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Using stable isotopes to identify the scaling effects of riparian peatlands on runoff generation processes and DOC mobilisation

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Knowledge of hydrological sources, flow paths, and their connectivity is fundamental to understanding stream flow generation and surface water quality in peatlands. Stable isotopes are proven tools for tracking the sources and flow paths of runoff. However, relativity few studies have used isotopes in peat-dominated catchments. Here, we combined 13 months (June 2014 – July 2015) of daily isotope measurements in stream water with daily DOC and 15 minute FDOM (fluorescent component of dissolved organic matter) data, at three nested scales in NE Scotland, to identify the hydrological processes occurring in riparian peatlands. We investigated how runoff generation processes in a small, riparian peatland dominated headwater catchment (0.65 km2) propagate to larger scales (3.2 km2 and 31 km2) with decreasing percentage of riparian peatland coverage. Isotope damping was most pronounced in the 0.65 km2 catchment due to high water storage in the organic soils which encouraged tracer mixing and resulted in attenuated runoff peaks. At the largest scale, stream flow and water isotope dynamics showed a more flashy response. Particularly insightful in this study was calculating the deviation of the isotopes from the local meteoric water line, the lc-excess. The lc-excess revealed evaporative fractionation in the peatland dominated catchment, particularly during summer low flows. This implied high hydrological connectivity in the form of constant seepage from the peatlands sustaining high baseflows at the headwater scale. This constant connectivity resulted in high DOC concentrations at the peatland site during baseflow ($\sim$ 5 mg l-1). In contrast, at the larger scales, DOC was minimal during low flows ($\sim$2 mg l-1) due to increased groundwater influence and the disconnection between DOC sources and the stream. Insights into event dynamics through the analysis of DOC hysteresis loops showed slight dilution on the rising limb, the strong influence of dry antecedent conditions and a quick recovery between events at the riparian peatland site. Again, these dynamics were driven by the tight coupling and high connectivity of the landscape to the stream. At larger scales, the disconnection between the landscape units increased and the variable connectivity controlled runoff generation and DOC dynamics. The results presented here suggest that the hydrological processes occurring in riparian peatlands in headwater catchments are less evident at larger scales which may have implications for the larger scale impact of peatland restoration projects.