



Soil degradation in wooded rangelands of southwest Spain

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The paper presents a review on soil degradation studies carried out since 1990 in wooded rangelands in Extremadura. In the semiarid and subhumid parts of the south-western Iberian Peninsula open evergreen woodlands dominated by *Quercus* species are widespread (dehesas and montados). They are composed of grasslands with a varying degree of tree cover, ranging from treeless to more than 80 individuals per hectare. In some areas shrubs form a third component of the vegetation. Dehesas are subject to a complex exploitation system with agro-silvo-pastoral land use. The dominant soil degradation phenomena include different forms of water erosion and physical and biological degradation.

Regarding soil erosion and surface hydrology, research has been carried out at different spatial scales. Sheetwash and overland flow were investigated along hillslopes and in microplots, whereas gully erosion and runoff production were monitored in small experimental catchments. Recently, physical and biological degradation has been studied in a large number of farms, representing the most important types of rangelands in the region of Extremadura. This included a rapid appraisal of degradation features, the determination of soil properties and a study on the distribution and activity of gullies.

Soil degradation varies strongly with regard to the natural factors, but also with respect to land use and management. Sheetwash (interrill erosion) is the dominant process on hillslopes, with a mean soil loss rate of 0.63 t ha⁻¹. However rainfall variation and land management, especially livestock density, produce changes in soil cover. With low to moderate livestock densities and during prolonged periods with low rainfall (droughts), the vegetation cover may be strongly reduced, provoking high soil losses, whereas during normal or humid periods interrill erosion is low. Excessive stocking rates may exacerbate sheetwash, producing severe soil degradation, regardless of rainfall conditions.

In Extremadura, gullies are localized and permanent features, representing only a small fraction of the total land and are mainly located in valley bottoms with an alluvial sediment fill. Individual gullies may present high soil losses, constitute an obstacle for traffic and enhance drainage of subsurface flow (valley bottoms probably dry up more quickly). They are more frequent on schist and greywacke than on granites, the dominant rock types in SW Spain. Monitoring of a gully system during a period of 7 years has shown that a strong relationship exists between catchment hydrology (rainfall and runoff) and erosion in the channel. However, a study of the same gully system for the period from 1947 until 2002 has shown increases of erosion during a period when large parts of the catchment were cultivated and when livestock numbers were increased. The latter is mainly related with animal trampling in the vicinity and along the margins of the gully.

Rill erosion is not a frequent phenomenon in dehesa, limited mainly to areas which are ploughed for cultivation or shrub cleaning. Very high erosion may occur when tillage practice immediately precedes exceptional rainstorms.

Other soil degradation processes important in wooded rangelands are soil compaction, reduction of organic matter content, biological activity, plant available water and infiltration capacity. The few quantitative data available to date show that in large parts of the region soils are degraded (shallow, low organic matter content and high bulk density, etc.). This can be the result of centuries of agrosilvopastoral land use but is certainly also the consequence of inadequate land management in many areas at present. The large spatial variation of factors (vegetation, soils, relief, climate, land use and land management) is a characteristic feature of wooded rangelands in the Iberian Peninsula, and together with the temporal changes of these factors, makes it very difficult to discriminate the causes of soil degradation which are related with land management. The latter constitutes however an important task in order to be able to propose soil conservation measures. To achieve this research is presently carried out on the development of an evaluation system based on soil degradation indicators.