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Tipping points in Anthropocene fluvial dynamics

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Many rivers have undergone dramatic changes over the last millennia due to anthropogenic on- and offsite impacts. These changes have important implications for the geomorphic and hydrological functioning of the river. In this study we compare the influence of large-scaled off-site anthropogenic impact on three European river systems. We do this using traditional geomorphological methods, combined with palynological and archaeological data; for each catchment a Holocene sediment budget was constructed.

The Dijle catchment is located in the central Belgian loess belt, and has undergone intense agriculture for at least the last 2000 year. Pre-Anthropocene floodplain are big marshes lacking a well-established river channel. Anthropogenic deforestation in the headwaters resulted in a sediment pulse from the Bronze Age on. In the main floodplain sediments gradually covered the peat layer, starting near a newly formed river channel and expanding over time towards the floodplain edges. In contrast, this transition is abrupt in the smaller tributary floodplains. Comparison with palynological data shows that this abrupt transition occurs when human impact reaches a certain threshold.

The Valdaine region is located in the French Pre-Alps. Floodplain deposition increased over time since the Neolithic time period due to human induced and fire related soil erosion. This general aggradation trend is however interrupted by three major river incision phases which are caused by human land abandonment and dry periods. A second major change in floodplain geomorphology occurs during the High Roman Period and the last 800 year: the fine-grained meandering river changes to a gravel loaded braided river. During this period the upstream mountain reaches became a major sediment source due to deforestation, possibly combined with climate change. During the last century reforestation and land abandonment has led to a new incision phases, and floodplain are now a major source of gravel while the river partially maintains its braided pattern.

The Amblève River in the Belgian Ardennes uplands underwent less dramatic changes. Large parts of the catchment are deforested during the last 700 years, leading to an increase in floodplain sedimentation. Despite this major sediment pulse, change in floodplain morphology remained limited to an increase in bank height. We argue that a combination of floodplain and channel morphology, the fine texture of supplied sediment and the high stream power of channel forming events result is a system that is less sensitive to change. Also the relative short time of impact may play a role.

These three examples demonstrate the varying impact of human deforestation on floodplain geomorphology. For the Dijle and Valdaine region this lead to dramatic changes once a certain tipping point is reached. In contrast the Amblève river is more resilient to human impact due to its specific morphological setting. The morphology of the catchments and the nature of supplied sediments plays a major role in the sensitivity of fluvial systems to environmental impact. Once the tipping points are reached, it is difficult for the river to revert to its original state and floodplains remain highly impacted.