Estimating embeddedness from bankfull shear velocity in gravel streambeds to assess sediment impacts on aquatic habitat and biota

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Extended Abstract

Excess fine sediment (<2 mm) deposition on gravel streambeds can degrade habitat quality for stream biota. Stream ecologists commonly measure fine sediment via a metric called embeddedness, a measure of the extent to which coarse particles are surrounded by, or embedded into, a finer substrate. Average embeddedness of a stream reach is physically measured to assess habitat quality and there are no widely used methods to estimate or predict embeddedness from remotely sensed data. Our preliminary results show that we can predict embeddedness in the Dan and Roanoke River Basins in Virginia and North Carolina from bankfull shear velocity, which can be calculated using stream geometry characteristics measured in the field or acquired through remote sensing (Czuba et al., 2022). Shear velocity can be calculated from slope and depth. From the National Hydrography Database, slope and drainage area are available and bankfull depth can be calculated from drainage area via regional curves. Shear velocity at bankfull stage determines how fine sediment mobilized in the bed will be suspended in the water column. As average reach shear velocity (u_*, *m/s*) increases, sand is increasingly transported higher in the water column, decreasing sand presence in the bed and thus percent embeddedness (*emb, %*). This relationship can be characterized by: $emb = a\,(u_*)^{-b}$, where a and b are empirical coefficients. For the generalized relationship, a = 10 and b = 1. Under bankfull shear velocities of approximately 0.1 m/s, the bed shifts from gravel to sand, which is equated to 100% embedded (Lamb & Venditti 2016).

We are conducting ongoing investigations on the relationship between bankfull shear velocity and embeddedness at several scales. The United States Environmental Protection Agency (USEPA) has publicly available data from National River and Stream Assessment (NRSA) surveys which include channel geometry and embeddedness measurements and fish and macroinvertebrate metrics. This allows us to test the relationship between shear velocity and embeddedness on a national scale as well as assess which fish and macroinvertebrate metrics are correlated with embeddedness. The shear velocity calculated from bankfull depth and slope is plotted with measured embeddedness for selected states in Figure 1. In regards to biota, in selected regions, intolerant fish taxa decrease with increasing embeddedness ($R^2 = 0.42$) as do percent EPT (Ephemeroptera, Plecoptera, and Trichoptera) macroinvertebrate individuals ($R^2 = 0.38$). On a watershed scale, we are repeating measurements of embeddedness in the upper Roanoke basin in southwest Virginia, as well as at several cross sections in a well-instrumented reach of Stroubles Creek near Virginia Tech. This allows us to explore how embeddedness changes over time in response to changing hydrologic conditions and to what extent our predictive relationship holds. Where this predictive relationship does hold, we are able to make predictions of embeddedness throughout an entire river network. These predictions may lead to more robust assessments of aquatic habitat and biota.

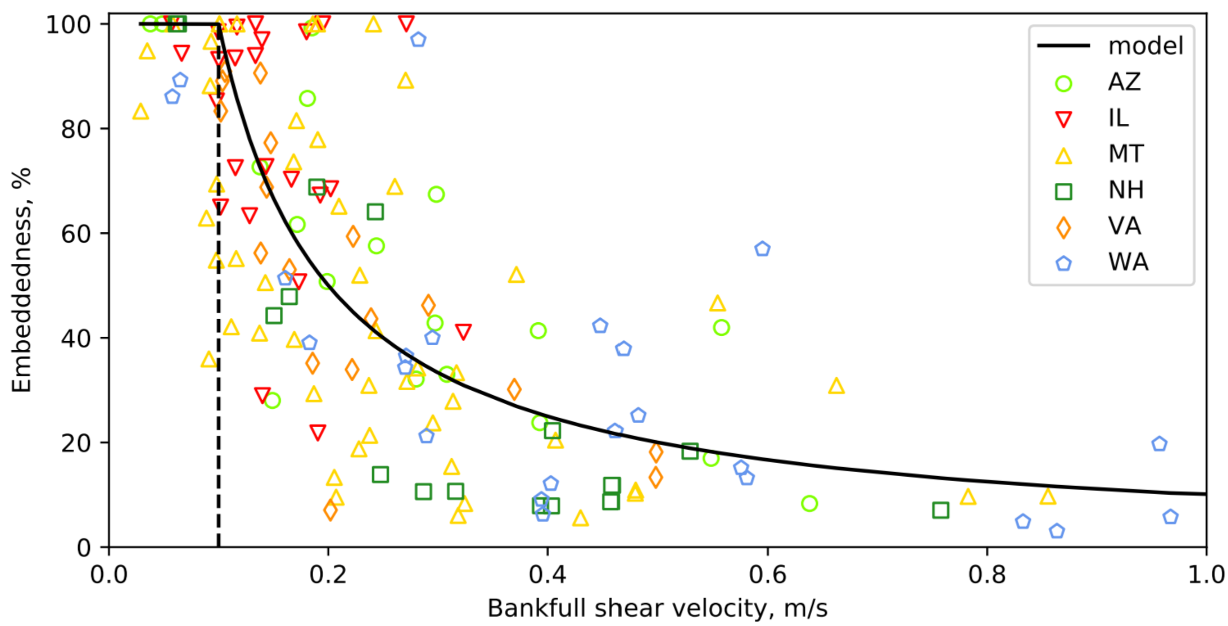

Figure 1: Measured embeddedness at 2018-19 EPA NRSA sites and calculated reach shear velocity with slope and bankfull depth following modeled relationship

References

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