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Variability in geomorphic response to anthropogenic disturbance

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Humans have greatly impacted the processes and intensities of erosion, sediment transport and storage since the introduction of agriculture. However, the relation between the intensity of anthropogenic disturbance and the magnitude of change in sediment dynamics is highly non-linear due to the importance of intrinsic controls on sediment propagation. Especially the buffering capacity of slopes and floodplains can be held responsible for this non-linearity, as both sinks store the produced sediment temporarily, obscuring the relation between sediment production and sediment output. Slope-stream connectivity, but also the duration and typology of anthropogenic disturbance controls the existence of thresholds that need to be crossed before significant changes in downstream sediment dynamics are recorded following human impact. Many internal feedback mechanisms, such as those between erosion and soil thickness, further complicate the story. Several concepts have been developed over the last few decades to explain the complex behavior of sediment transfers in the combined hillslope-fluvial system, including the 'sediment cascade' model and the 'fast-in, slow-out' model. However, none of these concepts seems to hold universally when reconstructing historical sediment dynamics for contrasting environments, as is illustrated with case-studies from a range of environments in Belgium, Turkey and the USA. Detailed field-based sediment budgets from these contrasting settings combined with spatial modeling of sediment fluxes covering time periods ranging from 200 to over 5000 years, as well as the use of pollen and sediment provenancing techniques, shows that no overarching concept of sediment source-to-sink following anthropogenic disturbance can be established. Rather, depending on the duration and typology of anthropogenic disturbances, in combination with local environmental conditions, unique patterns of geomorphic process response emerge. As a result, unraveling the human impact from current-day sediment archives and predicting the impact of future human disturbances on river and sediment behavior remains a major challenge. This has important implications for interpreting contemporary sediment yields as well as downstream sediment records in large floodplains, delta's and the marine environment, in terms of changes in the drivers of environmental change.