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Short-term effect of drying and waterlogging on decomposition within a hydrological restoration chronosequence of a blanket peat catchment

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Peatland ecosystems contain one-third of the world's soil carbon store and are therefore a significant component of the global carbon cycle. Historically, peatlands were drained for agricultural reclamation that has led to degradation and potential loss of a variety of ecosystem services including carbon sequestration and potable water quality due to water discoloration. The impact of rewetting by grip-blocking on dissolved organic carbon (DOC) export in peat bogs appears dependent on the length of time following rewetting but the mechanisms responsible are not fully understood (Wallage et al. 2006; Worrall et al. 2007; Holl et al 2009). For long-term management of ecosystem services in peatlands, particularly for carbon sequestration, it is critical that the mechanisms responsible for peat decomposition following drainage and resulting DOC export can be proven empirically. Freeman et al (2001) and Fenner and Freeman (2011) describe in detail the enzyme latch mechanism responsible for decomposition of peat following drought and rewetting events in which oxygen constraints on the enzyme phenol oxidase prevent the decomposition of peatland carbon, namely by degrading phenolic compounds that inhibit the hydrolase enzymes. The enzymic latch sits within a regulatory pathway of process-specific limitations, which are sequentially removed as drought proceeds, constituting a biogeochemical cascade with potent positive feedbacks to carbon loss (Fenner and Freeman, 2011). Evidence has accumulated that re-wetting the peat actually accelerates carbon losses, owing to drought induced increases in nutrient and carbon levels that stimulate anaerobic decomposition (Fenner and Freeman, 2011). Therefore, as stated by Holl et al. (2009) the 'long-term recovery of the water table creates different biogeochemical conditions than short-term water table elevation, i.e. there is no simple relationship between water saturation and DOC concentrations.' The aim of this study funded by the Natural Environment Research Council (NERC) was to compare the short-term effect of laboratory manipulation in peat water content (air drying and waterlogging) on important decomposition pools (DOC and phenolics) and processes (extracellular enzyme activities, carbon dioxide production) along a hydrological restoration chronosequence within the Geltsdale National Nature Reserve (NNR) blanket peat catchment. The chronosequence consisted of four locations of unmanaged peatland (wet pristine and eroded gully) and managed peatland (grip-blocked < 2 years and grip-blocked < 7 years), located in relatively close proximity to minimise variation in local temperature and rainfall. These locations represented a potential chronosequence in temporal hydrological restoration in the order eroded gully < grip-blocked 2 years < grip-blocked 7 years < wet pristine. We hypothesized that the short-term response of decomposition pools and processes to drying and waterlogging would differ significantly between these locations, depending to an extent on peat depth, hydrological management, and length of hydrological recharge.

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