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Erosion-Induced Carbon Fluxes from Semiarid Rangelands: Implications of Vegetation Cover and Enrichment Dynamics for Carbon Inputs to Aquatic Systems

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Dryland ecosystems are a globally significant of the global carbon cycle. They cover ca. 40% of the land surface, and dominate both the long-term trend and interannual variability in the terrestrial carbon sink. Therefore, developing process-based understanding of carbon dynamics in drylands is essential for understanding terrestrial carbon dynamics globally. This study focuses on the amounts of organic carbon (OC) eroded from semiarid hillslopes. Dryland ecosystems are characteristically susceptible to change. One example of this is the encroachment of woody shrubs into former grasslands, substantially altering the structure and function of these landscapes. We established four, 30 x 10 m runoff plots across an ecotone from grass- to shrub dominated landscapes, which we monitored during natural rainstorm events over four monsoon seasons. The OC fluxes associated with the eroded sediment were analysed, yielding detailed information on the lateral efflux of OC from these hillslopes. Previous monitoring by our group has demonstrated that production of dissolved OC from these dryland soils is very low.

Erosion-induced effluxes of OC were found to systematically increase across the grass-shrub ecotone, resulting in six-fold increases in event-average OC fluxes. The increases were caused by to changes in both erosion rates (three and a half-fold increase) and OC enrichment (almost two-fold increase). Eroded sediments were enriched in OC by up to an order of magnitude, and OC enrichment was a persistent phenomenon. Systematic differences in OC enrichment between different plant functional types in unmanaged ecosystems have not been examined closely in previous work. Together, these findings suggest that (i) failing to consider OC enrichment risks substantially underestimating the input of OC to aquatic systems, and (ii) given the magnitude of systematic differences observed between different plant functional types, attempting to represent OC enrichment via a single, universally-applied coefficient may be overly simplistic.

OC enrichment was highly variable between events, and in the 37 storm ensemble analysed, there were no strong relationships between OC enrichment and individual metrics of event intensity or magnitude (total rainfall, peak 1-minute rainfall intensity, runoff coefficient, peak 1-minute runoff, total runoff, total sediment event-flux, integrated event sediment concentration). This suggests caution should be exercised when extrapolating process-understanding from small-scale laboratory experiments to complex natural ecosystems. We have integrated these new insights into the erosional dynamics of OC with our previous work employing stable isotopes and lipid biomarkers to provenance eroded OC, in order to develop new understanding of erosion-induced OC redistribution in shrub-encroached semi-arid ecosystems. This understanding is critical for understanding the delivery of OC to aquatic systems and thus availability for in-stream processing.