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Analysis of the impact of biomechanical traits of European black Poplar on riverbank flow resistance

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Predicting the effects of riparian plants on river flow dynamics is fundamental for an appropriate river management. Riparian woody vegetation enhances bank cohesion and provides ecosystem services by mitigating nutrient and sediment loads to the river flow and enhancing biodiversity.

However riparian trees also contribute to river flow resistance and thus can have a significant impact on flow dynamics during flood events. The flow-plant interaction mainly depends on plant morphological characters (e.g. diameter, height, canopy size, foliage density) and biomechanical properties, such as its flexural rigidity. This study aims at testing the hypothesis that the hydrodynamic behaviour of the European black Poplar (\textit{Populus nigra} L.), a common woody riparian plant, is influenced by specific biomechanical traits developed as result of its adaptation to different river ecosystems. We examine the morphological and biomechanical properties of living stems of black Poplar sampled in two different riverine environments in Southern Italy located only a few kilometres apart. The two sample sets of living stems exhibit similar morphological traits but significantly different Young module of elasticity. We compared the drag forces that the flow would exert on these two different sets of plants for a wide range of flow velocities, by employing a numerical model that accounts for the bending behaviour of the woody plant due to the hydrodynamic load, under the hypothesis of complete submergence. A Monte Carlo approach was applied in order to account for the stochastic variability of the morphological and mechanical parameters affecting plant biomechanical behaviour. We identified a threshold value of the plant diameter, above which the two sets of European black Poplars are subjected to drag forces that differ by more than 25{\%} on average, for flow velocities larger than 1 m/s.