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Water erosion and soil properties patterns along selected rainfall events in cultivated and abandoned terraced fields under renaturalisation

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ABSTRACT

Current cultivated soils (C) and soils under different age of agricultural abandonment and plant cover like forest (F), meadows (M) and scrubs (S) were surveyed at any high (H) or low (L) rainfall event generating runoff to record erosion and both dissolved and eroded carbon and nitrogen. This survey was conducted from January 2009 to April 2010 and was also addressed to determine soil properties such as surface temperature (ST), moisture (SM), bulk density (BD), shear strength (SS), pH, organic carbon (SOC), total nitrogen (N_T), total phosphorus (P_T), CO_2 emission, glomalin (GRSP), and β-Glucosidase, Phosphatase and Protease activities. The overall data set allowed accomplishing with the objective of the research, seeking differences in soil properties according to the previous land use, land abandonment and repeated fire occurrence. ANOVA of repeated measures showed runoff variance statistically significant within soil uses at L rainfall ($p < 0.05$). Eroded soil and eroded carbon varied significantly among soil environments ($p < 0.05$) at both H and L rainfall. However, erosion rates were low when compared to other Spanish sites. Soils under meadows (M) showed higher SOC and GRSP, and higher enzyme activities, and were identified as important natural firebreaks, besides their susceptibility to sediment and nutrient depletion. Similarly, soils F and S, though repeatedly affected by fire, showed satisfactory soil properties. The poorest soil properties were found in cultivated soils (C) that increased their erosion rates by 838%, 733% and 188% with respect to F, S and M soils along the observed period. In general, soils with higher organic carbon content (M > S > F) showed proportionally lesser CO_2 emission, indicating their tendency to act as carbon sink. The shallowness of the soil profiles, overgrazing and frequent fire occurrence were found to be soil ecosystems threatening elements in areas deserving special attention for the risk of irreversible degradation processes. Unpredictable and erratic fire occurrence all over the area also suggests environmental protection through prevention plans.

1. Introduction

The landscape is a valuable piece of land playing important environmental functions under natural or man-made conditions (de Groot, 2006). Along the evolution of the landscape, the soil is a component of paramount importance because of resulting from the synergism of different environmental processes, and being one of the most reliable indicators of environmental quality (Bouma, 2000). Conserving the soil resource is considered fundamental for human society. However, soil degradation processes are frequently recorded and may particularly affect fragile mountainous areas of the Mediterranean region, after agricultural release of old terraced fields occurred in the last century. Land abandonment and the subsequent reduction of agricultural utilized area has become an important issue in a number of regions and countries within the European Union. Corbelle and Crecente (2008) estimated in some 17 millions of hectares the amount of abandoned land in the EU, while Thivet (2011) reported that 300,000 ha of abandoned terraced soils in Mediterranean countries may rise to 1.5 millions in 2025. Many authors have reported on the free re-naturalisation process of abandoned fields, causing contradictory effects such as soil and plant biodiversity enrichment (Kardol et al., 2005), reducing erosion hazard (Pardini et al. 2003; Koulouri and Giourga, 2007), or triggering wildfire occurrence in the completely unmanaged spontaneously colonized scrubland areas (Pardini et al., 2004). Therefore, special attention should be deserved to newly formed (renaturalized) environments (Cramer et al., 2008). Moreover, agricultural land no longer used for

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cultivation and successfully reverted to natural vegetation may also allow soil organic carbon accumulation and preservation, contributing to reduce CO_2 emission (Post and Kwon, 2004). Unfortunately, the spontaneous colonization of vegetation of large portions of the territory after abandonment generally leads to disorganised and extended scrubland, which is reported to be the most fire-prone land cover (Moreira et al., 2009). Through proper management of large abandoned areas ecosystem damages may be reduced by hindering restriction of plant species and intensification of erosion processes following a devastating fire. In the North-Eastern part of Spain, the abandonment of mid-mountain terraced lands has occurred progressively when vines and olive groves cultivation shifted in the best plots of plain areas (Lasanta et al., 2000; Dunjó et al., 2003). Accordingly, the traditional infrastructures to protect the soil and preserve the landscape heterogeneity have been deteriorated causing soil loss and nutrient decline by water erosion (Dunjó et al., 2004). Pardini and Gispert (2006) found low erosion rates in the study area but inferred that such amounts may be misleading due the very shallow nature of the investigated soils. Indeed, the evolution of abandoned land is of paramount importance for a better understanding of soil ecosystem dynamics (Pardini et al., 1991), and in view to consider these areas as potential carbon sinks. Recent studies in the same areas have concluded that carbon dioxide fluxes released from soil to the atmosphere decreased when increasing healthy soil conditions due to proper vegetation succession (Emran et al., 2012a), and that this dynamics had positive effects on soil aggregation and organic carbon stocks (Emran et al., 2012b). The objective of this work was to analyse the erosion response of cultivated and abandoned soils to rainfall and how relevant physical, chemical, biological and biochemical properties may be affected in order to establish soil conditions under the spontaneous renaturalization process of the study area.

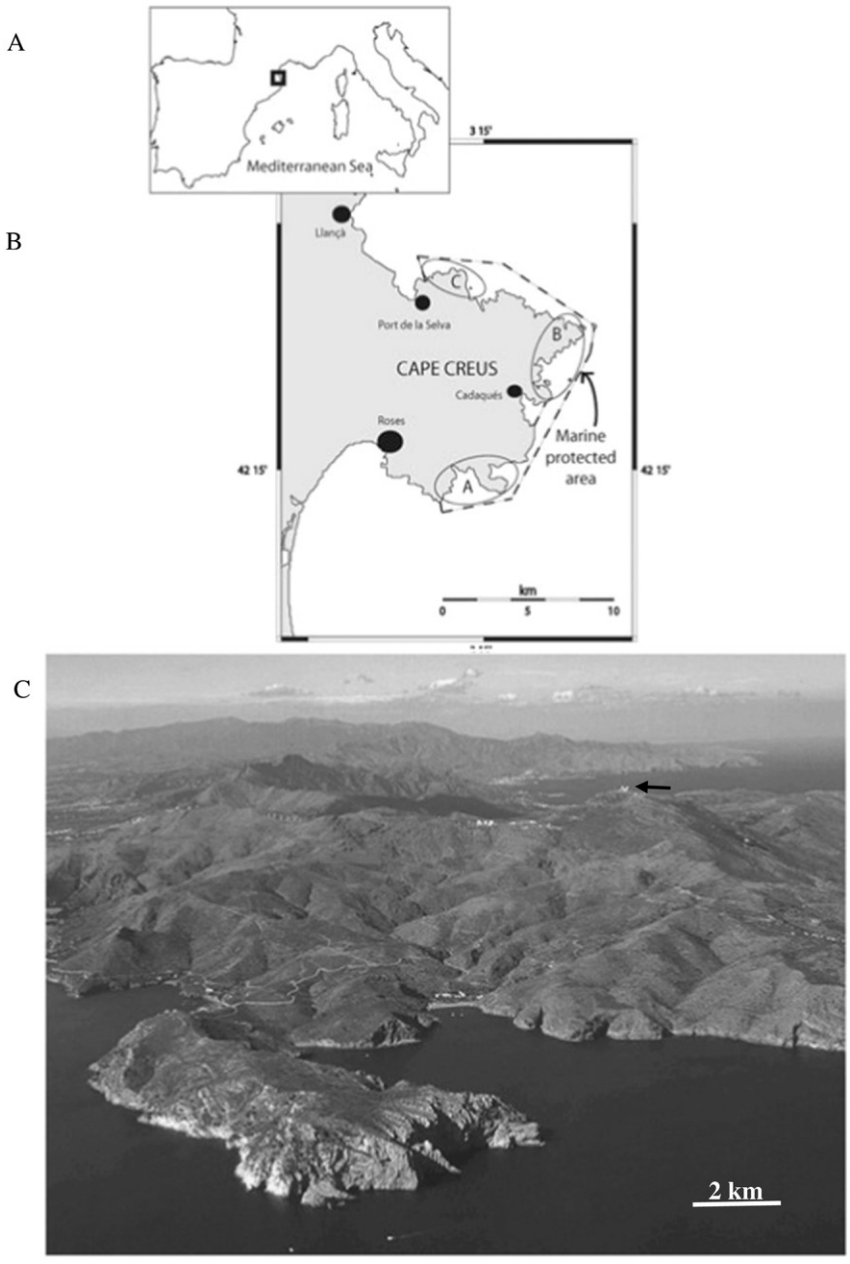

Fig. 1. Geographical context of the study area (A), the enlargement of the Cap de Creus area (B), and a general view of the mid-mountainous morphology where the highest mountain(C) is 672 m asl (see arrow).