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Strapline: Greenhouse gas emissions

Wetter is better for peat carbon

The role of peatlands in future climate change is uncertain because peat-derived greenhouse gas emissions are difficult to predict. Now research shows that reduced methane emissions from drying peatlands are likely to be outweighed by increasing carbon dioxide emissions.

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Peatlands are organic-rich wetlands that store huge amounts of terrestrial carbon. However, changes in surface wetness can cause peatlands to switch between being net sinks and net sources of greenhouse gases. Drier conditions lead to an increase in carbon dioxide (CO_2) emissions, but can also suppress methane emissions[1]. Climate change and large-scale drainage of peatlands for agriculture and forestry are thought to be causing widespread drying of these ecosystems[2]. However, the net effect upon peatland global warming potential is unclear due to the trade-off between CO_2 and methane emissions. Writing in this issue of *Nature Climate Change*, Yuanyuan Huang and colleagues[3] show that falling water tables are likely to lead to future increases in CO_2 emissions that more than outweigh reduced methane emissions. They show that under both high- and low-emissions scenarios, drying peatlands are likely to have a net global warming effect by the end of the 21st century.

Peat consists of dead plant matter, or detritus, that has accumulated over thousands of years without decomposing, because of waterlogged conditions that starve decomposers of oxygen (Figure 1). This means that a proportion of the carbon fixed by peatland plants during photosynthesis each year is trapped at the Earth's surface in the form of peat[4]. Set against this long-term carbon-sink function is the fact that peatlands also emit important greenhouse gases, including CO_2 and methane. Emission rates can be highly variable between seasons and between years, and depend on local environmental conditions. Previous research has shown that temperature, peat surface wetness, and peat biochemical conditions are all important controls on peatland emissions of CO_2 and methane[5,6].

The role of surface wetness in controlling peatland global warming potential has proved a particularly challenging question for previous research. Wetness is commonly measured as the depth of the water table below the peat surface, which is usually just a few tens of cm or less in undamaged peatlands. When water tables are deep and the peat surface is dry, large amounts of CO_2 can be produced in well-oxygenated upper peat layers. However, dry conditions also suppress the emission of methane, which is oxidised in the dry, upper part of the peat profile. Shallow water tables and a wet peat surface have the opposite effect, reducing CO_2 emissions but allowing methane to escape to the atmosphere without being oxidised[1]. These competing effects have meant that until now it has been difficult to discern not only the magnitude, but even the direction of the overall response of peatland global warming potential to future climate change[7].

Huang et al.[3] analysed a large database of greenhouse gas flux measurements from experimentally-dried peatlands around the world to develop a statistical model that can be used to estimate future emissions. They found changes in water table to be the dominant control on both CO_2 and methane fluxes. Falling water tables lead to a linear increase in global warming potential due to increasing CO_2 emissions from the decomposition of drying peat that more than outweigh the reductions in methane emissions, leading to an overall warming effect.

By linking their emissions model to global simulations of future climate and hydrological change, Huang et al.[3] were able to project likely future changes in peat-derived greenhouse gas budgets and global warming potential. Under the high emissions scenario RCP8.5, they found that intense drying of the world's peatlands is likely to cause increased CO_2 emissions and, despite some reduction in methane emissions, a net increase in global warming equivalent to 860 million tons of CO_2 by 2100. Even under the low-emissions scenario RCP2.6, Huang et al.[3] estimate that peatlands will still have a strong global warming effect, equivalent to 730 million tons of CO_2.

Another recent article shows that a narrow optimum range of water-table depths exists, within which peatland emissions of both CO_2 and methane are low enough that their combined warming effect is outweighed by photosynthesis, allowing peatlands to provide a net cooling effect. Writing recently in *Nature*, Chris Evans and colleagues[8] found that average water tables between 5 and 13 cm below the peat surface provide a trade-off between CO_2 and methane emissions that generates an important net cooling effect from peatlands. This cooling effect is strongest for water tables 10 cm below the surface.

Evans et al.[8] also found that all drained sites in their analysis were net sources of CO_2 to the atmosphere, while all peatlands that functioned as net sinks were either pristine and undrained, or had been restored and rewetted after historical drainage. Although these wetter sites are also likely to be stronger sources of methane, Evans et al.[8] show that the savings in CO_2 emissions in wet, pristine peatlands compared to drained sites more than compensate for increased methane emissions in most cases.

Both of these new studies[3,8] clearly highlight the urgent need for conservation strategies to promote wet conditions, particularly in drained peatlands. As Evans et al.[8] note, rewetting schemes are often seen to be at odds with the demand for crops grown on drained peat. Nutritional and economic reliance on such crops means that wholesale abandonment of agricultural peatlands and restoration of water tables as shallow as 10 cm is an unlikely goal in many cases.

However, Evans et al.[8] demonstrate that restricting water tables to no deeper than 45 cm in cropland peat and 25 cm in grassland peat could, if applied globally, reduce their present-day emissions by 65 %. This is equivalent to an 11.5 % reduction in all global CO_2 emissions from land use, or 1.3 % of total global human CO_2 emissions. They argue that more modest rewetting goals such as these could allow countries with extensive agricultural peatlands to make important CO_2 savings without jeopardising crop production, particularly if wetland-adapted crops can be made commercially viable for cultivation on partially-rewetted peat.

These two new studies represent landmark findings, but a number of important questions remain. Neither study considers permafrost-specific processes. An estimated 185 billion tons of carbon, equivalent to approximately a quarter of the entire atmospheric stock, is currently trapped in permafrost peat[9]. Rapid warming in the Arctic in recent decades is beginning to mobilise this carbon into water bodies and the atmosphere, with potentially large feedbacks to climate[9,10]. Additionally, Huang et al.[3] acknowledge that tropical peatlands are under-represented in their analysis, yet the tropics are home to some of the most damaged peatlands in the world[11]. Evans et al.[8] note that proper consideration of tropical peatlands also warrants that nitrous-oxide emissions are accounted for, a greenhouse gas 265 times more potent than CO_2, and which is emitted by tropical peat[12].

Despite the remaining uncertainties, the findings in both of these studies[3,8] show the importance of maintaining or restoring wet conditions to minimise greenhouse gas emissions from both natural and agricultural peatlands.

References

1. Moore, T. R. & Knowles, R. *Can. J. Soil Sci.* **69**, 33–38 (1989).
2. Swindles, G. T. et al. *Nat. Geosci.* **12**, 922–928 (2019).
3. Huang, Y. et al. *Nat. Clim. Change* (2021) doi: 10.1038/s41558-021-01059-w.
4. Yu, Z. C., Loisel, J., Brosseau, D. P., Beilman, D. W. & Hunt, S. J. *Geophys. Res. Lett.* **37**, L13402 (2010).
5. Roulet, N. T., Lafleur, P. M., Richard, P. J. H., Moore, T. R., Humphreys, E. R. & Bubier, J. *Glob. Change Biol.* **13**, 397–411 (2007).
6. Turetsky, M. R. et al. *Glob. Change Biol.* **20**, 2183–2197 (2014).
7. Loisel, J. et al. *Nat. Clim. Change* **11**, 70–77 (2021).
8. Evans, C. D. et al. *Nature* (2021) doi: 10.1038/s41586-021-03523-1.
9. Hugelius, G. et al. *Proc. Natl. Acad. Sci.* **117**, 20438–20446 (2020).
10. Voigt, C. et al. *Glob. Change Biol.* **25**, 1746–1764 (2019).
11. Leifeld, J. & Menichetti, L. *Nat. Commun.* **9**, 1071 (2018).
12. Hatano, R., Toma, Y., Hamada, Y., Arai, H., Susilawati, H. L. & Inubushi, K. In *Tropical Peatland Ecosystems* (eds Osaki, M. & Tsuji, N.) pp. 339–351 (Springer, 2016).

Fig. 1 | New research shows that increased carbon dioxide emissions from drying peatlands will more than outweigh their reduced methane emissions, leading to a net global warming effect even under low-emissions scenarios. Author's own image.

Competing interests

The author declares no competing interests.