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The effects of soil moisture variability on the vegetation pattern in Mediterranean abandoned fields (Southern Spain)

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ABSTRACT

The demographic pressure decrease in Southern Spanish Mediterranean mountainous areas in the mid twentieth century led to the abandonment of agriculture and rupture in the geo-ecosystem balance which had existed until then. Since then, different phases of recovery have been put into action to return the landscape to its earlier natural condition according to climate and soil degradation state after the abandon. In Mediterranean climatic conditions (between subhumid and semi-arid regimes), degraded soil recovery has followed different tendencies rendering the landscape in heterogenic and complex one. This heterogeneity has manifested in the vegetation pattern of abandoned fields. In this paper, we analyze the state of three abandoned fields situated under different Mediterranean climatic conditions from the recovery point of view by means of monitoring the effects of spatial and temporal variability of soil moisture in the vegetation pattern over a period of two years sampling (Nov. 2002–Nov. 2004). The results showed that: i) more annual rainfall volume did not guarantee success in the biological recovery of the system due to the influence of other factors such as the degradation state of the soil post-abandonment or the steep slope gradient; ii) soil moisture variability tended to play a more important role in affecting vegetal cover in semi-arid conditions; and iii) in dry climatic conditions the system demonstrated greater signs of recovery (greater biodiversity).

1. Introduction

Some Mediterranean mountainous areas close to the coast are characterized by intensive human activity which has resulted in the destruction of large areas of natural vegetal cover and the cultivation of land not potentially for farming which had led to soil degradation processes (López-Bermúdez, 1993). Kosmas et al. (2000) pointed out that since the end of the 19th century land abandonment took place in marginal areas because of the agricultural crisis which constituted a real change in soil use at larger scale. These abandoned fields have experienced a process of vegetal re-colonization with different degrees of success, depending on climate and soil degradation. Where the resilience of the geo-ecosystem was low, recovery was weak or nil and processes of erosion appeared. In the rest of the Mediterranean areas, due to the fact that there was no continuity in the geo-ecosystem, a mosaic-like landscape of abandoned fields developed (Bergkamp, 1998) where three types of areas could co-exist: i) those which had barely recovered after degradation because of agricultural abandonment, with low vegetal cover and likely intense desertification processes (water erosion processes and soil degradation); ii) those which recovered with a certain degree of success, with an increase in vegetal cover due to the wetter climatic conditions and, in many cases, what could be defined as quasi-natural areas given that after more than fifty years of abandonment they look like natural areas rather than abandoned fields; and iii) those that are in an intermediate state.

Both abandoned fields and Mediterranean semi-arid rangeland show a mosaic vegetation pattern in two phases (Arnau-Rosalén et al., 2008; Lesschen et al., 2009): vegetated and bare soil areas. This type of spatial pattern directly affects to water erosion by defining sink and source runoff areas during rainfall events (Bergkamp, 1998; Calvo et al., 2003; Cammeraat and Imeson, 1999; Martínez-Murillo and Ruiz-Sinoga, 2007) causing hydrological connectivity processes between the different parts of the hillslope and the rest of the drainage system of the catchment (Puigdefábregas et al., 1999). The vegetation pattern is modified according to the slope gradient and rainfalls, with the vegetal cover percentage diminishing as the climate becomes more arid and the abiotic factors exerting greater control than biotic ones in the runoff generation processes (Katra et al., 2007; Lavee et al., 1998; Rietkerk et al., 2002; Shnerb et al., 2003). When soil degradation conditions become apparent, even in very rainy areas, abiotic factors may control the hydrodynamics of the hillslope where water erosion may be extreme (Boix et al., 1995). In these circumstances, the influence of hydrodynamics on the vegetation pattern is even greater if we take temporal variability into account, because vegetation depends almost exclusively on rainfall from October to May in a Mediterranean climate. This dependency on soil moisture is even more evident on those hillslopes with a geological metamorphic and impermeable

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substratum (e.g. phyllites and schists) with scarce infiltration capacity where the island fertility theory has been clearly observed in semi-arid environments (Puigdefábregas et al., 1999).

This study was carried out in three field sites which had been abandoned fifty years ago at least with metamorphic soil and located in different Mediterranean climatic conditions with the aim of establishing the effects of soil moisture variability on the vegetation pattern. The objectives were next: i) to characterize the relationship between vegetation pattern and soil moisture from the point of view of spatial and temporal variability; ii) to determine the hydrological and erosive consequences; and iii) to establish the level of resilience of the three sites and their proximity to their natural previous conditions with respect to their climate regimes.

2. Study area

The field sites have been selected according to the climatic gradient approach in which topography, geology and land use must be similar in order to compare them (Imeson and Lavee, 1998). They were located in the Cordillera Bética Litoral (Southern Spain) where a climatic gradient was registered (Fig. 1). Table 1 shows the geo-ecological features of the abandoned fields. All of them were characterized by a similar slope gradient and exposure, lithology, vegetal cover and land use but with different climatic conditions: Colmenar (CO) subhumid, Almogía (AL) dry-Mediterranean and Berja (BE) semi-arid. All of them were cultivated and abandoned at least 50 years ago, when shrub re-colonization began with varying degrees of success.

CO was located in the Mountains of Málaga and characterised by steep hillslopes with a Palaeozoic metamorphic geological substratum (Malaguide Complex with slates, phyllites and schists) where water erosion predominated. The 80-m-long south facing hillslope had a convex topographic profile and 51% maximum slope gradient. According to FAO (2006), associations of Regosols and haplic Leptosols, including chromic Cambisol near the top appeared on the hillslope. Soil depth did not usually exceed 25 cm especially at the bottom (where there were rock outcrops). Rock fragment cover of soil was above 50% and the soil texture was sandy clay loam. AL was also located in the Mountains of Málaga and its surroundings shared the same geographical features as CO. The 78-m-long south-facing hillslope was characterised by a rectilinear–convex topographic profile with a maximum slope gradient equal to 32%. Soil characteristics were similar to those in CO in terms of type, gravel content and texture. BE was situated in the Sierra of Contraviesa. The 48-m-long south-facing BE hillslope had a rectilinear–concave topographic profile, a maximum slope gradient of 30%, Palaeozoic metamorphic geological substratum (Alpujarride Complex, mica-schists). Some erosion morphologies of concentrated overland flow were observed (rills). Soils were very limited because of erosion by water: haplic Leptosol with Regosol at the bottom of the hillslope, loam–sandy texture, abundant gravel and thickness not exceeding 20 cm. In general, soil properties were not so degraded as it could be expected when climatic conditions became more arid. Only this tendency was observed in the organic carbon content and aggregate stability which diminished from CO to BE.

3. Methods

3.1. Analysis of vegetation pattern

After selecting the three field sites, we defined three open plots located at the top, middle and bottom section of each hillslope with a dimension of 5×5 m. The plot vegetation cover was described

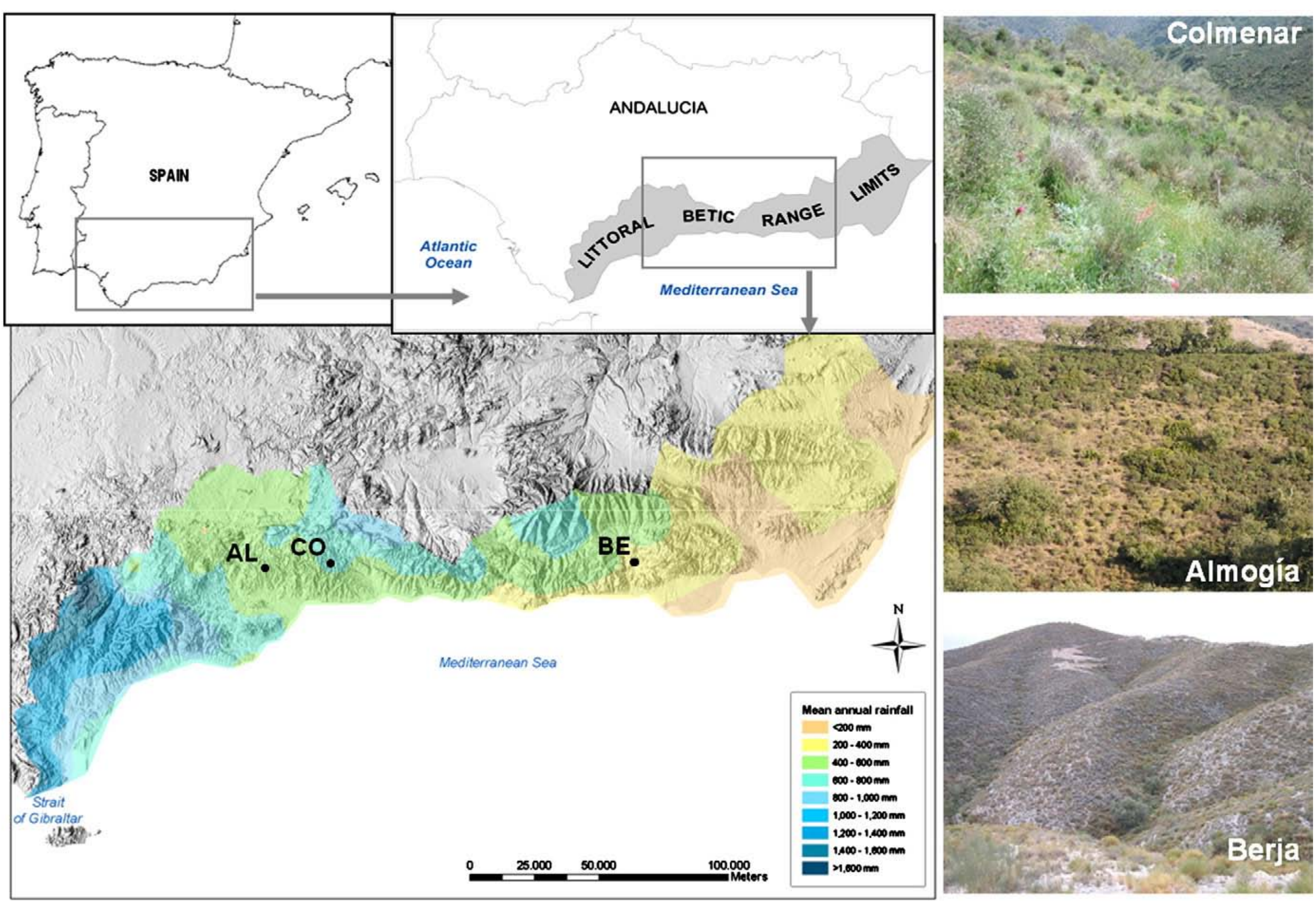

Fig. 1. Location and general view of the field sites.