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Longevity of terrestrial Carbon sinks: effects of soil degradation on greenhouse gas emissions

Nikolaus J. Kuhn, Samuel Berger, and Samuel Kuonen
University of Basel, Physical Geography, Environmental Sciences, Basel, Switzerland (nikolaus.kuhn@unibas.ch)

Soil erosion by water is a key process of soil and land degradation. In addition, significant amounts of nutrients and organic Carbon are moved from eroding source areas to landscape sinks. As a consequence, areas affected by erosion suffer a loss of fertility, while sinks experience the development of a stockpile of the deposited sediment, including soil organic matter and nutrients. The deposited nutrients are largely unavailable for the plants growing in these landscape sediment sinks once the thickness of the deposited layer is greater than the rooting depth of the plants. In addition, the deposited organic matter is decomposed slowly through the pack of sediment. At sites of erosion, nutrients have to be replaced and organic matter content of the soil declines due to a destruction of the A horizon. Over time, the risk of a significant reduction in productivity, for example caused by a loss of top soil with a sufficient water storage capacity for maximum plant growth, leads to a decline in CO_2 uptake by photosynthesis. Soil organic matter at eroding sites therefore declines and consequently the sediment that is moved to landscape sinks also has a smaller organic matter content than sediment generated from the non-degraded soil. The sediment sinks, on the other hand, emit an increasing amount of greenhouse gases as a consequence of the increasing amount of organic matter deposited while the upslope area is eroded. Over time, the perceived sink effect of soil erosion for greenhouse gases is therefore replaced with a neutral or positive emission balance of erosion in agricultural landscapes. Such a switch from none or a negative emission balance of agricultural landscapes to a positive balance carries the risk of accelerating climate change. In this study, we tried to estimate the risk associated with ongoing soil degradation and closing landscape soil organic matter sinks. Currently observed global erosion rates were linked to known limitations of soil productivity associated with erosion. Areas with high erosion rates and already erosion-induced damages to soil productivity were considered to be closing or closed landscape carbon sinks. The final global assessment indicates that severe soil degradation in Africa, the Americas and Asia carries the risk of closing terrestrial Carbon sinks that currently contribute to an unintended mitigation of greenhouse gas emissions.