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The disappearance of relict permafrost in boreal peatlands: effects on methane emissions and soil carbon storage

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Boreal peatlands have served throughout the Holocene as an important reservoir for atmospheric carbon. Today, peatlands store a substantial proportion of the estimated total boreal forest carbon stock. Northern peatlands often are underlain by permafrost, reflecting the thermal insulating qualities of peat that promote the aggradation and maintenance of permafrost. At the southernmost occurrence of discontinuous permafrost, permafrost is restricted exclusively to peatlands where it occurs within densely treed, elevated landforms situated in largely unfrozen peatlands. These localized permafrost features, representing relict permafrost from the Little Ice Age, are experiencing widespread degradation across interior Canada.

Here, we compare methane emissions and rates of peat accumulation across peatland sites in western Canada representing three permafrost regimes, including bogs with no surface permafrost, localized permafrost features, and internal lawns representing areas of permafrost degradation. Rates of net organic matter storage generally were faster in unfrozen bogs and internal lawns than in the permafrost landforms, suggesting that surface permafrost inhibits peat accumulation and that degradation of surface permafrost stimulates net carbon storage in peatlands. However, permafrost degradation was associated with 30-fold increases in methane emissions. Our results suggest that permafrost degradation in peatlands increases net carbon storage as peat for at least 70 years following permafrost degradation. However, in terms of radiative forcing, increased methane emissions to the atmosphere will partially or even completely offset this enhanced peatland carbon sink.