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Morphodynamic effects of vegetation and large wood in braided rivers

Hydrolink

MORPHODYNAMIC EFFECTS OF VEGETATION AND LARGE WOOD IN BRAIDED RIVERS

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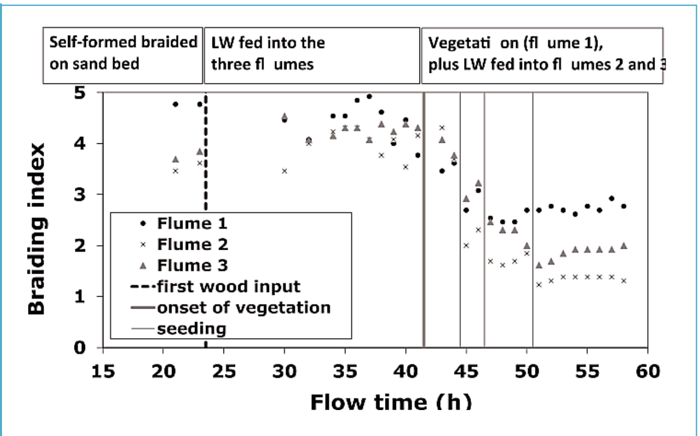
Riparian vegetation plays a crucial role in shaping rivers, acting as an ecological engineer that can increase roughness, stabilize banks, and reduce the number of anabranches in braided rivers (Gurnell, 2014). The geomorphic impact of living plants continues even after their erosion from the banks and transportation through the fluvial network.

Dead or living pieces of large wood can influence river erosion and sedimentation processes, channel morphology, hydraulics, and ecology. Both standing vegetation and large wood elements (LW) contribute to shaping braided river systems with islands, which represent the greatest level of ecosystem integrity in some fluvial systems. Generally, living vegetation acts to reduce channel width and braiding index (i.e. the number of channels per cross-section), whilst LW acts in the opposite way increasing the latter through pioneer islands. However, it is difficult to discriminate the relative importance of these two effects in the field, as they act together. Despite some flume studies on the effects of riparian vegetation on the planform of gravel-bed rivers (i.e. Tal & Paola, 2010), and preliminary attempts to simulate LW dynamics in a flume with mobile bed sediments (Welber et al., 2013), no experimental evidence exists on the integration of these two processes on braided rivers. The series of flume experiments presented here are thus the first reported attempt to elucidate the relative effects of riparian vegetation and LW on the planform configuration and dynamics of braided river systems.

Figure 1 - Reach-averaged braiding index during the different run configurations



Material and methods

Experiments were carried out in the Total Environment Simulator (6 m-wide, 11 m-long flume) at the University of Hull (UK). Three 1.7 m-wide flume channels were constructed inside the facility, and were filled with uniform size sand (d50 0.72 mm). A constant discharge and sand feed rate were imposed upstream, allowing a self-formed braided network to develop to a quasi-steady-state in terms of its morphological pattern and sediment fluxes. Then, cylindrical wooden dowels, representing logs, were fed into the three flume channels at different rates (see Bertoldi et al., 2014 for further details on the scaling approach). Subsequently, the logs were removed and alfalfa (Medicago sativa) was seeded in the

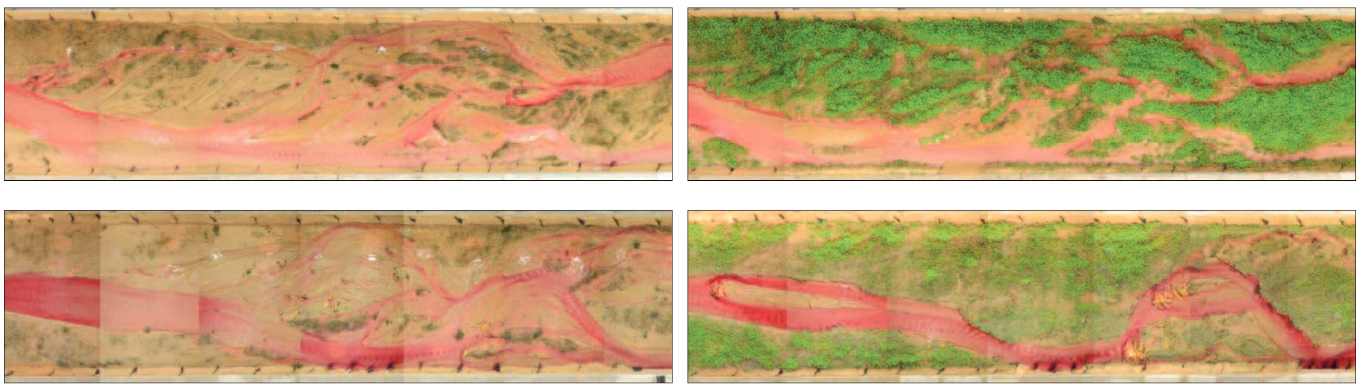


Figure 2 - Vertical photos of two flume channels with self-formed braided pattern taken a few days after the alfalfa seeding (on the left), and towards the end of the experiments (on the right). Photos refer to the flume channel where only alfalfa was seeded but no logs were fed into the system (above), and to the flume channel where logs were also fed at a rate of 120 logs h-1. Flow is from left to right.

three flume channels after the steady-state braided pattern was restored. The growth of the alfalfa seeds was assisted by continuous artificial illumination, and by maintaining a baseflow discharge that was below the threshold for sand transport. A higher flow rate, capable of reworking the braided morphology, was imposed after a week of plant growth. In two flume channels, LW was also fed into the channels, whereas the third channel was left to evolve under the sole influence of vegetation. Following this protocol, experiments were continued for four weeks. High-resolution vertical images covering the entire length of the flume channels were used to measure the reach-averaged braiding index.

Some interesting outcomes

The temporal evolution of braiding index in the flume channels was measured before and during LW dispersal simulations, and then during runs with vegetation growing on proto braidplains. The braiding index of the self-formed morphology without logs and vegetation ranges between 3.5 and 5, which is comparable with previous published experimental results. Interestingly, no statistically significant difference was observed in the index between pre- and post-wood input (Figure 1). This shows that wood alone, when free to move and deposit on a self-formed braided topography, does not significantly affect bed morphology at the reach scale, as assessed in terms of braiding index (see also Bertoldi et al., 2014). After alfalfa established in the flume channel without logs, the braiding index rapidly decreased from ~4.5 to ~2.5. Surprisingly, the braiding index tended to reduce even further in the channels with vegetation and LW, causing a shift towards an almost single-thread morphology (Figure 2). When vegetation and LW exerted their geomorphic role together, the percentage of wood deposited as single elements reduced from 45% to 25%, and jams tended to become larger and much more stable. Under these circumstances, wood remobilization decreased dramatically to $< 5\%$, and newly introduced logs were more likely to jam on already existing accumulations. Large jams formed under high wood input rate (see Figure 2) were particularly stable, and tended to deflect the flow, as commonly observed in single-thread rivers.

Final remarks and future works

These preliminary experiments are the first attempt to simulate the simultaneous effects of vegetation and large wood in braided river systems. Results show that neither wood storage volume nor wood input rate seems to affect braided channel morphology as expressed by the braiding index. This is likely because, for the initial conditions imposed on these experiments, it is the anabranch dynamics that controls wood storage and remobilization rather than the opposite. Also, when acting alone, vegetation rapidly reduces the braiding index, and forces flow into narrower and deeper channels. The addition of logs in vegetated braided rivers forces the formation of fewer but larger jams, which leads to the scour of deeper channels, eventually reducing the braiding index further. Large jams and vegetation also limit the lateral mobility of anabranch channels. Even if the flume is not a precise scaled model of a prototype fluvial system and inert wooden dowels cannot replicate biological activity (i.e. they do not grow, decay or resprout as most riparian plants), the present set of runs is the first successful attempt to simulate vegetation and large wood together in a flume. The results are very promising since they shed light on processes that cannot be fully observed in the field, due to the long time scales they act over. In addition, despite the simplicity of the experiments, the complex morphology that is typical of island-braided rivers appears to have been effectively reproduced (Figure 3).

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Figure 3 - Pieces of large wood stranded on a bar next to a big island in the flume (on the left) and on the Tagliamento River, in Italy (on the right). Flow is from left to right

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