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Evidence and modelling biomass selection by floods in a riverbed

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Riparian and in-bed vegetation growth and erosion dynamics are strongly coupled with river hydrologic and morphodynamic processes. Many field observations documented the engineering role of vegetation and its contribution to build, stabilize and control erosion and deposition on gravel bars. Yet unclear, is how do the interplay between the hydraulic time scale (arrival time of flood disturbances) and the vegetation germination and growth rates determines the statistical distribution of the surviving vegetation and of that being removed by flooding events. Soon after germination on exposed gravel bars, young vegetation can be removed by even moderate floods without substantial channel reworking, root anchoring being almost negligible at this stage of growth. Hence, understanding survival and uprooting dynamics of early germinated seedlings or rejuvinated woody debris is key to unravel their role in the future evolution of alluvial forms.

In this paper, we provide experimental evidence and a model on how the statistics of young biomass uprooted by flow depend on stream power and on the above- and below-ground characteristics of the biomass growing in the alluvial sediment. Particularly, we present results of recent laboratory experiments where periodic flow disturbances of constant magnitude have been run on sand flumes with vegetation growing in situ at a rate that is comparable to the interarrival time of disturbances. This allows to access the regime of competition between vegetation development and flood disturbances. While non-eroded plants continue to grow in the successive runs, flow erosion acts preferentially on plants that have a weaker root system. Eventually, the statistic of the uprooted biomass turns out to be time independent, leading to suppose the existence of a biomass selection mechanism operated by floods in alluvial floodplains. We then propose a simple time and state dependent stochastic model to quantitatively explain this conjecture. Eventually, our minimalist model can be solved analytically, and to a certain extent it helps shedding light on which components of the hydrologic and vegetation processes and related time scales control the erosion mechanism of early germinated vegetation.