Chapter 14
Abandonment of Agricultural Land, Agricultural Policy and Land Degradation in Mediterranean Europe

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Abstract Abandonment of agricultural land has been widespread phenomenon throughout Western Europe since the middle of the last century; a trend that up until the mid 1990s was exacerbated by the European Common Agricultural Policy. Typically, in dryland parts of Europe, abandonment of these agricultural areas causes them to revert to scrubland. Land abandonment does not result in a single response. This chapter examines examine the various deleterious processes of landscape change that may result from land abandonment in dryland regions of Europe, the changing patterns of vegetation that may result, and their environmental consequences. Abandonment of agricultural land almost always results in an increase in vegetation cover. Deleterious consequences include the formation of stone pavements, soil crusting, and gully formation. In lowland settings abandonment of terracing can lead to landsliding, terrace destruction and an increase in catchment connectivity. Responses to land abandonment vary widely dependent on conditions prior to and at the time of abandonment and according to the type of vegetation that colonizes the abandoned land. In the long term agricultural abandonment leads to the development of spatial pattern in the vegetation, which can confound simple relationships between vegetation cover and runoff and erosion rates. Empirical studies have documented the complexity and diversity of changes that accompany such degradation. Modelling the effects of abandonment of agricultural land is in its infancy, but is vital for informed policy-making. A more holistic view is needed of the effects of abandoning agricultural land so that the environmentally sound policies can be implemented.

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14.1 Introduction

Abandonment of agricultural land has been widespread phenomenon throughout Western Europe since the middle of the last century. Traditionally, increases in agricultural production have been accommodated through increases in the area of cultivated land (Slicher van Bath 1963), but more recently they have been obtained through greater productivity. A consequence of the higher yields achievable through a combination of mechanisation and the use of pesticides and fertilizers has been rural depopulation and the abandonment of both grazing lands having low stocking rates and areas of low-input arable land. Up until the mid-1990s, this trend was exacerbated by the European Common Agricultural Policy (CAP) (Strijker 2005). Even so, Bignall and Mc Cracken (1996) estimated that 82 % of farmland in Spain still fell into the category of low-intensity systems. A second cause of abandonment of agricultural land is its misuse. Land is abandoned because productivity falls due to erosion, loss of fertility, and poor soil management. Typically, in the dryland parts of Europe (see Fig. 1.1) abandonment of these agricultural areas causes them to revert to scrubland. For example, within the Encinares del Rio Alberche y Cofio, Special Conservation area in central Spain, Romero-Calcerrada and Perry (2004) showed an approximate doubling of scrubland between 1984 and 1999 and, correspondingly, a more than halving of the pastureland, and a smaller reduction in cropland.

These pressures on low-intensity agricultural land are expected to continue into the future as the benefits of increased mechanisation of agriculture are expected to remain high (Strijker 2005). For the most part the pressures will be focused on the most marginal agricultural land, but this is not always the case. In some environments the abandonment of agriculture is considered beneficial. Increased vegetation cover may reduce soil erosion and increase plant biodiversity, thereby providing habitats for a wider range of animal species. However, in a dryland setting such benefits may not be achieved so that policies such as set-aside, whereby farmers were paid to take land out of production, pursued until 2008, far from have environmental benefits, may have resulted in further land degradation. Furthermore, the replacement of the mosaic of agricultural land with a more uniform scrubland may decrease habitat variety and hence biodiversity (Hill et al. 2008).

It is not the case that land abandonment results in a single response. Studies of the effects of land abandonment have often reported conflicting results, and their differences may often be a result of local circumstances and the nature of land abandonment. In this chapter we focus on the detrimental effects of land abandonment. We examine the various deleterious processes of landscape change that may result from land abandonment in dryland regions of Europe, the changing patterns of vegetation that may result, and their environmental consequences. The review is based on existing literature, which shows considerable spatial bias within the dryland areas of Europe. In comparison to other countries, much work has been undertaken in Spain. Consequently, many of the examples used in this chapter are drawn from this country.

14.2 Landscape Processes Consequent upon Agricultural Abandonment

Several forms of agricultural abandonment may be identified, for which the process responses may differ. However, in almost all cases it eventually results in an increase in vegetation cover. The widely held view is that an increase in vegetation cover results in a reduction in runoff and erosion (Elwell and Stocking 1976; Francis and Thornes 1990). However, significant divergences from this typical response have been observed within Mediterranean Europe. Shrub colonization following abandonment of sloping farmland in the Central Pyrenees was reported to reduce runoff and sediment yield (Ruiz-Flaño et al. 1992; Ruiz-Flaño 1993), but the use of fire to reduce shrub cover and improve grassland for grazing resulted in rill and sheet erosion with the result that the fields became stone pavements. The significance of wildfires on abandoned farmland has also been identified by Puigdefabregas and Mendizabal (1998), who reported an increase in Spain in the annual area burnt by fires by 600 % between 1960 and 1990 (Prieto 1993).

In Portugal, abandonment of lowland farmland has led to crusting of soils, high runoff coefficients and sediment yields (Nunes et al. 2010). Soils rich in sodium are particularly susceptible and show cracking and very slow rates of plant colonization. As a result of slow colonization of plants, abandoned fields in Spain have been shown to be subject to gully formation and, in some cases, the development of badlands (López-Bermúdez and Romero-Díaz 1989; Cerdà 1997). Abandonment of lowland agricultural land in southeast Spain that has been subject to terracing has been shown to result in the collapse of terrace walls due to small landslides (Lasanta et al. 2001). Whereas prior to abandonment such damage to terraces was repaired, in the absence of such maintenance it may result in the development of piping (Romero-Díaz et al. 2007), and the formation of gullies (Lesschen et al. 2008a, b). The latter authors calculated rates of erosion on abandoned terraces of 87 Mg ha^{-1} a^{-1}, which is of the order of that reported in some semi-arid badlands. Lassanta et al. (2001) showed that, following small landslides, trampling by livestock contributed to erosion of landslide scars. Although plant recolonization after abandonment was found to have occurred in a study in southeast Spain by Cammeraat et al. (2005), thereby reducing shallow landsliding, a rapid decrease in soil permeability with depth resulted in more deep-seated failures that the plant roots were powerless to prevent. A further effect that has been reported for abandoned terraced agricultural land has been an increase in connectivity in the drainage network. Whereas well maintained terraces increase infiltration, their breaching allows runoff to progress from one terrace to the next. Meerkerk et al. (2009) reported a 3.2-fold increase in the area contributing sediment to a river system in southeast Spain between 1956 and 2006, and estimated that if all terraces were removed there would be a further 6-fold increase compared to the 2006 estimate.

A key factor (*ceteris paribus*) in the fate of abandoned land may be the state of the land at the time of abandonment. Dunjó et al. (2003) examined the physicochemical properties of soils under a range of land uses in Northeast Spain. They found that cultivated and recently abandoned locations had the lowest values for soil organic matter, nitrogen and water-holding capacity, and argued that soil management and condition at the time of abandonment were crucial in maintaining soils against progressive degradation. In a study on a range of substrates in Lesvos, Komas et al. (2000) identified a critical limit for soil depth, below which shrubby vegetation would not regenerate following land abandonment. Furthermore, this critical depth varied with substrate as a result of the different water-holding capacities of soils on these substrates. These authors defined two soil depths, termed *critical* and *crucial*, that are important for the consequences of land abandonment. Below the critical depth (between 25 and 30 cm) recovery of natural vegetation is very slow and erosion processes may be very active. The crucial depth (4–10 cm) is that below which perennial vegetation cannot be supported and any soil remaining at the time of abandonment will be eroded away.

A particular type of abandonment is that reported by Piccarreta et al. (2006), which characterises the consequences of changing CAP policy during the 1990s. Following subsidies to cultivate wheat, areas of former badland in Basilicata, Italy were remodelled to facilitate their use for agriculture (Reg. CEE 1765/92). This remodelling comprised flattening of landforms, reduction of gradients and breaking up of the soil surface. The subsequent implementation of set-aside (Reg. CEE 2078/92) led to the abandonment of many of these areas of cultivation, especially the former badlands which had low productivity. As a result rills, gullies mudflows and landslides led to significantly enhanced rates of soil erosion.

What is evident from these examples is that the response to land abandonment varies widely dependent on conditions prior to and at the time of abandonment. In addition, responses may vary according to the type of vegetation that colonizes the abandoned land. Bochet et al. (2000) showed distinct differences in the ability of *Stipa tenacissima*, *Anthyllis cytisoides* and *Rosmarinus officinalis* to control runoff and sediment loss. Consequently, in response to both pre-and post-abandonment differences the effects of land abandonment on land degradation will always be locally controlled. Empirical studies of the type reviewed in this section, therefore, have done no more than build up a body of case studies. From such cases studies it is difficult, if not impossible, to make predictions about the effects of land abandonment under any one set of environmental conditions. The multidimensionality of the controls and their interactions renders a sufficiently large data set a daunting task. Furthermore, typically these studies contrast pre-and post-abandonment with little attention to the sequences of change in the long term.

14.3 Long-Term Effects of Land Abandonment

One of the most significant changes that occur when agricultural land reverts to scrubland is the development of spatial pattern in the vegetation. In studies of runoff and erosion rates in semi-natural dryland vegetation, Parsons et al. (1996) attributed the greater rates of runoff and erosion on shrubland compared to grassland largely to differences in the spatial patterns of the two vegetation communities. Similarly, Puigdefabregas (2005) argued that vegetation-driven spatial heterogeneity in the landscape could confound simple relationships between vegetation cover and runoff and erosion rates. This argument accords with the findings of Parsons et al. (1996) on shrubland and grassland which showed a greater vegetation cover on the former (44 %) than on the latter (33 %). Cobo and Carriera (2004) showed that crop abandonment and colonization by *Artemisia* enhanced soil heterogeneity which, in turn, promoted heterogeneity in the growth of *Ratama* leading to enhanced erosion in inter-spaces.

The development of spatial heretogeneity in vegetation and soil properties after abandonment of land formerly used for cereal production was studied by Lesschen et al. (2008a, b) at a site in Southeast Spain. These authors used a space-for-time approach by studying two sequences of fields ranging from currently fallow through recently abandoned, long abandoned to semi-natural vegetation (unused for more than 50 years). Their study showed that vegetation recovery in semi-arid environments appears to be very slow such that species typical of abandoned land were present even after 40 years. The recovery rate was shown to be two to three times that of more humid environments (e.g. Beaufoy 2001) and, consistent with Kosmas et al. (2000) differed with substrate. This study also showed that vegetation patchiness increased with time since abandonment. The significance of vegetation patchiness for connectivity in runoff and sediment dynamics is examined further in Sect. 9.4.

Although space-for-time substitutions of this type allow greater insight into sequential differences following land abandonment, they are incapable of providing an understanding of the dynamics of change. Furthermore, they suffer from the same fundamental weakness of the before and after studies, namely that they can be no more than case studies of a set of changes that have been shown to be extremely variable in response to local conditions.

14.4 Modelling the Effects of Land Abandonment

In contrast to the relative wealth of empirical studies of responses to land abandonment, there has been a relative dearth of modelling studies that examine the effects of land abandonment on vegetation characteristics, runoff and erosion. One of the few studies to take a modelling approach has been that by Boer and Puigdefabregas (2005) who used a distributed soil erosion model to simulate the effects of vegetation patterns on runoff and sediment production. They used autocorrelation length to characterise patch size and showed that under most conditions spatially structured vegetation led to higher runoff rates compared to a spatially uniform vegetation cover, and that this difference varied with storm intensity, being highest for intermediate (40–50 mm h^{-1}) intensities (see Fig. 14.1). Similarly, more erosion was observed from the spatially structured vegetation (see Fig. 14.2).

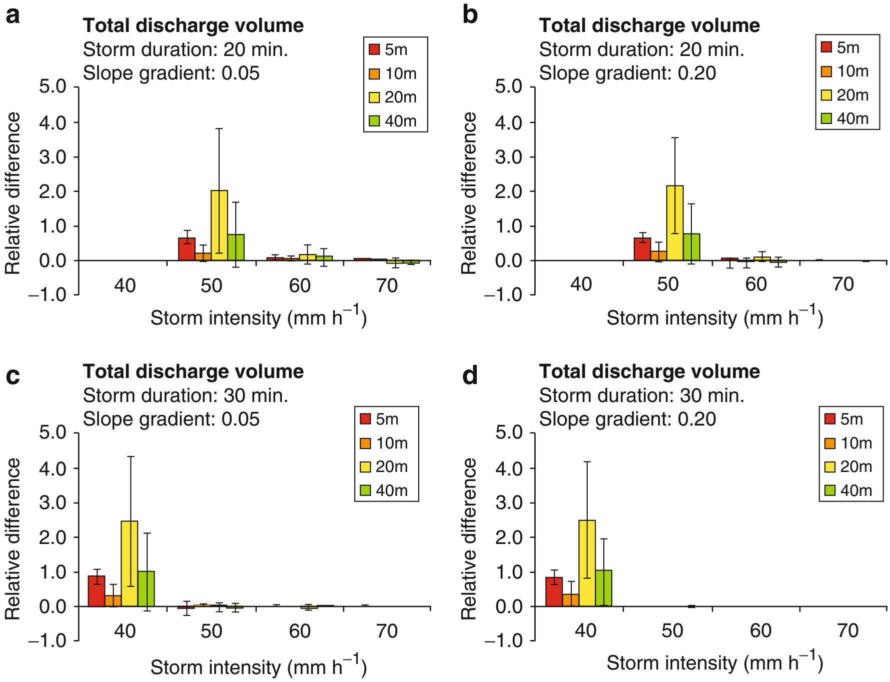

Fig. 14.1 Relative differences in predicted runoff coefficients in response to storms of 20 min (**a**, **b**) and 30 min (**c**, **d**) and different intensities among hillslopes with different spatially structured vegetation (autocorrelation lengths 5–40 m). The graphs show mean values and standard deviations for three realizations of each vegetation pattern (After Boer and Puigdefabregas 2005)

A somewhat more conceptual modelling approach is that presented by Garcia-Ruiz and Lana-Renault (2011), who propose patterns of change in runoff and erosion dependent upon the land use prior to abandonment (Fig. 14.3). These authors propose that runoff and erosion may either decrease or increase following abandonment leading in time to totally degraded stone pavement or stable shrub cover or forest.

The modelling approach presented by Boer and Puigdefabregas (2005) does allow the exploration of scenarios of land abandonment that, provided with suitable validation (as is given by these authors), and may overcome the weakness of a compendium of empirical case studies. However, what is lacking from this study is any understanding of the dynamics of change since it is based on steady-state runs of the LISEM soil erosion model with different input parameters. If the conceptual model of Garcia-Ruiz and Lana-Renault (2011) is to developed into a tool for both understanding the thresholds that govern which of the two proposed endpoints is reached at any location and for management purposes, then the dynamics of change need to be modelled. Such dynamics will need to incorporate at least all of the various processes described in Sect. 14.2.

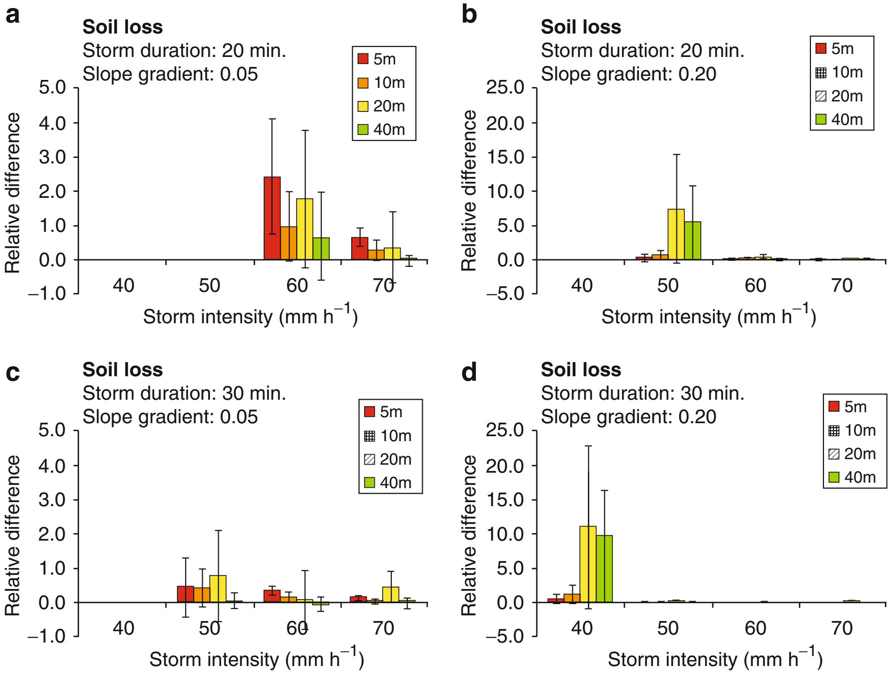

Fig. 14.2 Relative differences in predicted soil loss in response to storms of 20 min (**a**, **b**) and 30 min (**c**, **d**) and different intensities among hillslopes with different spatially structured vegetation (autocorrelation lengths 5–40 m). The graphs show mean values and standard deviations for three realizations of each vegetation pattern (After Boer and Puigdefabregas 2005, reproduced with permission of John Wiley & Sons)

14.5 Conclusion

Abandonment of agricultural land in the dryland parts of Europe has occurred in response to societal and technological changes, but also in response to agricultural policies within the European Union. The environmental changes that have taken place on this abandoned land have been unplanned, and in many instances led to unforeseen consequences in terms of land degradation. The process looks likely to continue through the coming decades, so that further land degradation is likely if current practices are continued. Against this background, there have been numerous empirical studies that have documented degradation and process changes that accompany such degradation. What these empirical studies have highlighted most of all is both the complexity and the diversity of responses to the abandonment of agricultural land. Modelling the effects of abandonment of agricultural land is in its infancy and has failed to take advantage of the wealth of empirical data to develop a dynamic understanding of land degradation. Such modelling is vital for

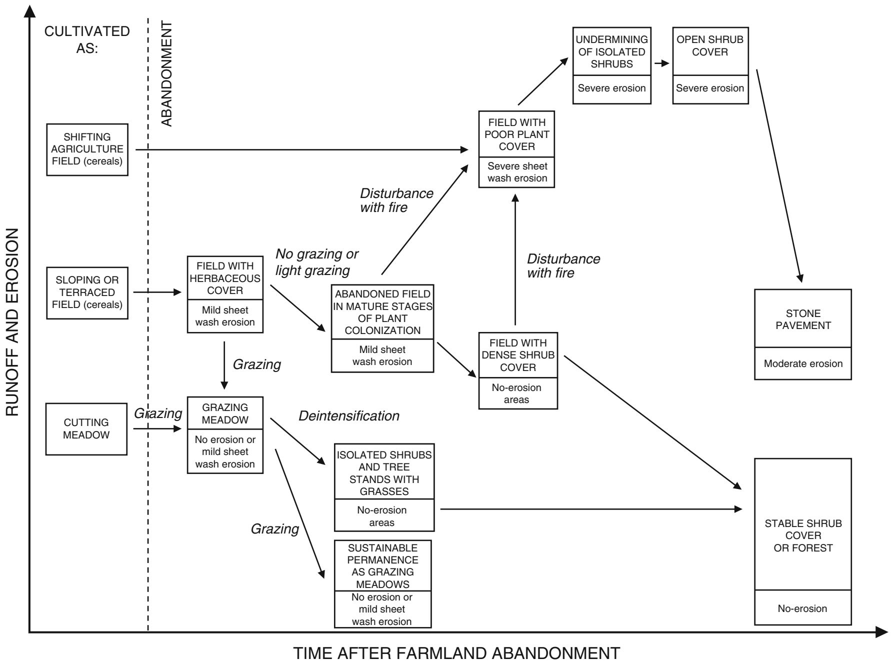

Fig. 14.3 Evolution of runoff and erosion after farmland abandonment under three scenarios: abandonment after use for shifting agriculture, sloping or terraced fields, and cutting meadows (Garcia-Ruiz and Lana Renault 2011, reproduced with permission of Elsevier)

informed policy-making. Furthermore, a more holistic view is needed of the effects of abandoning agricultural land so that the environmentally sound policies can be implemented.

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