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Warmer autumn temperatures triple carbon losses from an Irish grassland on drained organic soil

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Grasslands represent the dominant land-use and cultural backbone of the rural economy of Ireland. Similarly, it is the oldest and prevailing land-use for Irish managed peat soils, with at least 437,000 ha use as grassland (Connolly, 2019). Over one third of the national greenhouse gas (GHG) emissions are derived from grass-based agriculture, and the LULUCF sector is also a net GHG source, primarily due to the ongoing drainage of peat soils for agriculture which emit over 8 Mt CO_2-eq per year. Reducing the carbon (C) losses from organic soils has been highlighted as a key action for Ireland to reach its climate targets, and improved grassland management practices can provide a suitable strategy to offset GHG emissions without compromising productivity. However, research is required to assess the best management practices for optimum environmental and agricultural outcomes. In Ireland, despite their spatial extent and relevance to both the national emission inventories and climate mitigation strategies, only two studies on GHG emissions from grassland on peat soils have been published to date. More data is urgently needed in order to better understand the specific biogeochemical functioning of this type of agri-environmental system, assess the impact of management practices on their C and GHG dynamics, and evaluate their vulnerability to climate change.

Here we present 2 years of data from a former peat extraction site located in the Irish midlands (Lullymore grassland), that has been drained and managed for grass-based silage. For the first time in such agri-environmental systems on Irish soil, the eddy covariance technique was used to continuously monitor the Net Ecosystem Exchange (NEE) of carbon dioxide (CO_2). Additionally, weekly static chamber measurements were made to assess the soil-derived emission of methane (CH_4) and nitrous oxide (N_2O) and to estimate the full GHG budget of the site.

As might be expected from a drained organic soil system, the Lullymore grassland was a C source in both years, with 3 times more carbon emitted in 2021 than in 2020. The increase in emission observed in 2021 were due to higher autumn temperatures being on average 2°C warmer, in addition to drier conditions where the volumetric water content was in average 20% lower in September-November 2021 compared to 2020. This reduced the rate of NEE C uptake from -3.8 in 2020 to -2 t C ha^{-1} in 2021 due to higher rates of ecosystem respiration. C export through harvest were 4.9 and 5.4 t C ha^{-1}, resulting in a net C loss of 1.1 and 3.4 t C ha^{-1} in 2020 and 2021

respectively. Moreover, while CH_4 emissions seemed negligible, the N_2O emissions, in particular following the fertilisation event in the spring, are likely to increase the GHG budget significantly. This work indicates the potential for emission savings to be made from these systems and highlights the impact that inter-annual variability associated with future climate change can have on their GHG sink/source strength.