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Erosion effects on soil carbon and nutrient distribution: a meta-analysis

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Soil erosion has for a long time been considered as a process causing soil organic matter (SOM) loss, however, recent studies pointed out that erosion may increase soil carbon sequestration because only 10-30% of eroded topsoil material is transported into water bodies while the remaining 70-90% are transported in depositional settings. Soil erosion leads to variation in topsoil thickness and soil characteristics and leads to two different main types of erosion states develop along hillslope: the eroding and the depositional landform position. Disruption of aggregates and the transport of soil during erosion, likely leads to SOM loss in the eroding slope. In contrast, after deposition, the eroded material can be protected if it is incorporated into soil aggregates or sorbed to mineral surfaces, leading to an increase in SOM in the depositional landform position.

So far, there has been no study evaluating literature results on the effect of erosion on carbon and nutrient distribution in soils. We therefore reviewed the literature for the influence of erosion on carbon/nutrient contents and stocks in erosion affected landscapes. While 32 studies reported results on the enrichment of eroding sediments in carbon (C), nitrogen (N) and phosphorus (P), 39 studies reported results on carbon/nutrient contents and stocks in erosion affected landscapes.

The average C enrichment ratio (sediment C/soil C) was 1.56 while N enrichment ratio was 1.54 and P-enrichment ratio was 1.77. This indicates that the fine soil fractions, that carbon and nutrients are mostly associated to, were preferentially moved during soil erosion. High element contents in the original soils, resulted in relatively low enrichment ratios which may allow the conclusion that in low C- and nutrient soils, a relatively high portion of the elements are stored in the fine soil fraction. C and N enrichment ratios showed a significant positive relation (R^2=0.61), pointing to the strong ecological link of both elements.

Carbon and nutrient contents were comparable for all landscape positons (upslope, backslope, footslope, depositional). This indicates that carbon and nutrients, lost during an erosion event, are replenished relatively fast in the eroded slopes. In contrast, erosion induced C, N and P stocks increased from the upper towards the depositional soil site, resulting in a 1.6, a 1.4 and 2.2 time increase in C, N and P stocks for the depositional site, compared to the upslope position.

In conclusion, this meta-analysis indicates that carbon and nutrients are preferentially moved during soil erosion which might lead to loss in soil fertility and crop productivity after erosion events. However, similar C and nutrient contents along hillslopes indicate that elements are

replenished relatively fast in eroded soils after the occurrence of an erosion event. Increased soil stocks toward the depositional site can therefore be explained by increased soil depths in lower hillslope positions. Changes in soil depth, rather than changes in C and nutrient contents are therefore more likely to explain soil fertility losses in eroding slopes compared to depositional sites.