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Editorial

Critical Environmental Issues Confirm the Relevance of Abandoned Agricultural Land

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Abstract: Large areas worldwide have been affected by farmland abandonment and subsequent plant colonization with significant environmental consequences. Although the process of farmland abandonment has slowed down, vegetation recovery in abandoned lands is far from complete. In addition, agricultural areas and pasture lands with low-intensity activities could be abandoned in the near future. In this foreword, we review current knowledge of the impacts of farmland abandonment on water resources and soil conservation, and we highlight the open questions that still persist, in particular regarding terraced landscapes, afforested areas, abandonment of woody crops, traditional irrigated fields, solute yields, long-term trends in the response of abandoned areas, and the management of abandoned farmland. This Special Issue includes seven contributions that illustrate recent research into the hydrological, geomorphological, and edaphological consequences of farmland abandonment.

Keywords: farmland abandonment; land-use change; revegetation; hydrological response; soil erosion

1. Introduction

Farmland abandonment is a major land-use change in many rural territories, particularly in temperate, developed regions [1–3]. It usually affects less productive land that is less suitable for industrial-scale production [4] and includes both crops and pastures. In some instances, physical constraints (e.g., poor soils, scarce water resources, intense land degradation) have also caused the abandonment of agricultural land [5]. Finally, farmland abandonment can be induced by national or supranational policies, which regulate markets for particular products to the detriment of others [6,7].

Campbell et al. (2008) [2] estimated that 385–472 million hectares of farmland was abandoned worldwide between 1700 and 2000. 99% of this land abandonment occurred during the last 100 years of this period. It affected all parts of the world, but was more intense in the United States, Europe, and Australia. One of the first countries to experience farmland abandonment was the United States [1]. In the middle of the 19th century the northeastern regions started to be abandoned due to competition from agriculture in the Midwest and the Great Plains [8]. Waisanen and Bliss [9] estimated that around 75% of the agricultural land in these regions had been abandoned between 1880 and 1997. In Europe, farmland abandonment occurred mainly in the 20th century, more intensely after the 1950s [1]. Some regions, however, were already abandoned at the end of the 19th century. In Switzerland, farmland abandonment has been observed for more than 150 years [10]. In the Hérault region in France [11], abandonment of croplands at the end of the 19th century was detected.

Fuchs et al. (2012) [12] suggested that in Europe cropland decreased by almost 19% between 1950 and 2010 and semi-natural grasslands by almost 6%. In some mountain regions, however the process of land abandonment has been very intense, affecting for instance more than 80% of cultivated land in the Spanish Pyrenees [13] and around 70% in the eastern Alps [14]. Recent abandonment has been observed elsewhere: Eastern Europe, China, Australia and, to a lesser extent, Canada, South America (e.g., Argentina, Brazil), northern Africa and India, have seen a decrease in farming since the end of the 20th century [1,2]. In the Loess Plateau (China), the Grain-for-Green programs was launched in 1999 by the Government in order to control intense soil degradation and has converted large areas of arable land into artificial forests or into areas left to spontaneous plant colonization [15], with a total restored area estimated at almost 5 million hectares [16]. Australia has one of the highest levels of pasture abandonment, which started in the 1970s [2]. In Canada, the Lower Inventory for Tomorrow of 1970 promoted the withdrawal of cultivated land from production by offering financial compensation to farmers [17]. In Europe, withdrawal of agricultural land has been induced by the Common Agricultural Policy (CAP) since the 1990s, mainly in plains and piedmonts, in order to reduce food surpluses and to limit the costs of agricultural subsidies [6]. In Eastern European countries, the extensive abandonment of agricultural land occurred following the fall of the communist regimes in the 1990s. The subsequent agrarian reforms and the change to a market-oriented economy caused the collapse of many collective farms and the abandonment of agricultural practices [18]. For instance, Nikodemus et al. (2005) [19] showed that in Latvia land abandonment was extensive, with 50% of croplands no longer cultivated by 1999.

The process of farmland abandonment has slowed down in most developed countries [3]. The forecast surface subject to abandonment is highly variable, depending on the land-use model employed and the scenarios considered, but there is general agreement that it will particularly affect marginal areas with low-intensity activities [20,21]. Rural areas in developing countries might undergo a similar process in the near future, with agricultural intensification in the more productive areas and a decline in farming in the less productive ones. However, this trend is very uncertain due to the great many economical, demographical and political factors that affect farmland abandonment [20]. For instance, some relatively steep areas in Mediterranean piedmonts have been affected by increasing pressure for re-cultivation due to favourable market conditions, e.g., vineyards and almond and olive tree orchards, resulting in severe erosion problems [22].

In most cases, the abandonment of agricultural land leads to a process of natural vegetation recovery [23] (Figures 1 and 2). Colonization by plants, also known as secondary succession, is very complex in abandoned fields. It depends on both natural and human-induced factors, including climate, topography, soil conditions, the distance and floristic composition of bordering vegetation, the age of abandonment and management following the end of farming, particularly livestock grazing and the occurrence of fires [24–26]. Research carried out worldwide has shown that vegetation recovery in abandoned lands has significant implications for landscape, water resources, soil erosion and biodiversity [4,5,17,27]. This Special Issue includes seven contributions that focus on the hydrological and geomorphological consequences (soil hydraulic properties, runoff, soil erosion, solute export) of farmland abandonment in different environments, including terraced landscapes, afforested areas, abandoned land at different stages of succession and recent abandonment in irrigated land and steep vineyards. In this foreword, we review briefly the main impacts of farmland abandonment on water resources and soil conservation and identify the main questions that still need to be addressed by scientists and land managers. Our main purpose is to highlight the environmental relevance of abandoned agricultural land and to show that its management is a challenge that requires immediate responses.

Figure 1. Plant colonization in abandoned fields in a wet environment (Arnás catchment, Central Spanish Pyrenees). Forest stands occupy the gentle slopes in the forefront whereas the steep slopes in the background are colonized by shrubs. Photo by Jérôme Latron.

Figure 2. Abandoned terraces in the Upper Guadalentin basin in Murcia (southeast Spain). Land abandonment and slow revegetation produce soil erosion processes. Photo by Estela Nadal-Romero.

2. Brief Review of the Main Impacts of Farmland Abandonment on Water Resources and Soil Conservation

Vegetation expansion alters the water cycle and the partitioning of precipitation between evapotranspiration, runoff and groundwater flows. Thus, water yields usually decrease following revegetation due to increased rainfall interception and transpiration by forests and shrubs [28].

However, the hydrological impact of these processes varies greatly as it depends on several factors [29], such as climate conditions, the extent and spatial distribution of land-cover disturbance, the characteristics and depth of the soils, and the type, age or physiology of the vegetation.

The hydrological consequences of vegetation recovery on formerly cultivated land have been examined at different spatial scales. Several studies have reported declining river discharges and negative trends in highflows as shrubs and forest expand at the headwaters (e.g. [30–33]). At the small-catchment scale, studies worldwide have demonstrated that vegetation established after land abandonment noticeably reduces runoff coefficients and is a major factor affecting flood control (e.g. [34–38]). Some of these studies have shown that revegetation also affects flood hydrograph characteristics, with lower peakflows, slower response times and slower recession limbs in forested catchments [39,40]. These results have been supported by research carried out at a more detailed scale. For instance, Nadal-Romero et al. (2013) [41] reported very low or no overland flow on abandoned plots, especially on those covered by dense vegetation, when compared with plots covered by cereal crops or fallow land. In arid and semi-arid environments, however, the effect of land abandonment may be the opposite, as land abandonment may cause the formation of soil surface crusts that reduce soil infiltration and favor overland flow [42,43]. An increase in vegetation cover also reduces soil water content and aquifer recharge due to rainfall interception and high transpiration rates by trees; this effect is much stronger under dry conditions or in dry environments [15,44]. Finally, several studies [45,46] have shown that the expansion of forest may affect snow accumulation and distribution, as trees reduce beneath-canopy snow accumulation and alter snow melting rates, mainly due to interception and subsequent sublimation processes.

Land abandonment also has significant consequences for soil conservation and soil erosion [17]. Revegetation following land abandonment tends to improve soil properties in the long term [47], usually showing increased soil organic matter and soil fertility [48], greater aggregate stability [49], and higher infiltration capacity, water-holding capacity and hydraulic conductivity [50]. However, the evolution of these processes is conditioned by topography, soil quality prior to abandonment and land management after abandonment, especially the occurrence of fires [48].

Studies worldwide have demonstrated that the expansion of vegetation cover decreases soil erosion due to the protective role of vegetation against rainfall splash and reduces surface runoff. In abandoned arable land, soil erosion can be significant during the first stages of plant colonization, as shown by Ruiz-Flaño et al. (1992) [51] and by Cerdá et al. (2018) [52] for the Western Mediterranean region, but it decreases over time as vegetation cover becomes denser. In some cases, signs of severe erosion such as undermining of shrubs, rills or development of stone pavement have been detected in the oldest fields [51,53]. This is because these fields were normally located in the worst positions (e.g., steep slopes, stony soils) and were subject to recurrent burning for shifting agriculture [41], factors that constrained the establishment of dense vegetation cover. In mountain pasture lands, abandonment may initially trigger shallow landslides due to a change in plant communities, as shown by Tasser et al. (2003) [54] in several sub-alpine and alpine meadows in Europe. When precipitation is scarce and irregular, such as in arid and semi-arid regions, plant colonization is difficult and geomorphic activity is more intense. Moreover, the formation of soil surface crusts that promote overland flow enhances soil erosion, resulting in severe sheet wash erosion [55] and the development of rills and gullies [56]. In these environments, particular soil characteristics such as the presence of marls may accelerate soil erosion processes (i.e. piping) due to the dispersion of clay minerals [56]. As a consequence of soil erosion, abandoned fields may be subject to a significant loss of nutrients and organic matter, and a decline in soil quality [17]. Finally, extensive revegetation on formerly cultivated lands has favored the occurrence and propagation of wildfires (e.g. [57,58]), which usually cause intense soil erosion in the first years following the fire due to greater overland flow [59].

Likewise, the general expansion of vegetation implies a shrinkage of sediment sources [60] and a decrease in sediment supply from the hillslopes to the channels [61,62]. In semi-arid areas, although runoff and soil erosion can be locally high after farmland abandonment, vegetation tends to develop in patches that act as water and sediment sinks, thus reducing sediment delivery to the stream [42,63]. As a result, the rate of sedimentation levels of reservoirs, rivers and coastal areas has declined [64,65] and the morphology of rivers has changed, with the narrowing and incision of alluvial plains [66,67] and subsequent environmental implications [68].

The effects of farmland abandonment on terraced landscapes are manifold due to the great complexity of the hydrological and geomorphological processes that affect these man-made constructions [69,70]. Farmland abandonment often leads to the collapse of terrace structures that are no longer maintained. Soil saturation in the inner part of the terraces, usually caused by the inefficiency of the drainage systems following abandonment [71], encourages wall instability and the occurrence of mass movements. The failure of terrace risers results in scars that are frequently affected by gullying or livestock trampling. Modeling exercises have shown that the formation of gullies reactivates the original drainage network, so favoring hillslope-channel connections and increasing peakflow discharges and sediment yield (e.g. [72,73]). On very steep slopes, debris slips and cascade landslides have been observed under intense rainfall [74]. The development of vegetation cover tends to reduce geomorphic activity on terraces (especially surface erosion processes), but often fails to prevent terrace collapse [70]. In semi-arid fields with marl lithology, terrace abandonment enhances intense surface erosion and favors piping, which may lead to deep gully incisions [75].

3. Open Questions

Although the consequences of farmland abandonment on water resources and soil conservation have been extensively studied, unresolved questions persist and new scientific challenges have emerged. For instance, traditional woody crops such as vineyards and fruit orchards in both rainfed and irrigated areas have been abandoned in recent decades or could be abandoned in the near future [21,76]. Literature about the consequences of the abandonment of such traditional systems on soil conservation and hydrology is still scarce [76,77].

There are still many open questions concerning the abandonment of terraced landscapes: what is the frequency of terrace collapse and what are the temporal drivers [78]? To what extent and under which conditions can the original drainage network be reinstalled? What are the downstream effects of the degradation of terraced slopes? Some authors support the conservation and rehabilitation of terraced structures because of their environmental, productive and aesthetic functions [79,80], but a thorough assessment of such efforts is still lacking.

The published literature provides substantial information on how farmland abandonment affects soil properties and soil erosion. However, limited information is available on how the abandonment of agricultural land affects surface water quality and solute export [81]. This is important for understanding changes in soil fertility in abandoned lands and the risk of soil degradation. Similarly, more work has to be done on how much soils in abandoned fields are affected by water repellency [82], a phenomenon that decreases infiltration capacity and may explain the high variability of runoff responses in abandoned lands.

Although farmland abandonment is predicted to slow down, vegetation recovery in abandoned lands is far from being complete. There are still large areas covered with shrubs that should evolve into forest stands and large areas of high-altitude pastures that have been colonized by shrubs and trees over the last few decades (Figure 3), enhanced by livestock decline (particularly sheep and goats), a warming climate and the rise of atmospheric CO_2 [83]. This means that vegetation in former agricultural and pasture land will continue to expand in the coming decades, with increasing impacts on water resources and soil conservation. Moreover, the evolution of vegetation in fields abandoned for very long periods may give rise to new processes affecting the hydrological and geomorphological dynamics of these areas. For instance, as well as improving soil quality, the higher input of organic matter due to vegetation favors soil development [84] and a consequent increase in long-term soil water storage. There is evidence that transpiration of old trees is lower than that of young individuals [85], suggesting that the impact of revegetation on runoff may stabilize or even decrease over time. In some cases, after decades of abandonment, degradation of shrub cover due to senescence has been observed, indicating a possible increase in runoff and sediment yield in the long term [41]. All these questions highlight the need for further research based on long-term data series in order to detect trends and changes in the system response.

Figure 3. Recent colonization by *P. Uncinata* in the subalpine belt in the Spanish Pyrenees (Las Blancas), as a consequence of a decline in livestock grazing (particularly sheep). The taller trees are 20 years old and the small trees are 3–4 years old. Photo by José M. García-Ruiz.

Extensive afforestation programs have been established in formerly cultivated areas by national forest services in order to improve the use of abandoned land as a resource and to control hydrological and soil-erosion processes [86]. At present, though the time elapsed since the first plantations provides sufficient perspective to assess their hydrological and geomorphological efficiency, there have been few studies at the catchment scale (e.g. [62,87]).

One of the topics that currently arouses special interest is the management of abandoned land [88]. Till now, as most abandoned areas have been considered marginal in economic terms, they have lacked any management intervention, leading to a process of "rewilding" or landscape naturalization [89]. As shown above, the recovery of vegetation may have important environmental benefits such as soil conservation, moderation of the hydrological response (in the sense that peakflows are lower and are delayed) and improved water quality. It also increases carbon sequestration [90,91]. For some authors, it is the best option for nature conservation and biodiversity [92], although there are differing opinions on the latter. Many authors argue that the effects of rewilding on biodiversity can be both positive and negative, depending on the species considered [93]. Finally, the regeneration of forest may also enhance the recreational value of the landscape [94]. However, land abandonment can also have negative impacts: as seen above, expansion of shrubs and forests decreases runoff and reduces river discharges in many cases; the presence of dense, continuous forests favors the occurrence of large wildfires; when vegetation succession is very slow or is interrupted, intense soil degradation may occur [17]. Additionally, landscape naturalization is often seen as a significant loss of traditional landscapes and development opportunities for the local population [95]. Thus, for some authors, active management of abandoned land is necessary in order to improve the ecosystem services these areas provide to society [88]. They consider that forest intervention, including the recovery of degraded ecosystems and the control of plant succession by light human activity (e.g., shrub clearing for extensive stockbreeding), will benefit biodiversity, land productivity, water resources, soil conservation and wildfire risk [96]. At present, there is an intense debate regarding rewilding *versus* forest intervention and there is still no clear consensus about the optimal strategy for the management of old agricultural areas.

4. Final Remarks

Abandoned agricultural areas deserve special attention because of their influence on the provision of natural resources such as water and on soil conservation. However, benefits depend greatly on how these areas are managed, which, at present, is a controversial topic with conflicting positions. In the current context of degradation of natural resources and climate change projections, there is an urgent need for scientists to provide knowledge to help decide on the best way to manage former agricultural land. This would optimize the environmental services they can supply to society.

We would like to conclude this foreword by acknowledging the efforts of the authors and reviewers of the articles presented in this Special Issue. We hope very much that these are useful and relevant to the readers of Water.

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