Climate Change and the Permafrost Carbon Feedback

THE ISSUE. As permafrost thaws in a warming climate, once-frozen organic carbon is broken down by soil microbes, releasing the greenhouse gases carbon dioxide and methane to the atmosphere.

WHY IT MATTERS. Release of additional greenhouse gases to the atmosphere accelerates climate change and incurs additional societal costs for mitigation and adaptation.

STATE OF THE SCIENCE. Permafrost, perennially frozen ground, underlies one-quarter of exposed land in the Northern Hemisphere. There are at least ~1500 billion tons of organic carbon in permafrost zone soils, almost twice as much as currently exists in the atmosphere. That carbon—the remains of plants, animals, and microbes—has been preserved frozen in permafrost soils for hundreds to thousands of years. The potential for soil carbon to decompose and be emitted to the atmosphere as greenhouse gases increases with warming and thawing of permafrost. The ultimate impact on climate depends on how much carbon is released, how fast, and whether it is released as either carbon dioxide or methane.

Given current rates of warming, an estimated 130-160 billion tons of permafrost carbon could be released in the form of greenhouse gases—primarily carbon dioxide—during this century. Thus, emissions from thawing permafrost could be similar to other fluxes from other environmental changes, such as deforestation, but far less than fossil fuel emissions. Over this century and beyond, permafrost carbon emissions are likely to amplify warming caused by fossil fuel burning and other human activities incurring additional costs to society.

Loss of ground ice with thawing incurs additional local and regional costs to society through degradation of infrastructure and ecosystem services. Coastal infrastructure and ecosystems on permafrost are at risk of abrupt thaw due to warming permafrost and to erosion enhanced by sea-ice retreats.

WHERE THE SCIENCE IS HEADED. SEARCH scientists and their colleagues are quantifying landscape-scale carbon emissions to the atmosphere and detecting the release of old carbon from permafrost. Ongoing research also focuses on understanding large-scale changes in surface wetness that control releases of methane and carbon dioxide, measuring and modeling abrupt thaw processes, and quantifying the extent to which new plant carbon uptake can offset carbon emissions in a changing environment.

FURTHER READING

Schuur, E.A.G., A.D. McGuire, C. Schadel, G. Grosse, J.W. Harden, D.J. Hayes, G. Hugelius, C.D. Koven, P. Kuhry, D.M. Lawrence, S.M. Natali, D. Olefeldt, V.E. Romanovsky, K. Schaefer, M.R. Turetsky, C.C. Treat, and J.E. Vonk, 2015. Climate change and the permafrost carbon feedback. Nature 520:171-179, doi:10.1038/nature14338.

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