Vegetation Change and Water, Sediment and Carbon Dynamics in Semi-Arid Environments

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Abstract

This study develops understanding of vegetation change and water, sediment and carbon dynamics in semi-arid environments. Objectives were addressed using an integrated ecohydrological and biogeochemical approach. Fieldwork, over two contrasting grass-woody transitions at the Sevilleta National Wildlife Refuge, New Mexico, USA; quantified vegetation structure, soil structure and the spatial distribution of soil carbon resources. Over both transitions; woody sites showed a lower percentage vegetation cover and a greater heterogeneity in vegetation pattern, soil properties and soil carbon. Soil organic carbon differed in both quantity and source across the sites; with levels higher under vegetation, particularly at the woody sites. Biogeochemical analysis revealed soil organic carbon to be predominantly sourced from grass at the grassland sites. In contrast, at the woody sites soil organic carbon under vegetation patches was predominantly sourced from woody vegetation, whilst inter-patch areas exhibited a strong grass signature.

Investigation of function focussed on the hydrological response to intense rainfall events. Rainfall-runoff monitoring showed woody sites to exhibit greater; runoff coefficients, event discharge, eroded sediment and event carbon yields. In contrast to grass sites, biogeochemical analysis showed the loss of organic carbon from woody sites to exhibit a mixed source signal, reflecting the loss of carbon originating from both patch and interpatch areas. To examine the linkages between vegetation structure and hydrological function, a flow length metric was developed to quantify hydrological connectivity; with woody sites shown to have longer mean flow pathways. Furthermore, in addition to rainfall event characteristics, flow pathway lengths were shown to be a significant variable for explaining the variance within fluxes of water, sediment and carbon.

Results demonstrating increased event fluxes of sediment and carbon from woody sites have important implications for the quality of semi-arid landscapes and other degrading ecosystems globally. It is thus necessary to translate the understanding of carbon dynamics developed within this study to the landscape scale, so changing fluvial carbon fluxes can be incorporated into carbon budgets, research frameworks and land management strategies at policy-relevant scales.

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