Predicting geomorphic stability in low-order streams of the western Lake Superior basin

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To be delivered as a platform presentation/talk at the 98th Annual Meeting of the Ecological Society of America, Minneapolis, MN, August 4 – 9, 2013

Abstract:
Width:depth ratios, entrenchment ratios, gradients, and median substrate particle sizes (D50s) were measured in 32 second and third order stream reaches in the western Lake Superior basin, and stream reaches were assigned a Rosgen geomorphic classification. Over 700 measurements of suspended sediment concentration (SS) during snowmelt, baseflow, and precipitation events were taken in these reaches during 1997 through 1999. In-stream and riparian habitat quality were assessed along with land use and land cover in each stream's watershed. To evaluate channel stability, stream reaches were revisited in 2010 and 2011 and geomorphic assessments were repeated. Streams that more than doubled in width:depth ratio and/or moved to a new geomorphic classification since the time of the original measurements were considered unstable, all others were classified as stable. The effects of stability on SS outputs were analyzed via linear regression. Probit regression was used to determine if stability after 12 to 14 years could be predicted from morphological, SS, habitat, and land use/cover data collected at the beginning of the study.

For the more entrenched, gravel-substrate streams, SS outputs could be predicted by stability classification, discharge, and the density of roads in the watershed ($r^2 = 0.71$). Stability after 12 to 14 years could be predicted by the streams initial SS outputs, degree of shrub cover in the riparian zone, and quantity of woody debris in the streambed (Chi-Sq $p < 0.001$). In the less entrenched gravel bottom streams SS could be predicted by considering stability, discharge, fractions of sand in the streams' substrate, riparian shrub cover, and woody debris counts ($r^2 = 0.43$). Variables affecting longer-term stability included SS concentrations and riparian shrub cover (Chi-Sq $p < 0.001$). In streams with D50s of sand and lower width:depth ratios at the beginning of the study, SS exports were correlated with stability, discharge, the agricultural and road densities within the watershed, by fractions of the streams' banks visibly eroding, and by quantities of in-stream woody debris ($r^2 = 0.56$). SS outputs and woody debris counts proved valid predictors of longer-term stabilty (Chi-Sq $p <0.001$). This research indicates that SS concentrations and the availability of wood in the stream and riparian zone may be useful predictors of longer-term geomorphic stability.