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Drivers of channel morphology in semi-alluvial boulder-bed streams & implications for river restoration

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Research to understand the drivers of river form and processes has focussed on alluvial sand and gravel-bed channels. However, boulder-bed rivers are also an abundant channel type, particularly in previously glaciated and mountainous regions. Understanding boulder distribution in rivers is important because of their effects on channel hydraulics and sediment transport processes. Boulder-bed channels in low-relief, previously glaciated landscapes may be considered semi-alluvial since the boulders likely were not deposited by fluvial processes (unlike in e.g., step-pool mountain channels). However, the relative importance of glacial legacy sediment and fluvial processes as drivers of boulder-bed river morphology is poorly understood. This is especially true in northern Sweden where channel clearance for timber floating has resulted in the removal of boulders from most rivers. Restoration of these rivers involves the replacement of boulders but is challenged by a lack of geomorphological understanding.

This study aimed to quantify the morphological characteristics of northern Swedish boulder-bed streams and determine the association between fluvial and glacial legacy controls on these channels. We undertook a large-scale field campaign surveying 20 rivers (drainage area: 15 - 112 km^2) that have not been cleared for timber floating. At each reach, we measured channel morphology using a total station over approximately 100 m river length, surveying the channel planform, thalweg and 5 cross sections. In addition, we measured the location, diameter and protrusion of every boulder (> D_{84}) within each reach. We also conducted a survey of the size and density of boulders on the floodplain to compare to in-channel boulder distributions. We coupled this field campaign with analysis of digital elevation models, surficial geology, glacial landform maps, and hydrological data to investigate potential landscape controls on reach-scale geomorphology. Associations between drainage area, channel slope, width and D_{84} as well as longitudinal clustering of boulders into fluvial bed-forms would indicate fluvial rather than legacy glacial drivers.

Preliminary results show high variability in the morphology of reference sites, from low-gradient reaches with high floodplain connectivity to steep and narrow channels (Slope ranged 1.1 - 8.8%). D_{84} ranged from 0.4 m to 2.1 m with some sites having as many as 500 large boulders (> 1 m diameter) in a 100 m reach. D_{84} was not associated with channel slope and boulders were not clustered longitudinally in most reaches. This suggests that boulder spacing is the result of glacial legacy controls. These results are important for understanding geomorphic processes in boulder-

bed channels and how channel form relates to reach- and landscape-scale controls. The relative importance of fluvial versus glacial legacy controls on boulder-bed channel morphology is also important to help restoration practitioners more accurately identify reference states of boulder-bed channels in previously glaciated landscapes.