Land Use Policy 112 (2022) 105833

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

What is the future of abandoned agricultural lands? A systematic review of alternative trajectories in Europe

Catherine M.J. Fayet [a,b,*], Kate H. Reilly [a], Chantal Van Ham [a], Peter H. Verburg [b,c]

[a] International Union for Conservation of Nature (IUCN), Europe Regional Office, Boulevard Louis Schmidt 64, 1040 Brussels, Belgium
[b] Institute for Environmental Studies (IVM), VU University Amsterdam, De Boelelaan 1087, 1081HV Amsterdam, The Netherlands
[c] Swiss Federal Research Institute WSL, Zürcherstrasse 111, CH-8903 Birmensdorf, Switzerland

ARTICLE INFO

Keywords:
Driving forces
Land abandonment
Land use change
Landscape change
Secondary succession

ABSTRACT

Agricultural land abandonment and its impacts on landscape features have been a striking characteristic of many European rural areas over the last decades. Although previous research identified drivers and environmental impacts of abandonment, few described the post-agricultural abandonment trajectories. However, examining the driving forces leading to different post-agricultural abandonment trajectories is key to understand how alternative uses of these lands can be developed to address the environmental, economic, and social challenges faced in these areas. This paper reviews the literature of the different trajectories observed after agricultural abandonment and the related drivers and processes. Based on the literature evidence, we proposed a novel categorisation of different abandonment trajectories, with their drivers and landscape outcomes. In most reported cases, lands transitioned towards semi-natural landscapes and few returned to different agricultural uses after abandonment. The most common driving force of the landscape trajectory was the absence of land management where secondary succession processes led to semi-natural landscapes. Quality and state of these landscapes were variable. Alternative trajectories were essentially driven by institutional and socio-economic drivers within biophysical constraints and opportunities for (re-)afforestation, re-farming, and multifunctional uses of the land after abandonment. While abandoned lands can bring opportunities to respond to biodiversity and other environmental policy goals, the evidence across case studies suggests that adequate resources with institutional and socio-economic incentives are required to stimulate favourable development, mitigate, potential trade-offs, and support land management.

1. Introduction

Agricultural abandonment is a major driver of rural landscape changes. In contrast with intensification of farming systems, agricultural abandonment is observed in many marginal areas in Europe (Estel et al., 2015; Kuemmerle et al., 2016; Schulp et al., 2008; Stürck et al., 2018). Drivers and consequences of abandonment are now well understood (MacDonald et al., 2000; Rey Benayas et al., 2007; van der Zanden et al., 2017). However, opportunities that arise from abandoned lands have received less attention (Munroe et al., 2013). In this paper we describe the main post-agricultural abandonment trajectories and how they can provide opportunities to contribute to environmental policy goals, including biodiversity conservation, ecosystem restoration and climate change mitigation and adaptation, in line with the European Union (EU) Biodiversity Strategy for 2030 (European Commission, 2020a).

Agricultural abandonment can be defined as the cessation of agricultural activities and the complete withdrawal of agricultural management on land (Pointereau et al., 2008). This is however not irrevocable: abandonment has also been described as a complex phenomenon that can manifest as temporary, transitional, or permanent abandonment states (Keenleyside and Tucker, 2010). Described as a process, abandonment has the potential to lead to various outcomes such as recultivation, natural succession, or forestry (Gallemore et al., 2018; Munroe et al., 2013).

Biophysical, economic, social, institutional, and management factors are the main drivers of the cessation of agricultural activities (MacDonald et al., 2000; Rey Benayas et al., 2007; van der Zanden et al., 2017). Abandonment affects primarily remote areas where unfavourable climatic or topographic conditions for agriculture limit opportunities for profits and make the lands hardly competitive in a globalised

* Correspondence to: International Union for Conservation of Nature (IUCN), Europe Regional Boulevard Louis Schmidt 64, 1040 Brussels, Belgium.
E-mail address: catherine.fayet@iucn.org (C.M.J. Fayet).

https://doi.org/10.1016/j.landusepol.2021.105833
Received 28 September 2020; Received in revised form 8 February 2021; Accepted 22 October 2021
Available online 3 November 2021
0264-8377/

market (Keenleyside and Tucker, 2010; MacDonald et al., 2000; Rey Benayas et al., 2007; van der Zanden et al., 2017). Institutional and political drivers were also very influent in the East after the collapse of the Soviet Union, which led to large scale abandonment in the 1990s (Fischer et al., 2012; Terres et al., 2015). Land abandonment leads to context-specific outcomes for biodiversity, cultural heritage and ecosystem services: it can be followed by positive as well as negative consequences depending on the area's characteristics (Rey Benayas et al., 2007; van der Zanden et al., 2017) and perceptions of different individuals or groups in society (Ruskule et al., 2013; van der Zanden et al., 2018). So far, studies mostly focused on abandonment as an end-state and described impacts on the landscapes. However, land uses and covers generally change with time, which is what we explore here.

The potential of abandoned lands to contribute to sustainable land use transitions have received growing interest over the past years. Abandonment can for instance make land available to provide ecosystem services through nature-based solutions (European Environment Agency, 2019; Seddon et al., 2019) and can provide opportunities for landscape restoration (Wolff et al., 2018), reforestation (Zethof et al., 2019), carbon sequestration (Schulp et al., 2008) and rewilding (Ceausu et al., 2015; Navarro and Pereira, 2015). Rural landscapes can also be revitalised after abandonment with recultivation (Estel et al., 2015), hobby farming (Varotto and Lodatti, 2014) and leisure activities (Bauer et al., 2009; Vanslembrouck et al., 2005). However, the drivers that determine how these alternative trajectories are selected remain unexplored.

Assessing how these trajectories develop is key to understanding how current and future abandoned farmlands can contribute to social and environmental policy goals, and whether passive or active actions are required. In addition, it is important to go beyond case study analyses and gain an understanding at the European scale of the different trajectories in different contexts and regions. The originality of this study is that it provides a categorisation of possible abandonment trajectories based on the different landscape outcomes.

In this paper, we refer to *post-agricultural abandonment* trajectories (here after *post-abandonment trajectories* or *abandonment trajectories*) as the changes in land cover and land use observed after the cessation of agriculture activities. We firstly review the academic literature documenting case studies of post-abandonment trajectories across Europe to build an inventory that categories these different trajectories. Secondly, by examining the drivers of change, we analyse under what conditions alternative abandonment trajectories develop.

2. Methods

2.1. Paper selection

We selected case studies of agricultural abandonment from four systematic reviews on landscape change in Europe (Grădinaru et al., 2020; Lasanta et al., 2017; Plieninger et al., 2016; van Vliet et al., 2015). Additional queries in ISI Web of Science complemented our collection; the keyword string used to direct the search is in Supplementary Material S1. The selection process was documented according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Supplementary Material S1). We screened papers by title and abstract for preselection before examining the full text for inclusion. We used the following inclusion criteria:

- Papers describe the land use / land cover change(s) that occurred after agricultural abandonment in a location or region in continental Europe;
- Papers provide information on the drivers of the post-abandonment trajectories;
- While papers may document changes happening before 1945, only trajectories after 1945 are coded;
- Given the many definitions of agriculture abandonment in the literature (Grădinaru et al., 2020), we did not define a threshold for the number of years since farming or cultivation came to an end for the lands to be considered abandoned.

2.2. Coding and analysis

We used the information provided in the papers to describe post-abandonment trajectories for each case study (location affected by agricultural abandonment). Each post-abandonment trajectory was characterised with a unique ID and descriptive statistics (Supplementary Material S2). Different post-abandonment trajectories reported for the same location were coded separately. We aggregated information from different papers as one case study if these papers described the same trajectory for the same location. We mapped the locations using co-ordinates provided in the papers or used Google Maps to identify the location when precise information was lacking.

We designed a coding scheme that captures the dimensions frequently observed in post-abandonment trajectories. This coding describes post-abandonment trajectories at different levels, from the general direction of change (e.g., semi-natural, return to agricultural uses) to the resulting specific landscape features. We inventoried proposed processes and sub-processes that take place during the landscape change trajectory and determine the landscape outcomes (e.g., succession of natural vegetation). These processes were iteratively revised based on the case studies analysed and coded. We used four categories of drivers of abandonment and post-abandonment trajectory (biophysical, management, socio-economic, and institutional drivers). This coding was developed based on previous work on land abandonment (MacDonald et al., 2000; Plieninger et al., 2016; Rey Benayas et al., 2007) and adjusted for post-abandonment drivers using analysis of a preliminary set of case studies. The coding scheme was slightly refined during the review of the rest of the sample and based on feedback from the expert interviews as described below.

For the analyses, we built a conceptual framework of the different trajectories taken after abandonment and counted their occurrences. We recorded the drivers of abandonment and post-abandonment trajectories retrieved from the papers for each trajectory.

2.3. Expert interviews

To supplement insights from the systematic review and validate the insights obtained across case studies, ten experts with specialised knowledge in abandoned land management, landscape planning, ecosystem restoration, nature conservation, and rural policy development were contacted for online interviews between June and July 2020. These experts worked at various types of institutions, ranging from universities and research institutes to nature conservation NGOs in different European countries to reflect the geographical distribution of the case studies. We asked experts to share their knowledge on post-abandonment trajectories in the regions they work in and to comment on the conceptual framework and the drivers we had identified based in our review. Questions used and summary notes on information retrieved during interviews are provided in Supplementary Material S3.

3. Results

3.1. Case study characteristics

Screening by title and abstract, 355 articles were identified as potentially eligible. After further screening by full text, we selected 115 articles published between 1988 and 2020 (Fig. 1a), yielding 135 post-abandonment trajectories in 24 countries. To describe land use changes, the papers mostly used field work observations, aerial or orthophotography, and existing documents or maps (Fig. 1b). On average two different methods were used per study, with a maximum of four

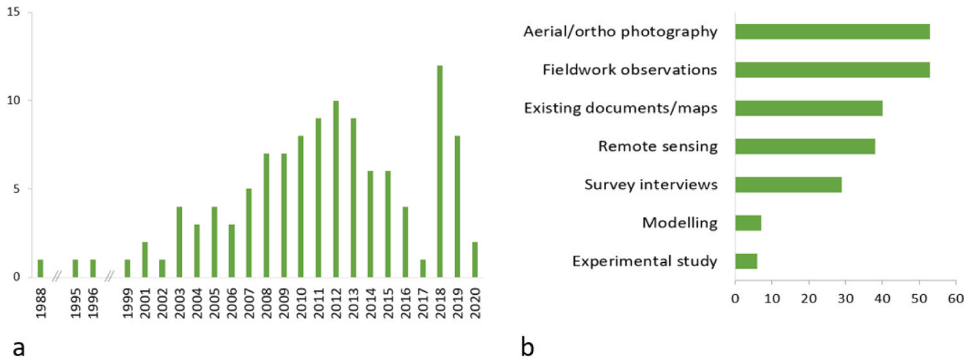

Fig. 1. Distribution of publications included by year (a) and type of analysis used (b).

methods.

Information on study site characteristics is provided in Supplementary Material S4. Cases were spread across Europe although most were in Spain (36%) and Italy (13%), two Mediterranean countries. When indicated, studies covered on average time periods of 39 years after abandonment, ranging from one to 104 years (median 35 years). The mean size of their study areas was 12,802 km^2 (median 274 km^2), with the smallest area being 0.07 km^2 and the largest being 462,420 km^2. Study areas included terraced landscapes in 18% of cases, 28% included protected areas (e.g., Natura 2000 and other national or regional designations), and fewer than 7% had an official cultural landscape recognition (e.g., UNESCO World Heritage list, National Nature Monument). Cropland was the most frequent land use before abandonment (38% of observations), followed by pastures and meadows (22% and 10% respectively). Other land uses included permanent crops (orchards, olive, and almond plantations) (9%), grasslands (when no distinction was made between pastures and meadows) (7%), vineyards (6%), livestock breeding and agropastoralism (4% and 3% respectively). We extracted and compiled information on drivers of abandonment for each trajectory (Supplementary Material S4).

3.2. Inventory of post-abandonment trajectories

Based on the distinctions made in the case studies, we built a conceptual framework representing the categorisation of different post-abandonment trajectories and their development (Fig. 2). We identified three alternative directions for the post-abandonment trajectories: return to agricultural uses, revegetation, and urban transformation. These directions define the general land transition after abandonment and can be subdivided into seven *landscape outcomes* that describe the current endpoint of the change trajectory. To explain how these landscape outcomes developed within each trajectory, we distinguished *processes* and *sub-processes* of land use/cover change.

3.2.1. Return to agricultural uses

One possible trajectory after abandonment is a *return to agricultural uses*, where the land is managed again, as we observed for 18 case studies (13% of all cases) where rural landscapes are *revived* with new economic and social activities. A first sub-process is *landscape preservation* which restores or maintains traditional landscape features (e.g., hedgerows, terraces). The outcome is a *Museum landscape* similar to the one before agricultural abandonment, serving educational or demonstration purposes (Lomba et al., 2019; Moreira et al., 2006) and cultural values. Second, reviving can imply *diversification* of land uses with

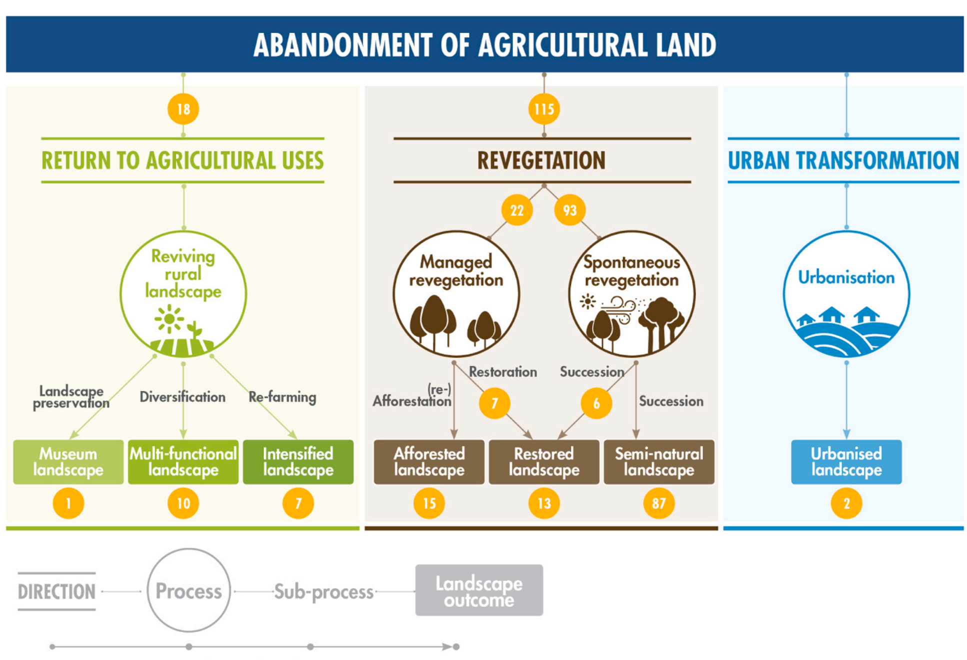

Fig. 2. Conceptual framework of post-abandonment trajectories (N = 135). The orange circles indicate the number of occurrences (cases) recorded.

low-impact management activities. The outcome of this trajectory is a *Multi-functional landscape* with various functions beyond agricultural and forest-based commodity production (Fagerholm et al., 2019; Fischer et al., 2017) that can support the provision of multiple ecosystem services (Stürck and Verburg, 2017). Third, we found 15 cases reporting that agricultural lands are cultivated (cropland) or managed (grassland) in a mono-functional way (contrary to multi-functional landscapes) leading to an *Intensified landscape*. We did not find examples of low-intensive, organic farming or sustainable practices (Oberč and Schnell, 2020), although we acknowledge this could also be a type of re-farming leading to less intensified landscapes.

3.2.2. Revegetation

Revegetation was the most frequent trajectory observed after abandonment (115, so 85% of all cases) and potentially leading to two different processes. First, *managed revegetation* can initiate or support land use and cover changes with the *(re-)afforestation* sub-process leading to *Afforested landscapes* where trees are primarily planted for commercial purposes (timber industry, wood biomass). A secondary objective of (re-)afforestation can be soil restoration when tree planting intends to address soil erosion or improve water quality (Nadal-Romero et al., 2016; Segura et al., 2020; Zethof et al., 2019). *Restoration* is a second sub-process where action is taken to restore natural vegetation by assisting vegetation recovery (site preparation, seedling, pruning, removal of invasive). The outcome of this trajectory is a *Restored landscape*, mostly including the improvement of biophysical and chemical conditions, such as water quality and water regulation (Hobbs and Harris, 2001). Alternatively, revegetation can involve *spontaneous revegetation* processes characterised by the absence of human management where the dominant sub-process is *succession*, also known as secondary succession, old-field succession, or forest regrowth (Chazdon et al., 2020; Pugnaire et al., 2006). The outcome of this trajectory is a *Semi-natural landscape*, the most common landscape outcome we recorded (87, so 64% of trajectories reported). Succession can lead to spontaneous restoration on degraded lands with natural regeneration (Chazdon et al., 2020; Sojneková and Chytrý, 2015) but it can also result in outcomes dominated by invasive species or non-native vegetation depending on the local conditions. Therefore, the quality of the resulting *Semi-natural landscape* and the functions it can provide vary widely. Restored landscapes can be the outcome of passive and active processes, both often referred to as rewilding (Morel et al., 2020; Perino et al., 2019).

3.2.3. Urban transformation

Some agricultural lands are urbanised after having been in a state of abandonment. The cases included in this study did not refer to urbanisation processes that directly led to loss of agricultural land but rather to agricultural land that had been in a state of abandonment and was later included in urban planning (e.g., house construction) (Grădinaru et al., 2015; Veteikis et al., 2011).

3.3. Distribution of post-abandonment trajectories

The geographical distribution of the case studies' post-abandonment landscape outcomes is shown in Fig. 3. For return to agricultural uses (Fig. 3a), most Multi-functional landscape outcomes were reported in Italy, Spain, and France, whereas Intensified landscape outcomes were more frequent in Eastern Europe (Latvia, Ukraine, and Carpathian region). The Museum landscape outcome case study was in the Czech Republic. Urbanised landscape outcomes were in Romania and Lithuania (Fig. 3a). We found Semi-natural landscape outcomes in all European regions, but mainly in Spain (27) and Italy (13) (Fig. 3b). Afforested landscape outcomes were only documented in Spain (11) and Portugal (4) (Fig. 3b). Restored landscapes (from managed restoration) were in Spain, Italy, the Netherlands, Belgium, and Sweden (Fig. 3b). Cases of spontaneous (unmanaged) restoration were found in Spain, Italy, Belgium, and the Czech Republic (Fig. 3b).

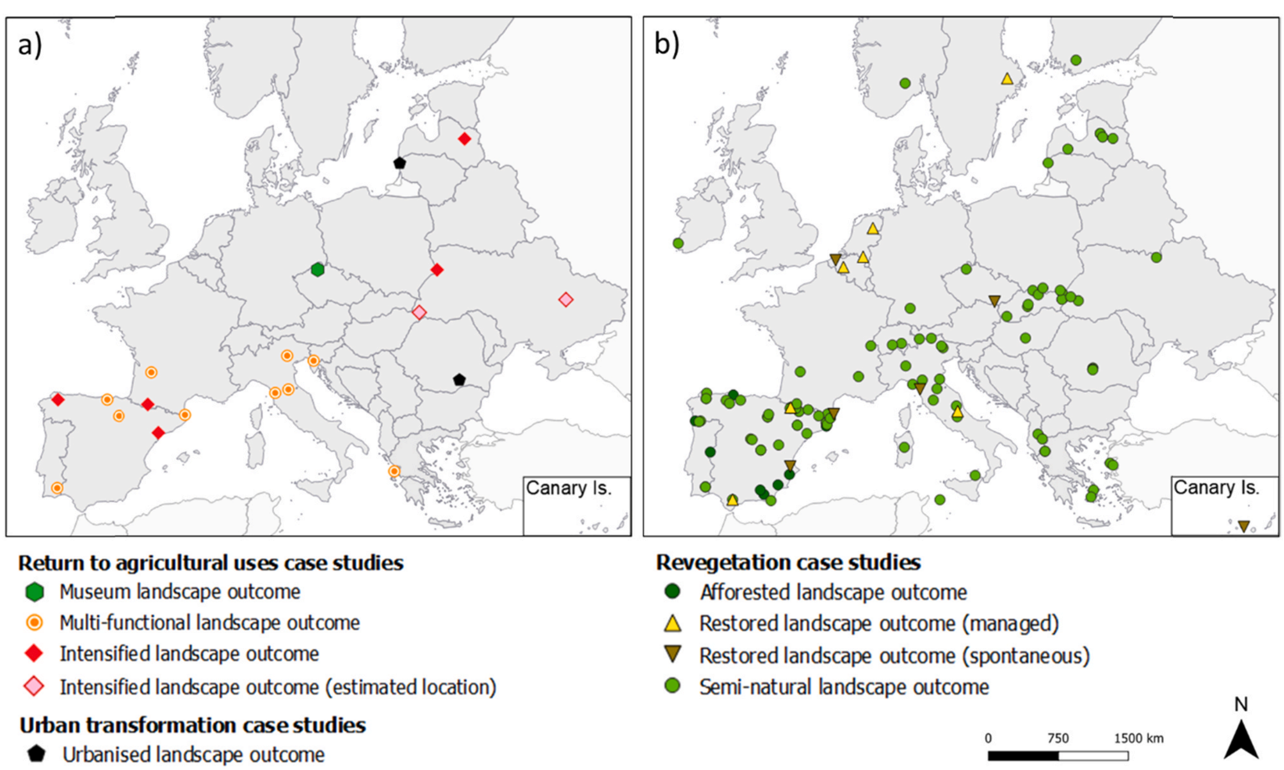

Fig. 3. Locations of the case studies differentiated by landscape outcomes of post-abandonment trajectories. 3a shows the locations of landscape outcomes for the return to agricultural uses trajectories and the urban transformation. Fig. 3b shows the locations of landscape outcomes of the revegetation trajectories. The two cases of Intensified landscape outcomes with a pink diamond symbol indicate approximate locations as exact information was not available for these two cases.

3.4. Drivers of the different landscape outcomes: passive and active trajectories

We recorded 344 observations of drivers of post-abandonment trajectories (Supplementary Material S4). The average number of drivers mentioned per trajectory was 2.5 (median 2; min. 1; max. 9). Management drivers were the most frequent category (48% of drivers), followed by institutional (21%), biophysical (16%), and socio-economic (15%) drivers. The most frequent driver mentioned was the absence of management, found in 69% of post-abandonment trajectories and accounting for 27% of all drivers recorded. Table 1 shows the detailed contributions of the different drivers to each landscape outcome.

Analysis of the drivers involved in each landscape outcome revealed that management, institutional and socio-economic drivers contributed differently to the development of what we labelled *passive* and *active* trajectories (Fig. 4). Specifically, we compared the drivers of trajectories in which there was mainly no intervention (Semi-natural landscape outcomes) as opposed to trajectories that benefitted mostly from active management interventions following abandonment (all the others).

Management drivers accounted for more than two thirds (68%) of the drivers of passive trajectories (Semi-natural landscape outcomes). However, the passive characteristic of this trajectory is outlined by the fact that they mostly consisted of an *absence* of management (54%) (Fig. 4a). By contrast, in active trajectories, absence of management was rare (3%) and active forms of interventions were more important (27% of drivers) (Fig. 4b). Management withdrawal in passive trajectories was linked with remoteness, lack of available workforce or reduced need and interest to use the land (Table 1). Biophysical and institutional drivers of passive trajectories were less frequent (16% and 11%, respectively) and socio-economic drivers even less (5%) compared to the dominant absence of management. Biophysical drivers included difficult topography, poor or degraded soils, and proximity to existing forests that favoured vegetation succession (Table 1). A contrasting pattern was noted for active trajectories (Fig. 4b) as institutional and socio-economic drivers together accounted for 54% of contributions, and specifically for at least half of the drivers of Multi-functional (70%), Afforested (57%) and Intensified (50%) landscape outcomes (Fig. 4c). Compared to other active trajectories, Restored landscapes showed a small share of socio-economic drivers (2%), a value close to the one observed for Semi-natural landscapes (5%). However, this was compensated by higher contributions of institutional drivers (26%) including mainly restoration programmes (e.g., Mercurio et al., 2010; van der Bij et al., 2018) and active forms of management (43%), including for instance mechanical tree planting to address soil erosion (Fernández et al., 2004; García-Ruiz et al., 1996) (Table 1).

Important institutional components driving Afforested landscape outcomes included afforestation programmes and subsidies (applicable for ten out of 15 cases). Socio-economic drivers mostly mentioned market opportunities from wood products (nine out of 15 cases) and a quarter of re-afforestation cases were also driven by the intention to restore degraded soils (Campo et al., 2019; Segura et al., 2020). Afforested landscapes were found on both fertile (Corbelle-Rico et al., 2012) and degraded lands (Nainggolan et al., 2012). Socio-economic drivers of Multi-functional landscapes included interest from (new) populations and landowners to manage abandoned lands. For example, in Italy, abandoned terraces were reused for hobby farming by individuals and families living in the vicinity (Varotto and Lodatti, 2014) and in Portugal multifunctionality consisted of the combination of forestry, agriculture and pastoralism (Van Doorn and Bakker, 2007). For about half of the cases, land was easily accessible. National or regional programmes for the reuse and clearing of abandoned lands were frequent drivers of multifunctional trajectories (recorded for seven out of ten cases) (Table 1).

The four categories of drivers contributed equally to Intensified landscape outcomes (Fig. 4c). Re-farming was driven by recultivation programmes in Spain and in the Carpathians (Cots-Folch et al., 2006; Griffiths et al., 2013) and supported by subsidies in more than half of cases. Intensification processes were mainly found on landscapes with fertile lands (six out of seven cases), suitable for mechanisation use (half of cases) and easily accessible. Access to markets was a key component of recultivation in Spain (Corbelle-Rico et al., 2012) and Eastern Europe (Griffiths et al., 2013; Smaliychuk et al., 2016; Stefanski et al., 2014).

The Museum landscape case was linked to leisure opportunities and subsidies while the Urbanised landscape outcomes were strongly driven by demographics (population growth), the housing market and land tenure conditions (Table 1).

3.5. Information from expert interviews

The experts interviewed often reported negative impacts on

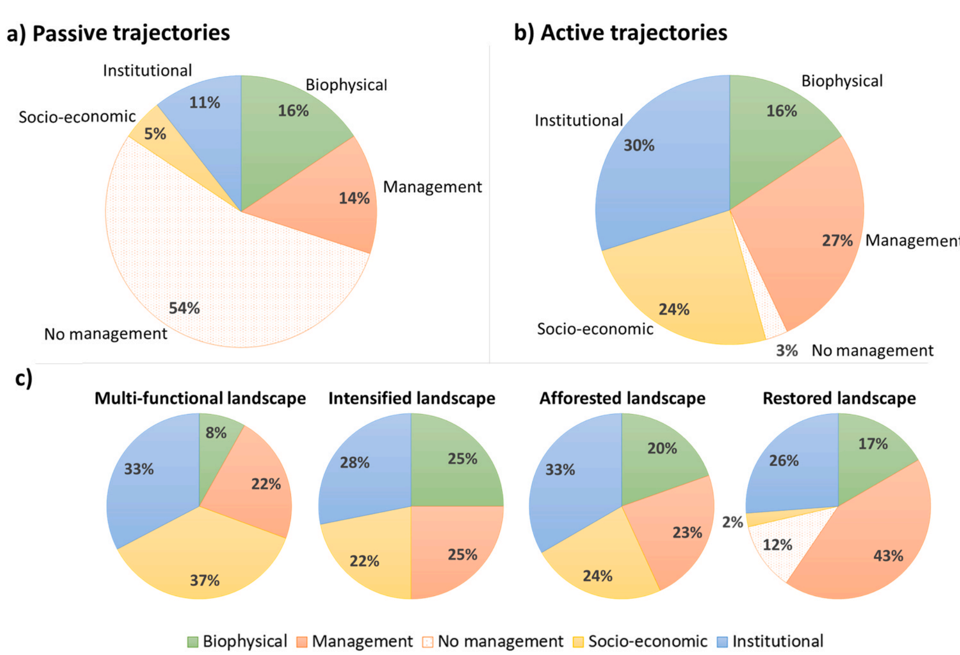

Fig. 4. Relative contributions of categories of drivers to the development of passive (a) and active (b) interventions on trajectories following abandonment. Fig. 4a shows the relative contributions of the drivers of Semi-natural landscape outcome trajectories. Fig. 4b shows the total relative contributions of drivers for all other landscape outcomes. Fig. 4c shows the contributions of drivers for selected landscape outcomes of active intervention trajectories. Urbanised and Museum landscape outcomes are not shown in Fig. 4c as only 3 cases were included in the analysis.

Table 1
Contributions of drivers to each landscape outcome. Numbers in brackets indicate the number of occurrences recorded.

Landscape outcomes	Drivers				Comments
	Biophysical	Management	Socio-economic	Institutional	
Semi-natural landscapes	Steep slopes (10) Degraded/Poor soils (8) Forest proximity (5) Fertile soils (1) Other (1): altitude and climate influences (in Peña-Angulo et al., 2019)	Absence management (87) Less grazing demand (11) Remoteness (8) Lack of workforce (3) Restore ecosystems (1)	New population interest (2) Leisure opportunities (2) Farmer decision (2) Farmer age (1) Other (1): new legislation allows logging (in Vanwambeke et al., 2012)	Protected area regulations (8) Programmes and interventions (2) Land tenure (6) Not-specified EU subsidies (1)	Semi-natural landscape outcomes were observed across all Europe, at various altitudes and climate regions and could lead to different vegetation outcomes (heterogeneous vegetation with grasses and scrubs, grasslands, or forest landscapes). About a quarter of them were found in protected areas (Natural parks, Biosphere reserve, Natura 2000). When reported, topography included steep, undulating, and flat landscapes. Most cases were on former croplands and about half on former pastures.
Restored landscapes	Steep slopes (3) Degraded/Poor soils (2) Address natural risks (1) Other (1): species- rich grasslands nearby (in Sojneková and Chytrý, 2015)	Restore ecosystems (12) Absence of management (5) Vegetation control (5) Mechanisation / Technology access (1)	Leisure opportunities (1)	Programmes and interventions (6) Protected area regulations (5)	Passively restored landscapes were found in various topographical conditions, heterogeneous landscapes, peatland and one case of former irrigated land. Half were in protected areas. Cases of active restoration were mostly on former grasslands and in protected areas (national parks or nature reserves).
Afforested landscapes	Degraded/Poor soils (3) Steep slopes (3) Address natural risks (2) Fertile soils (1) Other (1): above 600 m above sea level (in Nainggolan et al., 2012)	Restore ecosystems (5) Remote areas (4) Easy access (2) Less grazing demand (1)	Market opportunities (9) Farmer decision (2) Farmer age (1)	Programmes and interventions (10) EU CAP subsidies (3) Land tenure (2) Not-specified EU subsidies (1) National subsidies (1)	Afforestation programmes were the main drivers of afforested landscape outcomes and could often contribute to economic, environmental and restoration objectives simultaneously. Afforestation was both reported on former croplands and grasslands, in mountains or catchments with average altitudes comprised between 411 and 1148 m above sea level when reported. Only 4/15 of cases were in protected areas (Biosphere reserves, natural park, or special protected area).
Multi-functional landscapes	Address natural risks (3) Fertile soils (1)	Restore ecosystems (4) Easy access (4) Vegetation control (3)	New population interest (5) Farmer decision (4) Farmer age (3) Population growth (2) Urban proximity (2) Leisure opportunities (1) Market opportunities (1)	Programmes and interventions (7) EU CAP subsidies (3) Land tenure (2) Protected area regulations (2) Not-specified EU subsidies (1) National subsidies (1)	Found close to urban areas, easy to access and benefitted interest from population. Economic support (subsidies) and dedicated programmes were also important to promote multiple uses after abandonment for instance with animal grazing as vegetation control method. Tourism was also found compatible with recultivation and preservation of landscapes. Multi-functional landscape outcomes were mainly observed on former pastures and orchards, half were in protected areas, various topography types were found and 3/10 had terraces.
Intensified landscapes	Fertile soils (6) Other (2): moderate slope and distant to forest edge	Mechanisation / Technology access (4) Easy access (3) Remoteness (1)	Market opportunities (4) Farmer decision (1) Urban proximity (1) Other (1): distant from capital city	Programmes and interventions (2) Land tenure (2) Not-specified EU subsidies (2) National subsidies (2) EU CAP subsidies (1)	Intensified landscape outcomes were mostly found in Eastern Europe (4/7) on lands that have good soil and topographic conditions for agriculture. None of the re-farmed locations were included in protected areas. 6/7 were on former croplands and one case reported grassland management. Distance to capital city prevented job competitions, thus favouring the return of agricultural employment (Vanwambeke et al., 2012).
Museum landscapes			Leisure opportunities (1)	EU CAP Subsidies (1)	Only one case analysed (Dolejš et al., 2019). Occurred in a protected area, also recognised as cultural landscape.
Urbanised landscapes		Easy access (1)	Market opportunities (2) Urban proximity (2) Farmer decision (1) Population growth (1)	Land tenure (1)	A growing housing market provided financial opportunities that were more attractive than cultivation (Grădinaru et al., 2015; Veteikis et al., 2011).

biodiversity caused by the re-intensification of agriculture, which was either supported by EU Common Agricultural Policy (CAP) subsidies or driven by foreign investors (E1, E4, E8). The experts differed in their views of the contextual and management implications of natural succession. While some experts favoured spontaneous succession as an effective and low-cost option for biodiversity and nature conservation, others highlighted the need for land management and vegetation control. Secondary succession was specifically described as a threat for high nature value grasslands in Romania, Hungary, and the Czech Republic, and most experts from Eastern Europe mentioned risks with invasive species (E1, E2, E6). By contrast, a more positive view was reported for Spain and Belgium, where experts described secondary succession as benefitting the environment and creating recreational opportunities (E5, E6). Multi-functional landscapes were often described as valuable options to revive rural areas, including economic diversification with recreational activities (e.g., mountain bike tours – Romania, E4) or promotion of local products and certifications (E1). However, developing such options can be challenging due to opposition from local farmers and difficulty with financing (France, E9). Dealing with opposition and involving the local population is, according to one of the experts, a key component of successful post-abandonment trajectories: local people must benefit from the landscape and see interests in maintaining it (E4).

4. Discussion

The review of case studies across Europe revealed a variety of outcomes after agricultural abandonment, as shown in our conceptual framework. Agricultural abandonment is often seen as an endpoint, but our results indicate it is also the start of a new land use. Despite the potential for various uses, we found that in a large majority of cases, abandoned lands transitioned towards Semi-natural landscapes through processes of spontaneous vegetation succession. This echoes previous studies describing secondary succession as a common consequence of agricultural abandonment (MacDonald et al., 2000; Rey Benayas et al., 2007; van der Zanden et al., 2017). Although recultivation is a major process in Eastern Europe and more dominantly in Russia (Estel et al., 2015), we found that only a minority of lands in our sample returned to different forms of agricultural uses.

4.1. Development of alternative trajectories

While the drivers of abandonment found in our review were consistent with other reviews (MacDonald et al., 2000; Plieninger et al., 2016; Rey Benayas et al., 2007), our results contribute to a better understanding of the development of alternative post-abandonment trajectories, particularly the different patterns of drivers for passive and active intervention trajectories.

There are various reasons behind the dominant process (no intervention) of passive trajectories. Institutional (legal) drivers restrict land management in protected areas, but in some locations and contexts, lack of management can lead to loss of these landscapes' unique values as vegetation grows (Lasanta et al., 2015). Other reasons can be a lack of management capacity after rural exodus (Cohen et al., 2011; Detsis et al., 2010; Dolejš et al., 2019), a lack of interest due to limited economic opportunities in remote areas (Dolejš et al., 2019), or speculative reasons (Vanwambeke et al., 2012; E6).

To "opt out" from this "default" trajectory, institutional and socio-economic drivers are key. Specifically, we found that in all cases with more active management, *at least* institutional factors played a role in supporting interventions and thus the development of alternatives to unmanaged secondary succession. For example, land management policies provided subsidies and programmes for recultivation (Estel et al., 2015; Griffiths et al., 2013) and afforestation of abandoned agricultural lands (Jones et al., 2011; Van Doorn and Bakker, 2007). By contrast, we found that economic factors are important, but not essential. Indeed, while market opportunities for wood products were important components of afforestation processes (Tomaz et al., 2013), improving environmental conditions was a key objective of the restoration of abandoned farmlands (García-Ruiz et al., 2020).

While institutional and socio-economic drivers provide a framework for action and support management activities, biophysical conditions influence the feasibility of different trajectories in specific contexts. For instance, re-farming was more likely on land with favourable conditions for agricultural production (Estel et al., 2015; Griffiths et al., 2013) whereas semi-natural landscapes were mainly on steep or degraded lands unfavourable for intense production, as found in previous studies (MacDonald et al., 2000; Rey Benayas et al., 2007; van der Zanden et al., 2017).

4.2. Current opportunities on abandoned lands

The different post-abandonment trajectories show that current and future abandoned farmlands can provide valuable opportunities for nature restoration in Europe, in line with the EU Biodiversity Strategy for 2030 (European Commission, 2020a) and the post-2020 global biodiversity framework for biodiversity protection and ecosystem restoration (Convention on Biological Diversity, 2019). Without management, vegetation returns after abandonment, thus providing opportunities for nature-based solutions (Cohen-Shacham et al., 2016, 2019), including for carbon capture (Lasanta et al., 2015; Schulp et al., 2008), biodiversity recovery (Rey Benayas and Bullock, 2012; Rey Benayas et al., 2010) and recreational opportunities (Van Doorn and Bakker, 2007). Succession can also support spontaneous restoration at low cost (Chazdon et al., 2020). The numerous examples of Semi-natural landscape outcomes after abandonment that we recorded present many potential opportunities, especially in a context of limited land availability: "*We do not have space at all, everything is already occupied, and everything is already owned. So, these places* [abandoned farmlands] *can give a huge chance to create green infrastructure elements*" (E2 - Hungary).

The return to agricultural uses trajectories also resonate with the European Green Deal Farm to Fork Strategy by providing options for sustainable food production and economic returns for farmers (European Commission, 2020b). Sustainable agriculture can also be supported by empowering local communities with the diversification of revenue sources (E4), such as agritourism, which provides options to revitalise rural landscapes and can be aligned with principles of sustainable agriculture practices (Oberč and Schnell, 2020).

4.3. Considerations for trajectories implementations

Financial and institutional support are key to driving post-abandonment trajectories other than natural succession. Here we examine implications and trade-offs of these alternative trajectories.

As succession is mainly driven by biotic and abiotic factors (Lesschen et al., 2008; Pugnaire et al., 2006), outcomes are highly context-dependent. Succession can be the best option for biodiversity: "*I find natural succession very effective, especially when starting from arable land, as you have very rapidly encroachment from scrubs and various species. So, you have quickly nature rich forest ecosystems*" (E6). We found such examples on former croplands in our review (Baeten et al., 2010; Sojneková and Chytrý, 2015). Succession can however be a threat for biodiversity in high nature value grasslands in Eastern Europe (Chytry et al., 2009; Regos et al., 2016): "*The grasslands are so rich in flora and invertebrate fauna, forest edges, large vertebrates, big mammals, and birds species […] that if you stop mowing, or if you overgraze, you would lose a lot. And if we allow natural succession, we are actually losing biodiversity, not gaining it*" (E4). We found many cases of secondary succession in Eastern Europe (Fig. 3b), indicating that biodiversity might have been affected by these post-abandonment trajectories on grasslands. Uncontrolled succession can also increase wildfire risks in dry regions (Rey Benayas et al., 2007; van der Zanden et al., 2017), which can be an issue for some trajectories that we observed in the Mediterranean.

As part of the new EU Biodiversity Strategy for 2030 and climate neutrality objectives for 2050, the European Commission aims to plant an additional 3 billion trees by 2030 (European Commission, 2020a). Abandoned land can contribute to this ambition. However, climate change and pests are already threatening European forests (Seidl et al., 2018) and constitute strong challenges to current and future afforestation plans that could be envisioned. Alternatively, instead of relying on afforestation as a main climate change mitigation strategy (Bastin et al., 2019), some researchers recommend enhancing efforts to preserve ecosystems (e.g., grasslands, peatlands) that are equally or more valuable for carbon sequestration (Bengtsson et al., 2019; Burrascano et al., 2016; Veldman et al., 2015). Increasing support to restore such ecosystems on abandoned farmlands would therefore be a valuable trajectory.

As we observed in multi-functional trajectories, combining multiple (re-)uses on abandoned land can benefit both the environment and rural revitalisation, such as safeguarding and reviving traditional high nature value farmlands (Fundatia ADEPT Transilvania, WWF-Romania, and ProPark Foundation, 2016; E4). More intense forms of recultivation are also encouraged as part of the EU climate neutrality objectives (European Commission, 2018), particularly for biofuel production on fertile lands (notably in Eastern Europe) (European Commission, 2019). However, intense recultivation and agricultural expansion are often controversial for their negative impacts on biodiversity (Folberth et al., 2020; Kovács-Hostyánszki et al., 2016) and were generally seen as undesirable trajectories during interviews (E1, E7, E8).

Competing interests on land uses is another challenge for the development of sustainable post-abandonment trajectories. For instance, experts reported during interviews that nature conservation NGOs were often disadvantaged against forestry and agricultural sectors for land acquisition (E10), while in densely populated areas, high land prices driven by the housing market were major obstacles to conservation projects (E6). Stronger institutional and financial support may therefore be needed for the development of more nature conservation initiatives.

4.4. Shortcomings and future directions

Our framework of post-abandonment trajectories does not capture the temporality (length) of abandonment. This variable would, however, influence the feasibility and costs of developing trajectories for reusing abandoned lands. For instance, costs of recultivation and land clearing increase as vegetation grows, making this option less likely as years pass (E10).

Another potential shortcoming is linked to the selection of papers, as shown with the unequal distribution of case studies in Europe. We only found cases of afforestation in Portugal and Spain, which can be partly explained by past afforestation plans (Zanchi et al., 2007) and because forest gains were mostly attributed to secondary succession on abandoned farmlands in Eastern Europe (Chazdon et al., 2020). Hence, there was little need for afforestation programmes in these regions (E3, E4, E10). This does not exclude the possibility that we missed cases of afforestation elsewhere. The keywords used in the search could also be responsible for the low representation of cultural heritage preservation trajectories.

Given that climate change is expected to cause further abandonment and shifts in land use pattern across Europe (Falloon and Betts, 2010; Intergovernmental Panel on Climate Change, 2014), it could become an important driver of post-abandonment trajectories (Falloon and Betts, 2010) and hence deserves more attention in future studies.

5. Conclusions

This research went beyond studies on the drivers and impacts of agricultural abandonment to categorise alternative land trajectories that can develop after agricultural abandonment. Although spontaneous succession of vegetation was the dominant trajectory, we found a diversity of possible futures on abandoned farmlands leading to different outcomes and providing opportunities to contribute to current European environmental policies. Deviating from spontaneous succession was strongly influenced by institutional, socio-economic and management factors that initiate and support the development of alternative trajectories. This indicates that when different outcomes are desired or if spontaneous succession is unlikely to bring favourable outcomes, greater attention must be paid in current and future environmental policies to creating the institutional and socio-economic conditions that help move land use in the desired direction.

Acknowledgements

We thank the ten experts for their time and helpful contributions in the interviews. Their involvement provided valuable inputs for our study. We are also grateful for the informal follow-up interview given by one of the experts. The first author thanks Imre Sebestyén for his help in improving the design of the conceptual framework. The authors thank the two anonymous reviewers for their comments to improve the manuscript. This work was supported by the project TERRANOVA the European Landscape Learning Initiative, which has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 813904. The output reflects the views only of the authors, and the European Union cannot be held responsible for any use, which may be made of the information contained therein.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2021.105833.

References

Baeten, L., Velghe, D., Vanhellemont, M., De Frenne, P., Hermy, M., Verheyen, K., 2010. Early trajectories of spontaneous vegetation recovery after intensive agricultural land use. Restor. Ecol. 18 (SUPPL. 2), 379–386. https://doi.org/10.1111/j.1526-100X.2009.00627.x.

Bastin, J.-F., Finegold, Y., Garcia, C., Mollicone, D., Rezende, M., Routh, D., Crowther, T. W., 2019. The global tree restoration potential. Science 365 (6448), 76–79. https://doi.org/10.1126/science.aax0848.

Bauer, N., Wallner, A., Hunziker, M., 2009. The change of European landscapes: human-nature relationships, public attitudes towards rewilding, and the implications for landscape management in Switzerland. J. Environ. Manag. 90 (9), 2910–2920. https://doi.org/10.1016/j.jenvman.2008.01.021.

Bengtsson, J., Bullock, J.M., Egoh, B., Everson, C., Everson, T., O'Connor, T., O'Farrell, P. J., Smith, H.G., Lindborg, R., 2019. Grasslands—more important for ecosystem services than you might think. Ecosphere 10 (2), e02582. https://doi.org/10.1002/ecs2.2582.

Burrascano, S., Chytrý, M., Kuemmerle, T., Giarrizzo, E., Luyssaert, S., Sabatini, F.M., Blasi, C., 2016. Current European policies are unlikely to jointly foster carbon sequestration and protect biodiversity. Biol. Conserv. 201 (May), 370–376. https://doi.org/10.1016/j.biocon.2016.08.005.

Campo, J., Stijsiger, R.J., Nadal-Romero, E., Cammeraat, E.L.H., 2019. The effects of land abandonment and long-term afforestation practices on the organic carbon stock and lignin content of Mediterranean humid mountain soils. Eur. J. Soil Sci. 70 (5), 947–959. https://doi.org/10.1111/ejss.12799.

Ceausu, S., Hofmann, M., Navarro, L.M., Carver, S., Verburg, P.H., Pereira, H.M., 2015. Mapping opportunities and challenges for rewilding in Europe. Conserv. Biol. 29 (4), 1017–1027. https://doi.org/10.1111/cobi.12533.

Chazdon, R.L., Lindenmayer, D., Guariguata, M.R., Crouzeilles, R., Rey Benayas, J.M., Lazos Chavero, E., 2020. Fostering natural forest regeneration on former agricultural land through economic and policy interventions. Environ. Res. Lett. 15 (4), 043002 https://doi.org/10.1088/1748-9326/ab79e6.

Chytry, M., Pysek, P., Wild, J., Pino, J., Maskell, L.C., Vila, M., 2009. European map of alien plant invasions based on the quantitative assessment across habitats. Divers. Distrib. 15 (1), 98–107. https://doi.org/10.1111/j.1472-4642.2008.00515.x.

Cohen-Shacham, E., Andrade, A., Dalton, J., Dudley, N., Jones, M., Kumar, C., Walters, G., 2019. Core principles for successfully implementing and upscaling Nature-based Solutions. Environ. Sci. Policy 98, 20–29. https://doi.org/10.1016/j.envsci.2019.04.014.

Cohen-Shacham, E., Walters, G., Janzen, C., Maginnis, S., 2016. Nature-based Solutions to aDdress Global Societal Challenges. IUCN, Gland, Switzerland. https://doi.org/10.2305/IUCN.CH.2016.13.en.

Cohen, M., Varga, D., Vila, J., Barrasaud, E., 2011. A multi-scale and multi-disciplinary approach to monitor landscape dynamics: a case study in the Catalan pre-Pyrenees (Spain). Geogr. J. 177 (1), 79–91. https://doi.org/10.1111/J.1475-4959.2010.00368.xA.

Convention on Biological Diversity, 2019, Considerations on ecosystem restoration for the post-2020 global biodiversity framework, including on a possible successor to Aichi Biodiversity Target 15. https://doi.org/10.1017/CBO9781107415324.004.

Corbelle-Rico, E., Crecente-Maseda, R., Santé-Riveira, I., 2012. Multi-scale assessment and spatial modelling of agricultural land abandonment in a European peripheral region: Galicia (Spain), 1956-2004. Land Use Policy 29 (3), 493–501. https://doi.org/10.1016/j.landusepol.2011.08.008.

Cots-Folch, R., Martínez-Casasnovas, J.A., Ramos, M.C., 2006. Land terracing for new vineyard plantations in the north-eastern Spanish Mediterranean region: landscape effects of the EU Council Regulation policy for vineyards' restructuring. Agric., Ecosyst. Environ. 115 (1–4), 88–96. https://doi.org/10.1016/j.agee.2005.11.030.

Detsis, V., Ntasiopoulou, G., Chalkias, C., Efthimiou, G., 2010. Recent insular mediterranean landscape evolution: a case study on Syros, Greece. Landsc. Res. 35 (3), 361–381. https://doi.org/10.1080/01426391003746549.

Dolejš, M., Nádvorník, J., Raška, P., Riezner, J., 2019. Frozen histories or narratives of change? Contextualizing land-use dynamics for conservation of historical rural landscapes. Environ. Manag. 63 (3), 352–365. https://doi.org/10.1007/s00267-019-01136-z.

Estel, S., Kuemmerle, T., Alcántara, C., Levers, C., Prishchepov, A., & Hostert, P., 2015, Remote Sensing of Environment Mapping farmland abandonment and recultivation across Europe using MODIS NDVI time series. 163, 312–325. https://doi.org/10.1016/j.rse.2015.03.028.

European Commission, 2018. A clean planet for all: a European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy. COM (2018), 773 final. Available at: ⟨https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018DC0773⟩.

European Commission, 2019, Converting just 1% of land to renewable energy production can provide EU's electricity consumption. Available at: ⟨https://ec.europa.eu/jrc/en/news/converting-just-1-land-renewable-energy-production-can-provide-eus-electricity-consumption⟩ (accessed 22 July 2020).

European Commission, 2020a, EU Biodiversity Strategy for 2030. Bringing nature back into our lives. COM(2020) 380 final. Available at ⟨https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1590574123338&uri=CELEX:52020DC0380⟩ (accessed 10 August 2020).

European Commission, 2020b, Farm to Fork Strategy – for a fair, healthy and environmentally-friendly food system. Available at: ⟨https://ec.europa.eu/food/farm2fork_en⟩. (accessed 15 June 2020).

European Environment Agency, 2019, Climate change adaptation in the agriculture sector in Europe. https://doi.org/10.2800/537176.

Fagerholm, N., Torralba, M., Moreno, G., Girardello, M., Herzog, F., Aviron, S., Plieninger, T., 2019. Cross-site analysis of perceived ecosystem service benefits in multifunctional landscapes. Glob. Environ. Change 56, 134–147. https://doi.org/10.1016/j.gloenvcha.2019.04.002.

Falloon, P., Betts, R., 2010. Climate impacts on European agriculture and water management in the context of adaptation and mitigation-The importance of an integrated approach. Sci. Total Environ. 408 (23), 5667–5687. https://doi.org/10.1016/j.scitotenv.2009.05.002.

Fernández, J.B.G., Mora, M.R.G., Novo, F.G., 2004. Vegetation dynamics of Mediterranean shrublands in former cultural landscape at Grazalema Mountains, South Spain. Plant Ecol. 172 (1), 83–94. https://doi.org/10.1023/B:VEGE.0000026039.00969.7a.

Fischer, J., Hartel, T., Kuemmerle, T., 2012. Conservation policy in traditional farming landscapes. Conserv. Lett. 5 (4), 167–175. https://doi.org/10.1111/j.1755-263X.2012.00227.x.

Fischer, J., Meacham, M., Queiroz, C., 2017. A plea for multifunctional landscapes. Front. Ecol. Environ. 15 (2), 59. https://doi.org/10.1002/fee.1464.

Folberth, C., Khabarov, N., Balkovič, J., Skalský, R., Visconti, P., Ciais, P., Obersteiner, M., 2020. The global cropland-sparing potential of high-yield farming. Nat. Sustain. 3 (4), 281–289. https://doi.org/10.1038/s41893-020-0505-x.

Fundatia ADEPT Transilvania, WWF-Romania, & ProPark Foundation, 2016, Rural Development and High Nature Value Farmland in Romania. Available at: ⟨https://fundatia-adept.org/reports/⟩ (accessed 29 June 2020).

Gallemore, C., Munroe, D., van Berkel, D., 2018. Rural-to-urban migration and the geography of absentee non-industrial private forest ownership: a case from southeast Ohio. Appl. Geogr. 96, 141–152. https://doi.org/10.1016/j.apgeog.2018.05.010.

García-Ruiz, J.M., Lasanta, T., Nadal-Romero, E., Lana-Renault, N., Álvarez-Farizo, B., 2020. Rewilding and restoring cultural landscapes in Mediterranean mountains: opportunities and challenges. Land Use Policy 99, 104850. https://doi.org/10.1016/j.landusepol.2020.104850.

García-Ruiz, J.M., Lasanta, T., Ruiz-Flano, P., Ortigosa, L., White, S., González, C., Martí, C., 1996. Land-use changes and sustainable development in mountain areas: a case study in the Spanish Pyrenees. Landsc. Ecol. 11 (5), 267–277. https://doi.org/10.1007/BF02059854.

Grădinaru, S.R., Iojă, C.I.I., Vânău, G.O., Onose, D.A., 2020. Multi-dimensionality of land transformations: from definition to perspectives on land abandonment. Carpathian J. Earth Environ. Sci. 15 (1), 167–177. https://doi.org/10.26471/cjees/2020/015/119.

Grădinaru, S.R., Iojă, C.I., Onose, D.A., Gavrilidis, A.A., Pətru-Stupariu, I., Kienast, F., Hersperger, A.M., 2015. Land abandonment as a precursor of built-up development at the sprawling periphery of former socialist cities. Ecol. Indic. 57, 305–313. https://doi.org/10.1016/j.ecolind.2015.05.009.

Griffiths, P., Müller, D., Kuemmerle, T., Hostert, P., 2013. Agricultural land change in the Carpathian ecoregion after the breakdown of socialism and expansion of the European Union. Environ. Res. Lett. 8 (4), 045024 https://doi.org/10.1088/1748-9326/8/4/045024.

Hobbs, R.J., Harris, J.A., 2001. Restoration ecology: Repairing the earth's ecosystems in the new millennium. Restor. Ecol. 9 (2), 239–246. https://doi.org/10.1046/j.1526-100X.2001.009002239.x.

Intergovernmental Panel on Climate Change, 2014, Climate Change 2014: Synthesis Report - Summary Chapter for Policymakers. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (Eds.)], 31. https://doi.org/10.1017/CBO9781107415324.

Jones, N., de Graaff, J., Rodrigo, I., Duarte, F., 2011. Historical review of land use changes in Portugal (before and after EU integration in 1986) and their implications for land degradation and conservation, with a focus on Centro and Alentejo regions. Appl. Geogr. 31 (3), 1036–1048. https://doi.org/10.1016/j.apgeog.2011.01.024.

Keenleyside, C., Tucker, G., 2010. Farmland Abandonment in the EU: an Assessment of Trends and Prospects. Institute for European Environmental Policy, London.

Kovács-Hostyánszki, A., Földesi, R., Mózes, E., Szirák, Á., Fischer, J., Hanspach, J., Báldi, A., 2016. Conservation of pollinators in traditional agricultural landscapes - new challenges in Transylvania (Romania) posed by EU accession and recommendations for future research. PLoS One 11 (6), 1–20. https://doi.org/10.1371/journal.pone.0151650.

Kuemmerle, T., Levers, C., Erb, K., Estel, S., Jepsen, M.R., Müller, D., Plutzar, C., Stürck, J., Verkerk, P.J., Verburg, P.H., Reenberg, A., 2016. Hotspots of land use change in Europe. Environ. Res. Lett. 11, 064020 https://doi.org/10.1088/1748-9326/11/6/064020.

Lasanta, T., Arnáez, J., Pascual, N., Ruiz-Flaño, P., Errea, M.P., Lana-Renault, N., 2017. Space–time process and drivers of land abandonment in Europe. Catena 149, 810–823. https://doi.org/10.1016/j.catena.2016.02.024.

Lasanta, T., Nadal-Romero, E., Arnáez, J., 2015. Managing abandoned farmland to control the impact of re-vegetation on the environment. The state of the art in Europe. Environ. Sci. Policy 52, 99–109. https://doi.org/10.1016/j.envsci.2015.05.012.

Lesschen, J.P., Cammeraat, L.H., Kooijman, A.M., van Wesemael, B., 2008. Development of spatial heterogeneity in vegetation and soil properties after land abandonment in a semi-arid ecosystem. J. Arid Environ. 72, 2082–2092. https://doi.org/10.1016/j.jaridenv.2008.06.006.

Lomba, A., Moreira, F., Klimek, S., Jongman, R.H.G., Sullivan, C., Moran, J., Mccracken, D.I., 2019. Back to the future: rethinking socioecological systems underlying high nature value farmlands. Front. Ecol. Environ. 18 (1), 1–7. https://doi.org/10.1002/fee.2116.

MacDonald, D., Crabtree, J.R., Wiesinger, G., Dax, T., Stamou, N., Fleury, P., Gibon, A., 2000. Agricultural abandonment in mountain areas of Europe: environmental consequences and policy response. J. Environ. Manag. 59 (1), 47–69. https://doi.org/10.1006/jema.1999.0335.

Mercurio, R., Contu, F., Scarfò, F., 2010. New approaches concerning forest restoration in a protected area of central Italy: an introduction. Scand. J. For. Res. 25 (SUPPL. 8), 115–120. https://doi.org/10.1080/02827581.2010.485809.

Moreira, F., Queiroz, A.I., Aronson, J., 2006. Restoration principles applied to cultural landscapes. J. Nat. Conserv. 14 (3–4), 217–224. https://doi.org/10.1016/j.jnc.2006.05.007.

Morel, L., Barbe, L., Jung, V., Clément, B., Schnitzler, A., Ysnel, F., 2020. Passive rewilding may (also) restore phylogenetically rich and functionally resilient forest plant communities. Ecol. Appl. 30 (1), 1–12. https://doi.org/10.1002/eap.2007.

Munroe, D.K., van Berkel, D.B., Verburg, P.H., Olson, J.L., 2013. Alternative trajectories of land abandonment: causes, consequences and research challenges. Curr. Opin. Environ. Sustain. 5 (5), 471–476. https://doi.org/10.1016/j.cosust.2013.06.010.

Nadal-Romero, E., Cammeraat, E., Pérez-Cardiel, E., Lasanta, T., 2016. Effects of secondary succession and afforestation practices on soil properties after cropland abandonment in humid Mediterranean mountain areas. Agric., Ecosyst. Environ. 228, 91–100. https://doi.org/10.1016/j.agee.2016.05.003.

Nainggolan, D., de Vente, J., Boix-Fayos, C., Termansen, M., Hubacek, K., Reed, M.S., 2012. Afforestation, agricultural abandonment and intensification: Competing trajectories in semi-arid Mediterranean agro-ecosystems. Agric., Ecosyst. Environ. 159, 90–104. https://doi.org/10.1016/j.agee.2012.06.023.

Navarro, L.M., & Pereira, H.M., 2015, Rewilding Abandoned Landscapes in Europe. In Rewilding European Landscapes (pp. 3–23). https://doi.org/10.1007/978–3-319–12039-3_1.

Oberč, B.P., Schnell, A.A., 2020. Approaches to Sustainable Agriculture. Exploring the Pathways Towards the Future of Farming. IUCN EURO, Brussels, Belgium.

Peña-Angulo, D., Khorchani, M., Errea, P., Lasanta, T., Martínez-Arnáiz, M., Nadal-Romero, E., 2019. Factors explaining the diversity of land cover in abandoned fields in a Mediterranean mountain area. Catena 181, 104064. https://doi.org/10.1016/j.catena.2019.05.010.

Perino, A., Pereira, H.M., Navarro, L.M., Fernández, N., Bullock, J.M., Ceaușu, S., Cortés-Avizanda, A., van Klink, R., Kuemmerle, T., Lomba, A., Pe'er, G., Plieninger, T., Rey Benayas, J.M., Sandom, C.J., Svenning, J.C., Wheeler, H.C., 2019. Rewilding complex ecosystems. Science 364 (6438), eaav5570. https://doi.org/10.1126/science.aav5570.

Plieninger, T., Draux, H., Fagerholm, N., Bieling, C., Bürgi, M., Kizos, T., Verburg, P.H., 2016. The driving forces of landscape change in Europe: a systematic review of the evidence. Land Use Policy 57, 204–214. https://doi.org/10.1016/j.landusepol.2016.04.040.

Pointereau, P., Coulon, F., Girard, P., Lambotte, M., Stuczynski, T., Sánchez Ortega, V., Del Rio, A., 2008. Analysis of the driving forces behind farmland abandonment and the extent and location of agricultural areas that are actually abandoned or are in risk to be abandoned. In: Anguiano, E., Bamps, C., Terres, J.-M. (Eds.), JRC Scientific and Technical Reports. EUR 23411 EN.

Pugnaire, F.I., Luque, M.T., Armas, C., Gutiérrez, L., 2006. Colonization processes in semi-arid Mediterranean old-fields. J. Arid Environ. 65 (4), 591–603. https://doi.org/10.1016/j.jaridenv.2005.10.002.

Regos, A., Domínguez, J., Gil-Tena, A., Brotons, L., Ninyerola, M., Pons, X., 2016. Rural abandoned landscapes and bird assemblages: winners and losers in the rewilding of a marginal mountain area (NW Spain). Reg. Environ. Change 16 (1), 199–211. https://doi.org/10.1007/s10113-014-0740-77.

Rey Benayas, J.M., Bullock, J.M., 2012. Restoration of biodiversity and ecosystem services on agricultural land. Ecosystems 15 (6), 883–899. https://doi.org/10.1007/s10021-012-9552-0.

Rey Benayas, J.M., Galván, I., Carrascal, L.M., 2010. Differential effects of vegetation restoration in Mediterranean abandoned cropland by secondary succession and pine plantations on bird assemblages. For. Ecol. Manag. 260 (1), 87–95. https://doi.org/10.1016/j.foreco.2010.04.004.

Rey Benayas, J.M., Martins, A., Nicolau, J.M., Schulz, J.J., 2007. Abandonment of agricultural land: an overview of drivers and consequences. CAB Rev.: Perspect. Agric., Vet. Sci., Nutr. Nat. Resour. 2 (057) https://doi.org/10.1079/PAVSNNR20072057.

Ruskule, A., Nikodemus, O., Kasparinskis, R., Bell, S., Urtane, I., 2013. The perception of abandoned farmland by local people and experts: landscape value and perspectives on future land use. Landsc. Urban Plan. 115, 49–61. https://doi.org/10.1016/j.landurbplan.2013.03.012.

Schulp, C.J.E., Nabuurs, G.-J., Verburg, P.H., 2008. Future carbon sequestration in Europe-Effects of land use change. Agric., Ecosyst. Environ. 127 (3–4), 251–264. https://doi.org/10.1016/j.agee.2008.04.010.

Seddon, N., Sengupta, S., García-Espinosa, M., Hauler, I., Herr, D., Rizvi, A.R., 2019. Nature-based Solutions in Nationally Determined Contributions: Synthesis and Recommendations for Enhancing Climate Ambition and Action by 2020. IUCN and University of Oxford, Gland, Switzerland and Oxford, UK.

Segura, C., Navarro, F.B., Jiménez, M.N., Fernández-Ondoño, E., 2020. Implications of afforestation vs. secondary succession for soil properties under a semiarid climate. Sci. Total Environ. 704, 135393 https://doi.org/10.1016/j.scitotenv.2019.135393.

Seidl, R., Klonner, G., Rammer, W., Essl, F., Moreno, A., Neumann, M., Dullinger, S., 2018. Invasive alien pests threaten the carbon stored in Europe's forests. Nat. Commun. 9 (1), 1626. https://doi.org/10.1038/s41467-018-04096-w.

Smaliychuk, A., Müller, D., Prishchepov, A.V., Levers, C., Kruhlov, I., Kuemmerle, T., 2016. Recultivation of abandoned agricultural lands in Ukraine: patterns and drivers. Glob. Environ. Change 38, 70–81. https://doi.org/10.1016/j.gloenvcha.2016.02.009.

Sojneková, M., Chytrý, M., 2015. From arable land to species-rich semi-natural grasslands: succession in abandoned fields in a dry region of central Europe. Ecol. Eng. 77, 373–381. https://doi.org/10.1016/j.ecoleng.2015.01.042.

Stefanski, J., Chaskovskyy, O., Waske, B., 2014. Mapping and monitoring of land use changes in post-Soviet western Ukraine using remote sensing data. Appl. Geogr. 55, 155–164. https://doi.org/10.1016/j.apgeog.2014.08.003.

Stürck, J., Levers, C., van der Zanden, E.H., Schulp, C.J.E., Verkerk, P.J., Kuemmerle, T., Verburg, P.H., 2018. Simulating and delineating future land change trajectories across Europe. Reg. Environ. Change 18 (3), 733–749. https://doi.org/10.1007/s10113-015-0876-0.

Stürck, J., Verburg, P.H., 2017. Multifunctionality at what scale? A landscape multifunctionality assessment for the European Union under conditions of land use change. Landsc. Ecol. 32 (3), 481–500. https://doi.org/10.1007/s10980-016-0459-6.

Terres, J.M., Scacchiafichi, L.N., Wania, A., Ambar, M., Anguiano, E., Buckwell, A., Zobena, A., 2015. Farmland abandonment in Europe: identification of drivers and indicators, and development of a composite indicator of risk. Land Use Policy 49, 20–34. https://doi.org/10.1016/j.landusepol.2015.06.009.

Tomaz, C., Alegria, C., Monteiro, J.M., Teixeira, M.C., 2013. Land cover change and afforestation of marginal and abandoned agricultural land: a 10year analysis in a Mediterranean region. For. Ecol. Manag. 308, 40–49. https://doi.org/10.1016/j.foreco.2013.07.044.

van der Bij, A.U., Weijters, M.J., Bobbink, R., Harris, J.A., Pawlett, M., Ritz, K., van Diggelen, R., 2018. Facilitating ecosystem assembly: plant-soil interactions as a restoration tool. Biol. Conserv. 220, 272–279. https://doi.org/10.1016/j.biocon.2018.02.010.

van der Zanden, E.H., Carvalho-ribeiro, S.M., Verburg, P.H., 2018. Abandonment landscapes: user attitudes, alternative futures and land management in Castro Laboreiro, Portugal. Reg. Environ. Change 18, 1509–1520.

van der Zanden, E.H., Van Der, Verburg, P.H., Schulp, C.J.E., Verkerk, P.J., 2017. Trade-offs of European agricultural abandonment. Land Use Policy 62, 290–301. https://doi.org/10.1016/j.landusepol.2017.01.003.

Van Doorn, A.M., Bakker, M.M., 2007. The destination of arable land in a marginal agricultural landscape in South Portugal: an exploration of land use change determinants. Landsc. Ecol. 22, 1073–1087. https://doi.org/10.1007/s10980-007-9093-7.

van Vliet, J., de Groot, H.L.F., Rietveld, P., Verburg, P.H., 2015. Manifestations and underlying drivers of agricultural land use change in Europe. Landsc. Urban Plan. 133, 24–36. https://doi.org/10.1016/j.landurbplan.2014.09.001.

Vanslembrouck, I., van Huylenbroeck, G., van Meensel, J., 2005. Impact of agriculture on rural tourism: a hedonic pricing approach. J. Agric. Econ. 56 (1), 17–30.

Vanwambeke, S.O., Meyfroidt, P., Nikodemus, O., 2012. From USSR to EU: 20 years of rural landscape changes in Vidzeme, Latvia. Landsc. Urban Plan. 105, 241–249. https://doi.org/10.1016/j.landurbplan.2011.12.009.

Varotto, M., Lodatti, L., 2014. New family farmers for abandoned lands. Mt. Res. Dev. 34 (4), 315–325. https://doi.org/10.1659/mrd-journal-d-14-00012.1.

Veldman, J.W., Overbeck, G.E., Negreiros, D., Mahy, G., Le Stradic, S., Fernandes, G.W., Bond, W.J., 2015. Where tree planting and forest expansion are bad for biodiversity and ecosystem services. BioScience 65, 1011–1018. https://doi.org/10.1093/biosci/biv118.

Veteikis, D., Šabanovas, S., Jankauskaite, M., 2011. Landscape structure changes on the coastal plain of Lithuania during 1998-2009. Baltica 24 (2), 107–116.

Wolff, S., Schrammeijer, E.A., Schulp, C.J.E., Verburg, P.H., 2018. Meeting global land restoration and protection targets: What would the world look like in 2050? Glob. Environ. Change 52, 259–272. https://doi.org/10.1016/j.gloenvcha.2018.08.002.

Zanchi, G., Thiel, D., Green, T., Lindner, M., 2007. Forest Area Change and Afforestation in Europe: Critical Analysis of Available Data and the Relevance for International Environmental Policies. EFI Technical Report. European Forest Institute, Joensuu, p. 24.

Zethof, J.H.T., Cammeraat, E.L.H., Nadal-Romero, E., 2019. he enhancing effect of afforestation over secondary succession on soil quality under semiarid climate conditions. Science of the Total Environment 652, 1090–1101. https://doi.org/10.1016/j.scitotenv.2018.10.235.