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Explaining linkages (and lack of) between riparian vegetation biodiversity and geomorphic complexity in restored streams of northern Sweden

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Ecological theory suggests that species richness and habitat heterogeneity are positively correlated; therefore stream restoration often relies on increasing geomorphic complexity to promote biodiversity. However, past studies have failed to demonstrate a link between post-restoration biodiversity and geomorphic complexity. These studies have usually relied on only one metric for quantifying complexity, rather than a holistic metric for complexity that represents several aspects of the channel morphology, and have based their observations in catchments with widespread land-use impacts. We use a geomorphic complexity gradient based on five geomorphic aspects (longitudinal, cross-sectional, planform, sediment texture, and instream wood) to determine whether streams with higher levels of complexity also have greater riparian vegetation biodiversity. We also compare biodiversity values with the potential complexity of reaches based on the large-scale controls of valley and channel gradient and the presence of large glacial legacy sediment (boulders). We focus on tributary channels in boreal forests of northern Sweden, where stream modification associated with log-floating from the 1850s to the 1960s created highly simplified channels. Driven by concerns for fish, restoration began in the 1970s by returning large cobbles and boulders into the main channel from the channel edge, and evolved into 'demonstration restoration,' placing very large boulders and trees into the channel, reopening side channels, and constructing fish spawning areas.

We evaluate 22 reaches along tributaries of the Vindel River in northern Sweden with four restoration statuses: channelized, restored, demonstration restored, and unimpacted. Detailed morphologic, sediment, and instream wood data allow calculation of 29 metrics of geomorphic complexity, from which a complexity gradient was identified using multivariate statistics. The percent cover of riparian vegetation was identified in 0.5 x 0.5 m plots at three elevations above the low water stage (0, 40, and 80 cm) along five transects; additionally, we determined which species were present within the entire riparian zone (60 m long reach, up to 80 cm elevation). Three metrics of biodiversity were calculated on the plot level (richness, Shannon's diversity index, and evenness); only richness could be examined at the reach scale. There are significant relationships between riparian vegetation biodiversity and the overall complexity gradient at the medium elevation and, based on some metrics, at the low elevation. However, these relationships are not fully explanatory or always linear, explaining up to $\sim$40% of the variability and often being logarithmic. We conclude that reach-scale restoration of increasing complexity in a catchment without significant land-use impacts can have positive effects on biodiversity. However, there are several limiting factors in addition to channel complexity that affect the recovery of riparian zones after restoration: the potential complexity of a reach based on large-scale controls, time since restoration—which is a disturbance in itself, buffer distance to timber harvesting, distance and connectivity to colonist sources, and upland species (e.g., spruce trees) that have managed to colonize when the riparian zone was separated from the channel.