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Natural and anthropogenic controls on soil erosion in the Internal Betic Cordillera (southeast Spain)

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ABSTRACT

Soil erosion in southeast Spain is a complex process due to strong interactions between biophysical and human components. Significant progress has been achieved in the understanding of soil hydrological behavior, despite the fact that most investigations were focused on the experimental plot scale. Although experimental plots allow exploring the effect of multiple biophysical and anthropogenic factors, they provide limited insights in the combined effect of all factors acting together at the landscape scale. In this study, area-specific sediment yields (SSY) have been estimated based on the volume of sediment trapped behind 36 check dams in the southeast of Spain. Low SSY-values were reported (mean = 1.40 t ha^{-1} $year^{-1}$: median = 0.61 t ha^{-1} $year^{-1}$). SSY variability could be explained for 67% by catchment characteristics such as drainage area, soil characteristics, land cover, average catchment slope, and annual rainfall. The low SSY values are probably caused by the agricultural abandonment that occurred over the past decades and allowed the recovery of natural vegetation. Furthermore, our results suggest that the soils have eroded in the past to such an extent that nowadays not much sediment is detached by overland flow due to residual enrichment of clay and stones. Also, sediment is to a large extent trapped locally in the catchment, as indicated by the negative relationship between SSY and catchment area.

1. Introduction

Soil erosion in southeast Spain is a complex process due to strong interactions between biophysical and human components (Garcia-Ruiz, 2010; van der Leeuw, 1998). A proxy commonly used for the assessment of soil degradation is the estimation of a wide set of soil erosion rates performed at different spatial scales: at plot scale (e.g. Durán Zuazo et al., 2006; Kosmas et al., 1997; Romero-Díaz et al., 1999), micro-catchment scale (e.g. Cantón et al., 2001; Martinez-Mena et al., 2001; Puigdefabregas et al., 1999), and catchment scale (e.g. Avendaño Salas et al., 1997; Boix-Fayos et al., 2008; Martín-Rosales et al., 2003; Romero-Díaz et al., 2007; Sougnez et al., 2011). The compilation of results from previous experiments demonstrated that runoff generation and soil loss show a non-linear decrease with each unit increase in catchment area (e.g. Cammeraat, 2004; de Vente and Poesen, 2005). This observation was attributed to the dominance of different physical processes associated with different catchment sizes.

Significant progress has been achieved in the understanding of soil hydrological behavior, despite the fact that most investigations in the Almeria Province were focused on the experimental plot scale. Limitations of plot-scale experiments are that they cover relatively short time periods and are prone to disturbances and inadequate representation of natural conditions. Besides, annual and inter-annual variability of precipitation is high, so that the variability of the resulting datasets is large and the relationships retrieved are determined by a few storms. As a result, upscaling the findings from episodic phenomena in space and time from plot scale to wider temporal and spatial scales is highly uncertain. Although experimental plots allow exploring the effect of multiple factors such as soil properties, antecedent soil moisture, land cover, they provide limited insights in the combined effect of all factors acting together at the landscape scale (e.g. Boix-Fayos et al., 2006; Bracken and Croke, 2007).

During the last decades, reforestation programs have included the construction of a large number of check dams in Almeria Province. These dams trap sediment, and therewith allow investigating and quantifying erosion processes. As the sediment accumulates over years, and comes from all over the source area, studies on these dams are not prone to the limitations typical for the plot experiments (Molina et al., 2008). These regional erosion assessments are still rare although there are some examples for the Sierra de Gádor (Martín-Rosales et al., 2003). Moving from experimental plots to catchment scale allows integrating soil erosion processes in a more realistic and complex landscape context, including interactions of various drivers of soil erosion (Vanacker et al., 2007).

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