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Spatial and temporal variation of erosion processes in an Alpine catchment

C. Gwerder (1,2), D. Schnydrig (3), A. Badoux (2), B.W. McArdell (2), P. Molnar (1), and F. Schlunegger (3)

(1) Swiss Federal Institute of Technology ETH, Zürich, Switzerland, (2) Swiss Federal Research Institute WSL, Birmensdorf, Switzerland, (3) University of Berne, Berne, Switzerland (corina@student.ethz.ch / Fax: +41 44-7392488 / Phone: +41 44-7392480)

The temporal and spatial variations of sediment erosion in a steep Swiss Alpine catchment (9.5 km^2) was analyzed using the concepts of landscape connectivity and geomorphic coupling. The catchment was divided into directly coupled (connected to a major gully in the drainage network) or decoupled systems (which are not directly connected via gullies). The decoupled system (71% of the entire catchment area) was further divided into subsystems of forest (42% of the entire catchment area), grassland (14%), and decoupled erosion (15%). The decoupled erosion subsystem is characterized by slopes of unconsolidated sediment material with only little vegetative cover and lacking major gullies.

Sediment transport rates in the decoupled system were determined using 11 silt fence sediment traps distributed throughout the subsystems. Measured transport rates, extrapolated to the area occupied by each subsystem in the decoupled areas, are generally quite low (2.9*106 kg/year) and suggest that these areas are relatively inactive in comparison with the coupled system. The study period was relatively short (summer 2006), so it is possible that the action of large geomorphically-effective rainstorms is not reflected in measured transport rates and that the sediment measured was mainly transported as dry ravel.

The sediment transport rate in the coupled system is dominated by debris flows and was determined at the basin outlet using a basal force plate (8 m^2) and other instrumentation, where the volume of material is estimated using the calculated bulk density of debris flows and the front velocity integrated over the channel cross-sectional area

and the hydrograph. The sediment export rate from the system calculated in this manner is 390*106 kg/year, and is comparable to values measured in the previous two years.

A comparison of the sediment transport rates, neglecting any progressive storage or systematic erosion within the coupled system, shows that the coupled system transports three orders of magnitude more sediment than the uncoupled system. Petrographic analyses indicate that approximately 60% of the debris flow material is derived from mainly coupled high-elevation talus slopes (degraded permafrost?) on the southern side of the catchment.

Analyses of ortho-photographs from 1959, 1999 and 2004 show almost no change in the area occupied by the coupled or decoupled systems. Within the decoupled system we observed some afforestation on grassland areas (change from 26% to 14% of the total catchment area from 1959 to 1999) which is probably related to the abandonment of grazing activities due to frequent debris flow events across the access trail.

The rate of conversion of decoupled to coupled areas could be expected to be relatively large in such an active catchment, so the lack of any evidence of systematic change over 45 years is surprising. Explanations include the presence of a very large talus slope on the southern catchment wall that could provide the roughly 10 cm/year expected vertical erosion rates. We conclude that the concepts of landscape connectivity and coupling are useful for interpreting sediment transfer processes in steep Alpine catchments.