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Ecosystem recovery: a neglected factor in greenhouse gas emission from permafrost degradation.

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It is estimated that northern soils hold nearly twice as much carbon as the atmosphere. Permafrost degradation caused by a warming climate will destabilize this carbon store. Part of this carbon will enter the atmosphere as CO_2 or CH_4, contributing to a positive feedback on climate warming.

However, a neglected factor is the recovery of ecosystems after permafrost thaw. Modeling of thaw lake expansion and drainage has shown that thaw lake expansion by climatic warming is strongly limited by lake drainage. Thaw lakes are drained or filled in with sediment, followed by recolonization by generally productive wetland ecosystems. Decomposition of soil carbon also releases nutrients, enhancing vegetation recolonization in types of permafrost degradation features.

Examples from the Kytalyk/Chokurdagh research site in the Indigirka lowlands of northeastern Siberia illustrate that ecosystem recovery after localized permafrost degradation may effectively counteract carbon loss. The research site is located in a drained Early Holocene thaw lake basin, and is presently a greenhouse gas sink during the growing season. Formation of thaw ponds has increased strongly recently. Although fresh ponds may be emitting CO_2 and CH_4, they are rapidly invaded by vegetation which decreases net greenhouse gas emission, although the ponds continue to be a source of CH_4. Areas of intense mass wasting by permafrost slides are colonized by a productive pioneer vegetation, contributing to stabilization of the soil and enhancing CO_2 uptake.

It is therefore essential that not only the greenhouse gas emission related to permafrost degradation is quantified, but also the carbon sinks and recovery rates. Paleo-environmental and geomorphological studies may help to quantify recovery processes, in particular those processes that leave their trace in the sedimentary record. For instance Pleistocene and younger thaw lake deposits in Europe and Siberia may provide information on carbon loss and carbon storage in successive stages of development.