

# Large wood-related hazards during the extreme flood of 24 July 2014 in the Emme catchment (Switzerland)

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## INTRODUCTION

During the morning of 24 July 2014 a severe thunderstorm hit the Emmental region (canton of Berne, Switzerland). Intense rainfall (up to 96 mm in 7 hours) in the upper Emme catchment led to debris floods and debris flows in several of the steep tributaries. Mainly the torrents Sädelgraben and Gärtlebach transported considerable amounts of sediment and large wood (LW) (Fig. 1). The receiving Emme river produced an exceptionally large flood and caused large-scale inundations and severe overbank sedimentation. Lateral bank erosion occurred all along the Emme entraining sediments and wood from alluvial forests. A considerable amount of wood was deposited at the confluence of the lateral torrents with the Emme river and on the large inundated areas along the Emme. However, much wood was transported by the Emme river further downstream to clog a natural gorge (Räbloch, catchment size there: 96.4 km<sup>2</sup>).



Figure 1. Deposition of large wood on the left bank of the Sädelgraben (tributary to the Emme river) after the debris flood of 24 July 2014.

Few studies have documented the effect of high magnitude floods on LW recruitment, transport, and deposition. One of the most exhaustive investigations was carried out after the August 2005 flood in Switzerland. Although these studies brought sound knowledge regarding wood transport during floods, many relevant questions still remain open

to date. Therefore, the goals of this project, initiated by the Swiss Federal Office for the Environment (FOEN) were defined as follows: (i) establish a wood budget for the studied reach of the Emme river and its most active tributary, the Sädelgraben (1.3 km<sup>2</sup>) including a survey of the deposited wood and the recruitment processes with an associated estimation of input volumes; (ii) investigate size distribution of mobilized and deposited wood pieces in the Sädelgraben and the Emme.

## METHODS

**Sädelgraben:** Wood deposits along the Sädelgraben were surveyed in detail: (1) Wood deposited outside of the channel on the partially forested fan following massive overland flow. These pieces were surveyed in reference areas and based on the resulting deposition density the wood volume on the fan was estimated by extrapolation. (2) Wood stacked up in piles close to the torrent channel and the main road as a result of emergency measures. The volumes of the wood piles were measured and a characteristic pore volume was assumed. For the determination of the wood input into the Sädelgraben, landslides as well as bank erosion along the torrent were mapped including their contributing areas. To obtain a volume estimate of the entrained wood in the catchment, tree density and a typical tree diameter were determined within a reference area and local conversion tables applied.

**Emme:** To assess the volume and size distribution of the deposited wood along the banks of the Emme river, wood pieces were surveyed and counted along the 10 km study perimeter upstream of the natural gorge (Räbloch). Bank erosion was measured and mapped, and the potential recruited wood volume was estimated based on the riparian forest density.

## RESULTS AND CONCLUSIONS

A LW budget for the 24 July 2014 event in the Sädelgraben is proposed here. Deposited wood in the entire catchment (i.e. wood stacked up in piles, deposited on the fan, and deposited in the channel bed) amounts to approximately 340-660 m<sup>3</sup>. The largest contribution originates from fan deposits and is estimated to around 170 m<sup>3</sup>. On the other hand, wood recruited by landslides and bank erosion as well as wood mobilized from the channel bed amounts to roughly 340-620 m<sup>3</sup>. Here, the largest fraction of wood input appears to be caused by landslides. Hence, recruited and mobilized wood lies in the same order of magnitude as deposited wood. The analysis also suggests that only a negligible part of mobilized wood was exported from the catchment into the Emme river.

The size distribution of wood pieces transported in the Sädelgraben is different depending on whether wood pieces were stacked up in piles in the vicinity of the confluence with the Emme (originating from deposits along the downstream banks of the channel and from the area close to the clogged bridge of the valley bottom road) or naturally deposited on the fan (Fig. 2).

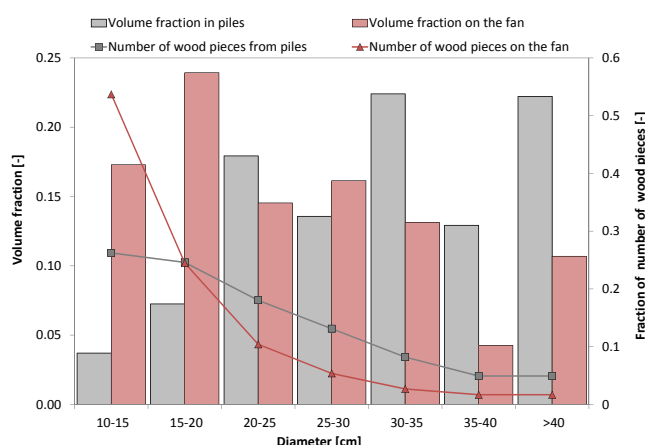


Figure 2. Size distribution of wood pieces along the Sädelgraben torrent: piled-up wood near the confluence with the Emme river (grey) and naturally deposited wood on the fan (red).

A very rough estimate of a LW budget in the upper Emme catchment was established. A total of 2800 m<sup>3</sup> of LW was deposited throughout the river system. This amount corresponds fairly well with data from the well-studied August 2005 flood event, considering both catchment size and peak discharge. The results suggest that the large amount of LW observed in the receiving Emme river probably originated from bank erosion in the main river channel itself due to the extraordinary volume and erosive force of flood waters. Recruitment of LW from torrent tributaries seems to play a subordinate role in the budget of the Emme.

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## KEYWORDS

exceptional flood, large wood transport; large wood recruitment; wood budget; Emme River

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