Managing abandoned farmland to control the impact of re-vegetation on the environment. The state of the art in Europe

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ABSTRACT

Background and Aims: In the last decades, large areas undergo a revegetation process as a result of land abandonment, producing significant environmental and landscape impacts. In this paper, revegetation impacts are identified. We present the solutions proposed by scientists to control the negative impacts of revegetation, from a literature review from studies carried out in Europe.

Results: Some scientists suggest letting the revegetation process continued to contribute to the naturalization of the landscape, reduce soil erosion, increase carbon sequestration and encourage recreational use of the territory. Other scientists, however, suggest the need to control the revegetation processes and retrieve abandoned land with productive purposes (extensive livestock and leisure), environmental objectives (reduction of fires and increasing biodiversity) and preserve cultural landscapes.

Conclusion: The scrubland clearing and extensive livestock is an appropriate strategy to manage abandoned lands, combining environmental, landscape and socio-economic benefits.

Keywords: Mediterranean landscape; Rural abandonment; Forest expansion; Rewilding; Vegetation management; Scrub clearing.

1. Introduction

Human activity transformed the vegetation and landscape in Europe, at least 7000 years ago, by deforestation and ploughing, to use land for crops and livestock (Grove and Rackham, 2000; Roberts, 2014). However, since the mid-20th century, with some precursors in the 19th century, the situation has been reversed and large areas of land in Europe have been abandoned (MacDonald et al., 2000; Serra et al., 2008; García-Ruiz and Lana-Renault, 2011), a process that is forecast to continue over the next decades (Rounsevell et al., 2006; Nowicki et al., 2007; Pointereau et al., 2008).

The initial and most visible consequence of land abandonment is re-vegetation through secondary succession. Re-vegetation can reduce soil erosion, increase biodiversity and create carbon sinks (Vallejo et al., 2006). Nevertheless, it can also lead to a reduction in many semi-natural, open habitats that were formerly maintained by traditional land management, causing

significant impacts on the landscape, biodiversity, the ecosystems dynamics and sustainability of the region (Marty et al., 2003, Kleijn et al., 2006). Hence, land abandonment is seen as one of the land use changes with important environmental and socio-economic impacts (San Román et al*.,* 2013; Beilin et al., 2014). These impacts can be positive or negative depending on local factors and the aims of conservation (Höchtl et al., 2005). Authors such as Keenleyside and Tucker (2010) stated that, in some cases, plant re-colonization and the disappearance of open spaces endanger semi-natural habitats causing a decreased in biodiversity. However, in other cases, abandonment might be beneficial as it helps restore natural habitats, particularly in landscapes highly fragmented by human activity (Haddad et al., 2015).

However, it must also be remembered that when mountain land is abandoned, the after-effects reach the lowlands, since the mountains provide these with resources and essential services, such as water supply, soil protection, forest and pasture, leisure areas, cultural landscapes, etc. (Ives, 1992; Mottet et al., 2006; Viviroli et al., 2007). Price (2004) stated that the mountains constitute the fundamental basis for life for about one tenth of the world's population, but they also provide goods and services to over half the world's population. However, these goods and services are endangered because of land abandonment (MEA, 2003). Thus, scientists, managers and those responsible for policies on land conservation have recently shown a growing interest in abandoned lands and their impacts on the landscape, biodiversity and ecosystems (Kates et al., 2001; Gellrich et al., 2007; Morán-Ordoñez et al., 2011).

This paper examines current knowledge of the impact of land abandonment on the environment and landscape, and the solutions proposed by scientists.

2. Land abandonment and the plant succession process

Land abandonment in Europe has occurred over the last two centuries and at first affected the mountain hillslopes, as these had a limited ability to compete in a global market (MacDonald et al., 2000). In the last thirty years, the abandonment process has spread to some lowlands, due to policy change in the countries of the former USSR, measures taken by the Common Agricultural Policy (CAP) to reduce production, and building on arable land of tourist resorts (Lesschen et al., 2007; Keenleyside and Tucker, 2010).

García-Ruiz and Lana-Renault (2011) stated that arable land in Europe has been abandoned in two different ways. On one hand, there is spontaneous abandonment, which affects mountain areas as a result of the gradual or sudden collapse of mountain societies. It also occurred in some semi-arid zones in south-east Spain in the 1970s because of soil salinization and a lack of water. On the other hand, abandonment has arisen from governments or EU policies. It only has affected specific areas, mainly plains and foothills. The CAP gave incentives for temporary (*set-aside*) or permanent (*land retirement*) abandonment of farmland between 1988 and 2008, in order to reduce over-production and costs for storing the excess (Walford, 2002). There is yet a third type of abandonment that could be called semi-induced. This has taken place in central and eastern Europe since 1990 following the restoration of lands to their former owners after the fall of communist regimes. The lack of interest in agriculture in many owners, that had emigrated to cities decades ago, or the lack of funds to start up a business led to the abandonment of many farms (Bell et al., 2010). Land abandonment was also promoted by the

collapse of collective farming, farmer retirement and young people emigration to cities (Pasakarmis and Maliene, 2009).

It is not easy to know how much land has been abandoned in Europe, since quantitative information is scarce before to 1970. Maps of abandoned land are very difficult to make, because the traces of former cultivated fields have disappeared due to the plant succession. In some mountains of Europe, Lasanta (2014) concluded that more than 75% of their arable land is no longer worked, a percentage that reaches 100% in some Mediterranean mountains. More information exists on recent abandonment. Feranec et al. (2010) studied the changes in agricultural use for 25 countries in Europe between 1990 and 2000, based on the Corine Land Cover, and concluded that changes in land use - mostly toward abandonment - affected 88,000 km^2, equivalent to 2.5% of the total area. Van Dijk et al. (2005) judged that between 10% and 20% of agricultural land has been abandoned in central and eastern Europe since 1990. It is also predicted that this process would continue in Europe over the coming decades. Nowicki et al. (2007) proposed an optimistic scenario where only 0.7% of farmland in Europe had been abandoned. Other authors raised the abandonment to 6.7% (Rienks, 2008; Verburg and Overmars, 2009).

Secondary succession or plant colonisation starts after land has been abandoned. This process conditions the structure of the landscape, biodiversity, fire regime, water availability on various spatial scales, soil conservation, and the provision of pasture (MacDonald et al., 2000; Pelorosso et al., 2009; Arnáez et al., 2011). Plant colonisation is a highly complex process, as it depends on multiple natural and human factors. Among the former are edaphic characteristics, topography of the hillside, climate, lithology and the distance to natural plant cover. Among anthropogenic factors are abandonment age, management during the period of cultivation and its ending, with emphasis on the use of livestock and fire (Gibson and Brown, 1985; Teira and Peco, 2003). Vicente-Serrano et al. (2005), Mottet et al. (2006) and Gellrich et al. (2007) maintained that, in plant succession patterns, bio-physical factors have as much weight as social ones.

The plant colonisation process is carried out in successive stages that gradually become more complex and whose speed depends on environmental conditions and human management. Within very few years (3-5), depending on soil fertility and climate conditions, the plot can be colonised by a very dense herbaceous cover, at least in wet and sub-humid areas, forming grazing or pasture meadows. If the pressure of animal grazing is relatively high, the fields can be used for pasture for decades. With lower grazing, scrubland creeps up soon. At first, the less demanding plants in terms of soil fertility arrive, and later others forming part of more developed communities (Tasser et al., 2007; Tzanopoulos et al., 2007; Sluiter and De Jong, 2007; Verburg and Overmars, 2009). The persistence and density of the scrubland cover depend to a large extent on wildfires (Pausas, 2003; Dunjó et al., 2003; Chauchard et al., 2007). If there are no fires and there are fertile soils, acceptable soil humidity and trees nearby, plant succession advances rapidly and within a few decades (less than 5) an abandoned arable field can become a dense wood (Nelson, 1990; Debussche et al., 1999; Taillefumier and Piégay, 2003; Tasser et al., 2007; Gellrich et al., 2007; Kuenmerle et al., 2008; Björnsen Gurung et al., 2009). However, scrubland can persist on thin, badly structured and eroded soil for decades, even though there is sufficient rainfall to develop forest and the woodland is relatively close to

the abandoned field. This often happens in the Mediterranean mountains (Pueyo and Beguería, 2007; Acácio et al., 2007) and also occurs in semi-arid areas, due to a high radiation, scarcity of water in summer and competition among plants for resources (Rey Benayas et al., 2002; Bonet and Pausas, 2004).

3. Environmental effects of re-vegetation after land abandonment

Abandoning farmland may give rise to a wide variety of environments depending on the balance between plant succession and soil erosion (Hobbs and Cramer, 2007; García-Ruiz and Lana-Renault, 2011). In some scenarios with favourable conditions, it can lead to forest ecosystems in a very short time. However, evolution towards the ecosystems prior to agriculture in others may stop, progress very slowly or become something completely different. Table 1 includes the environmental effects of land abandonment.

Among the positive effects are: i) an increase in plant cover arising from secondary succession, which is a positive process on a global scale, since it helps to compensate for the loss of large areas of forest, especially in tropical countries (MEA, 2005; Cayuela et al., 2006); ii) greater absorption of CO_2, the main cause of global warming (Schröter et al., 2005); iii) an increase in biodiversity in the initial stages of plant succession, and a reduction in the middle and final stages (Sickel et al., 2003; Suaréz-Seoane et al., 2002; Höchtl et al., 2005; Zaravali et al., 2007); iv) less flooding and better regulation of the water cycle, as a result of higher interception and infiltration rates (Cosandey et al., 2005; García-Ruiz et al., 2008); vi) runoff with a smaller load of sediment, and therefore of higher quality (Nadal-Romero et al., 2013); vii) reduced soil erosion due to plant cover protection from splash and disconnection of the sediment transport network (García-Ruiz and Lana-Renault, 2011); viii) a longer useful life for reservoirs due to less sediment contribution (López-Moreno et al., 2008 and 2011).

Table 1 also shows the negative effects of abandoning farmland. The most obvious are: i) a higher risk of starting and propagating fires because of increased plant biomass from plant succession (Scarascia-Mugnozza et al., 2000; Chauchard et al., 2007; Serra et al., 2008; Pausas and Keeley, 2009; Oliveira et al., 2014); ii) the loss of arable land and pastures, which could be essential for the sustainable development of mountain communities (Laguna and Lasanta, 2003; Bernués et al., 2005; García-Martínez et al., 2008); iii) reduced biodiversity in the medium and long term, at the same time as open spaces disappear with the advance of scrub and forest, causing the disappearance of species adapted to man-made environments (Nikodemus et al., 2005; Marini et al., 2008; Geri et al., 2010); iv) a reduction in river flows and less water in basins, relating to lower runoff coefficients due to increased vegetation (higher interception and consumption), which is very important in Mediterranean areas where water is a scarce resource (Beguería et al., 2003; López-Moreno, 2008 and 2011); v) uniform landscapes through the loss of farmland (Jongman, 2002; Nogués-Bravo, 2006; Sitzia et al., 2010); vi) the loss of cultural landscapes and management techniques required for their conservation, as they constitute an almost perfect symbiosis between nature and human management (Antrop, 1993; Lasanta et al., 2013; Sluis et al., 2014).

The effects may be positive or negative, depending of several circumstances, such as the place and date of abandonment, the subsequent management, the perception and value of a landscape by a social group, and the conservation objectives pursued (Hobbs and Gramer,

2007; Keenleyside and Tucker, 2010). Table 1 includes the main variable effects contained in the literature:

i) A possible increase in forestry production, which could provide incentive for economic development and, indirectly, maintain biodiversity and some features of the traditional landscape (Navarro and Pereira, 2012); however, other authors think that logging and forest by-products are not very profitable in Europe because of poor quality (Conti and Fagarazzi, 2005).

ii) Ecosystem services could be positively affected (regulation of discharges; higher carbon sequestration, etc.) or negatively (reduced flows, greater fire risk, disappearance of cultural landscapes, loss of biodiversity), with varying consequences depending on the area (MacDonald et al., 2000; Pereira et al., 2005).

iii) *Re-wilding* is seen by some as a positive effect, as it promotes a more natural landscape, reduces erosion and recovers wild animals (Gillson et al., 2011; Navarro and Pereira, 2012; Sop & Oldeland, 2013), whereas others think that the European mountain is a highly cultural, humanised landscape, and these features should not be lost (Plieniger et al., 2006; Farina, 2007).

iv) Abandoning land usually means an increase in the size of patches and fragmentation of the landscape, which could affect biodiversity. In principle, larger patches help to maintain populations with a greater number of species and more diverse composition. In humanised areas, however, there are species that have adapted to mosaic landscapes, which can be substituted if the patches increase in size and open spaces are reduced (Burel and Baudry, 2002).

v) Some parts of society view and value abandoned land negatively, as it means the loss of cultural landscapes, and also because it creates a feeling that the land is badly managed (Hunziker, 1995; Höchtl et al., 2005; Benjamin et al., 2007). On the other hand, there are parts of society that place a positive value on abandoned land, arguing that an increase in natural vegetation provides aesthetic values (Rogge et al., 2007; Nijnik and Mather, 2008; Nassauer, 2011).

4. Scientists' proposals for management of abandoned land

The content of the above pages has pointed out that land abandonment and the ensuing plant succession can have positive and negative effects on the environment. Therefore, there are two suggestions on what to do with abandoned land: i) do not intervene and allow the natural process to continue (passive management); or ii) take a more critical attitude and manage the land to control negative environmental impacts. Bauer et al. (2009) and Vila Subirós et al. (2015) concluded that there is no consensus on the priorities of population about the management of abandoned land, suggesting the need to promote participatory processes with stakeholders.

Scientists who favour letting nature take its course say that re-vegetation leads to re-wilding ecosystems, which could allow an increase in wild ungulates filling the traditional role of extensive livestock farming in maintaining a diverse and stable landscape (San Miguel-Ayanz et

al., 2010). Navarro and Pereira (2012) stated that Mediterranean landscapes are more sustainable with greater re-wilding, as it reduces the risk of soil erosion. They insisted that the regeneration of forest could provide some ecosystem services, such as carbon sequestration, and serve as a leisure area for many city dwellers. Finally, they suggested that those who want to keep using mountain hillslopes for traditional agriculture, underestimate the huge amount of work that humans have to do to make it sustainable.

However, other scientists say that the advantages of re-wilding are more illusory than real (Conti and Fagarazzi, 2005). They also emphasise that the European landscape is very highly humanised, especially in the Mediterranean (Vera et al., 2006). Gill (2006) stated that historically the concept of "forest" in Europe refers to places that have trees and herbivores. This forest is more similar to a park or savannah than to a space enclosed by trees. Similarly, it is argued that the landscape in Mediterranean regions is cultural and formed by farming hillsides and extensive livestock pasturing (Farina, 2007; San Miguel-Ayanz et al., 2010). Pelorosso et al. (2011) concluded that landscapes of abandoned lands need effective management to maintain their functionality to support sustainable development.

Several scientists propose intervening in the landscape, in order to lessen the negative effects of abandoning land and breaking the trend which would lead to re-wilded landscape. They think that abandoned fields provide an opportunity for management, to set up new land uses (Cogliastro et al., 2003; Benjamín et al., 2008). Quetier et al. (2005) stated that cultural landscapes are now recognised as they maintain flora and fauna that are very important to biodiversity. Kizos and Koulouri (2006) added that it has been clearly proven that landscapes and their structure are only preserved when they are functional; therefore, cultural landscapes require maintenance work to preserve their environmental, and cultural functions. Machado (2004) suggested a diversification in land management, so that areas requiring protection are more natural, while the rest of the land must be sustainable. Le Houérou (1993) proposed lines of intervention for a more ecological management of farmland abandoned in the northern Mediterranean. These included the introduction or expansion of agri-forest systems to promote pasturing, while at the same time promoting development of tourism, the fauna, hunting and outdoor sports. Sayadi et al. (2009) indicated that recovering abandoned fields is a strategy to boost the attractiveness of the landscape, which helps to promote the sustainable development of a territory. They also pointed out that one of tourists' preferences is the abandoned farmland recovery, which is considered to be of prime importance in improving the attractiveness of the countryside. Several studies show that residential property is more expensive in mountain areas if the landscape has been created and maintained by farming (Irwin and Bocktael, 2001; Ready and Addalla, 2005). Vanslemsbrouk et al. (2005) proved that agricultural landscapes were more popular for rural tourism and that tourists were willing to pay more to holiday there.

Contributions from scientific papers have been fundamental in recent years in boosting support measures from the European Union for extensive livestock farming as an agent to maintain traditional landscapes (Mottet et al., 2006; García-Martínez et al., 2008). Petanidou et al. (2008) demanded that public administrations subsidize farmers for the upkeep of

terraces on the island of Nysiros, since they are of socio-economic, ecological and tourism value. Cullinova et al. (1999) asked for incentives for livestock farmers because of their contribution towards managing the landscape. In the French Pyrenees, Mottet et al. (2006) showed that abandoned fields could be recovered through local initiatives if the public administration helped. Quetier et al. (2005) concluded that in the Roquefort cheese producing region, public money helped grazing on natural pastures, leading to greater control over scrub and woodland.

Scientists have proposed methods for controlling re-vegetation after land has been abandoned. These include the use of animals as a tool to manage abandoned farmland both for production and environmental purposes (Mouillot et al., 2003; Calvo-Iglesias et al., 2006; Rescia et al., 2008). Gibón (2005) stated that extensive livestock farming can change a landscape of scrub to a different one, with a mosaic of land use comprising forest, pasture, shrub and meadowland. This landscape can incorporate a high production value (pasture, timber, firewood, etc.), an important ecological and cultural value (soils, pollination, bio-chemical cycles, education, leisure, etc.), the regulation of geo-system (soil conservation, water regulation, water quality, flood control, etc.) and the support of a wide variety of habitats.

The combined use of extensive livestock and scrubland clearing in selected areas with abandoned fields is proposed by various authors (Photos 1 and 2) (Lasanta et al., 2009). Sferi et al. (2005) and Lasanta et al. (2006) studied the current land uses and land covers in two Pyrenean valleys (307.7 km^2) (Figure 1A). Also they analysed the predicted scenario for the mid-21th century if the present rate of re-vegetation continues (Figure 1B), or if scrubland clearing will be carry out in selected areas of abandoned fields (Figure 1C). Figure 1 shows that, at present, the area for the scenario with scrubland clearance is more fragmented, with small patches spread across the landscape. However, in the predicted scenario, the landscape will consist of just a few, very large patches. Here, pine and deciduous forest will increase in size (Figure 2) to cover from 48.8% currently to 71.3% in the future scenario. On the other hand, mixed forest will decrease from 4,091 ha to 698 ha. Sub-alpine and alpine pastures (summer grazing) will also decrease slightly (from 3,980 ha to 3,499 ha), while meadows will double in size. Scrubland will disappear. Land cover and land use will be reduced to three types: meadows, woodland and summer pastures. Changes between the present and the managed scenarios would be reduced to a decrease in the area of scrubland (from 3909 ha to 1726 ha), and an increase in meadow (from 983 ha to 3273 ha).

Table 2 gives information on the structure of the landscape in the three situations. The Shannon and Weaver (1962) diversity index would be higher (1.938) for the shrub clearance scenario, while it would be reduced to 1.489 in the predicted scenario; on the other hand, the dominance index would be higher in the predicted scenario. In short, not intervening on the land would mean a much more uniform and less fragmented landscape, with a loss of biodiversity and greater risk of fire (Lasanta et al., 2006).

5. Conclusions

In Europe, important land use changes occur from mid-twentieth century, highlighting the abandonment of agricultural land by the collapse of some rural societies, the low land productivity, political changes and incentive measures by the EU to cease farming.

Land abandonment is the beginning of a process of plant succession leading to a scrubland landscape, which has outstanding environmental, landscape and socio-economic implications. Such implications are positive or negative depending on the scale of work, on the local factors (biophysical and management), and on the perception and valuation that a particular social group presents about landscape and conservation.

Society and scientists are divided on how to manage abandoned lands. Some of them think that it is necessary a passive management of revegetation process, with the aim of restoring natural ecosystem processes and reduce human control over the landscape. For them, land abandonment is an opportunity to improve the habitat for many species that were severely affected by landscape fragmentation during its agricultural use.

Other scientist and some part of the population propose intervene the landscape. They remark that in the present-day situation of widespread land abandonment, degradation of the landscape, less biodiversity and a loss of resources and ecosystem services, alternatives for managing abandoned farmland must be proposed in order to control the negative effects of re-vegetation processes. It must be remembered that good management of abandoned farmlands has important consequences, due to the large area they occupy and the resources and services they can provide to society as a whole. It is known that a serious breakdown of a society in one territory is the prelude to the collapse of the economy in adjoining areas.

The information provided by some authors on the beneficial effects of clearing scrubland from abandoned fields, together with grazing, allows us to conclude that it would be a suitable strategy for re-organising space in marginal areas, without heavy intervention or negative impact.

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Photo 1.
Abandoned field after the scrubland clearing in the Central Pyrenees.

Photo 2.
Abandoned fields after the scrubland clearing in the Iberian Range (Spain).

Fig. 1.

Land uses and Land covers in the Hecho and Aragüés valleys (Spanish Pyrenees). (A) Present situation; (B) expected scenario without intervention; (C) managed scenario with the scrubland clearing in selected areas of abandoned fields.

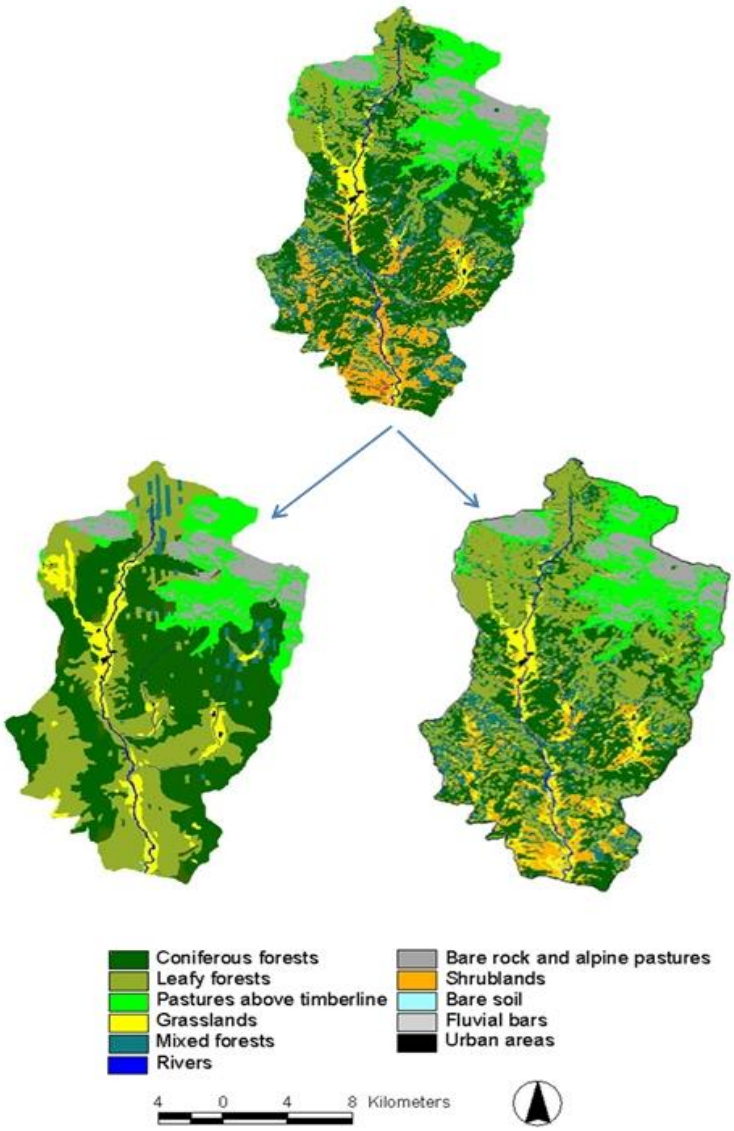

Fig. 2.
Land covers in the present situation and in two expected scenarios by mid-XXI Century in the Hecho and Aragüés valleys (Spanish Pyrenees).