in most ASEAN countries are an important policy step to promote sustainable peatland management. However, insufficient law enforcement, lack of inter-agency coordination, relatively weak governance, and poor institutional capacity for forest and peatland management have been barriers to its implementation.

The problem of transboundary haze pollution will require a strong regional solution. ASEAN has played a leadership role in pushing the ASEAN Agreement on Transboundary Haze Pollution (AATHP), ratified by all ASEAN member states. The AATHP seeks to promote sustainable peatland management, restore damaged peatlands, and reduce the rate of further degradation. However, there is still a need for credible data to prioritize action, a

strengthened and inclusive coordination mechanism to align various stakeholder actions to tackle an agreed set of priorities, as well as funds to promote haze-free agriculture and the sustainable management of peat swamp forests. The IFAD-funded regional program Measurable Action for Haze-Free Sustainable Land Management in Southeast Asia (MAHFSA), implemented by ASEAN with support from the Global Environment Centre and the Center for International Forestry Research, aims to address this gap.

The MAHFSA program is complemented by in-country projects in both Indonesia (ongoing GEF5 SMPEI, and recently started GEF6 IMPLI projects) and Malaysia (recently started GEF6 SMPEM, and ongoing IFAD project TAKE-SMPEM). These projects seek to institutionalize sustainable peatland management at the national level, scale-up landscape-level planning models, build capacity on fire-free alternative livelihoods, and raise awareness to tackle land clearance by fire at the local level.

These initiatives are playing a catalytic role in halting further degradation of forests and peatlands by preventing conversion and land clearance using fire. They are also encouraging the adoption of haze-free farming systems by both smallholders and large plantations. But there can be no room for complacency. We must continue to strengthen regional coordination to protect and restore peatlands – and all the rich variety of flora and fauna they are home to – as well as preserve the health of the people in Southeast Asia.

- https://news.mongabay.com/2021/06/efforts-to-restore-tropical-peatlands-need-fire-free-plantations-commentary/

The IUCN advisory mission on its way through the peat swamp forests of Colchis, Georgia. Photo: Hans Joosten.

Georgia

IUCN recommends Colchic rainforest and wetlands (Georgia) for the World Heritage List

IUCN, the official advisor on nature to UNESCO's World Heritage Committee, recommends two new inscriptions on the prestigious World Heritage List for sites in Georgia and Japan. Both places harbour a rich diversity of plant and animal species, many of which cannot be found anywhere else on Earth.

The Colchic Rainforests and Wetlands site, in Georgia, is recommended for inscription by IUCN for its exceptional biodiversity values. The site includes seven areas of rainforests, peatlands and mires in the Colchis, a distinct ecological region in Eurasia. It harbours numerous species of plants and animals adapted to extremely humid

climate, including the Critically Endangered Colchic sturgeon (*Acipenser colchicus*) as well as 1,100 species of plants, some 500 species of vertebrates, and many invertebrates. IUCN's advice is part of a first release of documents by UNESCO for the 44th World Heritage meeting, taking place online from 16 to 31 July and hosted by China.

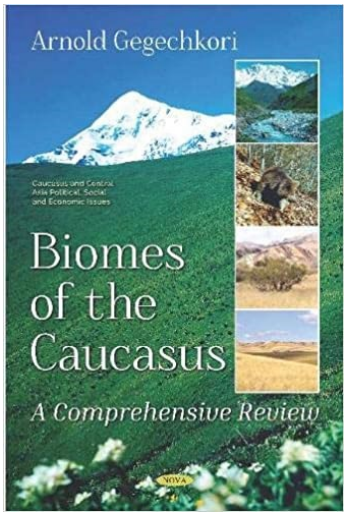
- https://iucn.org/node/34632

Arnold Gegechkori (1940 - 2021). Photo: Hans Joosten

IMCG member and acclaimed biologist Arnold Gegechkori dies of Covid at 81

Georgia's acclaimed biologist, ecology teacher, TV presenter and IMCG member Arnold Gegechkori died in the last weekend of May at age 81 of Covid-19, with his long-standing colleagues, students and the wider public attending his funeral on the following Tuesday. Tributes flowed that week to mark the legacy of the scientist who published hundreds of scientific works, articles and books, led lectures at Georgian and foreign universities, worked at the zoology department of the Georgian National Museum, and for over three decades presented the popular Georgian Public Broadcaster programme *The Gates of Nature* that introduced the natural world to a wide range of viewers. The Georgian National Museum network paid its own homage to Arnold with an obituary on social media that praised his work on studying biodiversity of the Caucasus region - including all of its protected areas - as well as his expeditions to most of the 36 "hotspots" of biodiversity across the world.

Arnold was a member of numerous local and international communities and unions of naturalists, geographers, and ecologists, and recipient of prizes including the Order of Honour of Georgia in 2013, the Ivane Javakhishvili Medal of the Tbilisi State University in 2000, the International Man of the Year title from the International Biographical Centre in the United Kingdom in 2000, and the 'Guard of the Nature' Medal of the Ministry of Nature Protection of Georgia in 1994. IMCG will especially remember him for his efforts to make the 2009 IMCG Field Symposium and Congress into a scientific and social highlight.



The GNM obituary noted Arnold's leadership of the museum 's Caucasus expeditions that resulted in diversified collections of fauna, including exhibits subject of international conventions of environmental protection and the Georgian Red List of endangered species. His authorship of around 600 scientific articles and books also received a mention. These works include *Biomes of the Caucasus: A Comprehensive Review* (2019), the first scientific work in English on the subject, which he had originally prepared as the extensive excursion guide for the IMCG Field Symposium in Georgia and Armenia in 2009. Arnold spent 16 years teaching students of natural sciences as full professor at the Tbilisi State University Faculty of Exact and Natural Sciences, where he led the biodiversity direction and the bachelor's programme of Ecology. His educational work also included lectures presented at universities in the USA, Australia, New Zealand, Kenya, Mexico and Ecuador.

- https://agenda.ge/en/news/2021/1476

Indonesia

Palm oil exports reach decade high $3 billion in May

The value of Indonesian palm oil product exports reached a decade high in May as commodity prices rose in line with the economic recovery seen in numerous developed and emerging economies. The average price of crude palm oil (CPO) on the Rotterdam market in terms of cost, insurance and freight (CIF) similarly reached a decade high at US$1,241 per ton. At around $3 billion, palm oil products accounted for 18.5 percent of Indonesia's total exports in May. "The rise in exports was also supported by the 12 percent increase in volumes to 2.95 million tons [in May] from April," the Indonesian Palm Oil Association (Gapki) reported in a press release published on July 14. The biggest monthly increase in volume was seen in products derived from palm kernel oil (PKO), followed by derivative CPO products.

- https://www.thejakartapost.com/paper/2021/07/15/palm-oil-exports-reach-decade-high-3-billion-in-may.html.

Paper giant APRIL's expansion plan alarms environmentalists

A plan by one of Indonesia's largest pulp and paper companies to ramp up production in the Indonesian province of Riau, Sumatra, has alarmed environmental groups. Asia Pacific Resources International Limited, or APRIL, is slated to boost capacity by signicantly expanding its mill operations in the heartland of Indonesia's pulpwood industry. Riau is home to APRIL's main pulp and paper subsidiary, Riau Andalan Pulp & Paper (PT RAPP), which plans — subject to approval by the local authorities — to increase pulp capacity to 5.8 million tonnes per year, and production of paperboard of 2.9 million tonnes per year, according to data from PT RAPP's environmental impact assessment. If approved, the first phase of new production capacity will come online in 2025. APRIL says that it will increase production by improving the productivity and efficiency of its operations and will not expand its plantations. But environmental groups question where the wood will come from to meet such a large increase in capacity.

According to a calculation made by Eyes on the Forest (EoF), a coalition of non-governmental organisations (NGOs) that investigates forest clearing and land-grabbing in Indonesia, APRIL's capacity increase could put about 120,000 hectares of natural forests at risk every year to feed its mills.

APRIL told Eco-Business that its growth plans are in line with the company's sustainability policy, which has ruled out clearing natural forests for the past six years. APRIL2030, a net-zero commitment made last year by the company, will stop the expansion of any of its current land concessions.

Christopher Barr, executive director of Woods & Wayside International, a non-profit that analyses Indonesia's pulp industry, said that APRIL's mill expansion would increase its annual wood consumption in Indonesia by more than 50 per cent if fully implemented. Meeting this demand "will create significant challenges for APRIL's wood supply and intensify pressures on the resource base for decades to come," he said. "We all need to be asking

what risks this poses for deforestation, conversion of carbon-rich peatlands, and conflicts with local communities," he told Eco-Business.

Riau is known for its peatlands, has experienced Indonesia's highest rates of deforestation in recent years, and has lost about half of its forest cover. The area is also fire-prone. The drainage of peat to plant acacia and eucalyptus, the crops of the pulp and paper industry, leaves it vulnerable to fire, resulting in the outbreaks of haze air pollution that blight much of Southeast Asia almost every year.

Barr said he is "not optimistic" APRIL can meet such a large increase in wood demand from its existing plantations alone, and called on APRIL to release a detailed wood supply plan for public review by independent experts. APRIL said that it is self-sufficient in fibre supply, and increased efficiencies, productivity gains and land optimisation will mean that it will not need to source fibre outside of its own concessions and supply chain. "APRIL has not applied for additional industrial plantation licenses, nor do we plan to do so," the company said.

Questions about APRIL's expansion plans come four years after similar concerns were raised over the opening of a large pulpwood mill in South Sumatra by APRIL's key competitor, Asia Pulp and Paper (APP).

APRIL and APP, which combined control 80 per cent of Indonesia's pulpwood industry, have both made high-level commitments to stop clearing rainforests to expand their operations following years of campaigning from environmental groups. These commitments have been called into question over their use of suppliers linked to deforestation.

APRIL, and parent company Royal Golden Eagle, produced a zero-deforestation policy in 2015 after years of being labelled an industry laggard in tackling deforestation. APRIL has invested millions in infrastructure and social programmes to prevent and suppress fire in peatland areas, and points to the Restorasi Ekosistem Riau (RER), a forest restoration area in Riau, to showcase its conservation efforts.

A report from a coalition of non-government organisations, published in 2019, warned that the presence of agribusinesses on peatlands poses an ongoing threat to these climate-critical areas, which act as powerful carbon sinks. The report highlighted that APRIL and other high-profile pulpwood companies have pumped money into projects that have increased land-use pressure on drained peatlands while promoting their sustainability and fire control efforts. APRIL has argued that it is committed to "responsible, science-led forestry" on peatland, and said it is legally obliged to continue operations on its licensed peatland concession areas. About half of APRIL's 480,000 hectares of cultivated land are on peat.

- https://www.eco-business.com/news/paper-giant-aprils-expansion-plan-alarms-environmentalists/?sw-signup=true

Why Indonesia's rice paddy expansion is raising climate concerns

A desire for self-sufficiency in food production can conflict with environmental stewardship. In Indonesia's peat forests, that conflict has serious implications for the world's carbon emissions. So far, Sebangau National Park has been spared the fate of other carbon-rich forests that were cleared for rice production in the 1990s. Under President Suharto, Indonesia converted 1.6 million hectares of peat forest for his Mega Rice Project, which became one of the biggest agricultural catastrophes in modern times. The rice failed to grow in acidic soil, and the irrigation canals that were built drained the waters that had inundated peat forests. The result: parched peatland that burned repeatedly, spreading haze across Southeast Asia.

Indonesia's parched peatland accounted for 76% of its forest fires in 2019, according to an analysis by David Gaveau, a landscape ecologist who studies deforestation. In the same year, at least half of the mega-fires in Borneo started in Central Kalimantan, says Fatkhurohman, a spatial-planning consultant in Palangkaraya, the provincial capital.

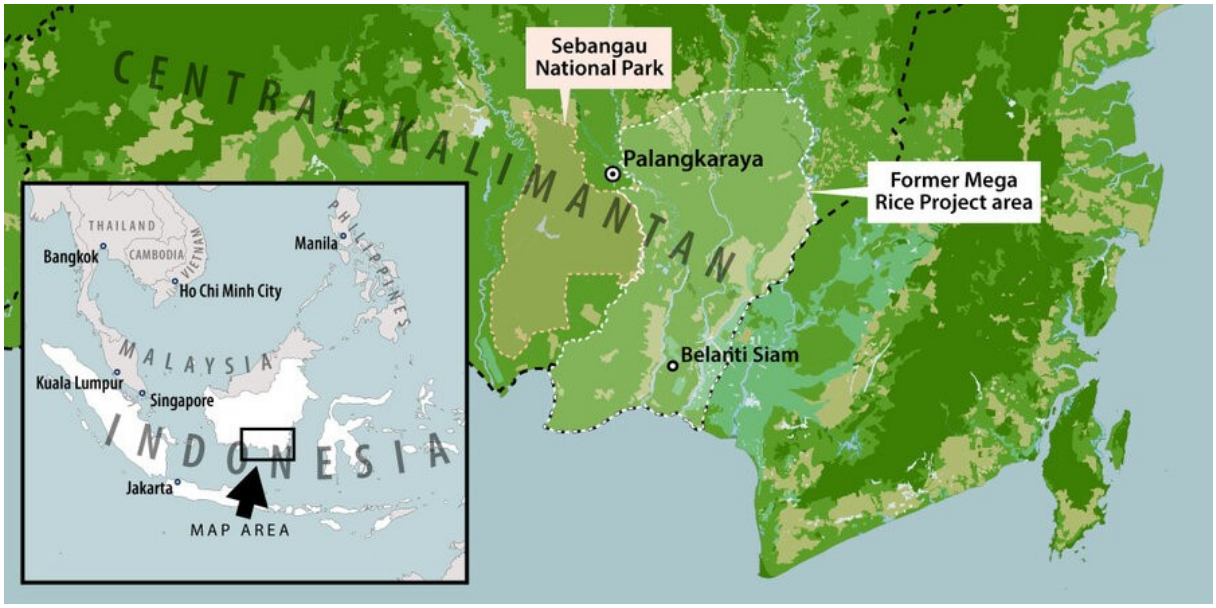
Now President Joko Widodo has a plan for this degraded land: Plant rice in vast quantities so that a nation of 276 million people always has enough to eat. The promise is that rice cultivation on Borneo will also spread prosperity and help prevent forest fires. Put simply, this time will be different. Or so the story goes.

President Widodo's government insists that technology and better planning will make his project succeed where Mr. Suharto's failed so spectacularly. It's a high-stakes strategy that has consequences far beyond Indonesia's borders, given its outsize greenhouse gas emissions. At the Sebangau research center run by the Center for International Cooperation in Sustainable Management of Tropical Peatland (CIMTROP), the new rice-planting project is cause for concern. Kitso Kusin, a senior researcher, says Indonesia needs to conserve its remaining

peat-swamp forests like Sebangau and to replant the degraded peatlands with native trees. He and other critics worry that agricultural land conversion on a mass scale could lead to more devastating fires and deadly haze.

Illegal rice cultivation in Sebangau National Park, Central-Kalimantan. Photo: Hans Joosten.

There are also serious questions about the effectiveness of the technology that underlies the government's ambitious production targets. Is it really different this time? And what happens to farmers if the peatland resists their efforts? Mr. Suharto's rice project "made Central Kalimantan into a source of disaster," Mr. Kusin says. If the new one fails, he warns, "we're going to be the victims again."



Indonesia's plan to produce rice and other food crops was initially framed as a response to the pandemic and the risk of international food shortages. "Providing food stocks is a strategic agenda that we need to adopt to anticipate a food crisis [caused] by the COVID-19 pandemic," Mr. Widodo said in September 2020. Mr. Widodo's proposed food estates would eventually cover an even larger area than Mr. Suharto's: at least 2 million hectares of land on the island of Sumatra and in Kalimantan. The first stage is to plant rice on 165,000 hectares of former Mega Rice Project land in Kalimantan. The site is a showcase for Indonesian President Joko Widodo's food estate program.

Yiyi Sulaeman, the head of the Ministry of Agriculture's Wetland Agriculture Research agency, says this stage of the project is feasible because the peatland has been consumed by repeated fires, leaving only a thin layer of peat and mineral soil on which to plant rice. Mr. Sulaeman says the project can also be a strategy to prevent forest fires. "If we keep on neglecting these degraded lands, the chance of forest fires is higher," he says. But when the land is used for farming, the farmers will look after it and put out any wildfires. Researchers at the Ministry of Agriculture have developed a range of homegrown technologies to improve the soil and boost productivity. These include organic fertilizers to decrease soil acidity and peatland-friendly rice variants designed to have higher yields and to resist disease, says Susi Susilawati, an agriculture ministry researcher in Palangkaraya.

To test its technology, the Ministry of Agriculture is using a 1,000-hectare rice-growing area in Belanti Siam as a showcase for the entire food estate project. Its researchers are helping farmers there to apply their research to peatland crop production. Last October, Mr. Widodo visited the site and spoke optimistically about the program's prospects in Central Kalimantan, referring to fertilizer-spraying drones and floating tractors designed to plow two hectares of land a day. "This [technology] is an acceleration of speed because we are going to work on a very vast area," he said. "Mechanization and modern tools are needed."

Rice cultivation in the Ex-Mega-Rice-Project area, Central-Kalimantan. Photo: Hans Joosten.

On a recent cloudy afternoon in Belanti Siam, there was little sign of this acceleration of speed – and indications that not everything was going to plan. Farmers were working the rice fields but without the promised new technologies. No floating tractor could be seen, only manual plows. Most of the farmers are migrants who moved

here in the 1990s and at first struggled to grow rice on cleared peatland; the recurrent fires eventually made it feasible to plant. Now blocks of yellow and green rice paddies stretch to the horizon. Ahmad Darmaji, one of the farmers, said they were using a variant called Hibrida Suppadi 89 that is known by farmers to resist pyrite, a toxic compound found in degraded peatland. The variant came not from the government but from a commercial distributor. Safrudin Mahendra, the director of Save Our Borneo, a conservation nonprofit, says many farmers in Belanti Siam are now reluctant to use technologies supplied by the government. He found that those farmers who did follow the government's guidance had disappointing results. "Several farmers' groups whom we met in Belanti Siam did not harvest anything at all," he says.

While one of the government's variants worked well, many did not, says Heriyanto, a farmer who owns three hectares of land at the site, in a phone interview. The variant that he was given produced a much lower yield. "It was an extraordinary drop. I could usually get eight to nine tons per two hectares with Suppadi 89, but I only got two tons of rice" per two hectares, he says. Mr. Heriyanto, who like some Indonesians goes by one name, adds that his crop was infected by a fungus. Mr. Safrudin says the food estate project is flawed because Jakarta hasn't clearly set out the rules, and its approach is confusing farmers. For example, he says, the government pressured farmers to plant earlier than usual last year, in October, so as to be able to harvest three crops a year rather than two. That meant that farmers did not wait – as they normally do – until the season of high winds (and mouse reproduction) was over. The result? The paddies failed to produce. That is a warning signal for what lies ahead, he cautions. "We've already seen a failure," he says. "And if it fails on the showcase site, what will happen in other areas that have never been used since the 1990s?" Ms. Susilawati, the government researcher, insists that planting did not start until late November, pointing to a schedule at her agency's base camp in Belanti Siam. But that is not how Mr. Heriyanto and other farmers remember it. Ms. Susilawati told the Monitor that the first planting cycle was a success because the average yield was 4.6 tons of rice per hectare. She admits that some variants produced low yields and contracted diseases, adding that extreme weather led farmers to harvest prematurely. Heavy rains also caused humidity and disease. But crop failures only occurred on 26 hectares, or less than 3% of fields, she says. Ms. Suilawati says farmers at Belanti Siam are still eager to plant her agency's new rice variants. As for the floating tractors, that's not her agency's role. "We only teach farmers how to use this mechanization," says Ms. Susilawati. She adds that farmers are already using two tractors for land preparation. But the challenge of converting Indonesia's peatland for sustainable food production goes beyond a lack of tractors and reliable rice variants.

When he visited other project sites last year in Talio and Dadahup villages, Mr. Kusin found that their crops had failed to thrive. In those sites, the problem is irrigation: Too much water leads to flooding, but insufficient water means pyrite will poison the crops. Mr. Sulaeman says this problem can be managed. The government is now revitalizing irrigation canals built in the 1990s. This system is "designed by experts on soil science and hydrologists. ... It won't create negative environmental impact," he says. Still, Mr. Kusin worries that this could be a double-edged sword since canals built around deep peat areas could deplete the carbon-rich water. "Canals always decrease the height of the water table," he says. More dried-up peatland means a greater risk of fires that spew more carbon and toxic haze into the atmosphere, which experts say have caused respiratory illness for millions of people across Southeast Asia. But those who have suffered the most are the residents of Central Kalimantan.

These include Mr. Kusin's colleagues. One of them is CIMTROP's founder, Suwido Limin, an agricultural professor at the University of Palangkaraya who spoke out against Mr. Suharto's mega project. Since the 1997 haze disaster, not only did Mr. Limin study the science of peatland restoration in his lab, but he also went into the field to fight wildfires and to block canals that were depleting peat swamps. He died in 2016 after being diagnosed with a cancer that his colleagues believe was the result of his repeated exposure to fires and haze.

- https://www.csmonitor.com/Environment/2021/0520/Why-Indonesia-s-rice-paddy-expansion-is-raising-climate-concerns

Japan

Mitsubishi board beats back climate resolution

Mitsubishi UFJ Financial Group (8306.T) shareholders on Tuesday, June 29, defeated a proposal for the bank to align its business with global targets on climate change. Activist investors in Europe and the United States trying to halt climate change have successfully compelled companies to divest their fossil fuel holdings but the tactic has failed in Japan so far. This is the fourth time since 2020 a so-called shareholder climate resolution has been defeated after being brought before a Japanese listed company.

Mitsubishi UFJ's board opposed the resolution saying the "essential content" of the proposal "has already been incorporated into the company's management strategies," with a recent carbon neutrality pledge and other policy changes. Non-governmental organizations Kiko Network and Rainforest Action Network offered the resolution, supported by a number of shareholders, including EOS at Federated Hermes, which focuses on sustainable investing. "While we welcome the recent updates to the company's policies and the net zero commitment for 2050, we do not believe these are sufficiently aligned to limiting global warming to 1.5 degrees Celsius," Sachi Suzuki, associated director for engagement at EOS at Federated Hermes, said in an email.

- https://www.reuters.com/world/asia-pacific/mufj-board-beats-back-climate-resolution-activists-falter-japan-2021-06-29/

Why Investors must hold MUFG Bank accountable for climate impacts

Shareholders of Japan's largest bank Mitsubishi UFJ Financial Group (MUFG) will vote Tuesday, June 29, on a resolution calling on the company to align its financing and investments with the goals of the Paris Climate Agreement. As Asia's worst financier of fossil fuels - $148 billion since the adoption of the Paris Agreement - the resolution could have a significant impact on the world's climate trajectory, and trigger other Asian banks to follow suit, including in my home country of Indonesia. But MUFG's climate footprint goes beyond fossil fuels, and this resolution could also have a long-lasting impact on the world's remaining tropical forests and peatlands, which are critical to solving the climate crisis, not to mention global biodiversity and land rights.

The International Panel on Climate Change (IPCC) estimates that nearly a quarter of global emissions come from land use change, with around 11% resulting from deforestation and conversion of natural ecosystems for human use. Additional to this are carbon-rich peatlands, which alone account for 5.6% of global anthropogenic emissions. In short, it will be impossible to hit the 1.5 degree goal of the Paris Climate Agreement without halting deforestation and protecting other vital ecosystems like peatlands.

MUFG is highly exposed to sectors with major impacts on climate through deforestation and peatland degradation. According to the Forests & Finance database, MUFG is the largest banker of the palm oil industry based outside of Southeast Asia, ranking seventh globally, and a major funder of the pulp & paper industry in Indonesia and Brazil. Together, MUFG provided $2.3 billion in loans and underwriting (2016-2019) to these forest-risk sector operations alone.

In May, MUFG announced its commitment to achieve net zero financed emissions by 2050 and amended some of its policies on coal, palm oil, and forestry, presumably to address concerns raised by the shareholder resolution. Yet the 2050 pledge fails to provide any metrics or short or medium term targets for its financing of all fossil fuels or land use change. The changes to the financing safeguards aren't even adequate to address the climate emergency, and contain loopholes allowing MUFG to continue business-as-usual. This should be a major concern for shareholders as it neglects the risk of stranded assets.

For instance, MUFG amended its financing safeguards for palm oil producers by requesting its clients to adopt a 'No Deforestation, No Peatland, No Exploitation' (NDPE) policy, which is the emerging international best practice standard being adopted by international brands and banks. Yet they've left out palm oil traders that play a critical role, and exempted their Indonesian bank subsidiary Bank Danamon from applying the bank policies, despite it being a major financier of the Sinar Mas Group - Indonesia's second largest palm oil producer that has destroyed vast areas of forests and peatland for its plantations. In a similar fashion, their NDPE standard doesn't apply to other sectors that threaten forests and peatlands, particularly the pulp & paper sector, where MUFG has channeled over a billion dollars in loans and credit since 2016. To get a sense of the climate impacts of MUFG's pulp clients, consider Indonesia's Royal Golden Eagle Group (RGE). MUFG is currently participating in seven

syndicated loans totalling over USD $5.7 billion to RGE, three of which MUFG is serving as the lead arranger. While Forests & Finance only attributes USD $140 million of these loans to MUFG's financing of RGE pulp sector operations, MUFG's responsibility is far greater because of the role that it plays. New data from online platform Trase provides geospatial estimates of RGE's environmental impacts. RGE's vast pulp mills are fed by wood fibre from plantations that have caused 67,740 ha hectares of deforestation (2015-2019). Around a third of RGE affiliate's land bank is located on carbon-rich peatlands, with over a quarter of the land actually designated for protection by the Indonesian government. The climate impacts of draining peatlands for plantations are severe. A conservative estimate of the emissions from RGE affiliate plantations is around 101 million tonnes CO_2e in the five years 2015-2019. Once cleared of trees and drained, peatland becomes highly flammable, resulting in recurring land fires across Indonesia's peatlands, including the concessions of RGE affiliates, which turbo-charge GHG emissions, kicking off a further estimated 46 million tonnes CO_2e. Together, RGE's estimated emissions over five years are 138 million tonnes, equivalent to more emissions than the Czech Republic or around 14% of the annual emissions of the entire global aviation industry.

These figures illustrate the profound risks linked to land-use change emissions that are not being addressed by MUFG. Currently, MUFG's policies do not prohibit its clients like RGE from deforestation or converting more peatlands into plantations. RGE plans to expand production by 50% through increasing the intensity of production on its peatland plantations, which will likely accelerate peatland subsidence and GHG emissions as well as the risk of fires. RGE also continues to source from suppliers that are involved in deforestation and peatland degradation in both its pulp and paper and palm oil operations.

If Indonesia is to tackle its growing CO_2 emissions, it will have to protect and restore peatlands, and this process represents a serious risk to RGE's business, making much of its plantation landbank "stranded assets" and representing a material financial risk to MUFG as its creditor.

To mitigate the climate risks of its financing, MUFG cannot continue to cherry-pick sectors to address, while sticking to business-as-usual in others.

- https://www.ibtimes.com/why-investors-must-hold-mufg-bank-accountable-climate-impacts-3237613

Singapore

Low risk of severe transboundary haze in region this year, thanks partly to Covid-19: Study

The risk of severe and prolonged haze across the region this year is low with the Indonesian authorities remaining committed to preventing a repeat of 2019's unhealthy levels of poor air quality, a Singapore think-tank has concluded. Despite initial fears that the Covid-19 pandemic could contribute to haze, researchers at the Singapore Institute of International Affairs (SIIA) also found that the pandemic has disrupted land clearing and planting activities by farmers, lowering the likelihood of severe haze this year. The assessment was made by SIIA researchers in their third annual edition of the Haze Outlook Report, released on Thursday, June 24. The report categorizes the likelihood of a severe transboundary haze incident occurring according to levels of low, moderate or high risk. The risk level is assessed based on three factors: The weather, Indonesia's land management policy and human behaviour. The first two editions of the annual report, in 2019 and 2020, had predicted a moderate risk of the region experiencing a severe haze incident. This is the first time the report has predicted a low or "green" risk. Speaking at an online launch event, Associate Professor Simon Tay, SIIA chairman, said that the biggest contributor to the lowered risk this year was the positive steps taken by the Indonesian authorities to contain the haze. Assoc Prof Tay, who also teaches at the National University of Singapore's law faculty, said: "The renewal of the Peatland and Mangrove Restoration Agency as the special entity is significant. The renewal,

we feel, will help deepen (the agency's) areas and commitments." The agency, which is tasked to restore degraded peatland and mangrove ecosystems in Indonesia, had its mandate renewed by the Indonesian government last December.

The report also found that unlike previous transboundary haze incidents in 2019 and 2015, which occurred during severe drought years, weather conditions in the region are expected to be "normal or average" during the dry season from June to September this year. This means that there is "no elevated risk" of fires and haze due to the weather, the report's authors wrote. The report also noted that there are "signals" that Indonesia continues to take forest and land management seriously, even during the Covid-19 pandemic. For instance, the Peatland and Mangrove Restoration Agency had restored about 835,000ha of peatland in public land by the end of last year — an area more than 10 times the size of Singapore. Most of the fires in Indonesia occur on dry peatland, leading to haze. The Indonesian authorities have also continued to carry out weather modification efforts such as cloud seeding, a technique to promote rain, since last year.

Touching on the impact of human behaviour, Assoc Prof Tay said that when the pandemic hit last year, there was uncertainty over how it would affect outreach and education efforts to stop unsafe practices leading to fires in Indonesia. There was also concern that farmers would rush to clear land to cash in on rising agricultural commodity prices due to Covid-19. However, the report assessed that the pandemic had disrupted land clearing and planting activities by small farmers and bigger-scale businesses instead, lowering the risk of a severe haze incident this year.

Most companies interviewed by the researchers also said that plantations are a long-cycle business. This means that firms are unlikely to plant more as an immediate reaction to shifts in the market. Responding to a question at the launch on where the region stands now that it has missed the target set by the Association of Southeast Asian Nations (Asean) to be transboundary haze-free by 2020, Assoc Prof Tay said that while zero haze is a "great target", it will be difficult to get there.

- https://www.todayonline.com/singapore/low-risk-severe-transboundary-haze-region-year-thanks-partly-covid-19-study

Europe

Globally, 10–20% of peatlands have been drained for agriculture or forestry, and these emit 6% of global CO_2 emissions. Some European countries have more than 60% of their agricultural emissions originating from cultivated organic soils, and the fate of South-East Asian peatlands is of global concern. Furthermore, drainage destroys the original biodiversity, strongly impacts soil properties and may contribute to the eutrophication of surface waters. Besides classical re-wetting measures addressing nature conservation goals, innovative mitigation measures that sustain economically viable biomass production while diminishing environmental impacts and supporting ecosystem services are increasingly studied. Approaches might encompass both productive use of wet peatlands ("paludiculture") and water and soil management in conventional agriculture. To be successful, the highly diverse hydrological conditions and peat properties need to be known and understood. Still, implementing innovations in practice and into national GHG inventories remains a challenge.

We invite hydrological, soil physical and chemical as well as greenhouse gas studies addressing all approaches to improve the management of organic soils. Laboratory, field and modelling studies are all welcome. We are also looking forward to contributions that address stake involvement, policy coherence and identify policy instruments for initiating and implementing new management practices or national soil strategies for organic soils.

- https://eurosoil-congress.com/

European Union

Protecting our precious peat

Restoring and managing peatlands could improve water retention and quality, store carbon, reduce greenhouse gas emissions and improve biodiversity. Since 1992 LIFE has been working hard on this. The EU Habitats Directive and the Natura 2000 network of protected areas are vital for saving Europe's peatlands. 33 000 km^2 of peatlands are already protected under this Directive across 8 700 Natura 2000 sites. Also, the European Commission's EU Biodiversity Strategy for 2030 calls for peatland restoration and strict protection. This is vital as only 10% of Europe's peatlands are currently in good condition.

Between 1992 and 2018, LIFE funded 363 projects to conserve and restore Europe's drained and degraded peatlands. Typical actions have included rewetting by damming and closing drainage systems, deforestation on drained peatlands and getting rid of invasive alien species. Highlights of LIFE's work so far have been the restoration of 170 000 hectares of mires in the United Kingdom and 40% of Belgium's peatlands.

Considering the high rates of biodiversity loss and climate change impacts, it was deemed critical to safeguard peatlands through effective management and active restoration. It was also agreed that LIFE peatland projects can contribute to reaching the European Green Deal's ambitious targets. The new LIFE programme will aim to restore and conserve all peatlands – be they in the Natura 2000 network or not. This includes severely degraded peatlands from agricultural and forestry use as well as from industrial peat extraction.

Communicating the importance of peatlands is vital for awareness-raising and social media outreach has a particularly important role to play. Also, LIFE's experience in developing sophisticated monitoring systems is a big chance for researchers and research organisations to apply for LIFE funding

Some of LIFE's best peatland projects participated in IPC2021. They include: LIFE Peat Restore, LIFE Mires Estonia, Hydrology LIFE, Marches Mosses BogLIFE, LIFE Welsh Raised Bogs, LIFE REstore

Presentation: The LIFE programme and peatland restoration

Recording: LIFE at the 16th International Peatland Congress 2021

Factsheet: Peatlands for LIFE

- https://cinea.ec.europa.eu/news/protecting-our-precious-peat-2021-05-12_en

iDiv German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig

UFZ HELMHOLTZ Centre for Environmental Research

THÜNEN

Universität Rostock Traditio et Innovatio

With respect to the preservation of the soil carbon pools, the Green Architecture can be more pivotal. Drained, agriculturally-used **peatlands** account for merely 3% of the EU's agricultural land but contribute 25% of the EU's GHG emissions related to agriculture. To tackle this source efficiently:

- **Eligibility criteria** and the **enhanced conditionality** should exclude freshly drained peatlands from receiving CAP support.
- **GAEC 2** should cover all organic soils according to GHG reporting under United Nations Framework Convention on Climate Change (UNFCCC) and exclude any new drainage or deepening of existing drainage level and the irreversible transformation of the soil profile such as deep ploughing.
- With the help of appropriate **support instruments** (especially AECM and non-productive investments), water tables should be raised close to the surface in as many peatlands as possible. Only by raising the water table, the decline in soil carbon stock can be stopped.
- **Paludiculture** should be recognized as an agricultural land-use, and eligible for CAP support; and the conversion of species-poor grasslands on organic soils into paludiculture should be exempted from the ban on converting permanent grasslands (GAEC 1)

Synthesis report: https://www.thuenen.de/media/publikationen/thuenen-workingpaper/ThuenenWorkingPaper_175_Vol1.pdf
Policy brief: https://www.thuenen.de/media/publikationen/thuenen-workingpaper/ThuenenWorkingPaper_175_Vol1.pdf

Peatland Round Table — moving beyond peat extraction

On September 2, 2021 (14:00 CET), LIFE Peat Restore will co-host along with Eurosite (Home – Eurosite) an online panel discussion on the future of the peat industry, with a focus on how we can move beyond peat extraction. Peatland experts will discuss with industry representatives as well as national government and EU officials the challenges, conflicts and possible solutions to the phase out of peat use. Peatlands cover less than 3% of the earth's land surface, but they are believed to contain twice as much carbon as the world's forests. The destruction of peatlands is responsible for 5 to 7 percent of global greenhouse gas emissions. That is more than all air traffic. Peat extraction devastates in only a few decades a carbon rich ecosystem that takes millennia to form. Healthy peatlands are vital to our lives. They afford us protection from floods and fires, as well as filter our water and keep our air clean. When degraded, they are capable of great harm, as they become a fire risk to communities, pollute our water and release significant amounts of carbon dioxide into the atmosphere.

The recent push for a just transition is making us question many economic activities that have been causing substantial and long lasting harm to the environment, biodiversity and climate. Over the last years the momentum has been growing, driven largely by consumers' push for change. As the consequence of the climate crisis aggravates, the need to reconsider economic activities like peat extraction becomes undeniable.

But how do we phase out peat extraction without leaving people behind? What happens to the peat sector and the people whose work depends on it? How do we transition to a more sustainable practice, while keeping employment in the same region? Moreover, as one country phases out peat extraction, how do we prevent leakage of the climate and environmental impacts into other countries, which continue to export peat? These are some of the questions the panels will address.

The first panel will focus on the phase out of peat use from a policy perspective. Representatives of the government from peatland rich countries, like Estonia, and big peat importers, like Germany, will discuss with the European Commission representative and renowned peatland expert, the policy issues surrounding peatland phase out strategies. The second panel will address potential ways forward for the peat industry from a practical perspective. The participation of representatives from the Latvian Peat Association and Growing Media Europe on the one hand, and representative of an environmental organisation along with companies committed to a future without peat extraction on the other, will ensure a lively discussion. Both panels will be chaired by Niall Ó Brolcháin, policy co-ordinator of Interreg's Care Peat project. This event is supported by Interreg's Care Peat, Carbon Connects and CANAPE. NABU is a member of the Global Peatlands Initiative. Please register here.

- https://www.eurosite.org/events/peatlands-for-climate-moving-beyond-peat-extraction/

Belarus

Peat-football tournament…: where others try to restore…

The III National Peat Bog Football Tournament of Belarus was held on Saturday June 27 in Pravdinski village, Pukhovichi district. Peat football is played in a boggy peat bog which is extremely difficult to play. The extreme game was invented in Finland, but it has its supporters in Belarus as well. This year 19 teams entered the competition.

- https://www.sb.by/articles/fotofakt-turnir-po-torfyanomu-futbolu-sostoyalsya-v-pukhovichskom-rayone.html

Estonia

The Estonian Peat Database

Estonia is rich in peatlands, covering 22% of its territory (Orru 1992). Peat reserves amount to 2.4 billion tons, of which 1.0-1.2 million tons per year are extracted. In Estonia more than 9,836 peatlands, covering an area of more than one hectare, have been systematically investigated. Of these, 558 peatlands with a larger area and important for peat extraction, peatland formation studies and nature protection purposes have been studied in more detail. They have over time been sampled to determine the botanical content, degree of decomposition, ash content, pH, trace elements and natural moisture content of the peat, and detailed maps have been drawn up. These largely handwritten data have now been entered into the digital "Peat Database", compiled in the Institute of Geology at Tallinn University of Technology (2016-2021). It is the first digital peat database in Estonia and written in both the Estonian and the English language. Estonian peat is exported to more than 110 countries all over the world, therefore, the Digital Peat Database provides valuable information about peat quality, genesis and reserves.

Systematic studies of Estonian peatlands have been carried out chiefly by the Geological Survey of Estonia. All peat samples were analysed using a uniform methodology. They represent the whole peat sequence and different types of fens and bogs across Estonia. These data were included in unpublished reports of the Geological Survey, and are now now available in the digital archive (https://fond.egt.ee).

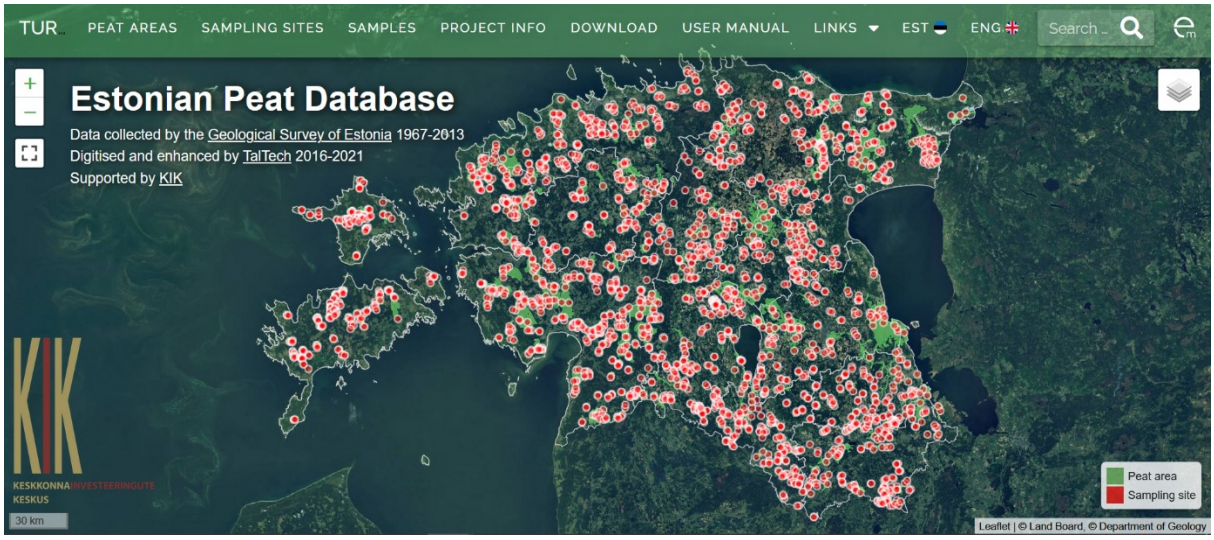
In 1967, a peat working group was established in the Geological Survey to conduct systematic geological surveys of peat deposits. As there are many peatlands in Estonia, the work was divided over several years. Every year, surveys are conducted in one to two of Estonia's 15 counties.

Peat surveys have already started in the winter, behind an office desk, where existing information on peatlands, such as previous surveys, soil maps, mire drainage data, etc., was examined. Based on this, areas where peat could be found, were selected and in the spring, acting on this information, we visited the peatlands to glean information on these areas. Peat research began with planning, based on topographic maps and orthophotos.

Peat research was carried out by a hand augert to determine the thickness of the peat. The first assessment of the peat was made in the field of an experienced peat geologist. Laboratory analyses of peat were performed by specialists in the Geological Survey laboratory. Information relating to peat, collected over almost 40 years (Estonian Peatland inventory and other peat deposit surveys) has been available through the Geological Foundation, however, much of this information was still on "paper", and was only scanned in 2020.

To ensure the free availability of peat data, all data were digitized at the Institute of Geology at Tallinn University of Technology. The first step of the work was to systematize and enter laboratory data into a digital database. Each peat sample and analysis was assigned a unique ID code, through which various data objects could be identified, referenced and linked. There were a total of 2,753 sampling points, whereby 32,942 samples were taken to determine botanical composition, degree of decomposition, ash content, pH, and natural moisture content of the peat). These samples contained a total of 165,807 plant determinations, in which the share of plant species (e.g., peat moss, reed, sedge, cotton-grass) in the peat-forming vegetation was determined. All sampling points passed through the entire peat deposit (as a rule, the sampling interval was 0.25 m) and in most cases, the sediment under the peat was also determined.

In a second step, orthophotos and available maps were georeferenced and linked to the information on absolute heights from the 5 m (DTM5) resolution model. An open-access database, compatible with geological mapping data and the catalogue of deposits in the environmental register, was compiled for public use. The database also comprises data on characteristic calorific values, trace element contents, drainage conditions, chemical composition of mire water, nature protection restrictions, Natura 2000 locations and peat extraction fields. A summarizing characterization was compiled for 558 peat deposits and peatlands (genesis, age, properties, characterization of reserves and potential fields of use). The data are deposited in the Geological Report Archive of the Survey.



The peat database has huge practical and scientific value. Peat extraction companies can find information on the thickness of the peat sequence, its extent and fields of use. Peat geologists gain information on peat genesis and temporal and spatial stratigraphical conditions. Ecologists have the opportunity to analyse various environmental changes. Information on climatic changes over the latest 10,000 years is reflected by the botanical content of peat. The database includes: 1) scanned and georeferenced maps of more than 550 peat areas, accompanied by

their characteristics and ca. 2,750 sampling sites, 2) nearly 33,000 peat samples with analytical data results, 3) over 165,000 identifications of plant species, 4) information on related data and links to other resources, notably the Environment Agency, Land Board and the Geological Survey of Estonia, 5) the Data User Manual, which includes: i) technical description of the Estonian peat database, ii) peat database web application TURBA, iii) general introduction and manuals, iv) map introduction and manual, v) search introduction and manual, vi) table introduction and manual, vii) graph introduction and manual, viii).public API, ix). map server and x) data download. The Estonian Peat Database can also be downloaded as a single data file. The creation of the Estonian Peat Database has been supported by the Environmental Investment Centre and the Estonian Research Infrastructure SaadreRoadmap NATARC. The translation of the database was supported by the Estonian Peat Association, Mikskaar AS, ASB Greenworld, Kekkilä BVB and OÜ Kalloveen Eesti.

- https://turba.geoloogia.info

Finland

Call for a tenure track or full professor position

Assistant professor / associate professor / professor Peatland forestry. Deadline for applications 30.8.2021.

- https://www2.helsinki.fi/en/open-positions/assistant-associate-professor-or-professor-peatland-forestry

Peat and Do Not Significant Harm guidelines for Just Transition Fund

The Finnish Association for Nature Conservation (Suomen luonnonsuojeluliitto) has addressed EU Commissioner Virginijus Sinkevičiusto express their concern about the possible use of 'Just Transition Fund' money for peat extraction. The Just Transition Fund is a key EU tool for supporting the territories most affected by the transition towards climate neutrality and for preventing an increase in regional disparities. The gradual fade-out of burning peat for energy in Finland has created a need for new livelihoods for people involved in the peat industry. Most peat that is extracted is used as a fuel, but some is used for growing media or animal bedding. New ways to use peat and new peat products such as biostimulants and active coal are also being developed in Finland. The Finnish Association is worried about these new initiatives and the continuation of old practices because they would continue to cause the same negative impacts on the environment as earlier. Peat extraction destroys peatland ecosystems and habitats, causes leaching of nutrients and dissolved organic matter to waters, and causes carbon dioxide emissions from the drained soils. All peat products should be replaced with more sustainable alternatives.

The Finnish peatlands have been under pressure for decades because of draining for agriculture, forestry and peat extraction. 54% of the peatland habitats are endangered and annual GHG emissions from peat soils are around 15 M tons of CO_2-e. We need to stop draining and exploiting peatlands, protect the most valuable areas and start to restore the degraded peatland ecosystems.

Just Transition Fund (JTF) money should not be given for developing new peat products as peat extraction is not in line with the DNSH (Do No Significant Harm) principle, which should apply to all funding.

- https://www.sll.fi/2021/06/11/peat-and-do-not-significant-harm-guidelines-for-just-transition-fund/
- https://www.europarl.europa.eu/factsheets/en/sheet/214/just-transition-fund

Germany

Oldest shoe in northern Germany found in bog

Archaeologists have discovered the oldest known shoe ever found in northern Germany, and maybe even the whole of Germany. The leather shoe was found next to a late Iron Age wooden plank path which dates to around 50 BCE., so the shoe is around 2,000 years old. It is a kind of sandal with the leather gathered in the front and pierced, a leather thong is threaded through holes to close the shoe. The wood plank path dubbed PR VI is remarkably well-preserved and runs 4 km through the middle of Brägeler Moor between Diepholz and Lohne. Plank paths were necessary infrastructure for humans to travel somewhat safely over the marshy boglands. They required a great deal of wood to be transported to the site and the route through the bog had to be cleared and

prepared for construction. More than 500 ancient plank paths are known to survive in Lower Saxony, but PR VI is exceptional. It is one of the longest bog trails not just in Germany but in the world. The existence of PR VI has been known for a century as sections of it were encountered in peat extraction. Until recently there was no funding to excavate it and document it archaeologically. Excavations finally began in June of 2019 and are expected to continue through 2022.

"The bogs of Lower Saxony hold the testimony of many thousands of years of history. They are a unique archive, as they have not only preserved processed shards and metal objects as decisive evidence of our history, but also organic finds," says Lower Saxony's Minister for Science and Culture, Björn Thümler, happily. "The best known are the bog corpses, but also wooden idols, long wooden paths and numerous other remnants of life at that time are part of it. A shoe that is lost and found again after 2,000 years, the oldest shoe from Lower Saxony to date, is an immensely personal testimony to a previous life. You can hardly get any more poetic to the people of that time. It is one of those testimonies that make time tangible as if under a magnifying glass."

In the immediate vicinity of the shoe there were remains of a broken carriage axle and other car fragments. You can almost grasp the incident in which the wearer lost the shoe: The axle of a wooden cart, probably pulled by cattle, broke in two and the cart had an accident on the bumpy road. While trying to recover the car parts, the owner of the shoe fell or stepped beside the path and the shoe got stuck in the sticky peat – where it was found now, over 2,000 years later.

The bog is now part of the Dümmer Nature Park which is dedicated to the conservation of the ecosystem and history of this remarkable landscape while making it more accessible to visitors. Part of the conservation program is rewetting bog that has been exposed to peat mining, and a large 520-meter section of PR VI will have to be removed before peat extraction and rewetting of the area. The ancient plank path will be a featured element in the nature park's improved trail system. It will be made "walkable" by a footbridge linked to a bog trail that parallels the original route. Visitors will be able to traverse the bog the way ancient travelers did, only their shoes will stay on their feet.

- http://www.thehistoryblog.com/archives/61594
- https://www.ndr.de/nachrichten/niedersachsen/Archaeologen-entdecken-wohl-aeltesten-Schuh-Norddeutschlands,schuh242.html

Restored wooden trackway in the Diepholzer Moor. Photo: Hans Joosten.

Audi joins forces with EU to fund study into peatland emission offsets

The Audi Environmental Foundation and an alliance of regional municipalities, cities and administrative districts are joining forces with the European Union's existing support programme to fund a study researching the capacity of peatland, woodland and humus to offset emissions. The study also aims to outline how regional farmers can repurpose their land for alternative uses and be financially rewarded for their efforts.

Peatland ecosystems are among the most efficient greenhouse gas stores on the planet. They have positive effects on our climate and provide a whole range of flora and fauna with valuable habitats. By launching the 'CO_2-Regio' project, the nonprofit Energie Effizient Einsetzen association has made it its mission to conserve this natural habitat with its exceptional biodiversity and promote the greenhouse gas storage capability of peatland. The project will formulate guidelines for farmers on how they can conserve and maintain any peatland on their estates, with particular importance attached to ensuring that these 'climate managers' receive proper financial compensation for their efforts.

Other focal points of the study include humus formation and reforestation - both equally effective climate protection measures that can also be easily implemented by owners of property with no peatland. The European Union's support programme will enable the findings of the study to be put into practice over the next two years. The feasibility study aims to create a carbon offsetting mechanism through peatland conservation, humus formation and reforestation with a view to strengthening regional business cycles and promoting alternative land uses. Since the measures have a long-term impact, they help to ensure that local farmers can continue to live off their land over the coming decades too. The aim is to enable all residents, as well as businesses and industries to attain sustainability certification, helping to promote business cycles, nature conservation, and climate protection at a local level.

- https://www.sgcarmart.com/news/article.php?AID=25054
- http://www.automobilsport.com/peatland-ecosystems-long-term-carbon-stores-co2-regio-study---223812.html
- Audi launches feasibility study to explore use of peatland ecosystems as long-term carbon stores

Mais field on peat in the Friedländer Große Wiese, Germany. Photo: Hans Joosten.

Peat reduction strategy

In the course of implementing the peat reduction strategy of the Federal Ministry of Food and Agriculture (BMEL), the German federal Agency for Renewable Resources recently published the video "Peat-free gardening like the pros" (https://youtu.be/FEH_HDdg83o). TV presenter and gardening expert Sabrina Nitsche visits the two ornamental plant nurseries Aflora and Floreco on the Lower Rhine, which produce flamingo flowers and mini-petunias peat-free. The two gardeners give tips on the correct handling of peat-free soil.

Ireland

Bord na Móna reinvents itself as climate solutions company

Bord na Móna has announced its transition to a climate solutions company after three years of work. The semi-state company has been transformed from a fossil fuel to a climate solutions company. The transformation means 80 per cent of all Bord na Móna employees now work in 'green' areas of the company, from renewable energy production, to recycling, peatland rehabilitation, and sustainable products. By 2030, Bord na Móna is aiming to supply a third of Irish homes with renewable energy.

Last year, the company announced its plan to raise €1.6 billion to fund a series of major climate focused projects, including wind, solar energy, battery storage, biomass, renewable gas and demand-side assets for delivery in this decade. The company has also made significant investments in domestic waste recycling infrastructure, Littleton farm plastics facility (on the site of a former briquette factory) in Co Tipperary and the expansion of operations of its tyre recycling facility in Drogheda. At the end of 2020, Bord na Móna launched the €126m, including €108 million in Government funding, Peatland Climate Action Scheme, which will harness the natural power of peatlands to secure a store of over 100 million tonnes of carbon in perpetuity, cut emissions, and capture millions of tonnes more in the coming years. In addition to securing employment for the 350 employees previously engaged in peat extraction activities it will play an important role in delivering the national policy objective of a carbon neutral Ireland by 2050. In January Bord na Móna announced that it has permanently ended all peat extraction activities.

Improving biodiversity and the development of amenities are also key aspects of the company's vision for the future. Much of the work on peatland rehabilitation will help the company meet important objectives concerning the improvement of habitats for native plants and animals on its peatlands. Bord na Móna chief executive Tom Donnellan said: "Bord na Móna is an iconic Irish company with a new purpose. Our new purpose is to help Ireland achieve net zero Carbon by 2050. Our new brand identity will help us tell our story and show the different ways we are doing this. "The battle against climate change is often portrayed negatively, in terms of all the things we have to reduce, give up, or cut back on. Bord na Móna's story of change is actually a very positive one. It shows that there are massive gains and opportunities to be found in climate action for the country and small communities. "In the past three years we have ended peat harvesting and are again hiring people across our businesses, creating high value, sustainable jobs in renewable energy, recycling operations, peatland rehabilitation and carbon farming and developing new sustainable horticulture and heating products."

- https://www.breakingnews.ie/business/bord-na-mona-reinvents-itself-as-climate-solutions-company-1132346.html

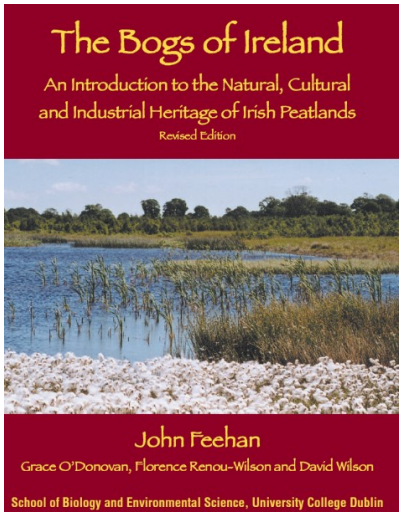
After 300 year absence from Ireland, hopes are flying high as pair of common cranes spotted nesting in bog

A pair of common cranes have been sighted nesting on Bord na Móna peatlands raising hopes they might be the first to breed in Ireland in 300 years. Although the exact location remains confidential to protect the birds, Bord na Móna confirmed the nest is located on a cutaway bog that was rewetted as part of ongoing efforts to rehabilitate peatlands. The company has already rehabilitated nearly 20,000 hectares of bogs, and last year announced that a further 33,000 hectares are to be rehabilitated as part of its Peatlands Climate Action Scheme. Ireland's cranes became extinct sometime between 1600 and 1700 due to overhunting by humans and foxes, as well as destruction of their natural habitat. The migratory birds that stand over a metre tall have deep connections to Irish culture and history. They appear in folklore tales such as Fionn Mac Cumhaill, the druids, St Colmcille, and the Book of Kells. The Irish for crane, "corr", forms part of many Irish placenames. They were even recorded as being the third most popular pet in Ireland during medieval times.

Conservation works in the UK have brought their population from 0 to over 200 in the past 50 years. This has lead to increases in crane sightings in Irish skies, and the nesting site in question has already had two failed breeding attempts in 2019 and 2020. “Pairs of common cranes usually take several years to successfully fledge chicks. This is why this sighting is particularly significant. Not only are we actually seeing these birds nesting in Ireland for the first time in 300 years, but we are very optimistic that this third attempt may yield the first crane born here in centuries,” said Mark McCorry, lead ecologist at Bord na Móna.

- https://www.independent.ie/irish-news/after-300-year-absence-from-ireland-hopes-are-flying-high-as-pair-of-common-cranes-spotted-nesting-in-bog-40435822.html

The Bogs of Ireland



On World Wetlands Day 2nd June 2021, the digital version was released of the Bogs of Ireland - An Introduction to the Natural, Cultural and Industrial Heritage of Irish Peatlands. Revised Edition by John Feehan, Grace O'Donovan, Florence Renou-Wilson, David Wilson. Since the firest publication of The Bogs of Ireland in 1996, research on Irish peatlands has been concentrated on two main areas: carbon sequestration and a re-evaluation of the prospects for afforestation of the cutaway. Apart from some minor corrections, the text of this digital version is essentially that of the original printed edition of 1996, with the exception of Chapters 5, 7 and 16, which have been expanded and rewritten to take account of recent and ongoing research and developments in these two areas. Download the entire book 78 Mb) from: https://www.ucd.ie/swamp/t4media/Bogs%20of%20Ireland.pdf

Peatlands Gathering is coming in October 2021 - register now!

Natural Capital Ireland is delighted to join forces with members of the peatland community to bring you the inaugural Peatlands Gathering event, taking place online October 7 and 8, 2021 (with the prospect of optional field trips around Irish sites on October 9th). Peatlands Gathering 2021 will feature contributions by those who are actively involved in these areas of great environmental and cultural significance from Ireland and around the world, with participants in farming and conservation of peatlands, scientific understanding of greenhouse gas emissions and water management, the rehabilitation and restoration of degraded peatlands, community stewardship and experts in various cultural aspects. Ireland’s extensive peatlands feature prominently in many aspects of our society, as they have done for decades and centuries past. The many, varied cultural and scientific perspectives on the management of these peatlands has brought us to a place where there are still several different viewpoints on where the future lies in relation to this amazing natural resource so we'll have much to discuss. Peatlands Gathering is being organised and coordinated by a range of leading interest groups, including Community Wetlands Forum, CarePeat, Irish Peatland Society, EPA, and researchers from major institutions including UCD, TCD, NUIG, UL and GMIT.

A programme of presentations and discussions on peatlands for October 7th & 8th, 2021 will share knowledge of peat projects, research and initiatives, as well as identifying challenges, and data and policy gaps in this area. If COVID allows, on October 9th, Peatlands Gathering will offer field trips to peatland areas where projects have been undertaken..

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- https://www.naturalcapitalireland.com/post/peatlands-gathering-is-coming-in-october-2021-register-now-for-this-exciting-new-online-event

Guarantee needed for farmland which adjoins rewetting projects

The Irish Creamery Milk Suppliers Association has called for safeguards to be put in place for farmers whose lands border bog areas proposed for rewetting.

- https://www.farmersjournal.ie/guarantee-needed-for-farmland-which-adjoins-rewetting-projects-icmsa-630037

Call for bog cutting to be made a protected heritage practice

Independent TD for Laois Offaly Carol Nolan has reiterated her call for traditional peat harvesting to be recognised as a cultural practice protected by domestic and EU law. "In April I wrote to Minister for Culture, Catherine Martin asking her to examine the possibility of recognising peat harvesting as a protected cultural practice. Unfortunately, the Minister's office has been less than helpful in term of its engagement on this matter. "However, when I raised the matter with the officials from the Department of Heritage, there was a welcome openness to the suggestion and a positive sense that it was certainly an idea worth exploring. "The Department also made it known that the Minister of State for Heritage, Malcolm Noonan was currently engaged in a two-month public consultation on the mid-term review of the National Peatlands Strategy. "This same Strategy explicitly recognises that turf cutting by citizens for their own domestic fuel needs is "a valued traditional activity across many peatlands."

Peat extraction in Ireland. Photo: Hans Joosten.

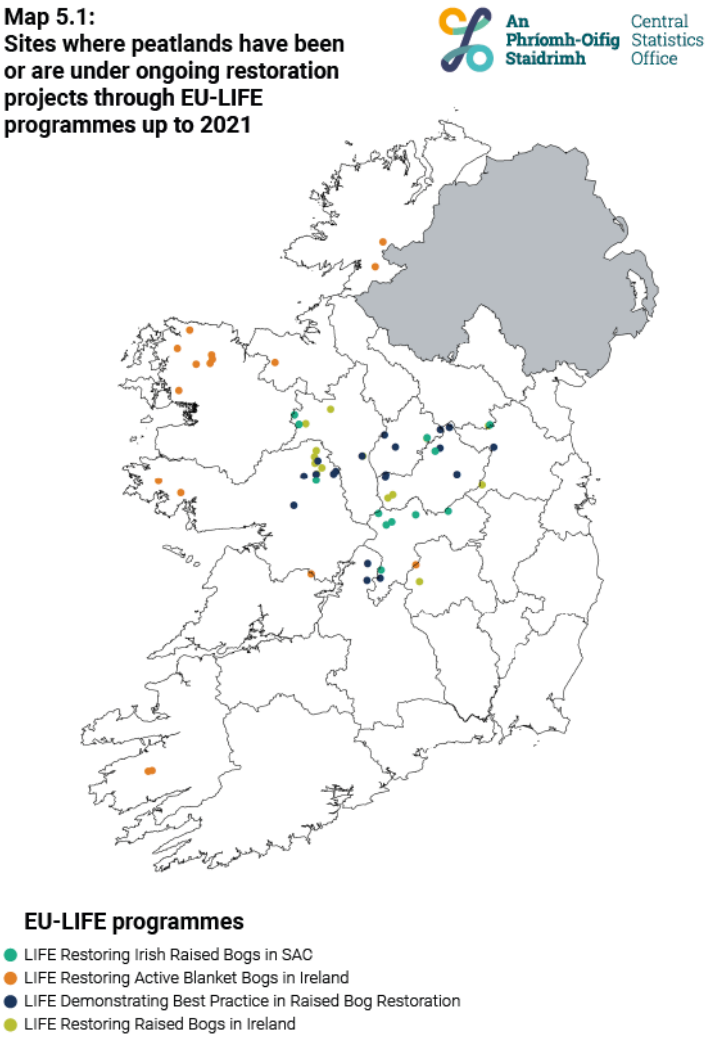
She suggested that within that recognition, clear scope for turf cutting to become a protected cultural practice. "As I made clear to the officials from the Department, we must find a way to end the creeping criminalisation of turf cutting, because effectively this is what is happening. "It is being seen more and more as a some kind of ecological crime instead of a valued traditional practice worth protecting for future generations. "The review of the National Peatland Strategy should accept that view as part of the consultation process."

- https://www.independent.ie/business/farming/forestry-enviro/environment/call-for-bog-cutting-to-be-made-a-protected-heritage-practice-40472475.html
- https://www.offalyexpress.ie/news/home/637271/peat-harvesting-should-be-protected-cultural-practice-offaly-td.html

Peatlands and Heathlands 2018

The Central Statistics Office of Ireland has published its 'Ecosystem Accounts – Peatlands and Heathlands 2018' document to provide a "coherent and harmonised understanding of ecosystems and their relationships to the economy and the overall beneficiaries of ecosystem goods and services". Find the report under:

- https://www.cso.ie/en/releasesandpublications/fp/fp-eap/ecosystemaccounts-peatlandsandheathlands2018/



Lithuania

Lithuania: 16 million Euro reserved for restoring 8000 ha

16 mln. Euro has been earmarked in the Lithuanian EU Recovery and Resilience Facility plan for restoration of 8000 ha of currently drained agricultural peatlands. The plan was submitted to the European Commission on 17th May. The measure aims to reduce greenhouse gas emissions from agriculturally used peatlands by reversing negative impacts of drainage until 2026 and paving the road for further upscaling. So far, restoration projects were concentrating on rewetting protected raised bogs. Now, Lithuania is targeting agriculturally utilized fens which requires intensive cooperation of institutions, NGOs and land users but holds a huge potential as nature-based solution for climate action, especially in a peatland rich country like Lithuania. This is also an affirming result of the successful cooperation of the Lithuanian Foundation for Peatlands restoration and Conservation (FPRC) and the Succow Foundation, partner in the Greifswald Mire Centre. Around Baisogala, the organisations are rewetting agricultural land for carbon credits and could induce their experiences into the now accepted "New Generations' Lithuania"-plan. For restoring peatlands in the Baltics, the Succow Foundation is also engaged in the EU-funded projects DESIRE and LifeOrgBalt. The EU Recovery and Resilience Facility will make €672.5 billion

in loans and grants available to support reforms and investments undertaken by Member States. The aim is to mitigate the economic and social impact of the Covid19 pandemic and make European economies and societies more sustainable, resilient and better prepared for the challenges and opportunities of the green and digital transitions.

Netherlands

https://www.vpro.nl/programmas/tegenlicht/lees/artikelen/2021/weg-met-het-eindeloze-droge-gras-de-toekomst-van-nederland-ligt-in-het-veen.html

Norway

The ban on new cultivation of peatlands has not been lifted

Christian Steel (christian.steel@sabima.no)

The mires in Norway give us great outdoor life experiences, store large amounts of carbon, are a historical archive, dampen floods and purify water, and are not least habitat for a myriad of plants, insects, birds and other animals. A nature's super system that provides us with ecosystem services we depend on. Destruction of mires is therefore uncommonly unprofitable for society. A square kilometer of destroyed mire can emit the equivalent of an incredible 150,000 cars in one year. And mires that disappear can be another nail in the coffin for the migratory birds, which lose another resting place and continue to decline in number and into the red list.

Political attention to the conservation of bogs has increased sharply in recent years. Last year, the government wisely adopted a regulation banning new cultivation of bogs - with the possibility of exceptions where there are special needs in agriculture. The state administrators report that the ban has worked. Municipalities have tightened up and found better solutions for farmers' cultivation needs, unlike before when permits for environmentally hostile cultivation of bogs were granted over a low shoe. Some exemptions have nevertheless been granted where no other solutions have been found.

It was therefore frivolous, populist and short-sighted of the Centre Party to put forward a proposal to lift this ban for one year after it was introduced, without evaluation. Emissions from agriculture's new cultivation of bogs are far from insignificant. As much as a third of agriculture's greenhouse gas emissions come from cultivated bogs - as much as from all ruminants. With the climate commitments that agriculture now has, it would be a great

disservice to tempt agriculture to actions that necessarily lead to large greenhouse gas emissions from even more cultivated bogs.
Therefore, all parties except the Progress Party voted against the Centre Party's proposal to lift the ban on new cultivation on mires. A large majority in the Storting, the parliament of Norway, would rather keep or strengthen the ban. Unfortunately, the Labour Party's proposal created considerable uncertainty about where the road goes next and what a "comprehensive plan" for better mire conservation actually means. What is beyond any doubt is that the Labour Party voted against the proposal to lift the ban.
The Labour Party has repeatedly emphasized that it wants a stricter management of mires. The Conservatives, the Liberals, the Christian Democrats, the Social Democrats and the Labour Party ran up and down the Storting's rostrum during the consideration of the proposal and tried to be the best in preserving mires. The Centre Party had proposed to write explicitly in the Land Act that it should not be allowed to ban new cultivation, but this was voted down.

Agricultural peatland drainage on Smøla, Norway. Photo: Hans Joosten.

The law as it now stands authorizes the government to formulate the new cultivation regulations as the government believes is best for achieving the purpose of the law and the state. The only logical conclusion the government can draw from this is to keep the ban in the regulations as it is today, and supplement the ban with requirements for a comprehensive plan to be able to grant dispensation.
Minister of Agriculture and Food Olaug Bollestad must take up the guidelines from the Storting where a clear majority wants stronger mire protection. She must leave the regulations in peace, and use her efforts to help agriculture achieve its climate goals. As soon as possible, she must also send a circular to all the country's municipalities and ask them to start work on making a comprehensive plan to preserve their mires against both new cultivation, demolition, peat extraction and other destruction.

- https://www.nationen.no/motkultur/debatt/forbudet-mot-nydyrking-av-myr-er-ikke-opphevet/

United Kingdom

Manchester-based video production studio Standby Productions has launched a new video, which it has gifted to charity partner The Wildlife Trust for Manchester, Lancashire and North Merseyside (LWT). The video, Save Our Peatlands, is hoped to help combat the destruction of local peatlands. https://www.youtube.com/watch?v=Dd0cg4zhFv0

Fenland farmers to be hit financially by government plans to reduce peat usage

Peat bans will cost farmers in Cambridgeshire, as the government moves to reduce the greenhouse gas emissions surrounding peat compost and peatland farming. Fenland farmers rely on imported peat to grow vegetables and salad greens, but the government has announced plans to make recommendations for sustainable farming to preserve the peatlands, potentially costing farmers. It has also announced a consultation to ban the sale of peat to amateur gardeners as part of a long-term plan to reduce the country's peat usage announced in the England Peat Action Plan. The government will also fund the restoration of 35,000 hectares of peatland by 2025, with the potential for more in the future. The big news for Fenland farmers regarding the government's plans for peat is adapting farming practices to minimise emissions and soil loss so the county does not see the "continued disappearance" of what is left of peat soils, said Rob Wise, environmental advisor for the National Farmers' Union (NFU) East Anglia. In Cambridgeshire, the Fenland has some peatland areas, but unlike other parts of the country, Fen farmers do not extract peat to export for commercial usage. The peat soil makes the Fens highly productive when it comes to vegetable and salad production, making it some of the most valuable farmland in the UK. The drainage of the soil means it dries out and blows away.

The main impact of the changes on the area - which produces around 80 per cent of the UK's vegetables and salad greens - is the alternative farming methods necessary that could be costly. The increased costs are unlikely to be passed onto consumers as supermarkets will try to remain competitive, but many farmers could struggle with profitability. Farmers will have to wait until the government's Lowland Agricultural Peat Task Force develops recommendations to extend the lifespan of these areas.

- https://www.cambridge-news.co.uk/news/local-news/fenland-farmers-hit-financially-government-20643808

IUCN UK Peatland Programme Conference 2020: Registration now open

As 2021 welcomes the emergence of country level plans for peatland conservation and management across the UK this year's conference will celebrate the progress being made by peatland partnerships and communities to protect, enhance and restore these valuable areas. We will reflect on the funding, evidence and communication needed to achieve effective action for peatlands and explore learnings to ensure progress continues along a road to recovery.

Registration for this year's IUCN UK Peatland Programme conference 'Peatlands in Partnership: a road to recovery' is now open with free access to the event. The conference will be brought to you as a virtual event taking place on the 13th - 16th September 2021 in partnership with Pennine PeatLIFE, led by the North Pennines Area of Outstanding Natural Beauty (AONB) Partnership in collaboration with Yorkshire Wildlife Trust and Forest of Bowland AONB Partnership, and Moors for the Future Partnership's MoorLIFE2020 project. The annual conference series present opportunities for policy makers, scientists, land managers and practitioners from different disciplines to share their knowledge, experience and enthusiasm of peatland conservation and management. A call for exhibitors and presentation of research will open soon. Further announcements regarding the conference will be available here and shared on Twitter @IUCNpeat #PeatConf21

Ministers urged to harness the power of peat bogs to help save the planet

Scotland's peat bogs have the potential to make a massive contribution in the battle to cut carbon dioxide emissions, campaigners say. The country is home to two-thirds of the all the UK'S peatland, and the amount of carbon they store is equivalent to 140 years' worth of Scotland's greenhouse gas emissions. Its peat bogs are capable of storing more carbon than all the forests in the UK and France combined. The Scottish Government has pledged a £250 million investment in peatland restoration over the next 10 years.

Restoration of peatland is a key part of a major project by Loch Lomond and the Trossachs National Park Authority to address climate change and nature loss. Meanwhile in Inverclyde, campaigners are calling for the restoration of the extensive Duchal Moor. Liz Parsons of environmental group Yearn Stane said: "Blanket bogs like Duchal Moor have been taken for granted. We now realise this is a hugely significant habitat for biodiversity, carbon capture and flood prevention." The Loch Lomond and the Trossachs National Park Authority sees restoration of peatland as a key way to address climate change and nature loss.

MP Ronnie Cowan is campaigning for some of the £250m to be directed towards Duchal.

He said: "Land that historically was drained has become brittle but, restored to peatland, this area will provide valuable carbon storage and have many benefits to people and nature." In a letter to Cowan this month, Mairi Mcallan, minister for Environment, Biodiversity and Land Reform, stated: "The Scottish Government has committed to make large-scale and rapid changes to the way we use and manage our land, including commitments to increase woodland creation to 18,000 hectares per year by 2024/25 and to restore 250,000 hectares of peatland by 2030."

- https://www.pressreader.com/uk/the-sunday-post-inverness/20210627/281560883765979

New chair to lead Task Force on Sustainable Farming of Peatlands

Robert Caudwell has been announced as the Chair of the Lowland Agricultural Peat Task Force – a group tasked with improving the condition of England's farmed lowland peat. Robert, who currently chairs the Association of Drainage Authorities (ADA), will explore how lowland agricultural peatlands can be better managed to safeguard productive agriculture as well as contributing to the government's net zero by 2050 target. The Task Force will be a key component of the government's forthcoming England Peat Strategy. Lowland peatlands provide some of the country's most fertile soils and play a vital role in producing food for our nation. Centuries of draining to support intensive agriculture have led to degraded peat soils, which emit more than 9 million tonnes of greenhouse gas emissions each year – the highest emissions of all peatlands in England.

Robert Caudwell, Chair of the Lowland Agricultural Peat Task Force, said: "Climate change is posing new pressures for lowland peatlands – including more frequent and intense flooding events, and prolonged periods of summer drought. Under such trying conditions, now is the time to explore how we can farm these lands more sustainably to preserve their future and protect our climate. In the long-term we must harness innovation: exploring ways for our peatland to help us to be more resilient to flooding and drought and mitigate climate change by protecting the carbon stored in soil." The Task Force marks the start of a conversation between farmers, risk management authorities, conservationists and other key stakeholders, working with Government on a viable plan of action.

Robert will bring together key players including farmers, water management stakeholders, conservationists, academics, and government and its agencies, to co-ordinate work already underway to encourage sustainable farming of lowland peatlands and recommend new solutions. The findings of the Task Force will inform future

agricultural policy. Robert is a leading figure in water management and brings over 40 years' experience in arable and horticultural farming. Robert is uniquely placed to explore more sustainable measures, including innovative ways to re-wet farmed peatlands, effects on flood risk, farming profits and food production, and long-term opportunities for paludiculture (wet agriculture). The Task Force will be supported by four regional sub-groups, which will advise on the circumstances of England's most extensive lowland peatlands spanning North-East, North-West, South-West and East England. The Task Force will also be supported by a sub-group composed of experts in paludiculture.

Membership of the Task Force includes Andrea Kelly (Broads Authority), Charles Shropshire (G's Global), Chris Evans (UK Centre For Ecology & Hydrology), Daniel Johns (Anglian Water), Deborah Land (Natural England), Ian Moodie (Association of Drainage Authorities), Julie Foley (Environment Agency), Olly Watts (RSPB), Philippa Arnold (National Farmers Union), Richard Lindsay (University of East London), Stephen Briggs (Innovation for Agriculture) and colleagues from Defra and the Environment Agency.

- https://businessnewswales.com/new-chair-to-lead-task-force-on-sustainable-farming-of-peatlands/

Potato field on drained peatland in East-Anglia, UK. Photo: Hans Joosten.

CAP funding ineffective at combatting climate change, say auditors

EU agricultural funding for combatting climate action has so far been ineffective, according to a damning new report from the European Court of Auditors, which criticises inaction on livestock farming and calls for a "polluter pays" principle. The report, released on Monday 21 June, found that although over a quarter of all 2014-2020 – amounting to more than €100 billion – of EU agricultural spending was earmarked for climate change, there has been no improvement in greenhouse gas emissions from agriculture since 2010. Viorel Ștefan, the member of the European Court of Auditors responsible for the report, highlighted at a press conference that despite a higher ambition on climate change and the corresponding changes made to the EU's Common Agricultural Policy, "very little changed compared to the previous period" and the money spent on climate action was therefore "overstated". Stressing that there is "no more time to waste," Ștefan urged action, pointing out that the EU's role in mitigating climate change in the agricultural sector is crucial given that "the EU sets environmental standards and co-finances most of member states' agricultural spending".

The report puts this failure down to the fact that most of the measures supported by the CAP have a low climate-mitigation potential, while there is far less support on offer for those with high mitigation potential. Most notably, the report reserved harsh criticism of the fact that the CAP does little to incentivise a reduction in livestock production. Despite the fact that livestock emissions account for half of agricultural greenhouse gas (GHG) emissions and that these emissions are directly linked to the size of the livestock herd, the CAP "does not seek to limit livestock numbers; nor does it provide incentives to reduce them", the auditors pointed out. Meanwhile, while chemical fertilisers and manure account for almost a third of agricultural emissions, auditors point out their use actually increased between 2010 and 2018. The report also reserves criticism for the fact that the CAP pays farmers who cultivate drained peatlands. Although these make up less than 2% of EU farmland, they are responsible for 20% of the bloc's agriculture emissions. Highlighting that, on balance, the benefits of rewetting peatland outweigh the cons, one auditor called the CAP's approach to peatlands "perverse" given that, as it stands, farmers stand to lose money by reverting peatlands back. However, there is currently staunch opposition to the inclusion of stronger measures on peatlands and wetlands in the CAP reform from countries like Ireland, where an estimated 300,000 acres of permanent grassland is on drained, carbon-rich soils.

One suggestion put forth by the auditors is the introduction of the "polluter pays" principle, i.e. ensuring that those who cause pollution, in this case, farmers, meet the costs to which it gives rise, into agriculture. EU law currently only explicitly applies the polluter-pays principle to its environmental policies but not to agricultural greenhouse gas emissions. It seems the European Commission was open to the suggestion, promising to carry out a study to "assess the polluter pays principle in relation to agriculture greenhouse gas emissions", while the ECA is due to publish a more in-depth report on the principle in the coming weeks. On other fronts, however, the Commission was more reluctant to take action, saying it was unwilling to commit to yearly progress reports on the CAP's impact towards combating climate change on the basis it was too demanding, a stance that was criticised by the auditors. "This represents a significant amount of money and we should know its impact on GHG emissions," one auditor said.

- https://www.euractiv.com/section/agriculture-food/news/all-words-no-action-cap-funding-ineffective-at-combatting-climate-change-say-auditors/

Labour and SNP call for licensed grouse shooting to cut wildlife crime and tackle climate crisis

A debate on a ban on grouse shooting, following a petition which was signed by over 111,000 people, has brought UK opposition parties together to call for licensing of grouse estates across the country for the first time. Last year, the Scottish National Party SNP, Scotland's largest party, announced a strict licensing scheme would be rolled out in Scotland, and the Labour Party has also signalled it would support similar legislation in England. The petition was launched by campaign group Wild Justice, made up of naturalist and TV presenter Chris Packham, scientist and author Dr Mark Avery and conservationist Dr Ruth Tingay. It called for a ban on the practice of driven grouse shooting – where large numbers of red grouse are driven into the sky above people with shotguns. Dr Avery told *The Independent*: "Scotland has gone for licensing and Labour now supports it too. That would be a big step forward in England. "Driven grouse shooting is coming to an end – it's bad for the climate, bad for flooding and simply bad, as it's underpinned by illegal killing of birds of prey such as harriers, falcons, kites and eagles."

The practice is highly controversial due to the numerous impacts on the upland regions where grouse estates operate. Conservationists argue that practices such as burning heather – which causes the plant to produce fresh green shoots the grouse eat – kills off other vegetation and species, dries out critical peatlands increasing surface water runoff, and reduces biodiversity. Furthermore, raptor persecution – the illegal killing of birds of prey – as well as legal killing of other animals including cats, foxes, badgers, hares, stoats and weasels, is concentrated around grouse estates, as gamekeepers seek to protect the valuable grouse and their eggs from predators, or disease. The debate follows a partial ban by the government on burning heather and grass on peatlands, which was introduced in January this year. The ban only applies to specific areas of "blanket bogs", but caused outrage among the grouse shooting fraternity.

The RSPB has long called for licensing to reduce the impacts of grouse moor land management on the natural world. Martin Fowlie from the RSPB told *The Independent*: "Reform is urgently needed, and the RSPB is

determined to work with governments, members of the shooting community, and other conservation organisations to bring this about across the UK. In short, we want to see an end to environmentally unsustainable gamebird shooting. “For driven grouse shooting we think that reform leading to an improvement in the environmental condition of our uplands will most effectively be achieved through the introduction of licences for ‘driven’ grouse shoots. These would set minimum environmental standards which, if breached, would result in losing the right to shoot. Failure to deliver effective reform will result in the RSPB eventually calling for a ban on driven grouse shooting.”

Wildlife Campaigner and director of Ban Bloodsports on Yorkshire’s Moors, Luke Steele, told *The Independent*: “Labour, the Conservatives and the SNP have come together to say ‘we need more regulation of grouse moors’, which is unprecedented. “What we’re seeing is that the opposition parties are going further than the government in that by saying we need to license grouse moors so we can give proper robust powers to shut down grouse estates that are implicated in wildlife crime and environmental damage through burning, but also, compel those landowners to migrate the uplands to a healthy state. “Raptor persecution is an ongoing issue. With hen harriers alone we should have 300 breeding pairs, and we’ve got less than 50 birds overall, in terms of chicks hatching. The bigger picture is that there are buzzards, goshawks, peregrine falcons and other species being shot, poisoned and trapped.” He added: “To maintain a grouse moor you need an artificially high number of red grouse to shoot. To be able to shoot them you need to kill off all the predators and burn the peatlands to create that habitat and encourage the population to reach those unnaturally high densities. “It contributes to flooding… because the peatlands have been damaged and don’t hold back the huge amounts of water they should do. On top of that, the burning releases climate-altering gases into the atmosphere, driving climate change.”

Labour MP Olivia Blake added: “The nature and climate emergency go hand in hand. Last week the CCC report was clear: protecting our peatland is a precondition of meeting our net zero obligations and mitigating the effects of global heating we’re already seeing. There is a huge amount of work to be done and therefore there is a huge opportunity for jobs in our uplands in conservation.”

However, the debate dismissed the call for an outright ban on driven grouse shooting as the petition called for, while environment minister Rebecca Pow said the government currently had no plans to introduce licences for grouse shooting in England. Nonetheless, she said the government was “watching Scotland closely and we can all learn lessons all round”.

- https://www.independent.co.uk/climate-change/news/grouse-moor-licence-labour-snp-b1870767.html

Pioneering peatland process could open up new housing possibities for the Highlands 28 June 2021

More environmentally friendly methods for laying housing foundations on peatland could pave the way for increased economic development in parts of the Highlands and Islands. A research consortium involving Edinburgh Napier University and Heriot-Watt University, with support from the Highland Council, HIE, Construction Scotland Innovation Centre (CSIC) and Jahama Highland Estates, is assessing the feasibility of a range of construction methods to minimise disturbance to peat and mitigate the environmental impacts. The Scottish Environment Protection Agency (SEPA), NatureScot, ECOSystems Tech Ltd and the Scottish Government are also supporting the initiative. Dr John McDougall, of Edinburgh Napier University, said: “Peatland has long posed a challenge to construction, the solution to which has commonly been an aggressive practice of removal. More recently, planners, environmental agencies and engineers have become increasingly aware of the very significant role of intact peat in the carbon cycle. "In this context, it is exciting to be leading a re-evaluation of foundation options in the context of geotechnical, environmental and economic factors.”

As much as 20 per cent of Scottish land is covered in peat soil. However, the soil is often unsuitable for building upon because of low strength, landslide risks and its tendency to deform under load. In parts of the Highlands and Islands, where peatland is commonly found, new housing is in short supply and some sites earmarked for housing development can be complicated by the presence of peat. Finding viable, sustainable methods for building on peatland that align with restoration work already underway, could transform Scotland’s approach to rural housing, the supporters of the research project believe. Good quality, affordable homes could help to reverse population decline and promote economic growth in rural areas, encouraging a young and talented workforce to move to, and remain in, the Highlands and Islands.

Councillor Trish Robertson, who chairs Highland Council's economy and infrastructure committee, said: "Highland Council is happy to support this research project as a way of exploring innovative ways of achieving our objectives of delivering more affordable housing and inclusive economic growth, while safeguarding better croft and other agricultural land, and reducing the carbon emissions presently caused by development on poorer agricultural land, which often contains significant peat deposits. I am hopeful that the results of the research can have a practical application for future developments and help us even better achieve our objectives."

Construction teams have previously relied on excavate-and-replace techniques, however, this project will explore a number of options that allow peat – and stored carbon – to be left in place, such as deep-soil-mixing, and piling. Timber piling would use tree trunks or long poles of timber to carry the foundations of a building. Disturbance of the peatland would be minimised, especially the presence groundwater, which is essential if peat is to continue to accumulate.

The aim of the first phase of the project is to assess and compare the geotechnical suitability, environmental impact, logistics and cost implications of the different approaches. In a second phase, live field trials are planned to assess the suitability of proposed solutions.

- https://www.ross-shirejournal.co.uk/news/highland-council-and-hie-backed-research-could-up-up-highlan-242918/

Northern Ireland Peatland Strategy consultation

Environment Minister, Edwin Poots MLA, has launched a public consultation on the draft Northern Ireland Peatland Strategy 2021-2040, during a visit to Cuilcagh Mountain Special Area of Conservation in County Fermanagh. During the visit, the Minister met with local landowners and Ulster Wildlife, who are working together and with other partners through the Collaborative Action for the Natural Network (CANN) project to restore precious peatland habitat on this iconic mountain. Due to the popularity of the Cuilcagh Mountain boardwalk, erosion was caused to the very fragile upland habitat. The CANN project, funded under the INTERREG VA Programme, has delivered habitat restoration and improved the path which leads to the summit cairn.

Speaking after the visit, Minister Poots says, "Fresh air, beautiful views and the wish for some physical activity, have established the Cuilcagh Mountain boardwalk as a must-see visitor attraction in Northern Ireland. "Of course, as its popularity increases, our efforts to protect it must also increase. "Peatland restoration is a really important nature-based solution for addressing the climate and biodiversity crisis. I have therefore issued a public consultation on a draft Northern Ireland Peatland Strategy and I am keen to hear a range of views about our proposals to take forward peatland conservation and restoration over the next two decades. "DAERA has a vision of a protected and enhanced natural environment, which underpins our emerging policies and programmes to deliver ecological and climate resilience through nature-based solutions, green growth and sustainable agriculture."

During the visit, Jennifer Fulton, CEO of Ulster Wildlife commended the local landowners for their interest and commitment. "Farmers have a vital role to play as stewards of Cuilcagh Mountain, ensuring its rare habitats and species are cared for and protected for current and future generations," she says. "By blocking drains to rewet the peat so that it sequesters carbon and by carefully re-profiling bare eroded peat, they have taken the first steps on the journey towards net-zero carbon. This also improves the biodiversity value of the area."

The public consultation on the draft Northern Ireland Peatland Strategy 2021-2040 will be open for 12 weeks from 9 June until 1 September 2021 and is available on the DAERA website.

- http://newrytimes.com/2021/06/18/peatland-consultation-launched-newry-times/
- https://www.agriland.ie/farming-news/poots-launches-peatland-strategy-consultation/
- https://www.farmersjournal.ie/peat-compost-to-be-banned-in-ni-by-2025-627578

Northern Ireland peatland strategy proposes payments for bog restoration

The Northern Ireland Peatland Strategy 2021-2040 Consultation Document outlined a series of 41 priority actions to be implemented within the next 20 years to restore and protect the region's bogs. One of the priorities was to develop land management schemes that provide targeted support to underpin the appropriate management of all peatlands. It was suggested these would support, and where necessary require, landowners to deliver land uses that are compatible with healthy peatlands, including sustainable grazing regimes and innovation in farming methods and machinery and as well as for the development of alternative peat products. It also proposes

establishing peatland restoration demonstration sites on land in either public or private ownership. The strategy's six key objectives are:

- By 2040, all peatlands supporting semi-natural vegetation are being managed for their peatland biodiversity and ecosystem function;
- By 2030, degraded peatland habitats are prioritised for restoration to favourable conservation status. By 2040, all high priority degraded peatlands will be under restoration management;
- High Priority degraded peatlands in Northern Ireland are under sustainable management;
- By 2025, stakeholders understand the need for peatland conservation and restoration and have the capacity to deliver the Strategic Objectives and Actions contained within the Northern Ireland Peatland Strategy;
- Peatlands are recognised for their unique biodiversity and ecosystem services provision;
- The necessary structures are in place to deliver on the Strategic Objectives and Actions contained within the Northern Ireland Peatland Strategy.

The strategy will also encourage government bodies and agencies to stop using peat by end of 2022. It will also seek to **ban** the use, import and sale of peat compost in Northern Ireland by 2025, and conduct a review on the potential for a ban on peat extraction on all publicly owned land by 2022.

The document highlights around 44% of publicly owned woodland in Northern Ireland is on peat soils. It suggests identifying and prioritising areas of afforested peat on Forest Service land for restoration to peatland habitat, particularly where biodiversity and carbon gains would be maximised. It also developing a coordinated strategic approach to wildfires. And, develop, publish and implement an Ammonia Strategy, which will include priority actions to address nitrogen deposition on peatland.

The strategy document acknowledges that restoring Northern Ireland's peatlands will require "a collaborative approach involving government, landowners, land managers, public sector bodies and environmental groups, guided by scientific and technical expertise, appropriate legislation and policies and with a robust funding mechanism in place."

- www.daera-ni.gov.uk/consultations/ni-peatland-strategy-consultation
- https://www.daera-ni.gov.uk/news/poots-launches-peatland-consultation
- https://www.agriland.ie/farming-news/ni-peatland-strategy-proposes-payments-for-bog-restoration/
- https://www.farmersjournal.ie/peat-compost-to-be-banned-in-ni-by-2025-627578

England launches Peat Action Plan

The IUCN UK Peatland Programme (IUCN UK PP) welcomes the long-awaited publication of the England Peat Action Plan (EPAP). We are pleased to see the Plan outline a suite of policy and management interventions for England's peatlands released alongside complementary woodland plans in a bid to halt the decline of nature and wildlife. The EPAP has been developed to align with the broad principles of the IUCN UK PP's UK Peatland Strategy (2018): the connectedness of UK, National and regional strategic planning for peatlands set out in these documents is in itself is a world leading approach, helping other countries who are developing a strategic approach as required by IUCN, UN and Ramsar resolutions. This is a global challenge and the UK as a top ten peatland nation has to show leadership. The England Peat Action Plan outlines measures to:

- Develop an updated peat map by 2024
- Fund 35,000ha of restoration by 2025 with ELMs schemes (Sustainable Farming Incentive, Local Nature Recovery and Landscape Recovery) to deliver beyond 2024.
- Continue to convene the Lowland Agricultural Peat Task Force to identify a more sustainable future for lowland agricultural peatlands.
- Ban the sale of peat and peat containing products in the amateur sector by 2024.
- Continue to protect our peat from fire by both phasing out managed burning and reducing the risk of wildfire.

As of 2020 peatlands are now accounted for in the UK greenhouse gas inventory and it is important that peatlands continue to be seen as nature-based solution to climate change and play a key role in our green recovery. The scale and urgency of the biodiversity and climate crises demands an urgent move from peatland planning to implementation. While the Plan does not include long-term targets for peatlands we recognise the

ambition to publish national and regional implementation plans to detail the future trajectory of recovery for England's peatlands. These plans will need to engage across different land use sectors to tackle current policy challenges and threats to peatlands. Policy intervention needs to be secured with blended public and private finance and a long term approach to providing economic support (e.g. through agriculture payments) to land managers who maintain and restore peatlands.

The Plan recognises the need for funding which goes beyond capital grant support and acknowledges the role that private finance, such as that achieved through the Peatland Code, will play a role in delivering restoration at scale. While long-term plans for restoration and associated funding beyond 2025 remain unclear, funding for approximately 10% of England's peatlands is secured through the formal launch of the Nature for Climate Peatland Grant Scheme. Details of that scheme can be found at: https://www.gov.uk/guidance/nature-for-climate-peatland-grant-scheme.

- https://www.iucn-uk-peatlandprogramme.org/news/england-launches-peat-action-plan
- https://www.fwi.co.uk/business/payments-schemes/environmental-schemes/defra-launches-new-peatland-restoration-fund-for-england

Holme Post, evidencing huge peat losses in East-Anglian drained fens. Photo: Hans Joosten.

Farmers seek funding to help cut peatland carbon emissions

Farmers and conservationists are pioneering ways to reduce the environmental impact of farming on peat, as pressure mounts to cut emissions from UK peatlands. There are also calls for specific funding focused on peatlands to help farmers switch to more sustainable systems. Lowland agricultural crop and grassland peat soils which have been drained, ploughed and fertilised account for more than half of the 23 million tonnes of annual carbon dioxide emissions from UK peatlands, analysis led by the UK Centre for Ecology and Hydrology (UKCEH) estimates. Jack Clough, from the University of East London's Sustainability Research Institute, said that where carbon-rich peatlands have been drained, microbes convert peat to carbon dioxide in the presence of oxygen, "literally turning peat into thin air". The peat is disappearing at the rate of around 1-3cm a year and where the water table is well below the surface – typically around 40-100cm – because of drainage, it produces around 25-40 tonnes of carbon dioxide per hectare a year, he said.

Soil scientist-turned farmer Stephen Briggs, who farms on peat and clay in Cambridgeshire in East Anglia's productive fens, said: "The only way to completely stop peat degradation, from losing these peat soils, and completely reducing carbon emissions is to stop farming them and to reflood them." Briggs acknowledged that this would have serious implications for livelihoods, the economy and food security: "There's always going to be compromise, trying to find ways of farming and managing the land that reduces as far as practical the further oxidation and degradation of peat soils whilst still being productive".

While the internal drainage board controls the local water table, Briggs, who is a member of the Nature Friendly Farming Network (NFFN) and sits on the Environment Department (Defra) Lowland Agricultural Peat Task Force, is taking steps to prevent water loss and protect soils. His organic agroforestry system has rows of fruit trees with wildlife-friendly plants running through the fields with conventional crops such as barley, wheat and vegetables inbetween. The trees act like hedges to slow down wind and evaporation; avoiding artificial pesticides and fertilisers improves soil structure, and 'companion' crops such as clover grown under the main crops keeps carbon cycling through the soil, he said. Soil health on his farm has improved; wildlife has increased; the fruit trees are locking up carbon, and the land is more productive per hectare, Briggs said. He added that a package of solutions was needed for farming on peat: "There should be a separate innovation fund to allow farmers to try things at a small scale", in addition to the new agricultural payments programme.

A few miles from Briggs' farm, the Water Works project by Bedfordshire, Cambridgeshire and Northamptonshire (BCN) Wildlife Trust is trialling a more radical solution which involves reflooding the land while maintaining productive farming. The wet farming or paludiculture experiment, funded by the People's Postcode Lottery, has created test beds where the water table will be kept to within 10cm of the surface to prevent carbon loss. Crops including bulrush, which could be used for insulation, and sweet manna grass – a gluten-free grain – as well as novel crops including wild celery, yellow flag iris and meadowsweet, with uses including food, medicine, and gin flavourings, were planted last year. The crops have all survived the very wet winter and dry April, although local Chinese water deer treated the flag iris as a salad bar, BCN Wildlife Trust's Kate Carver wryly noted. Sphagnum moss, which has multiple potential uses, including as a substitute for peat in vegetable growing and gardening, is being planted this summer.

Carver said: "Through our field-scale trials and monitoring programmes, we aim to prove that wet farming can prevent the loss of carbon; prevent the loss of peat soils; clean water, and support wildlife." The scheme aims to demonstrate wet farming crops could be grown on a "real life" fenland farm and offer new opportunities to farmers, with the potential to ripple out over the wider fens, she said.

The Sustainability Research Institute' Clough, with colleagues, is monitoring the carbon emissions, soil surface levels and water table at the Water Works scheme. He said research showed that each 10cm increase in the water table could reduce emissions from the peat soils by around three tonnes per hectare per year, although it needed to rise to the levels seen in paludiculture to largely halt them. There is also evidence that some conventional crops could grow in soils with higher water levels, although more research is needed to assess the trade-offs, such as lower yields, he said. Raising the water table on conventional farming could buy time to develop paludiculture (wet farming on peatlands) or other solutions such as a "carbon farming" markets, which pay farmers specifically to protect the carbon in their land. "I think paludiculture can play a valuable role now, but in the short term some sort of environmental payment or subsidy will help it take off. There is real potential for public and private finance to expand paludiculture, which will make a positive difference to the way we manage our peat," he said. A separate report from Bangor University advised that the UK needs to protect and restore its carbon-rich peatlands or risk undermining efforts to tackle its carbon emissions. Its study similarly concluded that not only are nature-based solutions to climate change effective, they can also help to enhance biodiversity, improve human wellbeing and bring economic benefits.

In January 2020, the Committee on Climate Change (CCC) noted that the UK government should begin with some urgency to make substantial efforts to shift land use across the UK and change people's eating habits in order to lower overall carbon emissions. In its report, it included a section on the importance of restoring peatlands - at least 50 per cent of upland peat and 25 per cent of lowland peat.

- https://eandt.theiet.org/content/articles/2021/06/farmers-need-funding-to-help-cut-carbon-emissions-from-peatlands-environmentalists-say/

Wales' first carbon-funded peatland restoration project is complete

A peatland restoration project at Bwlch y Groes on the edge of the Snowdonia National Park is the first of its kind in Wales to be completed with the benefit of carbon funding, following validation under the Peatland Code. Thanks to funding by the Welsh Peatlands Sustainable Management Scheme, a project led by the Snowdonia National Park Authority, and in conjunction with the Roberts family who have farmed at Pennant Farm, Llanymawddwy for several generations, the 66 hectare peatland restoration project has been successfully completed. Restoration works to re-profile and block the extensive hagg and gully complexes across the site were carried out by experienced peatland contractors throughout winter 2020-21. It is estimated that over the next 35 years, the restoration of the site will halt the loss of 2,335 tons of carbon emissions equivalent, which roughly equates to the amount of carbon dioxide generated from burning 632* household tanks of oil. As well as halting the loss of carbon from the site and protecting the significant store of carbon in the peatland, it is anticipated the restoration works will have wide-spread co-benefits as such improved water quality, steadier water flow, increased biodiversity, and improved habitat conditions for freshwater invertebrates and birds. The site sits within the Berwyn and South Clwyd Mountains, which is one of the largest areas of upland heath in Europe and is the most important upland area in Wales for breeding birds, including a wide range of internationally important species.

The project was co-funded funded via public funding from the Welsh Peatlands Sustainable Management Scheme (SMS) project alongside private funding generated from the sale of carbon credits through Forest Carbon – the first peatland project to have benefited from this 'blended funding' approach in Wales. The sale of carbon credits was made possible through gaining validation from the Peatland Code, which is a voluntary certification standard for UK peatland projects. By choosing to submit the project through the Peatland Code, the Roberts family have ensured that the methods of restoration and plans for maintenance of the site meet the required standard, and that the calculated carbon savings are accurate. This validation has allowed the Roberts family to sell these carbon savings on the carbon market, generating income for the ongoing maintenance of the site for the next 35 years.

DEYA Brewing, working in conjunction with Forest Carbon, have committed to acquire the 2,335 tCO_2e of carbon savings that the project is estimated to deliver over the next 35 years, thus providing funding for the sustainable management of the site and securing the future environmental benefits of a restored peatland. George Hepburne Scott, Director at Forest Carbon said: "This is the third peatland restoration project in the UK, where Forest Carbon have helped utilise carbon funding alongside public grants to help finance their delivery. We believe there is huge scope to build on these projects and scale up rates of restoration over the coming years by more effectively blending the use of private and public funding". Rachel Harvey, Welsh Peatlands Project Manager at Snowdonia National Park Authority said: "This is only the third validated Peatland Code site in Wales, and the first to be co-funded with carbon finance and public funding. Bwlch y Groes is not only an excellent example of how the Peatland Code can facilitate long-term peatland restoration, but it's also acting as a trailblazer for similar sites owned by single landowners or farming families. We hope the success at Bwlch y Groes will lead to many more of our Welsh peatlands adopting the Peatland Code for long-term restoration and management". Sion and Lisa Roberts of Pennant Farm, the landowners said: "We are very pleased to be able to rear livestock for food production alongside enhancing habitats and increasing the carbon store at Bwlch y Groes. The process has been very straightforward from restoration works to selling the carbon credits, and we are looking forward to further potential projects in years to come". Theo Freyne, owner of DEYA Brewing, said: "The investment that DEYA Brewing have made into the delivery of the Bwlch y Groes peatland restoration project is part of our wider efforts to mitigate the impacts of our residual emissions whilst we are making every effort to implement internal carbon reduction measures across our brewing operation".

- https://www.iucn-uk-peatlandprogramme.org/news/wales-first-carbon-funded-peatland-restoration-project-complete
- https://www.wales247.co.uk/wales-first-carbon-funded-peatland-restoration-project-is-complete

Moors for the Future deliver biggest conservation season yet in a challenging year

Against a backdrop of ever-changing circumstances and a challenging year for nature, Moors for the Future Partnership is pleased to say that the conservation work this year has not only been completed successfully, but

has been the largest conservation season to date for the Partnership. The difficulties of working through the pandemic and a prolonged period of extraordinarily snowy weather presented a double challenge over the last twelve months. Working on the high moor tops and then collating data from the conservation work delivered had been tricky, yet in some aspects of the work, such as sphagnum planting and gully blocking, they have achieved an increase on last year's efforts. It was a record year for gully blocking – almost 10,000 gully blocks constructed (exceeding the previous record of 8,268 in 2019-20), over half of which were peat dams. It was also a record year for sphagnum planting; just over 1,035 hectares were planted, which is just a little bit over the previous record of 1,004 hectares (2019-20). Similarly 68 hectares of plug plants were planted including heather, cotton grass and bilberry, which is a little over the previous record of 59.7 hectares, again achieved in 2019-20.
New conservation techniques have also been trialled. Conservation Contracts Manager Steve Maynard says: "Following the proof-of-concept trials in 2019-20, this past year of 2020-21 saw bunds being constructed by us on a landscape scale for the first time – over 100 hectares achieved."

- https://www.iucn-uk-peatlandprogramme.org/news/moors-future-deliver-biggest-conservation-season-yet-challenging-year

Start of ground surveys for Scottish rocket site

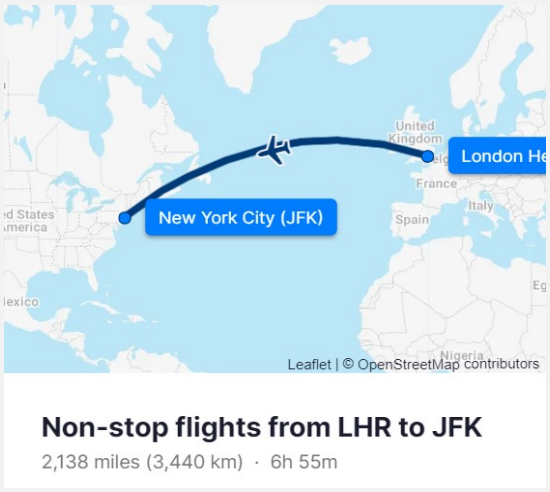
Detailed ground investigations have started at the end of May at the site of a proposed £17.3m Space Hub Sutherland satellite launch project in the Scottish Highlands, a facility capable of placing small commercial satellites into orbit via up to 12 rocket launches a year. Over a six weeks period the survey team will study soil and bedrock at the 4.2 hectare site, to inform the detailed design of foundations, access roads and buildings, including the spaceport control centre and launch pad. The investigation will also assess groundwater and ground gases at the peatland site. Public agency Highlands and Islands Enterprise (HIE) has proposed building the facility for launching small satellites on the Moine Peninsula, an area of peatland and crofts on the Highlands' north coast.
The project still faces legal hurdles, however. Scotland's highest court, the Court of Session, is undertaking a judicial review of planning approval granted in August last year by the Highland Council. The review was secured by lawyers acting for Wildland, a privately held company that owns substantial tracts of neighbouring land. Lawyers of Wildland argued that documents showed Highland Council did not appear to have properly considered the impact that people visiting the site could have on the local environment. Advocate Malcolm Thomson QC said: "There's nothing about visitor viewing facilities, car parking, nothing of that nature. "There are the obvious difficulties about keeping people out of the LEZ (launch exclusion zone) - there's no physical demarcation of it." Highlands and Islands Enterprise HIE also requires approval from the Scottish Land Court, with the site subject to grazing rights. Livestock would need to be kept out of a 690-hectare exclusion zone during launches, with HIE proposing compensation for local crofters.
The UK Government has cleared one other major barrier to the project. On May 24, the Department for Transport announced new regulations allowing satellite launches from the UK will come into effect this summer. The new rules were developed by the UK Space Agency and Civil Aviation Authority. Transport secretary Grant Shapps said: "We want to be the first country to launch into orbit from Europe", adding that the first launches could take place "from 2022". The DfT said spaceport projects are under way in Cornwall and Wales as well as in Scotland.
Science minister Amanda Solloway said: "Continuing to grow our launch capability will help bring jobs and economic benefits across the UK. The Space Industry Regulations we've tabled today will create a supportive, attractive and safe environment for commercial spaceflight."

- https://www.constructionnews.co.uk/civils/bam-nuttall-begins-ground-surveys-for-scottish-rocket-site-25-05-2021/
- https://www.bbc.com/news/uk-scotland-highlands-islands-57403221

Heathrow and the peat-offsetting of flying

BirkshireLive reported on June 11, 2021, that a resident of Birkshire, Matthew Gorman, has on the Queen's Birthday been awarded with the Order of the British Empire (MBE) for making travel greener. Gorman, the Carbon Strategy Director of Heathrow Airport, told BerkshireLive that one of the initiatives he had led was the airport spending £94,000 on obtaining 70 acres of peatland near Manchester, which led to carbon savings on almost 64,000 flights to New York.

Reading such a message makes me prick up my ears in disbelief: 70 acres is ~28 ha, one flight from Heathrow to New York JFK is 3,440 km. An economy-class flight from London to New York emits - according to the calculator from the International Civil Aviation Organization - 0.33 tonnes of CO_2 per passenger. The normal Boeing 777-200LR 'Worldliner' on this route has been laid out for 301 passengers. One flight would then produce something like 300 x 0.33 tonnes of CO_2 = 100 tonnes CO_2, i.e. 64,000 flights would produce ~ 6.4 Mt of CO_2 or 1.75 Mt (1,750.000 t) of carbon. How much Carbon does 28 ha of peatland contain? That depends on the peat thickness, which we do not know. But we can calculate how thick the peat must be to contain the claimed 1.75 Mt of carbon.



Picture: Robert and Shana ParkeHarrison

Peat contains something like 50 kgC/m^3 meaning that 28 ha of peat of one meter thick would contain 280,000 x 50 kg = 14,000 t C. To arrive at 1.75 Mt of carbon, the peatland thus should be in average 12.5 m thick. Not impossible, but quite on the high side…

Buying and securing a peatland is, however, not equal to compensating for emissions from airplanes. 'Offsets' are only generated when the peatland first was a carbon source and this carbon source has been reduced by aimful activities, i.e. by rewetting.

As of June, 2021, there are 226 flights per week flying from London to New York (New York is Heathrow Airport's most popular destination). The 64,000 flights would thus be consumed in 5.5 years. Peat oxidation would, however, never consume 12.5 m of peat within these few years, this would take at least 1250 years of continued drainage, i.e. far beyond 2050 when all drained peatlands should have been rewetted and all emissions should have stopped. Ergo: Heathrow "compensation" takes an unacceptable claim on future emissions that never may happen and implies that the company does not accept the Paris Agreement…

DEFRA action plan targets 'absolute' end for peat extraction

The sale of peat for amateur use in gardening is set to be banned by 2024, under government plans set out to protect England's largest carbon store. Promising "swift progress", DEFRA's Peat Action Plan proposes that a point-of-sale tax on peat-containing growing media should be introduced, inspired by the plastic bag charge. All sellers of horticultural peat would also be obliged to report on the volume of peat they sell each year, both in bags and plant pots. A call for evidence will follow on the wider uses of peat in the retail sector, such as in the cultivation of turf and the production of whisky and cosmetics. The department will also consult this year on phasing out all horticultural uses of peat, with a ban on professional use by the end of the next parliament, in 2029, being under consideration. The initial focus on amateur use is because it constitutes about 80% of consumption, the action plan says.

Furthermore, the government has also committed to fund the restoration of at least 35,000 hectares of peatland by 2025 "immediately", tripling the average rate over 1990-2013. The £50m funding forms "just the start" of ambitions for wider restoration, says the strategy.

The Office for National Statistics recently estimated that the cost of restoring all UK peatlands to near natural condition would be between £8.4 to £21.3bn. But this is dwarfed by the carbon benefits, valued at around £109bn.

The plan came amid a flurry of policy announcements made by environment secretary George Eustice on May 18, including a new Tree Strategy and statutory targets for improving biodiversity. "Our peatlands are an iconic feature of England's landscape. Often referred to as 'our national rainforest', they perform many functions – they are our largest terrestrial carbon store, a haven for rare wildlife, a record of our past, and natural providers of water regulation. Yet, for too long we have taken this valuable natural resource for granted. Only 13% of England's peatlands are in a near natural state," he said. "This action plan sets out our vision to reverse this decline. Our aim is to prevent further loss of peatland habitats and to restore more peatland landscapes to their natural state. Re-wetting peatland areas and returning them to their natural state could make a significant contribution to achieving our targets on reducing carbon emissions, as well as having other benefits for water quality, nature and flood mitigation," Eustice added. But the plan would affect more than the UK, considering that two-thirds of the UK's peat is supplied from the rest of Europe, particularly Ireland and the Baltic states. "This means we are effectively exporting our carbon footprint. We shall continue to focus on reducing demand for peat in horticulture, recognising the need to protect not only England's peatland, but peatland in other countries affected by the current demand in England," said the secretary of state.

Crispin Truman, chief executive of countryside campaign group CPRE, said May 18 was "a big day for nature". "Healthy wet peatlands – which have come to be known as the UK's own threatened and degraded rainforests - have locked up billions of tonnes of carbon for thousands of years and the England Peat Action Plan recognises their value. It is hugely welcome to see the proposed ban on peat-based composts and an ultimate phase-out of burning being considered. While plans to restore upland and rewet lowland peatlands sound promising, we need to see them fleshed out in binding targets, with the funding to match the scale of the challenge we face on peatlands." A further part of the plan is to produce a detailed map of peatland, following recent criticism over how new rules on burning can be enforced.

The plan recognises that a voluntary approach to reducing the consumption of peat "has not delivered". Ten years ago, the government set out voluntary targets for amateur horticulture to go peat-free by 2020, with the professional sector following in 2030. "We note that there has been some progress by particular manufacturers, retailers and growers … the UK's soft fruit industry has successfully transitioned from using peat to coir. The total volume of peat sold in the UK is 25% lower in 2019 compared to 2011 but is still way off our ambition. The volume of peat sold in the UK rose by 9% in 2020 due to unprecedented demand throughout the year and the impact of the global pandemic on the supply chains for alternative materials," says the plan. However, some retailers have already made the switch, with Co-op supermarkets announcing the switch only last month. The Royal Horticultural Society also pledged to go peat-free by 2025 back in March.

DEFRA has promised to work with the industry to source more sustainable materials, including coir from coconut husks, wood fibre and bark, which "have shown great promise as replacements for peat and are included in many of the products on the market today. Sphagnum farming on lowland peatlands in England offers the opportunity to source more alternative materials," says the plan. "There is potential to use considerably more composted plant and food waste to produce high and consistent quality composts suitable for supply to growing media manufacturers in the UK and Republic of Ireland, and with the right policy drivers government can help all the relevant industries make valuable and sustainable contributions towards our Net Zero targets," said Jenny Grant, head of organics and natural capital at the Association for Renewable Energy and Clean Technology.

- https://www.endsreport.com/article/1716500/defra-action-plan-targets-absolute-end-peat-extraction
- https://www.theguardian.com/environment/2021/may/18/sales-of-peat-compost-to-gardeners-to-be-banned-from-2024

£22 million funding to restore Scotland's peatlands

Projects to restore Scotland's peatlands will get a share of £22 million this year to significantly reduce carbon emissions and support biodiversity as part of the government's climate change plan. Last year the Scottish Government announced a £250 million ten-year funding package to support peatland restoration, with a target of restoring 250,000 hectares of degraded peatland by 2030. In 2021-22, five partners including NatureScot and

Scottish Water will get a share of £22 million to deliver a range of new and existing restoration projects across Scotland. Environment Minister Mairi McAllan recently said: “Peatlands are an integral part of Scotland’s cultural and natural heritage, and cover more than 20% of our country. Restoring and protecting this precious natural resource is a key part of our response to the twin crises of climate change and biodiversity loss. Scotland is centre stage this year with COP26 in Glasgow and our significant investment in peatland restoration is just one of the ways we are demonstrating our world leading climate action.”

Welcoming the funding, NatureScot Chief Executive Francesca Osowska said: “This significant new funding comes in a year when Scotland has a huge opportunity to address the many challenges and pressures that nature is facing as we look towards both the nature COP15 in Kunming, China, and COP26 on climate change in Glasgow.

“Since 2012, NatureScot’s Peatland ACTION initiative has already put more than 25,000 hectares of peatland on the road to recovery, with 75% of all peatland restored in Scotland funded through the project. We are committed to providing leadership and guidance to partners as we work to build on that progress, restore more of our peatlands to good condition and ensure a nature-rich future for Scotland."

The Scottish Government has committed in the Climate Change Plan update and the current Programme for Government to restoring 250,000 hectares of degraded peatland by 2030, with an annual target of 20,000 hectares.

- https://www.wired-gov.net/wg/news.nsf/articles/Funding+to+restore+Scotlands+iconic+peatlands+07062021150500?open

Will England’s Peat Action Plan help us to tackle climate change AND recover nature?

Ali Morse and Barnaby Coupe of the Wildlife Trusts explore what the England Peat Action Plan and the England Trees Action Plan. mean for nature. With the right policies, they could deliver significant benefits for biodiversity as well as climate – but do these plans pass the test?

Our overarching hope for the Peat Action Plan was that it would set out ambitious targets for peatland restoration. The Wildlife Trusts want to see a commitment to restoring all upland peatlands and at least a quarter of lowland peats. Government’s own advisors, the Climate Change Committee, say this needs to happen to reduce net carbon emissions to zero. In our view it’s also imperative to allow nature to recover, across a network of peat bogs and fens that are part of a landscape where 30% of land is protected and managed for nature. Government have committed more than £50m through the Nature for Climate Fund to restore 35,000ha of peatland by 2025. This is a promising start, but in England we need to restore around 10 times that to meet the committee’s recommendations. This should include all SSSIs, a large portion of which are currently in poor condition. These longer-term targets are missing from the Action Plan – but Government have said they *will* set out plans for peatland restoration that are in line with those required to meet carbon budgets.

We wanted to see a reduction in the practices that damage peatlands. Drainage dries out peat soils allowing CO_2 to escape, so must be reduced to help arrest climate change. There are no new policies to drive a reduction in drainage and, despite positive words, no commitment to supporting farmers in a transition to wetter farming. A Lowland Agricultural Peat Taskforce has, however, been set up to look at this issue, as the plan does recognise that ‘conventional agricultural production on drained peatlands is inherently unsustainable’. Burning is a much-debated management practice but one which scientific opinion largely considers to be damaging. A ban on all peatland burning would prevent future site degradation, but new laws brought in earlier this year implement a ban only on internationally-protected sites, and offer a number of exemptions. Whilst the ban is a step in the right direction, it must not be considered as ‘job done’, as the majority of peatlands could still be subject to ongoing damage through burning. Extraction from peat from bogs both here and abroad continues, all to provide gardeners with a growing medium that could be replaced by more sustainable products, or by home composting. This must end, yet despite failed voluntary targets to phase out peat, Government has not yet committed to action. The Wildlife Trusts are calling for a ban on peat compost sales - so far supported by over thirty thousand people - and an end to the use of peat in horticulture altogether by 2025. Instead, disappointingly, Government will be consulting on what steps to take next - although a ban will feature as one of the more decisive options within the consultation. We want to see legislation in place to ban the sale of peat composts before the Government hosts key climate talks, COP26, in November this year.

While trees play an important role in absorbing carbon emissions, nature will suffer if the Plan creates incentives to plant trees on land which is not suitableand on precious habitats such as peatlands and wildflower meadows – and there are currently no safeguards in the Plan to ensure that this doesn't happen. Despite promises from Defra and the Forestry Commission, in the last year irreplaceable peat soils were ploughed up in Cumbria, and conifers replanted on key areas for potential heathland recovery in Dorset. Ploughing up high nature-value habitats and planting rows of non-native conifers, comes at huge cost to nature, in a short-sighted drive to increase tree cover.

Producing the two documents in tandem gave the Government the opportunity create alignment on some potentially tricky issues. Will the demand for tree saplings for planting projects lead to an increase in use of peat compost as a growing medium? Will sites that could be restored to bog or fen, locking in carbon for the long-term, instead be given over to short-term tree planting in the scramble to meet afforestation targets? And will the plans ensure that activity benefits climate *and* nature, rather than one at the other's expense?

On the latter, the jury is still out – there remains a risk that global climate targets could drive perverse outcomes for biodiversity, so this is an area that environmental organisations will pay close attention to. On tree planting, the Peat Action Plan at least acknowledges that there are current gaps in the decision-making framework that need to filled, so again, another area to watch. And there is no mention in either document of the environmental credentials of the saplings that will help us to meet these large tree planting targets.

Moreover, if words are to be matched by action, funding to help *deliver* against both plans will of course be needed. Of the £640 million available through the Nature for Climate Fund, £500 million has been pledged to support the delivery of the Tree Action Plan, with the money pledged for peatland recovery forming a much smaller portion of available funding – perhaps because for some, the protection and restoration of peatlands remains a contentious topic.

Our verdict? Overall, the England Peat Action Plan provides a promising start but could do much more to meet our tests on peatland restoration, drainage, burning and peat compost. While the England Trees Action Plan does include some significant positives including more support for natural regeneration, it fails to set out how high-value open habitats, and areas where these habitats could potentially be restored and connected, will be adequately protected from inappropriate tree planting.

Both documents herald a significant start, although fall short of the ambitious commitments needed to halt climate chaos *and* restore biodiversity. We are assured, though, that 'more is to come', in implementation plans, target-tracking and future funding - so The Wildlife Trusts look forward to working with Government, business, landowners and others to help deliver – and to go beyond – the ambitions set out in the England Trees and Peat Action Plans.

- https://www.wildlifetrusts.org/blog/guest/will-englands-tree-and-peat-action-plans-help-us-tackle-climate-change-and-recover
- https://news.sky.com/story/peat-compost-ban-welcomed-by-environmentalists-in-fight-against-climate-change-but-fears-about-burning-peatland-remain-12309826
- https://www.carbonbrief.org/qa-how-will-the-uks-strategies-for-trees-and-peat-help-achieve-net-zero-by-2050
- https://www.bbc.com/news/science-environment-57152169
- https://www.miragenews.com/bes-response-to-government-plans-to-tackle-562116/

Thursday, November 18, 2021 (1:00 PM - 2:00 PM) (EST): Webinar Peatland Mapping from boreal to tropical zone in Americas: https://members.sws.org/event-calendar/Details/november-2021-webinar-peatland-mapping-from-boreal-to-tropical-zone-in-americas-344282

North-America

Canada

New plan for Delta Nature Reserve, Burns Bog

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Metro Vancouver has a new plan in the works for the Delta Nature Reserve and parts of Burns Bog. The regional district provided Delta council with an update saying that Metro's board recently authorized staff to proceed with an engagement process for the development of a management plan for the nature reserve next to Burns Bog and the Delta South Surrey Regional Greenway. The plan would also include portions of the Burns Bog Ecological Conservancy Area east of Highway 91. Working with the City of Delta, Metro's new plan is to guide decision-making for the park lands and greenway over the next 20 years, including planning for habitat protection and enhancement, as well as new facilities and amenities "The Delta Nature Reserve is part of the Burns Bog Ecological Conservancy Area and has long been identified as a key component of the bog lands to be open to the public. Nearby portions of Burns Bog east of Highway 91 include a large paved area, previously used as a peat plant. Both areas have opportunities for habitat protection and enhancement as well as recreation and

education," the regional district explains. "Running along the eastern edge of these park lands is the future route of the Delta South Surrey Regional Greenway, a multi-use trail and greenway corridor. The first phase of the Delta South Surrey Regional Greenway currently runs from Mud Bay Park to 64th Avenue. The future extension of the greenway is from 64th north to the Alex Fraser Bridge, and potentially to the Fraser River," Metro adds.
The regional district also notes the planning area does not include the vast area of the Burns Bog Ecological Conservancy Area west of Highway 91, which will remain closed to the public. In 2020, the regional district received 50 per cent ownership and assumed operational control of the nature reserve from Delta.
There will be an opportunity for the public to provide feedback on the new management plan this summer, according to the regional district Metro Vancouver.

- https://www.delta-optimist.com/local-news/new-plan-for-delta-nature-reserve-burns-bog-3817608

Burns Bog Ecological Conservancy Area, Vancouver, British Columbia, Canada. Photo: Hans Joosten.

Five years after Fort McMurray Fire, researchers warn of wildfire risk from peatlands

Five years after the disastrous wildfire in Fort McMurray, Alberta, researchers are warning that the complex role of peatlands, a factor critical to projecting the risk and behaviour of future fires, is missing from the forecasting model. The Fort McMurray fire burned out of control from May 1 to July 5, 2016, though it continued to smoulder until it was finally declared extinguished Aug. 2, 2017.
Peat deposits – which are prevalent across Canada, especially in Alberta – are complex threats that can complicate and magnify the risk of severe, long-lasting fires and heavy smoke, but they are not yet part of the standard assessment tools that fire managers use. It's a critical gap that should be addressed urgently, say the authors of a new paper published in the International Journal of Wildland Fire, who have completed the first scientific assessment of peatland smouldering fire potential.

- https://www.enn.com/articles/67869-five-years-after-fort-mcmurray-fire-researchers-warn-of-wildfire-risk-from-peatlands
- https://www.commediaportal.ca/en/media/standing-together-protect-muskeg-northern-sk-peat-mining

South-America

Peru

03.06. Workshop Binational Patagonian Peatland Initiative by WCS, Ministry of Env. Chile et al.

- https://chile.wcs.org/Nosotros/Noticias/ID/16214/Seminario-Binacional-Turberas-de-Patagonia.aspx

Peatland conservation relevant papers May – June 2021.

Collected by Hans Joosten: joosten@uni-greifswald.de

1. Global Methane Assessment: Benefits and costs of mitigating methane emissions: https://wedocs.unep.org/bitstream/handle/20.500.11822/35913/GMA.pdf
2. 9000 years of changes in peat organic matter composition in Store Mosse (Sweden) traced using FTIR-ATR: https://onlinelibrary.wiley.com/doi/abs/10.1111/bor.12527
3. Post-glacial vegetation and landscape change in upland Ireland with particular reference to Mám Éan, Connemara: https://www.sciencedirect.com/science/article/pii/S0034666721000014
4. Soil respiration and litter decomposition along a salinity gradient in a saline boreal fen in the Athabasca Oil Sands Region: https://www.sciencedirect.com/science/article/abs/pii/S0016706121001440
5. Dire necessity or mere opportunity? Recurrent peat commercialisation from raised bog commons in the Early Modern Low Countries: https://www.thecommonsjournal.org/articles/10.5334/ijc.1054/
6. Water table depth, experimental warming, and reduced precipitation impact on litter decomposition in a temperate *Sphagnum*-peatland: https://www.sciencedirect.com/science/article/pii/S0048969721005209
7. Hydrological variation recorded in a subalpine peatland of Northeast Asia since the Little Ice Age and its possible driving mechanisms: https://www.sciencedirect.com/science/article/abs/pii/S0048969720384564
8. Microhabitat distribution of aquatic oligochaete communities in the Western Balkans peat bog: https://onlinelibrary.wiley.com/doi/10.1002/eco.2304
9. Mineralization of nitrogen and release of dissolved phosphorus and carbon in plant-amended organic soils: https://www.researchgate.net/profile/Vincent-Marmier/publication/351762558_Mineralization_of_nitrogen_and_release_of_dissolved_phosphorus_and_carbon_in_plant-amended_organic_soils/links/60a7e68545851522bc08f43a/Mineralization-of-nitrogen-and-release-of-dissolved-phosphorus-and-carbon-in-plant-amended-organic-soils.pdf
10. An integrated geophysical and GIS based approach improves estimation of peatland carbon stocks: https://www.sciencedirect.com/science/article/abs/pii/S0016706121002561
11. Comparing UAS LiDAR and Structure-from-Motion Photogrammetry for peatland mapping and Virtual Reality (VR) visualization: https://www.mdpi.com/2504-446X/5/2/36

12. Iron-bound organic carbon and their determinants in peatlands of China: https://www.sciencedirect.com/science/article/abs/pii/S0016706121000483
13. *Drepanocladus lycopodioides* rediscovered in the Czech Republic: Abandoned quarries as refugia for endangered fen species: https://www.sciencedirect.com/science/article/abs/pii/S0304377021000292
14. High sulfate concentrations maintain low methane emissions at a constructed fen over the first seven years of ecosystem development: https://www.sciencedirect.com/science/article/abs/pii/S0048969721030850
15. A 16.2-kyr lacustrine sediment record of mercury deposition in Dahu Swamp, eastern Nanling Mountains, southern China: Analysis of implications for climatic changes: https://www.sciencedirect.com/science/article/abs/pii/S1040618221002330
16. Dissolved organic carbon production and transport within a constructed fen watershed in the Athabasca Oil Sands Region, Alberta, Canada: https://www.sciencedirect.com/science/article/abs/pii/S0022169421005400
17. Impact of atmospheric optical properties on net ecosystem productivity of peatland in Poland: https://www.mdpi.com/2072-4292/13/11/2124
18. Climate Change and Land Use in Ireland: https://www.epa.ie/publications/research/climate-change/Research_Report_371.pdf
19. On the human appropriation of wetland primary production: https://www.sciencedirect.com/science/article/pii/S0048969721021677
20. Respiration of Russian soils: Climatic drivers and response to climate change: https://www.sciencedirect.com/science/article/pii/S0048969721023858/pdf?md5=12f56ebbedc74d4fbd2afab1811fff44&pid=1-s2.0-S0048969721023858-main.pdf
21. Coastal wetland ecosystems deliver large carbon stocks in tropical Mexico: https://www.sciencedirect.com/science/article/abs/pii/S0016706121002536
22. Chronic atmospheric reactive N deposition has breached the N sink capacity of a northern ombrotrophic peatbog increasing the gaseous and fluvial N losses: https://www.sciencedirect.com/science/article/pii/S0048969721026231
23. Shrub decline and expansion of wetland vegetation revealed by very high resolution land cover change detection in the Siberian lowland tundra: https://www.sciencedirect.com/science/article/pii/S0048969721019471
24. Drainage consequences and self-restoration of drained raised bogs in the south-eastern part of Western Siberia: Peat accumulation and vegetation dynamics: https://www.sciencedirect.com/science/article/abs/pii/S0341816221003222
25. Macroplastic in soil and peat. A case study from the remote islands of Mausund and Froan landscape conservation area, Norway; implications for coastal cleanups and biodiversity: https://www.sciencedirect.com/science/article/pii/S0048969721026188
26. Woody peat addition increases soil organic matter but its mineralization is affected by soil clay in the four degenerated erodible soils: https://www.sciencedirect.com/science/article/abs/pii/S0167880921001997
27. Late-Holocene landscape evolution and human presence in the northern Danube delta (Chilia distributary lobes): https://journals.sagepub.com/doi/full/10.1177/09596836211019121
28. Medium optimization for biomass production of three peat moss (*Sphagnum* L.) species using fractional factorial design and response surface methodology: https://www.sciencedirect.com/science/article/pii/S2589014X21001079
29. Natural climate solutions for Canada: https://advances.sciencemag.org/content/7/23/eabd6034
30. Revisiting tropical peatlands in Indonesia: Semi-detailed mapping, extent and depth distribution assessment: https://www.sciencedirect.com/science/article/abs/pii/S0016706121003153
31. The use of subsidence to estimate carbon loss from deforested and drained tropical peatlands in Indonesia: https://www.mdpi.com/1999-4907/12/6/732/htm
32. Investigating peatland stratigraphy and development of the Šijec bog (Slovenia) using near-surface geophysical methods: https://www.sciencedirect.com/science/article/pii/S0341816221003428
33. Large historical carbon emissions from cultivated northern peatlands: https://advances.sciencemag.org/content/7/23/eabf1332
34. Habitats supporting wader communities in Europe and relations between agricultural land use and breeding densities: A review: https://www.sciencedirect.com/science/article/pii/S2351989421002079

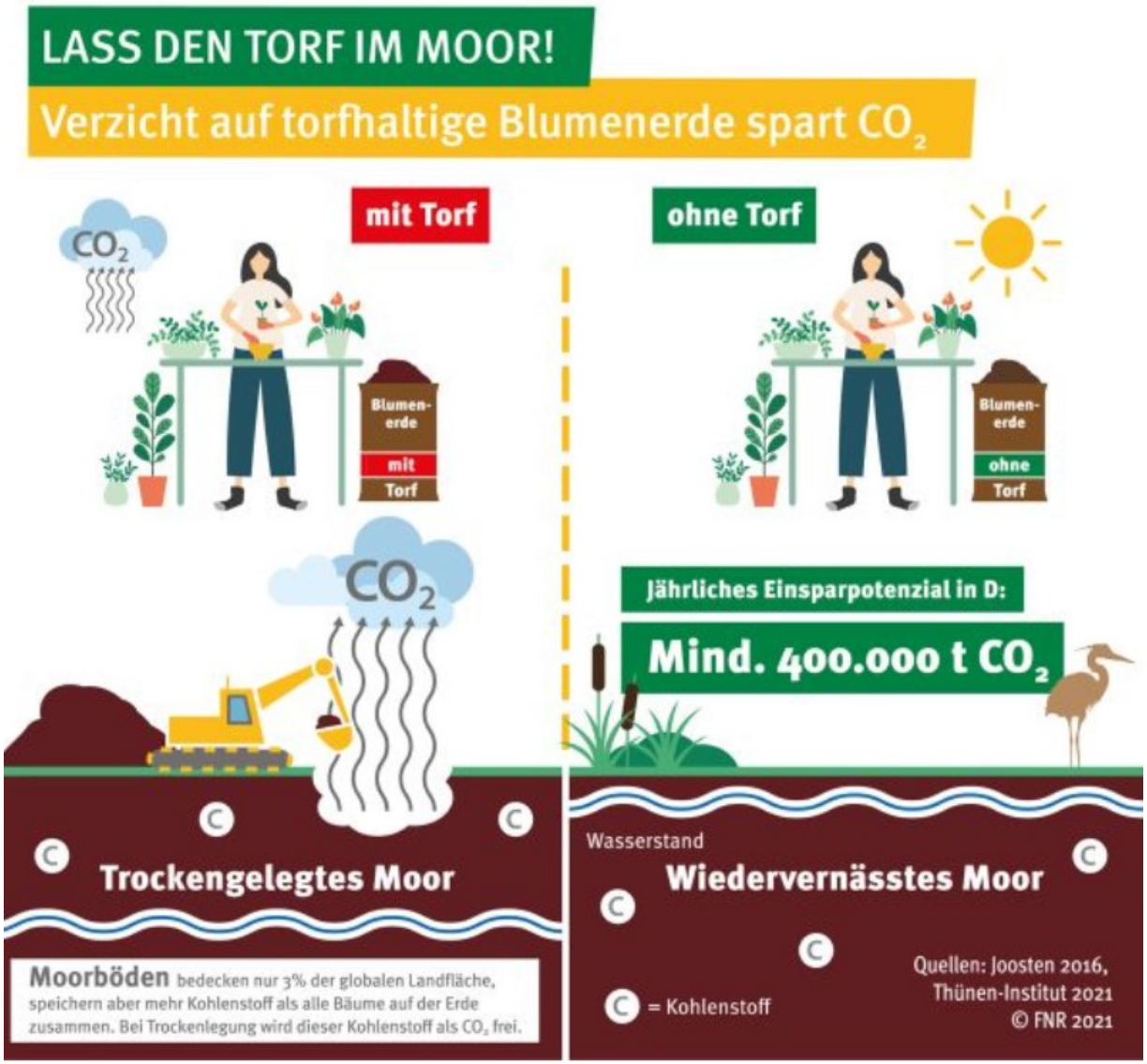
35. Restoration and meteorological variability highlight nested water supplies in middle altitude/latitude peatlands: Towards a hydrological conceptual model of the Frasne peatland, Jura Mountains, France: https://onlinelibrary.wiley.com/doi/abs/10.1002/eco.2315
36. Carbon accumulation rates of Holocene peatlands in central-eastern Europe document the driving role of human impact for the past 4000 years: https://cp.copernicus.org/preprints/cp-2021-65/
37. The burial under peat technique: An innovative method to restore Sphagnum peatlands impacted by mineral linear disturbances: https://www.frontiersin.org/articles/10.3389/feart.2021.658470/full
38. Predicting the structure and functions of peatland microbial communities from *Sphagnum* phylogeny, anatomical and morphological traits and metabolites: https://besjournals.onlinelibrary.wiley.com/doi/abs/10.1111/1365-2745.13728
39. Paludiculture Newsletter 2021_02: https://www.moorwissen.de/doc/newsletter/Paludiculture__Newsletter__2021_02_English.pdf
40. England Peat Action Plan: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/987859/england-peat-action-plan.pdf
41. Peatlands across Europe: Innovation & inspiration - State of the art & Guide to next steps: https://en.nabu.de/imperia/md/content/nabude/international/210603-peatlands-across-europe-web-version.pdf
42. Towards the quantification of blanket bog ecosystem services to water: https://www.epa.ie/publications/research/epa-research-2030/Research_Report_378.pdf
43. Optimizing fen peatland water-table depth for romaine lettuce growth to reduce peat wastage under future climate warming: https://onlinelibrary.wiley.com/doi/abs/10.1111/sum.12729
44. Non-growing season carbon emissions in a northern peatland are projected to increase under global warming: https://www.nature.com/articles/s43247-021-00184-w
45. Small-scale spatial variability of hydro-physical properties of natural and degraded peat soils: https://www.sciencedirect.com/science/article/pii/S0016706121002032
46. Soil carbon balance of afforested peatlands in the maritime temperate climatic zone: https://onlinelibrary.wiley.com/doi/10.1111/gcb.15654
47. A cautionary tale about using the apparent carbon accumulation rate (aCAR) obtained from peat cores: https://www.nature.com/articles/s41598-021-88766-8
48. Warming climate forcing impact from a sub-arctic peatland as a result of late Holocene permafrost aggradation and initiation of bare peat surfaces: https://www.sciencedirect.com/science/article/abs/pii/S0277379121002298
49. Holocene paleoclimate inferred from stable isotope (δ18O and δ13C) values in Sphagnum cellulose, Mohos peat bog, Romania: https://link.springer.com/article/10.1007/s10933-021-00202-z
50. Response of peatland CO_2 and CH_4 fluxes to experimental warming and the carbon balance: https://www.frontiersin.org/articles/10.3389/feart.2021.631368/full
51. Contribution of microbial photosynthesis to peatland carbon uptake along a latitudinal gradient: https://besjournals.onlinelibrary.wiley.com/doi/abs/10.1111/1365-2745.13732
52. Drainage ditches contribute considerably to the CH_4 budget of a drained and a rewetted temperate fen: https://link.springer.com/article/10.1007/s13157-021-01465-y
53. Montane palustrine wetlands of Lesotho: Vegetation, ecosystem services, current status, threats and conservation: https://link.springer.com/article/10.1007/s13157-021-01470-1
54. Hydro-ecological controls on soil carbon storage in subtropical freshwater depressional wetlands: https://link.springer.com/article/10.1007/s13157-021-01453-2
55. A critical review of the IUCN UK Peatland Programme's "Burning and Peatlands" position statement: https://link.springer.com/article/10.1007/s13157-021-01400-1
56. Regional wetland plant responses to sulfur and other porewater chemistry in calcareous rich fens: https://link.springer.com/article/10.1007/s13157-021-01438-1
57. Impact of vegetation harvesting on nutrient removal and plant biomass quality in wetland buffer zones: https://link.springer.com/article/10.1007/s10750-020-04256-4
58. Tradeoff of CO_2 and CH_4 emissions from global peatlands under water-table drawdown: https://www.nature.com/articles/s41558-021-01059-w
59. Characteristics and assessment of trace Elements (Hg, As, Sb, Se, and Bi) in mire surface water from the Changbai Mountains, Northeastern China: https://link.springer.com/article/10.1007/s11270-021-05173-5

60. Geochemistry and sedimentology of tropical mangrove sediments along the southwest coast of Sri Lanka: Fingerprints for development history of wetlands: https://www.sciencedirect.com/science/article/abs/pii/S2352485521002760
61. Field-grown and in vitro propagated Round-Leaved Sundew (*Drosera rotundifolia* L.) show differences in metabolic profiles and biological activities: https://www.mdpi.com/1420-3049/26/12/3581
62. Peatland subsidence enhances cultivated lowland flood risk: https://www.sciencedirect.com/science/article/pii/S0167198721001483
63. Permafrost thaw in northern peatlands: Rapid changes in ecosystem and landscape functions: https://link.springer.com/chapter/10.1007/978-3-030-71330-0_3
64. Alberta wetland classification system field guide: https://borealducks.lpages.co/alberta-wetland-classification-system-field-guide/
65. Soil metabolome response to whole-ecosystem warming at the Spruce and Peatland Responses under Changing Environments experiment: https://www.pnas.org/content/118/25/e2004192118/tab-article-info
66. Barriers and opportunities facing the UK Peatland Code: A case-study of blended green finance: https://www.sciencedirect.com/science/article/abs/pii/S0264837721003173
67. Peatland restoration and potential emissions savings on agricultural land: an evidence assessment: https://hdl.handle.net/1842/37696
68. Understanding the experiences of peatland restoration in Scotland: https://era.ed.ac.uk/handle/1842/37697
69. Long-term climate-influenced land cover change in discontinuous permafrost peatland complexes: https://hess.copernicus.org/articles/25/3301/2021/hess-25-3301-2021.pdf
70. Evapotranspiration and biogeochemical regulation in a mountain peatland: insights from eddy covariance and ionic balance measurements: https://www.sciencedirect.com/science/article/pii/S221458182100080X
71. Lesson learned from the development of sustainable rice farming in peatland: https://www.proquest.com/openview/0383efc314378fad5a223692dd4a5bcb/1
72. Towards sustainable soil stabilization in peatlands: Secondary raw materials as an alternative: https://www.mdpi.com/2071-1050/13/12/6726
73. Paludiculture as paludifuture on Dutch peatlands: An environmental and economic analysis of Typha cultivation and insulation production: https://www.sciencedirect.com/science/article/pii/S0048969721032320
74. Diversity of Testate Amoebae as an indicator of the conservation status of peatlands in Southwest Europe: https://www.mdpi.com/1424-2818/13/6/269
75. Low biodegradability of Dissolved Organic Matter from Southeast Asian peat-draining rivers: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020JG006182
76. Committed and projected future changes in global peatlands – continued transient model simulations since the Last Glacial Maximum: https://bg.copernicus.org/articles/18/3657/2021/
77. Experts and resource users split over solutions to peatland fires: https://www.sciencedirect.com/science/article/abs/pii/S0305750X21002096
78. Practical guidance for peatland restoration monitoring in Indonesia – A remote sensing approach using FAO-SEPAL platform: http://www.fao.org/3/cb4575en/cb4575en.pdf
79. Peat-GHG tool. A greenhouse gas calculator for peatland management in Indonesia - User manual: http://www.fao.org/3/cb4570en/cb4570en.pdf
80. Predicted vulnerability of carbon in permafrost peatlands with future climate change and permafrost thaw in Western Canada: https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020JG005872
81. Decision support framework for peatland protection and the establishment of new woodland (Interim) June 2021: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/992439/Decision_support_framework_for_peatland_protection_and_the_establishment_of_new_woodland__Interim__June_2021_FINAL.pdf
82. Methane production and oxidation potentials along a fen-bog gradient from southern boreal to subarctic peatlands in Finland: https://onlinelibrary.wiley.com/doi/10.1111/gcb.15740
83. Four peat humification-recorded Holocene hydroclimate changes in the southern Altai Mountains of China: https://journals.sagepub.com/doi/abs/10.1177/09596836211011674
84. Conventional subsoil irrigation techniques do not lower carbon emissions from drained peat meadows: https://bg.copernicus.org/articles/18/3881/2021/
85. The Source - 2020 Annual Review of Wetlands International: https://www.wetlands.org/download/22223/

86. Wie kommt das Moor in die Kunst?: https://phil.uni-greifswald.de/storages/uni-greifswald/fakultaet/phil/philosophische_fakultaet/Institute/Einrichtungen/GK_Baltic_Borderlands/IFZO/Transfer/Moor_und_Schule/IFZO_Moore_im_Kunstunterricht_2.pdf
87. Spring water table depth mediates within-site variation of soil temperature in groundwater-fed mires: https://onlinelibrary.wiley.com/doi/10.1002/hyp.14293?af=R
88. Soil microbial community response to permafrost degradation in palsa fields of the Hudson Bay Lowlands: Implications for greenhouse gas production in a warming climate: https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021GB006954
89. Plant species associations with alkaline environments associated with artesian spring wetlands: https://link.springer.com/content/pdf/10.1007/s11104-021-04903-2.pdf
90. Living between land and water – structural and functional adaptations in vegetative organs of bladderworts: https://link.springer.com/content/pdf/10.1007/s11104-021-04929-6.pdf
91. Shrub encroachment balances soil organic carbon pool by increasing carbon recalcitrance in a temperate herbaceous wetland: https://link.springer.com/content/pdf/10.1007/s11104-021-04975-0.pdf
92. Steady and ebullitive methane fluxes from active, restored and unrestored horticultural peatlands: https://www.sciencedirect.com/science/article/abs/pii/S0925857421001798
93. A simple and robust wetland classification approach by using optical indices, unsupervised and supervised machine learning algorithms: https://www.sciencedirect.com/science/article/abs/pii/S2352938521001051
94. Chemical and phytocoenological characteristics of two different Slovak peatlands: https://www.mdpi.com/2223-7747/10/7/1290
95. Assessment on the suitability of planting non-native peatlands species *Falcataria moluccana* (Miq.) Barneby & Grimes in rewetted peatlands: https://www.mdpi.com/2071-1050/13/13/7015
96. Negative emission farming: https://www.jswconline.org/content/76/3/61A
97. Geographic setting and groundwater table control carbon emission from Indonesian peatland: A meta-analysis: https://www.mdpi.com/1999-4907/12/7/832
98. Transformation of an oligotrophic *Sphagnum* bog during the process of rewetting: https://www.mdpi.com/2073-445X/10/7/670
99. Response of the peatland carbon dioxide sink function to future climate change scenarios and water level management: https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.15753
100. The stratigraphy of the blanket peatland and the development of environments on Bolshoi Shantar Island in the Late Glacial–Holocene: https://link.springer.com/article/10.1134/S1819714021030064
101. Warming promotes the use of organic matter as an electron acceptor in a peatland: https://www.sciencedirect.com/science/article/abs/pii/S0016706121003839
102. Come rain, come shine: Peatland carbon dynamics shift under extreme precipitation: https://www.frontiersin.org/articles/10.3389/fenvs.2021.659953/full
103. Extensive remineralization of peatland-derived dissolved organic carbon and ocean acidification in the Sunda Shelf Sea, Southeast Asia: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2021JC017292
104. Livestock-induced N_2O emissions may limit the benefits of converting cropland to grazed grassland as a greenhouse gas mitigation strategy for agricultural peatlands: https://www.sciencedirect.com/science/article/abs/pii/S0921344921003736
105. Biogeochemical evidence for environmental and vegetation changes in peatlands from the middle Yangtze river catchment during the medieval warm period and Little Ice Age: https://journals.sagepub.com/doi/abs/10.1177/09596836211025966
106. Assessing wood and soil carbon losses from a forest-peat fire in the boreo-nemoral zone: https://www.mdpi.com/1999-4907/12/7/880/pdf
107. Emerging challenges for sustainable development and forest conservation in Sarawak, Borneo: https://doi.org/10.1371/journal.pone.0229614
108. First steps toward a test procedure to identify peat substitutes for growing media by means of chemical, physical, and biological material characteristics: https://www.mdpi.com/2311-7524/7/7/164
109. Geographic setting and groundwater table control carbon emission from Indonesian peatland: A meta-analysis: https://www.mdpi.com/1999-4907/12/7/832

110. Utilization of image, LiDAR and gamma-ray information to improve environmental sustainability of cut-to-length wood harvesting operations in peatlands: A management systems perspective: https://www.mdpi.com/2220-9964/10/5/273
111. Soil respiration in Alder swamp (*Alnus glutinosa*) in southern taiga of European Russia depending on microrelief: https://www.mdpi.com/1999-4907/12/4/496
112. Wood anatomical traits reveal different structure of peat bog and lowland populations of *Pinus sylvestris* L. in the Carpathian region: https://www.mdpi.com/1999-4907/12/4/494
113. Monitoring of land subsidence in the Po river delta (Northern Italy) using geodetic networks: https://www.mdpi.com/2072-4292/13/8/1488
114. Relationship between phase composition and mechanical properties of peat soils stabilized using oil shale ash and pozzolanic additive: https://www.mdpi.com/2073-4441/13/7/942
115. Microbial community composition correlates with metal sorption in an ombrotrophic boreal bog: Implications for radionuclide retention: https://www.mdpi.com/2571-8789/5/1/19
116. The role of cultural heritage in visitor narratives of peatlands: analysis of online user-generated reviews from three peatland sites in England: https://www.tandfonline.com/doi/full/10.1080/13527258.2021.1941198
117. Mire plant diversity change over the last 10 000 years: importance of isostatic land uplift, climate, and local conditions: https://besjournals.onlinelibrary.wiley.com/doi/10.1111/1365-2745.13742
118. Conservation slows down emission increase from a tropical peatland in Indonesia: https://www.nature.com/articles/s41561-021-00785-2
119. Linking ecosystem changes to their social outcomes: Lost in translation: https://www.sciencedirect.com/science/article/pii/S2212041621000851
120. Methane emissions from an unmanaged degraded tropical peatland: Interacting influences of plant-processes and groundwater level: https://ui.adsabs.harvard.edu/abs/2021EGUGA..23.8119S/abstract
121. Gap-filling eddy covariance methane fluxes: Comparison of machine learning model predictions and uncertainties at FLUXNET-CH_4 wetlands: https://www.sciencedirect.com/science/article/abs/pii/S0168192321002124
122. Holocene climate changes inferred from peat humification: A case study from the Daiyun Mountains, Southeast China: https://www.sciencedirect.com/science/article/abs/pii/S1040618220304407
123. Dissolved organic carbon production and transport within a constructed fen watershed in the Athabasca Oil Sands Region, Alberta, Canada: https://www.sciencedirect.com/science/article/abs/pii/S0022169421005400
124. Effects of restoration strategies on vegetation establishment in retired cranberry bogs: https://link.springer.com/article/10.1007/s11258-021-01150-4
125. Effects of drainage on dissolved organic carbon (DOC) characteristics of surface water from a mountain peatland: https://www.sciencedirect.com/science/article/abs/pii/S0048969721029193
126. High sulfate concentrations maintain low methane emissions at a constructed fen over the first seven years of ecosystem development: https://www.sciencedirect.com/science/article/abs/pii/S0048969721030850
127. Holocene dynamics of an inland palsa peatland at Wiyâshâkimî Lake (Nunavik, Canada): https://www.tandfonline.com/doi/full/10.1080/11956860.2021.1907975
128. Permafrost condition determines plant community composition and community-level foliar functional traits in a boreal peatland: https://onlinelibrary.wiley.com/doi/full/10.1002/ece3.7818
129. Atmospheric nitrogen enrichment changes nutrient stoichiometry and reduces fungal N supply to peatland ericoid mycorrhizal shrubs: https://www.sciencedirect.com/science/article/pii/S0048969721038092
130. Late Holocene ENSO-related fire impact on vegetation, nutrient status and carbon accumulation of peatlands in Jambi, Sumatra, Indonesia: https://www.sciencedirect.com/science/article/abs/pii/S0034666721001068
131. Distribution of nickel (Ni) in peatland situated alongside mineral soil derived from ultrabasic rocks: https://jurnal.uns.ac.id/tanah/article/view/45417
132. Resilience and management of Arctic wetlands: Key findings and recommendations: https://www.caff.is/strategies-series/556-resilience-and-management-of-arctic-wetlands
133. Sustainable management and resilience of Arctic wetlands - Phase 2 report: https://www.caff.is/strategies-series/all-strategies-documents/573-resilience-and-management-of-arctic-wetlands-phase-2-report
134. An enormous missing contribution to global warming may have been right under our feet: https://www.washingtonpost.com/climate-environment/2021/06/04/an-enormous-missing-contribution-global-warming-may-have-been-right-under-our-feet/

135. Carbon dioxide dynamics and recovery of vegetation on restored peatlands: https://www.etera.ee/zoom/126023/view?page=1&p=separate
136. Restoring drained peatlands: now an environmental imperative: https://www.ramsar.org/sites/default/files/documents/library/factsheet_wetland_restoration_peatlands_062021_e.pdf
137. The governance of risk management on peatland: A case study of restoration in South Sumatra, Indonesia: https://wri-indonesia.org/sites/default/files/Working%20Paper%20Risk%20Governance.pdf
138. Empowerment based peatland ecosystem conservation for fire control and environmental conservation: http://www.envirobiotechjournals.com/EEC/v27i121/EEC-66.pdf
139. South-Siberian mountain mires: Perspectives on a potentially vulnerable remote source of biodiversity: https://link.springer.com/content/pdf/10.1007/s13280-021-01596-w.pdf
140. Market-based commons: Social agroforestry, fire mitigation strategies and green supply chains in Indonesia's peatlands: https://rgs-ibg.onlinelibrary.wiley.com/doi/10.1111/tran.12472
141. Impacts of historical ditching on peat volume and carbon in northern Minnesota USA peatlands: https://www.sciencedirect.com/science/article/pii/S030147972101152X
142. Application of agroforestry business models to tropical peatland restoration: https://link.springer.com/content/pdf/10.1007/s13280-021-01595-x.pdf
143. Assigning value to cultural ecosystem services: The significance of memory and imagination in the conservation of Irish peatlands: https://www.sciencedirect.com/science/article/pii/S221204162100084X
144. Long-term peatland dynamics and effects of peatland-mediated feedbacks on the climate system: http://pastglobalchanges.org/download/docs/magazine/2021-1/PAGESmagazine_2021%281%29_38-39.pdf
145. Wetter is better for peat carbon: https://www.nature.com/articles/s41558-021-01072-z.epdf
146. Graminoids vary in functional traits, carbon dioxide and methane fluxes in a restored peatland: implications for modeling carbon storage: https://www.biorxiv.org/content/10.1101/2021.05.27.445980v1
147. Anthropogenic impacts recorded by a 200-year peat profile from the Zoige Peatland, northeastern Qinghai–Tibetan Plateau: https://www.sciencedirect.com/science/article/abs/pii/S0341816221003210
148. Microbial resource limitation and regulation of soil carbon cycle in Zoige Plateau peatland soils: https://www.sciencedirect.com/science/article/abs/pii/S0341816221003362
149. Mapping smouldering fire potential in boreal peatlands and assessing interactions with the wildland–human interface in Alberta, Canada: https://www.publish.csiro.au/WF/WF21001
150. Overwintering fires in boreal forests: https://www.nature.com/articles/s41586-021-03437-y
151. The information system of the French Peatland Observation Service: Service National d'Observation Tourbières – A valuable tool to assess the impact of global changes on the hydrology and biogeochemistry of temperate peatlands through long term monitoring: https://onlinelibrary.wiley.com/doi/10.1002/hyp.14244
152. Evaluation of soil organic layers thickness and soil organic carbon stock in hemiboreal forests in Latvia: https://www.mdpi.com/1999-4907/12/7/840
153. Beyond net-zero emission in agriculture - Creating an enabling climate governance for agriculture: https://mk0eeborgicuypctuf7e.kinstacdn.com/wp-content/uploads/2021/07/Beyond-Net-zero-emissions-in-agriculture.pdf
154. Land and climate change: How do they relate to one another? A forest sector perspective: https://www.orgbalt.eu/wp-content/uploads/2021/03/LIFE-OrgBalt-1st-article-for-the-general-public.pdf
155. Spatial variability of surface peat properties and carbon emissions in a tropical peatland oil palm monoculture during a dry season: https://onlinelibrary.wiley.com/doi/full/10.1111/sum.12741
156. Gradients, species richness and communities in eastern Finnish sloping fens: http://www.sekj.org/PDF/anb58-free/anb58-289-312-OA.pdf
157. Land snail community patterns related to regional habitat conservation status of European spring fens: https://www.sciencedirect.com/science/article/abs/pii/S004896972101980X
158. Sources and sinks of greenhouse gases in the landscape: Approach for spatially explicit estimates: https://www.sciencedirect.com/science/article/pii/S0048969721017368/pdfft
159. Influence of disturbances and environmental changes on albedo in tropical peat ecosystems: https://www.sciencedirect.com/science/article/abs/pii/S0168192321000319



https://news.fnr.de/fnr-pressemitteilung/den-torf-im-moor-lassen-klima-schuetzen