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Fluvial organic carbon losses from oil palm plantations on peat

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Intact tropical peatlands are dense, long-term stores of carbon, with the largest share found within Southeast Asia. However, the future security of these ecosystems is under threat from land conversion – requiring deforestation, often accompanied by fire, and extensive peatland drainage. This compromises the resilience of these ecosystems to both natural and anthropogenic induced system perturbations and ultimately converts these carbon sinks into significant carbon sources. At present, there is a large knowledge gap surrounding the losses of fluvial organic carbon from intensively managed tropical peatlands, such as oil palm plantations (OPPs). The extensive drainage required to convert and sustain these plantations enhances carbon mineralization and associated dissolved organic carbon (DOC) losses which, in turn, contribute to global anthropogenic greenhouse gas emissions. Here we present data from the first detailed study focusing on the export of DOC from peatland OPPs and nearby stands of tropical peat swamp forests (PSF), in Sarawak, Malaysia. We find that total organic carbon (TOC) fluxes from the OPP main and collection drains (104 g C m-2 yr-1and 109 g C m-2 yr-1, respectively) across 17 OPP sample sites are a third larger than TOC losses reported from intact tropical PSF (63 g C m-2 yr-1; Moore et al., 2013) and are comparable to losses from degraded PSF (97 g C m-2 yr-1). 14C dating and age attribution analysis (Evans et al., 2014) of the DOC component revealed the presence of old (centuries to millennia) carbon, which was influenced by low (> 60 cm, below the peat surface), fluctuating watertables. By contrast, sites (five out of the six dated) which maintained high stable watertables (< 60 cm) displayed a greater proportion of recently fixed carbon (30 years before present, 1950) with lower overall TOC losses (as low as 69.3 g C m-2 yr-1). While this figure is comparable to the intact tropical PSF the quality of the carbon lost is significantly different (Materic et al., 2017). The measured fluxes from the forest reserves, within the plantation landscape, were of a similar magnitude (71.2 $\pm$ 11.0 g C m-2 yr-1 to 84.5 $\pm$ 13.1 g C m-2 yr-1) to the OPP estates. This was a consequence of modification of the natural forest hydrology by the adjacent plantation drainage system. The inclusion of the commonly ignored fluvial carbon component elevates the total carbon loss from peatland OPPs by 10%. We calculate current (2016) TOC losses from Peninsular Malaysia, Borneo and Sumatra to be 10.4 Tg C yr-1 (i.e. TOC losses from intact PSF + degraded PSF + industrial OPPs). This represents more than a two-fold increase in the region's fluvial TOC fluxes since 1990 (4.7 Tg C yr-1; Moore et al., 2013), with approximately one third of this derived from industrial OPPs (3.2 Tg C yr-1). Overall, our investigation reinforces the importance of considering alternative carbon loss pathways in studies of tropical peatland land conversion; with the maintenance of high and stable watertables key to reducing TOC losses and in achieving responsible peatland management.