

Long-term priming-induced changes in permafrost soil organic matter decomposition
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Project goal: The overall goal of this project is to advance system-level predictive understanding of the feedbacks of belowground microbial communities to multiple climate change factors and their impacts on soil carbon (C) cycling processes. The main objectives of this integrative project are to (i) determine the responses of microbial community structure, functions and activities to an increased input of easily decomposable C substrates to soil (priming effects); (ii) determine the extent to which priming enhances mineralization of native soil C; (iii) determine what proportion of the increased mineralization of native soil C is old C; (iv) determine if substrate input with different C quality distinctively affects microbial activity and soil organic matter decomposition; and (v) develop integrated bioinformatics and modeling approaches to scale information across different organizational levels. This study focuses on using laboratory incubations of soil as an isolated system to understand the influence of microbial processes on the release of C, and their response to changes in easily decomposable C substrate inputs.

<http://www.ou.edu/ieg.html>

Additional input of easily decomposable carbon can stimulate microbial activity, consequently increasing soil organic matter decomposition rates. This phenomenon, known as the priming effect, can exacerbate the effects of climate change by releasing more CO₂ from soils however, the extent to which it could decrease soil carbon is unknown. We incubated permafrost soil from a moist acidic tundra site in Healy, Alaska for 456 days at 15° C. Soil from surface and deep layers were amended with three pulses of uniformly ¹³C labeled glucose or cellulose, every 152 days. Substrate addition resulted in higher respiration rates in glucose amended soils; however, positive priming was only observed in deep layers. This suggests that microbes in deep layers are limited in energy, and the addition of easily decomposable carbon increases native soil organic matter decomposition. Here we also show, through data-model integration and synthesis, that approximately 58% of newly added C is transferred into SOC via replenishment, whereas the additional loss of old soil organic C (SOC) due to priming effect only accounts for 8.4% of the added new C in the first year after a one-time new C input. As a result, the new C input leads to a net increase in SOC, ranging from 40% to 49% of the added new

C. The magnitude of the net increase in SOC is positively correlated with the nitrogen-to-C ratio of the added substrates. Furthermore, a 100-year modeling experiment confirms that an increase in new C input leads to significant SOC accumulation over time. Our findings suggest that increasing plant productivity and the consequent increase in C input to soils likely promote SOC storage despite the enhanced decomposition of old C, which impacts C turnover time, but not necessarily C stocks.

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