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Microbial community responses to temperature increase the potential for soil carbon losses under climate change.

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There are concerns that global warming may stimulate decomposition rates in soils, with the extra CO_2 released representing a positive feedback to climate change. However, there is growing recognition that adaptation of soil microbial communities to temperature changes may alter the potential rate of carbon release. Critically, recent studies have produced conflicting results in terms of whether the medium-term soil microbial community response to temperature reduces (compensatory thermal adaptation) or enhances (enhancing thermal adaptation) the instantaneous direct positive effects of temperature on microbial activity. This lack of understanding adds considerably to uncertainty in predictions of the magnitude and direction of carbon-cycle feedbacks to climate change.

In this talk, I present results from one of the most extensive investigations ever undertaken into the role that microbial adaptation plays in controlling the temperature sensitivity of decomposition. Soils were collected from a range of ecosystem types, representing a thermal gradient from the Arctic to the Amazon. Our novel soil-cooling approach minimises issues associated with substrate depletion in warming studies, but still tests whether adaptation enhances or reduces the direct impact of temperature changes on microbial activity. We also investigated the mechanisms underlying changes in microbial respiration by quantifying changes in microbial community composition, microbial biomass, mass-specific activity, carbon-use efficiency, and enzyme activities.

Our results indicate that enhancing responses are much more common than compensatory thermal acclimation, with the latter being observed in less than 10% of cases. However, identifying the mechanisms underlying enhancing and compensatory adaptation remained elusive. No consistent changes were observed in terms of mass-specific activity, biomass or enzyme activity, indicating that current theory is inadequate in explaining observed patterns. Importantly, initial microbial community composition was the best predictor of the sign and magnitude of the adaptation response, but further research is required to develop process-based understanding.

In terms of the implications of our findings, although enhancing responses were observed in soils from all geographical regions, Arctic soils showed the strongest evidence for microbial community responses enhancing the direct effect of temperature changes. This suggests that the long-term effect of warming on soil respiration rates in the Arctic could be larger than predicted based on short-term measurements of temperature sensitivity. Consequently, the substantial stores of carbon present in high-latitude soils may be more vulnerable to climate warming than currently estimated.