Empirical Predictions of Large Wood Transport in Mountain Catchments

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INTRODUCTION

An important element responsible for the damaging effect of floods in mountain streams is the presence of instream wood or large wood (LW). The mobilization and transport of LW pieces is problematic for various reasons including the increase of flow resistance in channels leading to slower flood flows and higher inundation probability. Also, LW laden flows regularly lead to the clogging of bridges or other structures, and to the increase of sediment deposition at critical cross sections, both often associated with overbank flow and sedimentation. Hence, the adequate design of LW retention structures is important for flood mitigation in forested mountainous catchments. This task requires the improvement of predictive equations quantifying the possible LW loads during floods. Such empirical formulae have been developed in the past (Ishikawa, 1989; Rickenmann, 1997; Steeb et al., 2017). However, the database of existing wood load equations is very limited. The objectives of the present study were to (i) extend the data set of LW events, (ii) quantify wood transport during floods by comparing LW volumes with catchment and transport characteristics, and (iii) reveal empirical trends for better prediction of transported LW volumes. This investigation is part of the of the WoodFlow project supported by the Swiss Federal Office for the Environment (FOEN).

METHODS

Extraordinary LW events, like the one that occurred in 1978 upstream of the Palagnedra reservoir (**Fig. 1**), are especially helpful to increase process understanding. Various sources of information (e.g. hazard process documentations, field measurements or scientific literature) were used to compile an extensive data base on large wood transport with approximately 200 data entries. Flood events mainly from Swiss mountain streams were analyzed to quantify LW loads, catchment characteristics (drainage area, forest area, forested stream length, Melton ratio) and transport characteristics (discharge, runoff volume, sediment load).

RESULTS

The comparison of wood load and drainage area provides one of the highest correlations of all investigated parameters. Drainage area can be seen as a rough proxy for both hydrological conditions and wood availability. An in-depth analysis of the exceptional August 2005 flood event in Switzerland indicates that the duration of a flood is an important controlling factor for LW loads. The event lasted three days and resulted in roughly 5 times higher volumes of transported wood compared to other events with shorter durations. Persistent rainfall saturated soils and lead to

substantial LW recruitment from mass wasting processes such as landslides and debris flows. The long lasting flood flows in 2005 also caused higher mobilization of instream deadwood and more intense bank erosion processes. Catchments with LW recruitment from sporadic mass wasting typically tend to have higher wood loads for a given catchment size. The scatter of the data is somewhat smaller for larger watersheds, probably because effects of stochastic events in small sub-catchments are integrated and averaged.

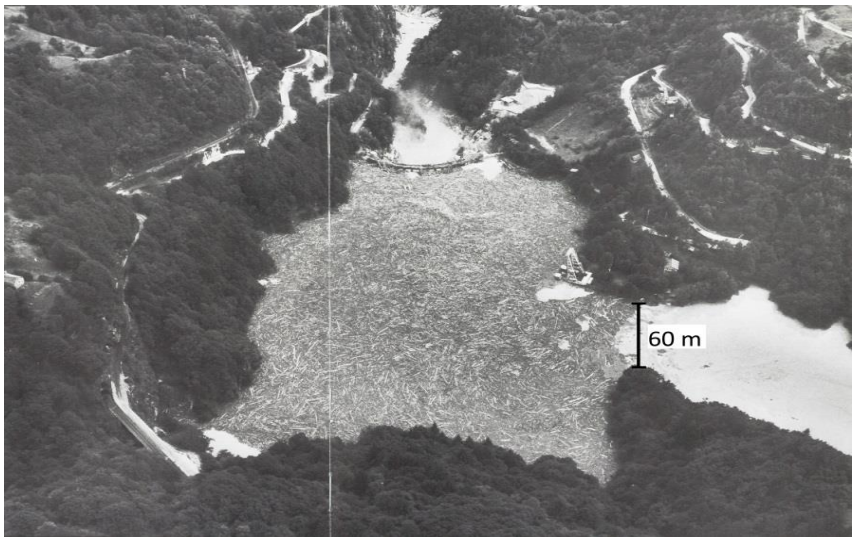

Fig. 1 Aerial picture of the Palagnedra reservoir after the exceptional August 1978 flood. Approximately 12'500 solid m^3 of LW were deposited upstream of the dam. Source: Heitmann & Zanetti (1980)

CONCLUSIONS

Despite the large variability of the data, clear trends are visible over several order of magnitudes. Typically, these relations can be best described with a power law regression. The results further show, that both, the duration of a flood event as well as the type of recruitment process, are important variables in defining the transported wood volume. The results of this study allow to define empirical estimation formulae for wood transport, including upper envelope curves (max. wood loads) which are important for the design of retention structures.

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