



Plant species composition and richness in abandoned agricultural terraces vs. natural soils on Lanzarote (Canary Islands)



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ABSTRACT

Farmland abandonment constitutes a major land use change, with its importance acknowledged today due to the implications it has for biodiversity and cultural values. The present paper analyzes the vegetation of several groups of abandoned agricultural terraces on the island of Lanzarote. Species composition, species richness and vegetation cover were examined and the terraces were compared to non-terraced soils (uncultivated, natural-soil control plots) in similar environmental conditions.

The number and diversity of species were found to be significantly higher in the terraced plots than in the control plots. Of the total species identified (41), five did not appear in the abandoned terraces, while sixteen were not present in the control plots. In addition, vegetation cover was significantly greater in the abandoned terrace fields than in the control plots. Canonical Correspondence Analysis (CCA) did not throw up differences in species composition between the abandoned terraces and control plots, while only a small number of environmental variables (mean temperature, annual precipitation, and sand percentage) proved significant in accounting for species distribution. Despite the absence of differences in species composition, we were able to create a gradient of preferences from abandoned fields to the control plots. Species behave individually in accordance with these environmental requirements.

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1. Introduction

Owing to urbanization, globalization and desertification, the abandonment of agricultural land is currently one of the main land use changes in developed countries (Geeson et al., 2002) and, as is becoming increasingly apparent, can lead to a potential loss of diversity and cultural values (Rackham, 2008; Palmer et al., 2010). A further increase in land abandonment is anticipated in the near future (Rounsevell et al., 2006): in the European Union, for example, an expected annual rate of abandonment of 3–4% of the total agricultural area has been reported. In Spain, the expected rate until 2030 will be 0.8% of total area per year (Keenleyside and Tucker, 2010). For its part, the government of the Canary Islands calculates that 60% of agricultural land has been abandoned in the archipelago in recent decades (<http://www.gobcan.es/agricultura/>

[temas/agricultura](#)). No specific programs exist for the restoration of these areas, largely due to the problems encountered in identifying the landowners but also due to the different soil categories, different forms of management, etc. This study seeks to provide management recommendations for such lands.

The cessation of extensive farming in the developing world has led to a substantial increase in dry grasslands and dwarf shrublands in marginal lands (Hernández, 1997). These abandoned terraces may be vulnerable to erosion due to the sparse initial vegetation cover, unfavorable soil properties and lack of maintenance of soil and water conservation structures (Gallart et al., 1994; Imeson et al., 1998). For erosion mitigation, restoration and reforestation, and in order to design specific management programs, it is important to understand how the vegetation and soil properties of these abandoned terraces change and how vegetation patterns develop (Lesschen et al., 2008). Changes in vegetation patterns may be an indication of the onset of desertification in arid areas, although in some cases positive aspects can arise from the abandonment of the lands as changes in vegetation cover may occur, affecting the

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availability of water resources and soil properties (Ruecker et al., 1998; Lasanta et al., 2000).

In Mediterranean areas, vegetation recovery cannot always be considered spontaneous after farmland abandonment, as various studies have shown (Tzanopoulos et al., 2005; Rackham, 2008; Palmer et al., 2010). Despite the specific characteristics of the sites studied, some general patterns emerge from such studies: the secondary succession after abandonment commences initially with annual or biannual plants and is followed by perennial forbs, grasses and shrubs in sub-humid Mediterranean climates (Lesschen et al., 2008). Meanwhile, Bonet (1997) found in semi-arid Mediterranean areas that annual plants and short-lived perennials present greater cover and species richness during the first phase of abandonment, forbs during the second and, finally, woody species after 10 years of abandonment. However, these colonization patterns are greatly affected by soil water holding capacity, weather conditions or terrace management. Although the number and composition of species are a good indicator of changes in pasture areas and in agricultural areas (Fernández-Lugo et al., 2011), some authors have found not relationship among these parameters and changes in management (Garnier et al., 2004).

The recovery of abandoned field vegetation is considered to be very rapid in some areas (2–3 years: Palmer et al., 2010) but slow in others (more than a decade: Lesschen et al., 2008). It should be noted also that vegetation is one of the key factors controlling overland flow generation, with runoff from bare patches infiltrating vegetated patches (Ludwig et al., 2005) thus making overland flow highly discontinuous (Cerdà, 1998; Lavee et al., 1998).

Many studies report that the soil loss from cultivated slopes is greater if conservation measures, such as terraces are not included (Arnáez et al., 2015) and terraces conservation is still considered to be one of the most advisable and effective measures for soil conservation (Wheaton and Monke, 2001). These terraces favor the natural plant colonization at a very rapid rate of plant succession (Palmer et al., 2010), but the conservation of the terraces is needed. Agriculture was the main economic activity in the Canary Islands prior to the 1960s. The high dependence on local production was characteristic of Lanzarote, where almost 20% of the landscape was under terrace management. The abandonment of terraces due to the migration of labor from agriculture to tourism services became evident in the space of just a few years (Martín, 2000). These negative effects are more intense in the case of Lanzarote, where almost a 50% of the surface is suffering high or medium intense eolic erosion (Rodríguez and Mora, 2000). This is a problem suffered by the Canary Islands as a whole, where – due to widespread erosion – soil loss is on the increase in tandem with terrace abandonment.

In our study we analyzed 50 groups of selected terraces on the island of Lanzarote, all of which were abandoned between 40 and 15 years ago. Traditionally, these poor soils were covered with tephra mulch to increase fertility, a technique that helped reduce salinity, sodicity and B content (Díaz et al., 2005). In the abandoned terraces and adjacent non-terraced fields we evaluated species composition, diversity and richness, as well as vegetation cover, in relation to soil physical parameters and environmental variables. Our main aim was to describe the plant community in these areas in order to determine whether ecological problems prevented the recovery of these plant communities and whether conservation actions are required to restore the abandoned areas. More specifically the following hypotheses were tested: i) vegetation composition is determined by environmental factors 40–15 years post-abandonment more than by terracing effects, ii) species richness and diversity are similar in the abandoned terraces and control soils, and iii) species composition differs in the terraced vs.

non-terraced plots.

Soil erosion following destruction of vegetation cover is the most common form of soil degradation in the Mediterranean (Ruecker et al., 1998) and in Canary islands. Conservation strategies and design suggestions for terraced landscapes, which are considered a cultural heritage of historical and human value, are extensively defended in the literature (Stanchi et al., 2012) and, even if they are economically non-viable, there are grounds to justify managing these terraces as in the past given the services they provide to ecosystems (vegetation recovery, protection against erosion and runoff, etc.).

2. Material and methods

2.1. Study site

The study was carried out on Lanzarote (Fig. 1), the north-easternmost of the Canary Islands (Spain). This arid/semi-arid island is 862 km² in size and is formed by basaltic rocks of volcanic origin. It is situated in the Atlantic Ocean, approximately 115 km off the west coast of Africa, between parallels 29°17 and 28°02 north latitude and meridians 13°25 and 14°30 west longitude. Annual precipitation on most of the island is below 150 mm, with no part receiving more than 300 mm yr⁻¹. Rainfall is seasonal (October to March) and presents high inter-annual variability. The high solar radiation (7.8 h sunshine per day), high temperatures (annual average of 18 °C) and moderate-strong winds produce extremely high potential evaporation rates (≈ 1800 mm yr⁻¹ in evaporation pan) (Tejedor et al., 2003).

Mass abandonment of the farming terraces commenced in the 1960s, largely as a result of the tourism boom and the resulting demand for labor in the construction and tourist industries, and has continued to the present day. Although feral goat grazing is common, it is limited to specific areas of the island.

At the end of the 1960s 9753 ha of terraces were active in Lanzarote, of which only 3400 ha remained by the late 1990s (Acosta, 2004). All the terraces selected for this study were abandoned during this period. Although a specific date cannot be given for the abandonment of each terrace, all have lain abandoned for a period of 40–15 years.

2.2. Sampling design

A total of 50 paired plots – 25 abandoned terraces and 25 non-terraced adjacent areas (hereafter “control plots”) – were sampled in June 2012 to measure the effects of terracing on vegetation characteristics. Terraced fields were farmed regularly until the 1970s when most were abandoned. Few of them continued to be cultivated until the 1990s and the exact date of abandonment is uncertain. Based on information provided by local inhabitants and environmental services, a range of 40–30 years for abandonment has been established in the plots studied that cover all of these terraces. The non-terraced soils adjacent to the terraced plots, which were never cultivated during the past century, were used as reference soils since they were considered typical of the soils developed under natural ecological conditions of the area. Environmental differences in the terraced and control soils were minimal because plot pairs were almost adjacent, avoiding border areas. For the most part, cereals and potatoes were the dominant crops in these fields, with fertilization based on homemade compost. Although feral goat grazing is common, it is limited to specific areas of the island.

Sampling during the summer period allows better identification of the permanent plant community than spring sampling, given that in the latter period annual and opportunistic species can

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