Landform Analysis, Vol. 17: 173–176 (2011)

Gullies development in afforested slopes in Southeastern Spain

José Damián Ruiz-Sinoga[1], Asunción Romero-Díaz[2], Francisco Belmonte-Serrato[2], Francisco Alonso-Sarría[2]

[1]*University of Malaga, Spain*
[2]*University of Murcia, Spain*
e-mail: sinoga@uma.es

Abstract: In semiarid regions, the main purpose of afforestation has been to provide a protective vegetative cover in order to prevent or reduce soil erosion. This paper shows the results of a study carried out in some areas afforested in the 1970s, in steep slopes and mostly in marls. Afforestation where performed using terraced with subsoiling, so the existing scrub vegetation was removed and *Pinus halepensis* was planted. The main conclusion is that human action developed in this semi-arid territory, perhaps because the technique applied was not the most suitable for afforestation, has led to the geomorphological activation of the slopes and the emergence and large development of gullies.

Keywords: afforestation, gullies, erosion rates, marls, semiarid region, Spain

Introduction and study area

In semiarid regions where erosion processes are important, due to the scarce existing vegetation and weather characteristic conditions (low rainfall, but sometimes of high intensity), the afforestation have been made and are continuing today with the purpose of providing a protective vegetative cover that prevents or reduces soil erosion.

Afforestations have not been always beneficial and not always the expected targets have been obtained, therefore, in occasions they have been opposed by different sectors of society. The criticism is related to the species and techniques selected for the afforestations. In respect to the used techniques, criticism has been made to the aggressive methods used, such as the terracing using bulldozers, that remove great quantity of soil for creating the terraces with the aim of favouring the infiltration and reducing erosion (Canga Cabanes 1989). But usually has the opposite effect, degrading the soils and increasing the erosion as it creates more slope instability (Garcia Ruiz & Ortigosa 1989, Ortigosa 1991, Chaparro Fuster & Esteve Selma 1995, De Wit & Brouwer 1989).

This research was carried out in "La atalaya" and "El Castellar" areas (Gualentín basin, Región of Murcia, South-eastern Spain) in order to shed light on the effect of afforestation on soil conservation or contrary to verify whether the erosion processes had increased.

The afforestations were carried out in the 70s of last century, in steep slopes and mostly in marls lithologies (Fig. 1), and were performed using terraced with subsoiling, so it was removed existing scrub vegetation and *Pinus halepensis* was planted.

Methodology

Using the geomorphological transects technique (Fig. 2) the number of existing gullies have been measured on slopes and terraces (Fig. 3), generated as a terracing result. We have calculated erosion rates.

Soil erosion was surveyed by means of 20 geomorphological transects. The geomorphologic transects technique have been previously used in different studies (García Ruiz & Ortigosa 1989, García Ruiz et al. 1991, Ruiz Flaño et al. 1992, Chaparro Fuster & Esteve Selma 1995 etc.) in the Mediterranean environments and it is efficient to survey the soil erosion process when the erosion rates are high.

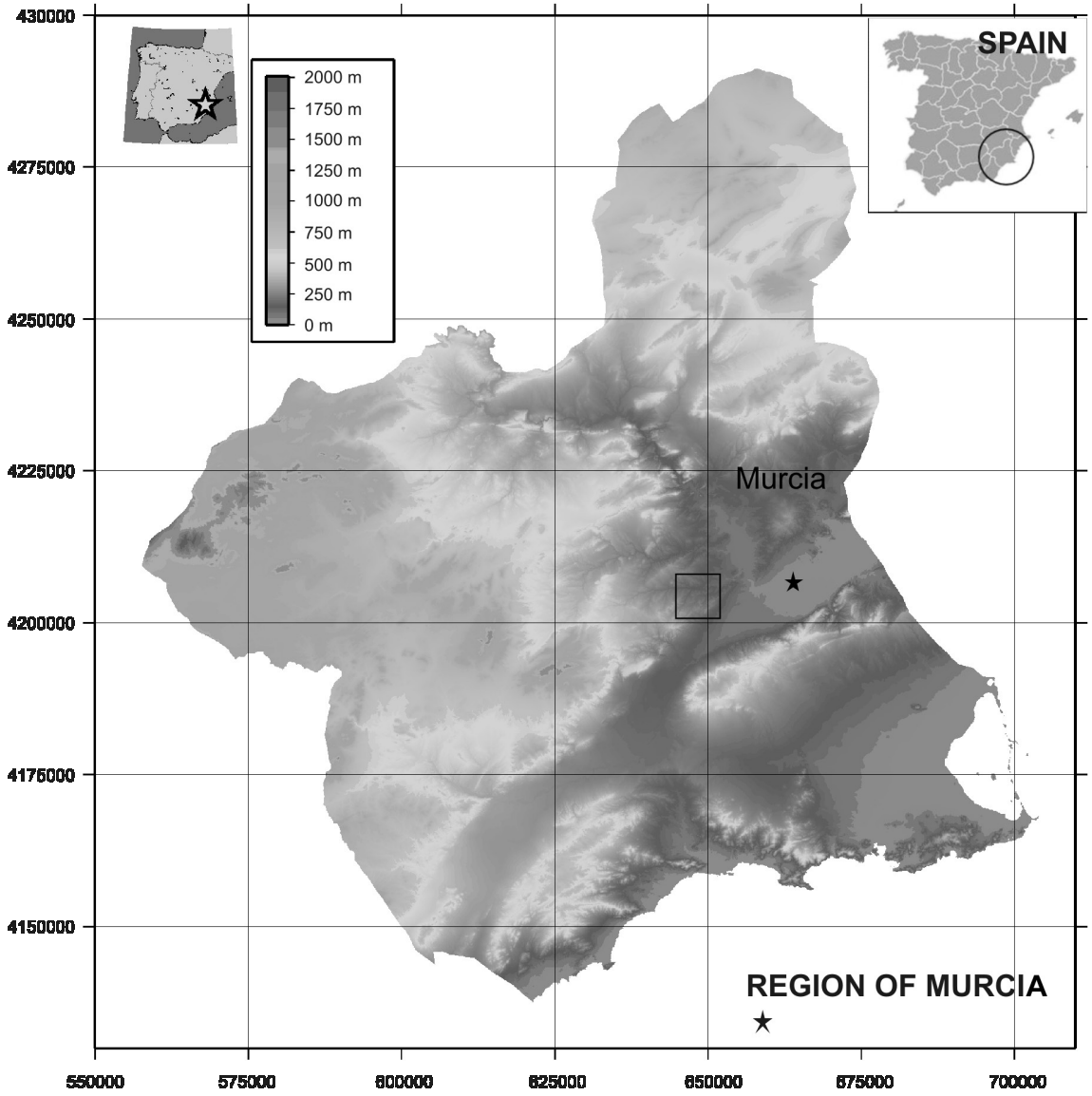

Fig. 1. Study area in the Region of Murcia (Spain)

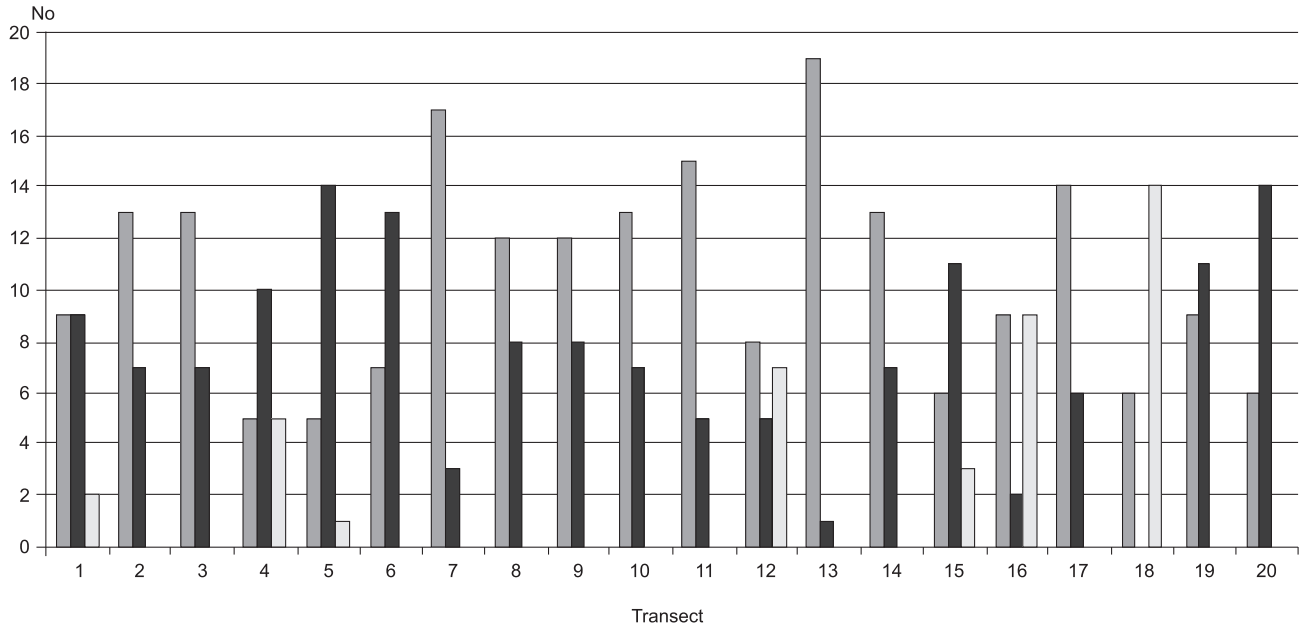

Fig. 2. Types of erosion observed: gully (gray), erosion diffuse (black), small landslides (light gray)

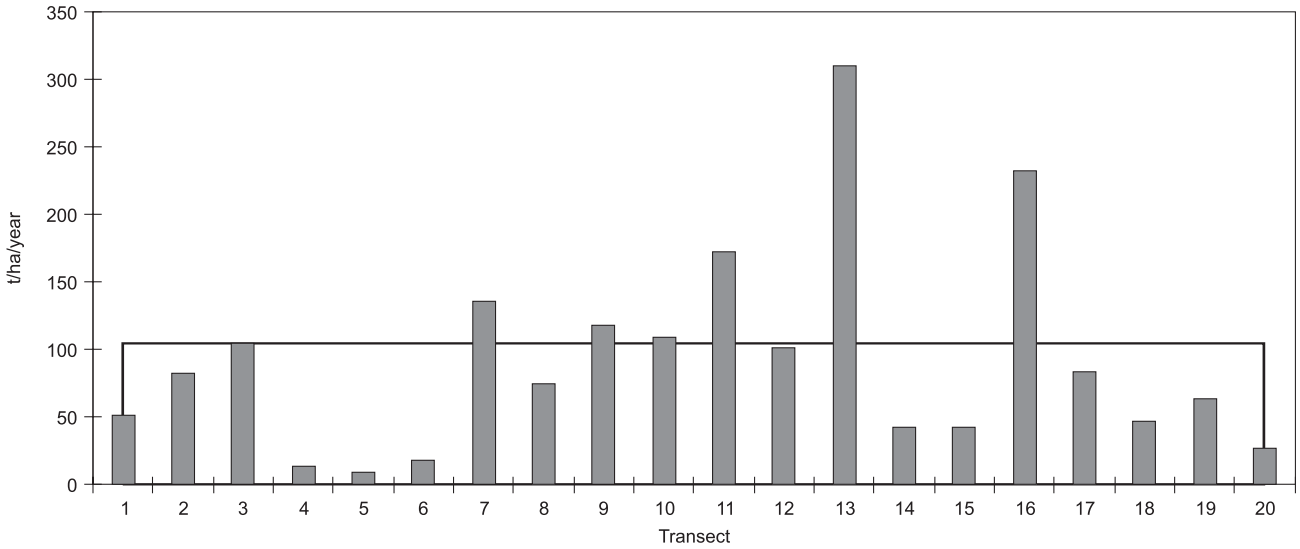

Fig. 3. Erosion rates calculated on transects

The technique consists in placing a metric ribbon of 20 metres long in the slope parallel to the contour lines. Along the metric ribbon the erosive forms are measured in order to obtain the frequency of gullies and rills. Length, width and depth were measured for each incision found along the metric ribbon. Three widths and three depths have been taken for establishing an average value at each rill and gully. The rill and gully survey allowed the calculation of the removed soil volume. As not all the rills have the same section, the three most frequent sections (triangular, rectangular and semicircular) were evaluated.

In non-terraced areas and without gullies, erosion plots have been installed, with the aim of evaluating the erosion rates in natural conditions. Three plots have been installed in approximately the same steepness to those terraced areas, for making the results comparable.

Results and discussion

Rills cover 53% of the surface of the slopes of the terraces (Fig. 2). Rills showed an average width of 133 cm, and an average depth of 83 cm. Mass movement cover 10 % of the soil surface (Romero Díaz & Belmonte Serrato 2008). The geomorphological transects informs that on marls, the average erosion rate was 105 t ha^{-1} yr^{-1}. From 20 analyzed transects, 8 have produced rates higher than 100 t ha^{-1} yr^{-1} and 2 of them surpassed 200 t ha^{-1} yr^{-1} (Fig. 3).

The measurements carried out on naturally vegetated and undisturbed slopes by means of collectors showed very low erosion rates (2 t ha^{-1} yr^{-1}). Soil erosion assessment on the afforested sites demonstrates that in marls areas erosion is very high and that due to afforestation using terraces with subsoiling the occurrence of gullies has increased dramatically (Fig. 4).

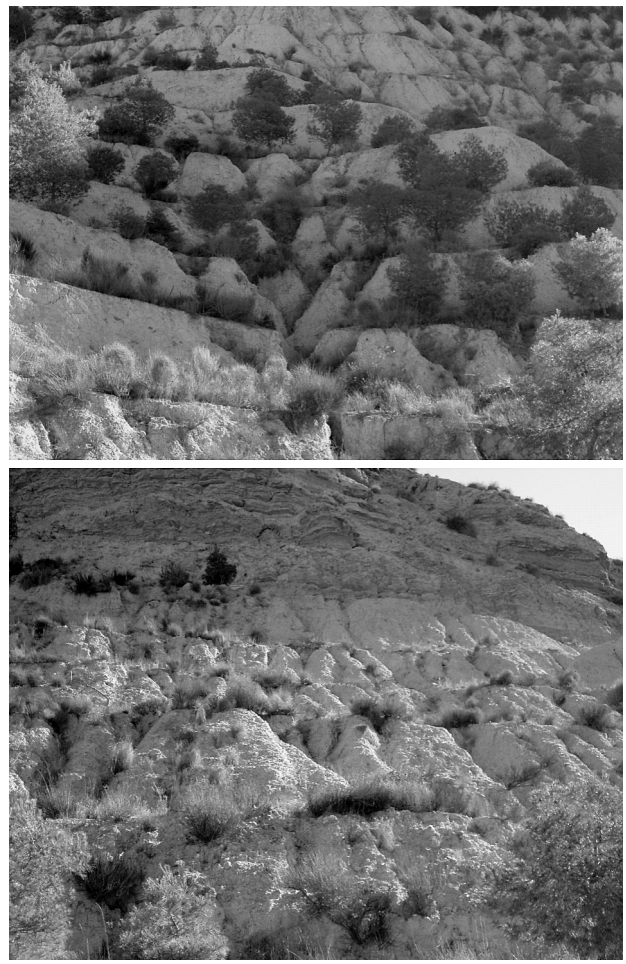

Fig. 4. Appearance of afforested slopes after 30 years (see: gullies that have formed in the forested terraces)

Conclusions

More than three decades later as we can see, afforestation has not reached its intended objectives:

protection of soils from erosion, improvement of soil and sustainment of vegetation of trees (Romero Díaz et al. 2010). Conversely, the emergence of a remarkable gullies development, sometimes large, and the establishment of a tree cover of low size and low density could be seen. The calculated erosion rates are to highlight medium values of. The calculated erosion rate reaches a very high value of 105 t ha^{-1} yr^{-1}. The soil characteristics, comparing them with nearby areas not forested, not have improved. And regarding the new implanted cover, sparse and development, does not provide the protective nature that was expected.

In conclusion, in this semi-arid territory the human action has led to the geomorphological activation of the slopes and the emergence of a large development of gullies, perhaps because the technique applied was not the most suitable for the eco-geomorphological system recovery.

References

Canga Cabañes J.L., 1989. *Impacto ambiental de las repoblaciones de protección*. Curso sobre estabilización de cauces torrenciales. Madrid.

Chaparro Fuster J., Esteve Selma M.A., 1995. Evolución geomorfologica de laderas repobladas mediante aterrazamientos en ambientes semiáridos (Murcia, SE de España). *Cuaternario y Geomorfología* 9 (1–2): 39–49.

De Witt A.M.W. & Brouwer L.C., 1998. The effect of afforestation as a restoration measure in a degraded area in a Mediterranean environment near Lorca (Spain). In: Uso J.L., Brebbia C.A. & Power H. (eds.) *Ecosystems and Sustainable Development*. Advances in Ecological Sciences, Vol I. Computacional Mechanics Publications, Southampton: 165–170.

García Ruiz J.M. & Ortigosa L.M., 1989. *Efectos geomorfológicos de la repoblación forestal. Evolución ecológica de las áreas reforestadas en el Pirineo aragonés*. CSIC, Zaragoza.

García Ruiz J.M., Ruiz Flaño P., Lasanta P., Monserrat G., Matínez Rica J.P. & Pardini G. 1991. Erosion in abandoned fields, what is the problem? In: Sala M., Rubio J.L. & García Ruiz J.M. (eds.) *Soil Erosion Studies in Spain*. Geoforma Ediciones: 97–108.

Ortigosa Izquierdo L.M., 1991. *Las repoblaciones forestales en La Rioja: resultados y consecuencias ambientales*. Geoforma Ediciones, Monografías Científicas, Logroño.

Romero Díaz A. & Belmonte Serrato F., 2008. *Erosión en forestaciones aterrazadas en medios semiáridos: Región de Murcia*. Editum, Murcia: 191 pp.

Romero Díaz A., Belmonte Serrato F. & Ruiz Sinoga J.D., 2010. The geomorphic impact of afforestations on soil erosion in Southeast Spain. *Land Degradation and Development* 21(2): 188–195.

Ruiz Flaño P., Lasanta Martínez T. & García Ruiz J.M., 1992. La variabilidad espacial de la producción de escorrentía y sedimentos como base para la gestión de campos abandonados. In: *Estudios de Geomorfología en España*: 221–230.