Variation of bedload rating and flow competence curves with stream and bed material parameters

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Abstract. Knowledge of bedload transport capacity (amount) and flow competence (largest bedload size) is needed when assessing how changes in water and sediment supply may affect the bedload transport regime, channel morphology and bed stability.

Bedload transport was measured using bedload traps in five steep (1-9%), forested, snowmelt regime slightly incised mountain streams having coarse gravel- and cobble-beds and basin area sizes of up to 60 km$^2$. Power function regressions were fitted to the relationships of gravel bedload transport rates and discharge (bedload rating curve) and to the largest bedload particle size and discharge (flow competence curve). The exponents and coefficients of the bedload rating and flow competence equations were compared to parameters describing stream size (basin area, bankfull width and flow) and the stream bed material (surface and subsurface $D_{50}$ sizes, surface sorting, armoring (surface $D_{50}$/subsurface $D_{50}$), and bed mobility (bedload $D_{max}$ at bankfull/surface $D_{50}$).

Strong positive relationships ($r^2 > 0.60$; many $> 0.90$) were found for exponents of the rating and flow competence curves with basin area size, bankfull flow and bankfull width and strong negative relationships with armoring. Because exponents and coefficients are inversely proportional, coefficients of the rating and flow competence equations had strong negative relationships with basin area size, bankfull flow, bankfull width and bed mobility, and strong positive relationships with armoring. By contrast, bedload samples from the Helley-Smith sampler collected at the same five streams showed strong positive relationships between rating curve exponents and the surface and subsurface $D_{50}$ size. Rating curve coefficients were strongly related to surface sorting, and flow competence coefficients to bed mobility.

These findings suggest that for small, forested, coarse-bedded, and incised mountain streams with snowmelt regimes, bedload rating and flow competence curves are predictable from stream size and bed material parameters. Comparison between results of this study, and with results found by others suggest that relationships vary depending on the bedload sampler used and on whether sand and pea gravel is included in the analysis. The relationships described above may not hold for larger, or non-mountain streams.

More fieldwork is needed to increase the data base of the study and to extend results to larger streams. Multivariate analysis, particularly multiple regression analysis, should prove useful in further evaluations.