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Mechanisms of vegetation removal by floods on bars of a heavily managed gravel bed river (The Isere River, France)

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In natural alpine gravel bed rivers, floods and their associated bedload transport maintain channels active and free of mature woody vegetation. In managed rivers, where flood regime and sediment supply have been modified by hydroelectric infrastructures and sediment mining, river beds tend to stabilize. As a result, in the recent past, mature vegetation has established on gravel bars of many gravel bed rivers worldwide. This established vegetation increases the risk of flooding by decreasing flow velocity and increasing water levels. In addition, the associated reduction in availability of pioneer habitats characteristic of these environments typically degrades biodiversity. Managing hydrology in a way that would limit vegetation establishment on bars presents an interesting management option. In this context, our study aims at understanding the impacts of floods of varying magnitude on vegetation removal, and identifying and quantifying the underlying mechanisms. Our study site is the Isère River, a heavily managed gravel bed river flowing in the western part of the French Alps.

We studied the impact of floods on sediment transport and vegetation survival at the bar scale through field monitoring from 2014 to 2015, focusing on young salicaceous vegetation (<2 yr old). Measurements were made before and after floods. Vegetation was monitored on 16m^2 plots through repeat photographs. Sediment transport was assessed using painted plots, scour chains, and topographic surveys. Hourly water discharge was obtained from the national gauging network. The hydraulics of monitored floods was characterized using a combination of field measurements and 2D hydraulic modeling: water levels were measured with pressure sensors and Large Scale Particle Velocimetry was used to measure flow velocities. These data were used to calibrate 2D hydrodynamic model using TELEMAC2D. At the reach scale, removal of mature vegetation was assed using a series of historical aerial photographs between 2001 and 2015.

Our monitoring period covered a series of floods with recurrence intervals of 2 to 4 times per year, as well as one large flood with a 10 year return period. Only the largest flood, which triggered important bed mobility, partially removed vegetation from bars. Young vegetation removal occurred through four different mechanisms: 1) burial under a thick layer of coarse sediments (> 30cm), 2) uprooting by surface scour, 3) uprooting by a combination of surface scour and sediment deposition resulting in no net topographic change, and 4) lateral erosion of the margins of main and secondary channels. Hydraulic modeling in progress will allow us to determine shear stress and durations associated with each of the four mechanisms of vegetation removal. As for mature vegetation removal at the reach scale, preliminary results indicate that lateral erosion is by far most efficient, in years marked by important floods (return period of at least 2 years).

In summary, our study thus far highlights that vegetation removal by floods from bars of the Isere River only occurs when there is important bed mobility, which in this system requires floods with a return period higher than 2 years.