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Towards an understanding of feedbacks between plant productivity, acidity and dissolved organic matter

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The recent origin of much dissolved organic carbon (DOC) (Tipping et al., 2010) implies that plant productivity is a major control on DOC fluxes. However, the flocculation, sorption and release of potentially-dissolved organic matter are governed by pH, and widespread increases in DOC concentrations observed in northern temperate freshwater systems seem to be primarily related to recovery from acidification (Monteith et al., 2007). We explore the relative importance of changes in productivity and pH using a model, MADOC, that incorporates both these effects (Rowe et al., 2014). The feedback whereby DOC affects pH is included. The model uses an annual timestep and relatively simple flow-routing, yet reproduces observed changes in DOC flux and pH in experimental (Evans et al., 2012) and survey data. However, the first version of the model probably over-estimated responses of plant productivity to nitrogen (N) deposition in upland semi-natural ecosystems.

There is a strong case that plant productivity is an important regulator of DOC fluxes, and theoretical reasons for suspecting widespread productivity increases in recent years due not only to N deposition but to temperature and increased atmospheric CO_2 concentrations. However, evidence that productivity has increased in upland semi-natural ecosystems is sparse, and few studies have assessed the major limitations to productivity in these habitats. In systems where phosphorus (P) limitation prevails, or which are co-limited, productivity responses to anthropogenic drivers will be limited. We present a revised version of the model that incorporates P cycling and appears to represent productivity responses to atmospheric N pollution more realistically.

Over the long term, relatively small fluxes of nutrient elements into and out of ecosystems can profoundly affect productivity and the accumulation of organic matter. Dissolved organic N (DON) is less easily intercepted by plants and microbes than mineral N, and DON leaching rates may thus control soil formation (Vitousek et al., 2010). Large observed DON concentrations that were observed in an experimental study are difficult to reconcile with the amount of N retention necessary to have accumulated observed organic matter stocks. We examine potential reasons for this discrepancy.

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