

# WHEN DID GULLY EROSION START TO BE ACCELERATED IN THE PENEDÈS – ANOIA VINEYARD REGION (NE SPAIN)?

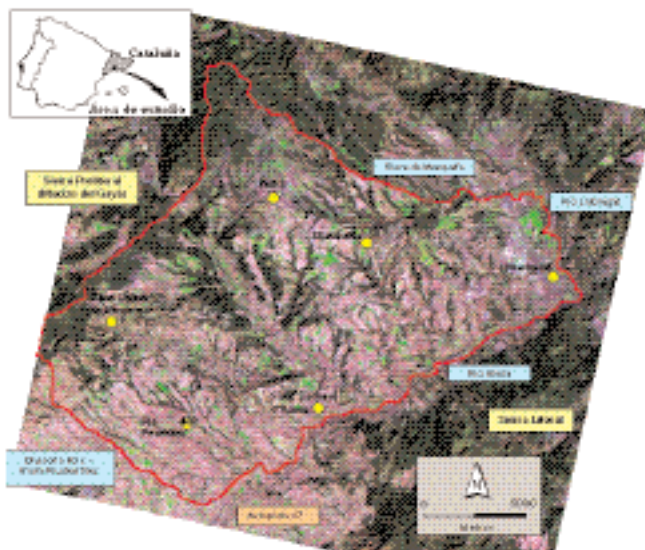
Martínez-Casasnovas, J.A.

University of Lleida, Department of Environment and Soil Science, Rovira Roure 191, 25198 Lleida, Spain.  
j.martinez@macs.udl.cat

## 1. Introduction

Gully erosion in the Penedès – Anoia region (NE Spain) is a regional problem, affecting between 23 to 32% of the land. This region is part of the Penedès Tertiary Depression, where calcilutites (marls) and, occasionally, sandstones and conglomerates outcrop. The depression has an age of between 25 to 2 millions of years (Oligocene to High Neogene).

One of the main characteristics of this area is the dissection of the landscape by a dense and deep network of gullies (Fig. 1). According to Martínez-Casasnovas (1998), the total volume excavated the gully network in the incoherent materials is about 466 hm<sup>3</sup> and a maximum depth of 60 m. The density of gullies reaches 4.8 km km<sup>-2</sup>, being this value considered as very severe.



**Fig. 1.** Location of the study area. A dense drainage network mainly formed by deep gullies can be observed. Landsat TM image, RGB 543, March 1993.

Gully erosion in this region is not a past phenomenon. In this respect, recent research by Martínez-Casasnovas et al. (2003) has shown that neat erosion rates in gullies reach 576±58 Tn ha<sup>-1</sup> year<sup>-1</sup> in the most active heads. However, some research questions arise about the magnitude of this problem: When did gully erosion start? When did it was accelerated? Is this acceleration related to the main land use in the region (vineyards)? The present work addresses those questions by analysing multitemporal remote sensing data

in order to determine historic gully retreat rates and to relate them to documented land use changes in the region.

## 2. Methods and material

The research was based on a multi-temporal analysis of aerial photograph stereo pairs from 1957 (1:30,000 scale) and aerial photographs and orthophotos from 1993 (1:25,000 scale). From this information, the gully retreat rate was computed for the period 1957-1993. The gullied area for 1957 was mapped by means of airphoto interpretation. The boundary of the eroded area was drawn along convex slope break lines that mark the incision of gullies in the unconsolidated Tertiary deposits. The result of the airphoto interpretation for 1957 was restituted by means of a digital photogrammetric process at scale of 1:25,000. The gullied area for 1993 was drawn on a 1:25,000 orthophoto produced by the Cartographic Institute of Catalonia and digitised as an ArcInfo polygon coverage. Both coverages were geo-referenced according to the UTM 31N co-ordinate system.

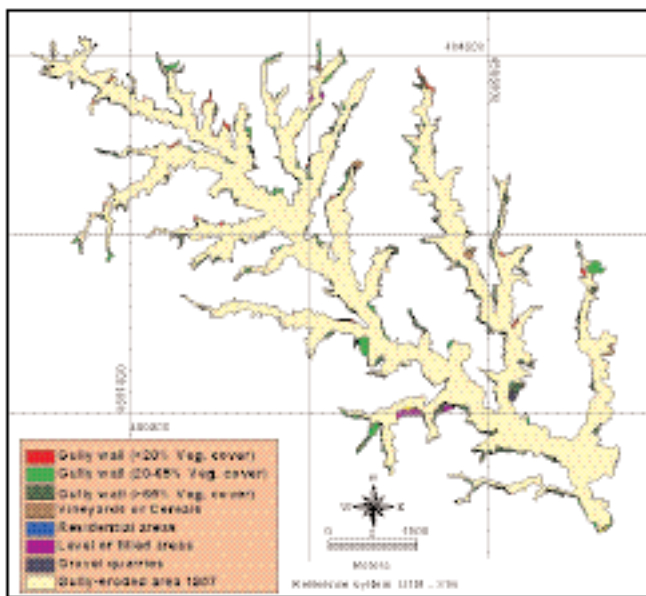
The coverages were overlaid using ArcInfo's Union command. A contingency matrix was derived from the Union coverage. This matrix gives information about the area covered by each mapped class at the respective dates as well as about two-dimensional or planimetric changes among the classes in the considered period. From this matrix the rate of gully walls retreat was computed.

## 3. Results and discussion

The total area affected by the retreat of gullies in the period 1957 – 1993 was 76.5 ha (in 36 years) (Fig. 2). This represents a rate of 2.1 ha year<sup>-1</sup> or, in terms of the catchment area, 0.9‰ m<sup>2</sup> year<sup>-1</sup>. The linear retreat of gully walls occurred at an average retreat rate of 0.2 m year<sup>-1</sup> along the perimeter of the gullies of the study area. However, this represents default rates since areas that were both eroded and filled within the studied period, and therefore not detected in the image interpretation process, may be included.

If this computed retreat rate was maintained over the time to come, it would last 840 years to erode the whole gully catchment. This is only a very hypothetical prediction, since only the last 36 years were considered to compute the

erosion rate. On the other way around, if the retreat rate is applied in a reverse way, the hypothetical start of the gully development in the study area could be estimated. Accordingly, it indicates that gully erosion would have started 320 years ago. This date is again very few probable, since the start of the incision of the gully system is most sure contemporary to the incision of the Anoia river (main river in the area). However, it reflects that the rate of gully erosion in the study area has not been always the same. In the recent past, the study area suffered one of the highest gully erosion rates of its history. It seems to be the consequence of a break in the equilibrium of the landscape system, which could have started four centuries ago.



**Fig. 2.** Areas of the sample area in the Penedès-Anoia region (Rierussa catchment) affected by gully erosion in the period 1957-1993.

What happened four centuries ago? Balcells (1980) reports that in the XVI century started in the Penedès region the massive plantation of vineyards under the protection of temporary contracts called *Rabassa Morta*. This supposed the clearing of shrublands and forested areas, which seems the most probable cause of the land use/cover disequilibrium responsible for the higher runoff and erosion rates. Particularly important seems to be the studied period (1957-1993), after the advent of the mechanisation. Other aspects different from the traditional soil and water conservation measures have been priority in this period (Porta et al. 1994, Poch et al. 1996).

Therefore, and although the measured rate of gully retreat is a measure of the past erosion and it could not have to be the same for the future, it is a measure of the very recent past erosion. Then, since the land use system has not changed towards implementing more soil and water conservation measures, similar, accelerated, gully erosion rates can be expected for the near future in the study area.

#### 4. Conclusions

The present research reveals the accelerated rates of gully erosion that the Penedès – Anoia vineyard region suffers, at least, since three centuries ago. This is consequence of a disequilibrium caused by an important and progressive (since that moment) land use/cover change that has favoured partial cover crops (vineyards) instead the original land cover vegetation. The acceleration of gully erosion could have been accentuated from the advent of mechanization, which also produced a removing of soil conservation measures to achieve larger fields for easier labour mechanization.

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