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Exploring the potential of the Graph Theory to large wood supply and transfer in river networks

Bryce Finch and Virginia Ruiz-Villanueva
University of Lausanne, Faculty of Geosciences and Environment, RivES, Switzerland (bryce.finch@unil.ch)

Large wood (LW) has earned increased attention as a component of fluvial systems as its ecological and physical benefits, as well as its contributions to damages during flood events, have been realized. As LW found in river networks had originated from outside of the channel corridor, significant efforts have been made to identify recruitment processes that supply LW to channels. Evidence has proved treefall, landslides, bank erosion, debris flows, and fluvial entrainment contribute to LW recruitment. Prediction and identification of the areas prone to these processes are very challenging but could serve to better understand wood dynamics. Therefore, identifying areas prone to recruitment processes, estimating available LW, and determining LW connections in a watershed will help design management strategies aimed at mitigating LW's impacts as well as provide insight on the movement and recruitment of LW in fluvial systems. Analogous challenges exist when dealing with sediment dynamics.

We applied the graph theory (GT) to instream LW supply and transfer. A GT is a set of nodes representing different entities (i.e., wood sources) with edges connecting nodes based on determined relationships (i.e., wood recruitment processes). The GT proves useful in exploring landscape connectivity with the capability of identifying critical nodes or regions, measuring properties of connectivity, identifying process coupling based on spatial patterns, and defining related geomorphological processes such as that of sediment cascades in which landscape components are coupled based on properties effecting sediment transfer.

GT proves capable of defining connections between LW recruitment from hillslopes to the channel and from channel segment to channel segment. Currently, the fuzzy logic toolbox presented by Ruiz-Villanueva and Stoffel (2018) has been utilized to delineate the connected, recruitment process prone areas for landslides, debris flows, and bank erosion in the study area of Vallon de Nant, Canton of Vaud, Switzerland. The delineated areas have been used in ArcPro in coalition with vegetation data to extract hillslope-to-channel connections and channel-to-channel connections. The channel or fluvial network has been segmented based on the presence of features which reduce downstream transfer of LW such as channel widening and presence of obstructions. The determined connections will be applied in the R package, igraph, to extract network properties of the constructed, instream LW GT model.

GT aids complex network analyses by providing a technique which retains only the critical information. Therefore, following the rigorous work of determining the system components,

connections, and constructing the graph model, additional analysis can be performed with streamlined performance. Through our graph representation of instream LW supply and transfer, we plan to use the mathematical framework and algorithms from graph theory to further our understanding of instream LW such as the likely origins based on cost analysis.

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Ruiz-Villanueva, V., Stoffel, M. (2018). Application of fuzzy logic to large organic matter recruitment in forested river basins. Proceedings of the 5th IAHR Europe Congress New Challenges in Hydraulic Research and Engineering, 467-468. doi:10.3850/978-981-11-2731-1_047-cd