Geophysical Research Abstracts
Vol. 13, EGU2011-5569, 2011
EGU General Assembly 2011

Processes and timing of sediment delivery from headwaters to trunk streams in Central Europe

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Previous studies of Holocene stream development in Central Europe have described silty overbank deposits as being the result of climate driven increased fluvial activity resulting in a higher number of floods. These extend from the Early Holocene, Subboreal (5660-2400 BP) (Becker and Schirmer 1977), and from the Medieval Ages when floodplain loams begin their latest deposition. High sediment delivery from unstable deforested and harvested slopes and the clearing of riparian vegetation have been given as a possible mechanisms. (Becker and Schirmer 1977; Lang, Bork et al. 2003; Szmanda, Oczkowski et al. 2004; Rommens, Verstraeten et al. 2006; Hoffmann, Lang et al. 2008), however the timing, source, and cause of these deposits still remain largely speculative. In order to address this problem, we followed sediment storage areas from a typical gully system in the Central European headwaters to the next trunkstream, the Elsava River, which then flows into the Main River.
On the basis of detailed field and chronological investigations we suggest that climate and human influences on catchment erosion processes can be confidently separated from each other, although this can be complicated through internal thresholds within the gully system. We find that gully incision occurred in four phases: 1.Younger Dryas – Early Holocene Transition (12,910-10,230 BP), 2. Early Holocene – mid Holocene (several phases between 10,661 – 5210 BP), 3. –Subatlantic period (2050 – 1730 BP) and 4. Human Migration Period (599 – 679 AD), despite the area remaining forested throughout this time, except for the Younger Dryas (phase 1). these phases are most likely due to climatic driven knickpoint retreat within the gully talweg, with most of the sediment being deposited immediately downstream within a cascade sediment system, and no evidence for slope contribution. We find slope instability in this catchment begins $\sim$900 AD and intensifies from $\sim$1100 AD until 1850 AD.
Additionally, we find only two major phases of sediment delivery from the catchment to the trunk stream: 1. Early Holocene (ca. 9300 – 7100 BP), and $\sim$600 BP. We attribute this first phase of gully-stream connectivity to climate driven gully initiation. The second phase of connectivity is more complicated, and displays colluvial fan deposits inter-fingering with the only floodplain loam deposits in this catchment, suggesting the two are coeval in development. We suggest this phase is related to threshold conditions within the gully, with an increase in long profile slope caused by human driven slope instability eventually triggering gully re-incision and stream sediment connectivity distinct from all previous phases. This phase of gully incision has been relatively minor, however sediment delivery to the fan has been comparatively large, which we attribute to lower magnitude events acting upon lower calibre silty sediments. We suggest that gully incision and deposition in these central European catchments was largely driven by high magnitude, low frequency storm events, from the Early Holocene until intensive human occupation lead to widespread slope instability. Since this time, the new finer material available to gully systems, and eventually to river floodplains, has been eroded by comparatively smaller events at times and rates dependent on catchment threshold conditions such as slope and drainage area.

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