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Historical Influence of Soil and Water Management on Carbon Erosion and Burial in the United States

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The documented history of U.S. soil and water management provides a unique opportunity to examine soil and sediment carbon storage under conditions of changing management practices. Historical acceleration of erosion due to cultivation has been moderated by improved soil management. Increased construction of dams and locks has expanded areas of aquatic sedimentation in reservoirs and ponds. Enhanced historical sediment deposition rates have been documented in lakes and estuaries. All of these changes have impacts on terrestrial carbon storage and turnover. The present-day carbon budget associated with erosion and burial cannot be determined without quantifying the time-dependent changes due to past and present soil and water management.

We use existing datasets with GIS and modeling techniques to estimate sediment and carbon budget trends since the year 1700 in the conterminous U.S. We begin by calculating historical sediment budget scenarios representing effects of soil- and water-management practices. Using estimates of historical cropland areas, distributions, and erosion yields, we calculate approximate "hindcast" erosion scenarios. We use systematic relationships among compiled sedimentation rates to estimate historical sedimentation for documented reservoirs, lakes, and ponds. Our analysis indicates that historical export of sediments to coastal areas is relatively insignificant, whereas substantial sediment deposition in upland areas is necessary to balance the historical sediment budget. Relatively recent rates of sedimentation in lakes and impoundments appear to match or exceed rates of upland erosion, suggesting that a fraction of recent sediment transport is derived from channel and bank erosion, including remobilization of historically deposited alluvium and colluvium.

For each historical sediment budget scenario, we apply models of carbon dynamics to time-dependent accounting of carbon in erosional and depositional environments. Our carbon calculations begin with estimates of the carbon content of soils at erosional and depositional sites. Rates of soil carbon production, erosion, degradation, transport, and burial are constrained by both sediment and carbon mass balances coupled to representations of landscape soil-carbon dynamics. We calculate rates of carbon burial in aquatic environments from estimates of composition and deposition rates of autochthonous and allochthonous sediment. We find that cumulative amounts of carbon affected by historical erosion and deposition are comparable to amounts of cumulative soil carbon depletion estimated in previous studies that have not considered erosion and deposition.

Our historical sediment budget scenarios imply a large historical transient of eroded and redeposited terrestrial sediments. An improved understanding of non-steady-state carbon dynamics in these sediments and in their incipient soils is needed to estimate the net effect of erosion and deposition on the historical and present-day exchange of carbon between the land and the atmosphere. The transient sediment pulse and accompanying biogeochemical and ecological responses have broad implications for management of water and ecosystems.