



Studying gully erosion processes in rangelands of SW Spain and guiding restoration strategies using the UAV+SfM workflow

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Gully erosion in agrosilvopastoral systems of SW Spain represents a common degradation process, but has been hardly analysed. Gully erosion is an important phenomenon in the valley bottoms of first and second order catchments of dehesas. The presence of gullies in these valley bottoms produces degradation due to soil loss but also favours drainage enhancing runoff. Previous works pointed out land use intensity as the main factor determining incision episodes in valley-bottom gullies at medium-term temporal scale. However, previous works have been limited because of the detailed spatial scale required to map, quantify and understand soil erosion processes in small gullies. The most common methods traditionally used to register gully topography are pin networks, topographic profilers, total stations, Light Detection and Ranging sensors, Terrestrial Laser Scanners, aerial photographs and traditional photogrammetry, Terrestrial Structure from Motion (SfM) and Global Navigation Satellite Systems.

In this study, we show how remote sensing new technologies can be applied to produce detailed maps (orthophotographs, DEMs and point clouds) of valley-bottom gullies and provide advice for better management strategies in dehesa farms. We focus on the use of fixed-wing UAVs that, theoretically, allow covering large surfaces with great detail. The main objectives of this work are:

- 1) testing the application of the UAV+SfM workflow to map valley-bottom gullies using a fixed-wing UAV and covering relatively large surfaces,
- 2) characterizing processes and identifying, if possible, causes of gully erosion and
- 3) recommend management strategies based on (1) and (2).

The study was carried out in five gully reaches located in three privately owned farms that are representative of the dehesa land use and exploitations systems (Buitrera, Parapuños and Raposera). The five selected reaches are located in valley bottoms formed by alluvial sediments covering the bedrock of Precambrian shales. These channels are typical of low order catchments in the SW Iberian Peninsula and present ephemeral discharges.

The resulting cartography allowed mapping soil erosion forms at outstanding spatial scales, with Ground Sampling Distances that ranged from 1.63 to 3.83 cm. The georeferencing Root Mean Square Errors were always bellow 2 cm. All study areas showed evidences of degradation with percentages of gullied reaches that varied from 55.16 to 100.00 %. Different features and processes were catalogued: vertical undercutting walls, headcuts, bank headcuts, collapsed materials, sediment deposits, etc.

The interpretation of these cartographic products guided the restoration activities in Parapuños study area. Permanent check dams were installed along the channel while temporal check dams were used to control the growth of bank headcuts. The most degraded area was fenced to protect against grazing. After one year, the success of these measures is difficult to analyse as an important drought took place in this period. Only fencing presented significant results, with high-resolution orthophotographs acquired one year after fencing showing a complete recovery of vegetation cover.