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Experiments on the temperature sensitivity of peat

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A large portion of the global soil carbon store is held in Northern peatlands, where low temperatures and anoxic conditions constrain rates of microbial decomposition. Projected increases in air temperature and evapotranspiration may relax these environmental constraints by exposing a greater thickness of peat to oxic conditions, as well as to higher (and possibly more variable) soil temperatures adding to atmospheric CO2 concentrations. However, across ecosystems, the quality of litter has been shown to contribute more to variability in decomposition rates than temperature. The temperature sensitivity of aerobic decomposition is therefore likely to differ across litter/peat in different states of degradation. Thermodynamic theory predicts that rates of decomposition of recalcitrant soil organic matter (SOM) will be more sensitive to increases in temperature than labile SOM.. To date, the response of these substrate types remains unexplored in peatland systems.

We tested the effects of vegetation type and degradation state on the temperature sensitivity of aerobic decomposition by tracking changes in litter/peat incubated in the laboratory for over a year. Litter/peat was collected from hollows in the lagg fen and bog plateau of a raised bog in central Sweden. At each location, two degradation states were sampled: fresh litter from near the moss surface and degraded peat from the upper part of the perennially anoxic layer. The samples were kept moist and incubated at 15 °C in a controlled environment chamber. At six-month intervals, temperature sensitivity of three replicates of each vegetation type-degradation state combination was assessed by measuring CO2 production at temperatures ramped up from 0 °C to 30 °C in daily 5 °C steps. The data were analysed using an Arrhenius-type equation: k = A exp(-Ea/(RT)), where k is respiration rate, A is frequency or pre-exponential factor, Ea is activation energy, R is the universal gas constant and T is temperature in Kelvin.

Patterns were similar for temperature-sensitivity parameters A and Ea, with both increasing markedly over the period of incubation. Degraded peat from the fen and bog sites responded similarly to temperature increases but, contrary to thermodynamic theory, was less sensitive than fresh litter to temperature manipulation. The magnitude of the differences between litter/peat types decreased over the incubation period, suggesting that substrate availability underpinned this response. We discuss the effect of substrate quality and abundance on our ability to model temperature response with a simple thermodynamic model such as the Arrhenius equation.. Our results illustrate the need for models that, as a minimum, are parameterised on a per-substrate basis and, perhaps more fundamentally, allow for time-dependent changes in temperature-sensitivity.