Rewilding Abandoned Farmland

An Analysis of the Impact of Rewilding on Biodiversity in Projects of Rewilding Europe

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Abstract

Biodiversity continues its devastating decline while Europe is facing an estimated 20 million ha of farmland abandonment until 2030. By reviewing scientific and grey literature, websites, and reports I investigate the impacts of rewilding on biodiversity in connection to abandoned farmland. In addition, I analyse the amount of abandoned farmland in three project areas from the *Rewilding Europe* organisation through a case study methodology. Rewilding shows both benefits and disadvantages when applied to abandoned farmland, depending on factors such as geographical location, climate, and nutrient abundance. Despite the project areas' claim to incorporate abandoned farmland it was not possible to ascertain the exact amount due to a general lack of geo-spatial data. With rewilding benefitting biodiversity in the right circumstances, the continuous abandonment of farmland and its potentially negative outcomes for biodiversity, it is imperative to conduct more research and detailed land cover change assessments.

Keywords: Rewilding, abandoned farmland, biodiversity, Rewilding Europe, keystone species, ecological integrity

Word count: 11617

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Acronyms

FLA	Farmland abandonment
RE	Rewilding Europe
CCIBIS	Carpathian Countries Integrated Biodiversity Information System

1. Introduction

1.1 Prologue

The world keeps growing. Populations and economies expand and with it their need for more resources. As a result the conversion of non-human environments into agricultural land continues to escalate (Dobrovolski et al., 2013; Lanz et al., 2018). With this escalation of agricultural expansion comes an increase of rural out-migration (Lasanta et al., 2015; Yang et al., 2020). Reasons range from lower income and urbanisation, to farmland losing nutrients (Ustaoglu & Collier, 2018). In Europe, this process has been exacerbated after the fall of the Soviet Union in 1990 which lead to farmland abandonment (FLA) in the East Bloc on a massive scale (Alcantara et al., 2013; Vuichard et al., 2008). This circumstance of more and more previously farmed landscapes lying fallow provides an opportunity to rectify a wrong that has been a staple of the Anthropocene and intensified especially through extensive farming, namely, the rapid decline of biodiversity.

Biodiversity numbers have been experiencing a nosedive (Lanz et al., 2018) in ecosystems ranging from wetlands to forests to estuaries and oceans. This decline has been going on for a long time and only accelerated in recent decades due to unimpeded global capitalistic growth resulting in the expansion of industry, urbanisation, and agriculture (Dobrovolski et al., 2013; Lanz et al., 2018). Biodiversity plays an integral part in the delicate balance of our world, which is why Rockström et al. (2009) included the reduction of it in the now famous nine planetary boundaries. There have been attempts to halt or ideally reverse the loss of biodiversity through various methods. However, the threshold for biodiversity loss has been crossed already, despite these efforts (Steffen et al., 2015). One arguably new method of environmental conservation and restoration that aims at amending this problem is rewilding.

Rewilding has been gaining grounds within the conservation and restoration community as well as sustainability science. Its focus on the restoration of natural processes by reinstating intact trophic cascades and minimal to zero human intervention/management (Corlett, 2016; Pettorelli et al., 2018; Prior & Ward, 2016) makes it stand out from other environmental restoration methods. More and more rewilding projects and organisations have established themselves over the last decades like the *Oostvaardersplassen* reserve in the Netherlands, the *Knepp Wildland* project in England, and the organisation *Rewilding Europe* (RE). Because rewilding as a conservation approach is still relatively novel, there is an ongoing debate within the broader conservation community about its definition, as there are several variants of it incorporated throughout the world (Lorimer et al., 2015; Perino et al., 2019). Variants range from active and passive rewilding to trophic or Pleistocene rewilding. Furthermore, rewilding is being utilised in numerous natural environments with ecological integrity ranging from low to very high. Accordingly, the outcomes differ while progress remains difficult to assess due to the concept's essence of avoiding clear goals and inherent flexibility in regard to adjusting its approach (Holmes et al., 2020).

1.2 Research aim and research questions

In this thesis I investigate the application of rewilding on farmland that has been abandoned in comparison to areas that have a higher ecological integrity. The point of comparison will be the impact on biodiversity. With this information I further intend to analyse the application of rewilding and the type of area utilized within the RE organisation. I chose RE as a point of investigation due to their status as a flagship organisation within the rewilding movement and their growth in prominence within the European conservation and restoration community. My goal is to clarify the impact of rewilding and which type of landscape is more suitable for rewilding in order to improve biodiversity and to assess how this is reflected within RE's choice of project areas. My research is guided by the following research questions:

1) After giving an overview of the current state of FLA in Europe, how much of abandoned farmland and areas with higher ecological integrity are found in the project areas of Rewilding Europe?

2) What are the impacts of rewilding on biodiversity when applied on abandoned farmland and how are they different when applied to areas with higher ecological integrity?

1.3 Contribution to sustainability science

Sustainability Science as a discipline attempts to understand the complex interactions between nature and human activities (Kates, 2001; Rokaya et al., 2017) and supports the transition towards a more sustainable and resilient society (Rokaya et al., 2017). According to Clark and Dickson (2003), certain priorities exist in the effort to achieve such a sustainable transition, namely water, energy, health, agriculture, and biodiversity (WEHAB). The way this has been done so far, according to Rokaya et al. (2017), is to focus on the *identification* of problems and the analysis of the surrounding science. In contrast, sustainability science, because of the complexities of present problems, shifts the focus to the *solving* of problems (Rokaya et al., 2017). Rewilding represents an attempt to solving a problem instead of 'simply' identifying it. However, it stands to reason that any proposed solutions need to stand up to scrutiny in order to avoid unnecessarily slow or even, in the long-term, harmful outcomes. As a result, such investigations would either strengthen implemented approaches at solving problems or pave the way for more suitable ones.

With this thesis I aim to contribute to the field of sustainability science by doing exactly that through focusing on two pressing sustainability issues: abandoned farmland and biodiversity decline. The findings would ideally lead to a more sustainable relationship between society and natural landscapes. In addition, the analysis of the type of project-landscapes of one of Europe's foremost rewilding organisations, has the potential to improve their project area selection in the future which could expand the positive impact of their projects, both environmentally and socio-economically. Lastly, the findings of this thesis would be able to shine a light on this specific and under-represented aspect of rewilding in an effort to expand the insights on this rising conservation approach.

1.4 Outline

Following the introduction, section 2 provides a condensed background on abandoned farmland with a focus on definition, drivers of the phenomenon, and ongoing trends. Section 2 will also include a summary of rewilding as a conservation approach and a short introduction of RE. The next section will focus on the theoretical foundation, followed by section 4 with the applied methodology of this thesis. The subsequent section 5 presents the findings which will focus on the amount of abandoned farmland and areas with higher ecological integrity within the project areas, as well as the impact of rewilding on biodiversity. These findings will then be analysed in an effort to answer the research questions and afterwards put into perspective during the discussion before being wrapped up in the conclusion.

2. Background

2.1 Abandoned Farmland

Abandoned farmland constitutes land that was previously agricultural but is no longer cultivated for either economic, social or other reasons (J. Terres et al., 2013). The former farmland has in addition not been converted into urban areas or afforested (Ustaoglu & Collier, 2018).

The reasons for the people leaving agricultural land are numerous and complex. In Eastern Europe, the collapse of the Soviet Union resulted in widespread agricultural reforms involving the liberalisation of prices and the privatisation of the agricultural sector (Alcantara et al., 2013; Kuemmerle et al., 2011). In addition, established regional and national markets were replaced by international ones which increased the competition, decreased capital investments, and lead to labour shortage due to the migration of rural populations to cities (Alcantara et al., 2013; Kuemmerle et al., 2011; Lasanta et al., 2015). This resulted in a massive post-soviet-union FLA in Eastern Europe of an estimated 20 million hectares (Kuemmerle et al., 2011; Vuichard et al., 2008). The various factors that are estimated to drive

FLA can be categorised into four general groups: biophysical, economic, farm stability and viability, and political and regional (Ustaoglu & Collier, 2018).

Biophysical factors include the climate with low temperatures and aridity, the soil (drainage, texture and stoniness, rooting depth, chemical property), climate, and the topography of the land such as slope and elevation (Perpiña Castillo et al., 2018; J. Terres et al., 2013; Ustaoglu & Collier, 2018).

Economic factors incorporate elements such as the structure of employment and income (Perpiña Castillo et al., 2018; J. Terres et al., 2013; J.-M. Terres et al., 2015; Ustaoglu & Collier, 2018). They further include the price of any given farmland as well as the rate of selling and/or buying it (J. Terres et al., 2013; Ustaoglu & Collier, 2018). Lastly, there is also the involvement in schemes of the Common Agricultural Policy (CAP) of the EU to be considered, which, between 1988 and 2008, championed incentives for farmers to either temporarily or permanently abandon land in an effort to scale down over-production and costs for storing excess produce (Lasanta et al., 2015; Perpiña Castillo et al., 2018).

Farm stability and viability looks at the income of individual farms in comparison to the regional average while considering possible subsidies and investments, as well as the decrease in intensity by which the land is being farmed (Navarro & Pereira, 2012; J. Terres et al., 2013; Ustaoglu & Collier, 2018). Social aspects such as the age of farmers and the percentage of possible successors also fall into this category, as well as the structure of the farms (J. Terres et al., 2013; Ustaoglu & Collier, 2018). This further refers to the actual size of the individual land parcels, possible fragmentation of holdings, and the remoteness and level of difficulty in accessing it (Navarro & Pereira, 2012; Perpiña Castillo et al., 2018; J. Terres et al., 2013; J.-M. Terres et al., 2015; Ustaoglu & Collier, 2018).

Lastly, there are *political and regional factors* such as rural to urban migration, driven by rising agricultural prices, the development of foreign trade, and diminishing demand for products (Navarro & Pereira, 2012; J. Terres et al., 2013; Ustaoglu & Collier, 2018). In the case of Eastern Europe this also refers to their transition process after the fall of the Soviet Union which resulted in issues such as a lack of funding in the agricultural sector and inadequately defined property rights (Lasanta et al., 2015; J. Terres et al., 2013; Ustaoglu & Collier, 2018). In general, the differences of land reforms on a national scale as well as the various levels of governmental support for the agricultural sector play into the political and regional context that drive FLA (Alcantara et al., 2013).

These impacts are felt most severe in mountainous areas which are experiencing the harshest levels of FLA in Europe (Lasanta et al., 2015; Navarro & Pereira, 2012; Ustaoglu & Collier, 2018). According to the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT), Europe's rural population has declined by 17% since 1961, with mountain areas around the Mediterranean experiencing out-migration of more than 50% (Ceaușu et al., 2015; Navarro & Pereira, 2012). In mountain farming communities the income is up to 40% lower than less disadvantaged areas and the access to education and employment for the younger generation is limited while the older generation has limited access to services (Navarro & Pereira, 2012). According to Navarro and Pereira (2012), this in turn leads to less capital investment in the areas and fewer job opportunities, which then again results in out-migration, creating several reinforcing feedback loops, which is illustrated by the causal loop diagram in Figure 1. This process mirrors the large-scale FLA experienced by former Soviet Union members described above.

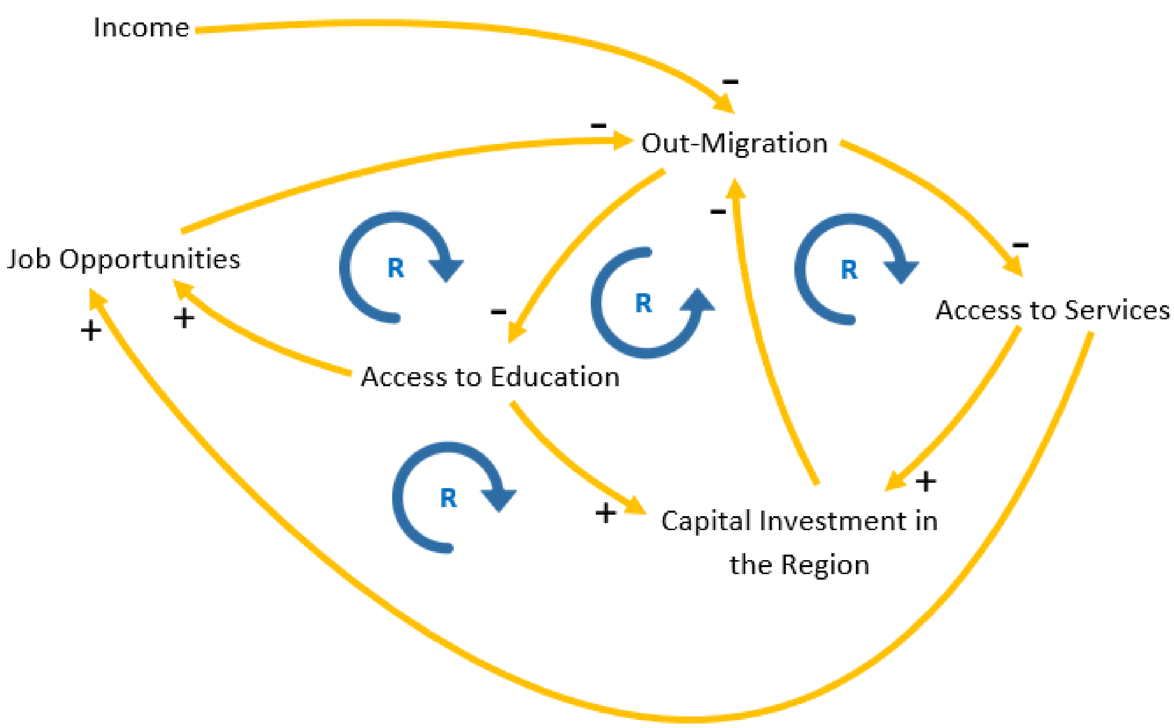

Figure 1. Causal loop diagram illustrating the interactions between factors leading to out-migration in marginalized mountain regions. A decrease in access to services and education leads to a decrease in capital investment in the region as well as fewer job opportunities (symbolised by plus signs). This, in combination with a decrease in income, in turn leads to an increase in out-migration (symbolised by minus signs). A higher out-migration then results in further decreases in access to services and education, thereby creating several reinforcing feedback loops (symbolised by blue R within circular arrow). Own work.

This extensive FLA can lead to both positive and negative impacts for the surrounding environment, which this thesis will get into later. A possible approach to nullify the negative impacts while retaining the positive ones is rewilding.

2.2 Rewilding

For the purpose of this thesis the term *rewilding* refers to a conservation and restoration approach that focuses on the re-establishment of ecological processes and trophic cascades after they have been diminished or lost through human activities (Corlett, 2016; Pettorelli et al., 2018; Prior & Ward, 2016). The manner by which to achieve this entails the re-introduction of regional keystone species or taxonsubstitutions[1] in the case of previous extinctions of the original keystone species (Bakker & Svenning, 2018; Corlett, 2016; Lorimer et al., 2015; Nogués-Bravo et al., 2016; Root-Bernstein et al., 2018). The main focus lies hereby on carnivores and/or large grazing herbivores (Corlett, 2016; Nogués-Bravo et al., 2016; Root-Bernstein et al., 2018). Furthermore, rewilding incorporates the removal of artificial barriers in the natural landscapes, previously set up by humans, such as fences and dams, and the recreation/re-establishment of natural landscapes, for example through reconnections of rivers and lakes and reflooding wetlands (Perino et al., 2019; Pettorelli et al., 2018). Another main staple of rewilding is the minimisation of human intervention with the overall goal of zero intervention and total self-regulation of the area (Corlett, 2016; Jepson et al., 2018; Toit & Pettorelli, 2019; Torres et al., 2018).

At the start of the rewilding process human intervention is often necessary to kick things off, for example through species reintroduction or river reconnection (Schepers & Jepson, 2016). The aim, however, is to gradually reduce the human input in the area until self-regulation is achieved (Jepson et al., 2018; Perino et al., 2019; Prior & Ward, 2016). This focus on the self-reliability and self-actualisation of nature makes rewilding a flexible conservation approach. There are no clear targets to aim for or specific species to focus on for deliberate protection (Holmes et al., 2020). After the initial input through species reintroduction or fence removal, nature is ideally left to its own devices and 'allowed' to develop on its own, no matter which direction it goes (Holmes et al., 2020; Perino et al., 2019; Pettorelli et al., 2018; Schepers & Jepson, 2016; Smit et al., 2015).

The origin of rewilding as a conservation concept can be traced back to the late 1980s to Michael Soulè (conservation biologist) and David Foreman (environmentalist) in the US who, with their *The Wildland Projects*, introduced the concept with a focus on establishing "large and well-connected core areas and releasing keystone species" (Lorimer et al., 2015; Pettorelli et al., 2018). The idea behind it was the assumption that to restore depleted ecosystems and their capability to maintain a richer biodiversity, it is crucial to recover the ecological roles of previously eradicated megafauna (Fernández et al., 2017; Perino et al., 2019). The concept of rewilding spread to Europe where its focus shifted from carnivores towards large grazing herbivores as ecological engineers, as showcased by the Oostvaardersplassen project in the Netherlands (Corlett, 2016; Lorimer et al., 2015; Nogués-Bravo et al., 2016). Throughout its over 20 years history, the concept of rewilding has inspired numerous adaptations and variants of its approach. The four most prominent are *Pleistocene, Trophic-, Active/Ecological-,* and *Passive rewilding* (see Table 1).

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[1] Introduction of "(de)domesticated and/or non-native analogues of missing species" (Lorimer et al., 2015, p. 40).

Table 1. Four most prominent rewilding approaches. Own work.

Pleistocene rewilding	Focuses on the advancement of megafauna with the aim to establish ecological processes that resemble the ecological landscape of the Pleistocene (Josh Donlan et al., 2006).
Trophic rewilding	Aims at the restoration of "top-down trophic interactions and associated trophic cascades [through species introductions] to promote self-regulating biodiverse ecosystems" (Svenning et al., 2016, p. 899).
Active/Ecological rewilding	Also prioritises the restoration of ecological processes (Corlett, 2016). However, it does so through interventions such as the clearing of vegetation and human made barriers (fences, dams) and the creation of artificial habitats (Navarro & Pereira, 2012).
Passive rewilding	Main goal is to minimize human intervention as much as possible, although it may be necessary in the initial stages of restoration (Navarro & Pereira, 2012).

2.3 *Rewilding Europe*

RE is an international non-profit organization that was founded in 2010 in the Netherlands in an effort to rebrand the previously existing organisation *Wild Europe Field Programme* (Jørgensen, 2015). The initiation of the organization was aided by WWF Netherlands, ARK Nature, Wild Wonders of Europe, and Conservation Capital (Helmer et al., 2015; *Rewilding Europe | Making Europe a Wilder Place*, n.d.). The aim of the organization is to rewild at least 1 million ha across continental Europe by 2022 (Helmer et al., 2015; Monbiot, 2014). They intend to achieve this through the creation of 10 "magnificent wildlife and wild areas of international quality" (*Rewilding Europe | Making Europe a Wilder Place*, n.d.). So far, they have established 8 wildlife areas across continental Europe[2] (*Rewilding Europe | Making Europe a Wilder Place*, n.d.). In total, RE has 10 objectives[3] that are to be worked towards, of which the first two can be seen in Table 2.

[2] Complete list in Appendix 10.1.

[3] Complete list in Appendix 10.2.

Table 2. First two objectives of *Rewilding Europe* (*Annual Review 2012*, 2012).

1	A total of at least 1 million ha (10,000 km2) of land will be 'rewilded' by the initiative and its partners, across 10 places covering different geographical regions of Europe, including different landscapes and habitats.
2	A substantial wildlife comeback (in particular for keystone or flagship species) will take place in the 10 rewilding areas, supported by re-introductions where appropriate or necessary, serving as the starting point for complete, functional ecosystems.

Part of RE's strategy lies in turning abandoned farmland into biologically productive areas with high biodiversity and intact ecosystems (Jørgensen, 2015) through active and trophic rewilding measures ranging from dam removal and habitat reconnection to species reintroduction (*Rewilding Europe | Making Europe a Wilder Place*, n.d.). In general, stopping the decline of biodiversity and ideally reversing it play a major part in the organizations overall mission (*Annual Review 2015*, 2016; *Annual Review 2017*, 2018; *Rewilding Europe | Making Europe a Wilder Place*, n.d.). To achieve this RE especially focuses on the reestablishment of large grazing herbivores such as wild horses and European bison in European landscapes (*Annual Review 2019*, 2020).

3. Theory

Within this thesis I lean on three theoretical concepts in order to strengthen my research. All three concepts combined provided my research with a theoretical framework with which to analyse and compare areas regarding abandoned farmland and ecological integrity as well as investigate different rewilding approaches and their impact on biodiversity.

1. *Ecological Integrity*
2. *Biodiversity*
3. *Keystone Species*

For the first concept, *ecological integrity*, I followed the definition put forth by Parrish et al. (2003) who defined it as:

> the ability of an ecological system to support and maintain a community of organisms that has species composition, diversity, and functional organization comparable to those of natural habitats within a region. An ecological system or species has integrity or is viable when its dominant ecological characteristics (e.g., elements of composition, structure, function, and ecological processes) occur within their natural ranges of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human disruptions. (p. 852)

The concept of ecological integrity aided my research and analysis in providing a framework to differentiate between areas with low productivity and areas with higher productivity. In this thesis abandoned farmlands will be seen as areas with low productivity and biosphere reserves and national parks will be seen as areas with higher productivity and/or higher ecological integrity. I am basing this distinction on the fact that biosphere reserves and national parks experience a (varying) degree of protection from anthropogenic influences and can therefore more reliably provide the characteristics of ecological integrity, as stated by Parrish et al. (2003) above, than abandoned farmland.

Biodiversity, which is part of the components of *ecological integrity*, concerns itself solely with the amount of different biological elements that occur naturally and are characterized by their relative frequencies, composition, and spatiotemporal distribution (Karr, 1993). This concept served as a point of comparison between the impact of rewilding on abandoned farmland and on areas with higher ecological integrity.

Lastly, I employed the theoretical concept of *keystone species*. The term itself has been coined by Robert T. Paine, a zoologist, in 1969 who defined it as species that are integral to the internal structure of their ecological community (its organization and diversity) which is determined by their abundance and activities (Bond, 1994; Cristancho & Vining, 2004; Mills et al., 1993). The concept has diversified over the years, which has led to various interpretations and definitions, as well as a general broadening of the term while being employed in the field of Ecology and Conservation (Cottee-Jones & Whittaker, 2012; Mills et al., 1993). According to Cottee-Jones and Whittaker (2012), an applicable and defendable definition of *keystone species* in today's time is "a species that is of demonstrable importance for ecosystem function" (p. 120), which is the definition that my research adhered to. Even though the *keystone species* concept does not directly connect the labelled species to biodiversity, it is still useful in my research as the conservation approach *rewilding*, as RE practices it, has a strong focus on the re-introduction and/or stabilization of large grazing keystone herbivores.

4. Methodology

4.1 Case Study

In order to provide an in-depth analysis of the application of rewilding in areas of abandoned farmland and areas with higher ecological integrity this thesis utilizes a case-study methodology. A case-study analysis lends itself to this research as it has a holistic approach and allows me as the researcher to get a full picture of the case(s) being analysed (Igwe & Odii, 2020). It also provides the opportunity to generalize findings (Igwe & Odii, 2020) as the results of this research may allow a better understanding of the circumstances in other rewilding projects. For this research I have chosen the following RE projects: the Southern Carpathians, the Central Apennines, and the Danube Delta. Tables 3-5 provide general information about the projects with the following paragraphs going into further detail.

Southern Carpathians

The Carpathians are Europe's largest mountain range which covers an area of about 210.000 km² and stretches across seven European nations (Czech Republic, Poland, Slovakia, Hungary, Ukraine, Romania, Serbia) (Kuemmerle et al., 2010; Kuemmerle, Perzanowski, et al., 2011; Promberger & Promberger, 2015). However, it is the Tarcu mountain in Romania which RE has chosen as its designated rewilding project in the region (*Bison and Biodiversity in the Tarcu Mountains Natura 2000 Site*, 2020; *Southern Carpathians*, n.d.). As the majority of FLA occurs in mountain areas and in Eastern Europe, I chose this project as it reflects these criteria. It further expresses RE's own tendency to pick mountain areas for their projects as 4 out of their 8 projects are located in mountain ranges (*Rewilding Europe | Making Europe a Wilder Place*, n.d.). Further information about the project can be found in Table 3.

Table 3. Information about Southern Carpathians project (*Annual Review 2019*, 2020; *Bison and Biodiversity in the Tarcu Mountains Natura 2000 Site*, 2020; *CCIBIS*, n.d.; *Southern Carpathians*, n.d.; Vasile, 2018). Own work.

Region	Tarcu mountain (978 km²), Romania, 22.000 inhabitants
Focus species	European bison, red deer, wolf, brown bear, Eurasian lynx
Main partner(s)	WWF-Romania
Local partner(s)	Avesta (Swedish wildlife park and bison breeder), European Bison Conservation Centre (Poland), Hunedoara Zoo, Romanian National Forest Administration, Town Hall of Armenis Commune, Local Council of Armenis Commune, Teregove Forest Division
Start of the project	2011

Central Apennines

The Apennines are a series of vast mountain ranges with a length of about 1.400 km that stretch across peninsular Italy (*Apennine Range | Mountains, Italy*, n.d.). The Central Apennines specifically cover the Italian regions of Abruzzo, Latium, and Molise (*Central Apennines Details*, n.d.). The Central Apennines project's goal is to establish vital wildlife corridors in order to connect the protected areas of the Abruzzo, Lazio and Molise National Park, the Majella National Park, and the Sirente Velino National Park (*Central Apennines*, n.d.; *Wildlife Comeback*, n.d.). As with the Southern Carpathians, the Central Apennines have experienced an increase in FLA over the last decades, which makes them a fitting project for this thesis. Furthermore, the project's focus on corridors rather than individual protected areas differentiates it further from the other two project areas. Additional information about the project can be seen in Table 4.

Table 4. Information about Central Apennines project (*Annual Review 2019*, 2020; *Central Apennines*, n.d.; *Central Apennines Details*, n.d.; *Wildlife Comeback*, n.d.). Own work.

Region	Central Apennines, Abruzzo, Latium, and Molise, Italy
Focus species	Marsican brown bear, Apennine wolf, Apennine chamois, griffon vulture, red deer
Main partner(s)	Rewilding Apennines, local Ngo Salviamo l'Orso (Associazione per la conservazione dell'orso bruno marsicano – ONLUS)
Local partner(s)	Several local municipalities, Abruzzo National Park
Start of the project	2013

Danube Delta

The Danube Delta, the second biggest delta in Europe, encompasses an area of around 580.000 ha which stretches across the borders of Ukraine, Romania, and Moldovia (Gâştescu, 1993, 2009) and connects the 2.800 km long Danube river to the black sea (Gâştescu, 1993; Gómez-Baggethun et al., 2019). I chose the Danube Delta project as part of my thesis because it represents a different landscape type in comparison to the other two project areas. Supplementary information about the project are presented in Table 5.

Table 5. Information about Danube Delta project (*Annual Review 2019*, 2020; *Danube Delta*, n.d.; *Rewilding Europe | Making Europe a Wilder Place*, n.d.; Gómez-Baggethun et al., 2019; Văidianu et al., 2014). Own work.

Region	Danube Delta, 580.000 ha, Ukraine, Romania, Moldovia, 13.000 inhabitants
Focus species	White pelican, Dalmatian pelican, Tauros, beaver, wild horse, water buffalo, red deer, kulan, demoiselle crane
Main partner(s)	Rewilding Ukraine, Rewilding Danube Delta, WWF-Romania
Local partner(s)	Askania-Nova Biosphere Reserve, Odessa Zoo, Danube Delta Research Institute (INCDDD), Danube Delta Biosphere Reserve Authority (DDBRA), Sfântu Gheorghe municipality (Romania), Romanian Forestry Department
Start of the project	2013

4.2 Scope

In the context of the Covid-19 pandemic I decided to focus on secondary data collection and analysis instead of fieldwork. This enabled me to choose multiple and more distant project areas for my research which more accurately reflect the marginalised agricultural areas described in 2.1. This further matches RE's strategy of turning abandoned farmland into biologically productive areas with high biodiversity and intact ecosystems (Jørgensen, 2015), as mentioned before in 2.3. In addition, having three project areas from different nations has the benefits of providing the opportunity of a cross-cultural exploratory investigation of the research topic.

Concerning the time scale, I decided to only consider FLA that occurred after 1990. I chose that time-period for two reasons. First, the further back in time one investigates FLA the more unreliable and constrained the available data on land-use statistics become, especially before the 1970s and in former member states of the Soviet Union (Alcantara et al., 2013; Kuemmerle et al., 2011; Lasanta et al., 2015; Ustaoglu & Collier, 2018). Second, the fall of the Soviet Union in 1990 impacted the rate of FLA significantly in former member states (Kuemmerle et al., 2011) and two out of the three projects I chose for my research are located in such regions.

4.3 Research design

Rewilding is a relatively new field of study with no overarching consensus on definitions. In addition, this novel conservation/restoration approach struggles with evaluating progress due to its inherent lack of clear goals and continuous flexibility regarding the development of its projects. In response, this thesis will apply an exploratory research design. Exploratory research is intended to provide adaptability to an investigation of an under researched or new topic (Leavy, 2017). This means that in the case of encountering an obstacle during the research that prevents one to continue it, exploratory research provides the necessary flexibility to adjust the methodological approach in order to continue the research (Leavy, 2017).

4.4 Data collection

I collected the necessary data through an extensive systematic literature review. The data would be of secondary nature instead of primary as it allows me to utilize already collected geo-spatial data on the land-use types of the project areas as well as the various impacts of rewilding on biodiversity. This enables me to focus on the aim of this thesis without being constrained by the task of collecting primary data myself.

4.4.1 Systematic literature review

A systematic literature review is a process constructed to aid the researcher in summarizing and assessing the largest amount of relevant literature in order to answer specific research questions (Boland et al., 2017; Ford & Pearce, 2010). The structure of a systematic literature is further designed to identify areas of uncertainty and possible new directions for future research within the topic of analysis while minimizing bias (Bryman, 2012; Ford & Pearce, 2010; Petticrew & Roberts, 2008). I employed a systematic literature review in order to review, interpret, and combine the scientific and grey literature on rewilding and its impact on biodiversity when applied on abandoned farmland and areas with higher ecological integrity.

The keywords in Table 6 were used for an online search process. It was conducted online and utilised scientific search engines such as GoogleScholar and LUBsearch from January to March 2021. The keywords were chosen to be as broad as possible to capture the diversity of rewilding approaches and their corresponding impacts on biodiversity, the scope and development of FLA, as well as the circumstances within the three project areas. The divisions on the left-hand side are inspired by the keywords list created by Ford & Pearce (2010).

Table 6. Keywords used in guiding the systematic literature review. Own work.

Keywords list						
Place names	Romania; Danube Delta; Ukraine; Moldovia; Black Sea; Southern Carpathians; Tarcu Mountains; Italy; Central Apennines; Abruzzo; Latium; Molise; Mediterranean					
Generic	Rewilding; farmland; biodiversity decline; Europe; impact; restoration; conservation; planetary boundaries; climate change					
Sections	Rewilding	*Rewilding Europe*	Abandoned Farmland	Impact of rewilding	Project areas	
Specific	Active rewilding; passive rewilding; trophic rewilding; pleistocene rewilding; trophic cascades; progress; keystone species; grazing; herbivores; carnivores; history; origins	Rewilding Europe; Organisation; continental; network; goals; aim; approach; funding; partners	Farmland abandonment; drivers; consequences; agriculture; fallow; migration; urbanisation; income; cattle	Impact; effect; diversity; species; soil; climate; landscape	Project partners; local flora and fauna; protected areas; national parks; nature reserves; biosphere reserves; Natura 2000	

The search process resulted in secondary data from 80 different academic journals, 10 reports and annual reviews, 18 websites, and 41 books, surveys, and dissertations. 19 out of the 80 journals provided multiple academic papers, of which the following five in Table 7 provided the most.

Table 7. Journals which provided the most sources. Own work.

Journal	No. of entries
Philosophical Transactions of the Royal Society for Ecological Restoration B: Biological Sciences	15
Biological Conservation	6
Proceedings of the National Academy of Sciences	6
Science	6
Conservation Biology	5

In total the research required the review of 136 scientific papers. The reports where sourced primarily from the European Commission with six, RE two, and the Wageningen University and the Institute for European Environmental Policy with one each. All sources were limited to publications in English. As the time scale placed upon my research focused on FLA after 1990 until today, I mirrored that decision in the data collection process and only considered sources that were published after 1990 as well. This was done to avoid incongruities with the data I collected and the project areas I was investigating. The systematic literature review resulted in a total of 166 sources which were subsequently divided into 5 different sections, inspired by the sections of the keywords list. How many sources went into which section can be seen in Table 8.

Table 8. Different research sections with corresponding number of sources. Own work.

SECTION	SOURCES
Rewilding	48
Rewilding Europe	9
Abandoned farmland	25
Impact of rewilding	28
Project areas	56

4.4.2 Supplementary sources

I also contacted RE directly through their contact form on their website and through e-mails sent to info@rewildingeurope.com. In addition, I looked up contact details of the team leaders of the respective projects and was able to send out inquiries about the amount of abandoned farmland to all three. I sent messages to the team leaders of the Central Apennines and the Southern Carpathians through LinkedIn and the team leader of the Danube Delta through his e-mail address. Only the team leader of the Central Apennines project responded to my inquiry. I was further given the authorization by said team leader to incorporate all the information provided to me. As this was the only response from RE, I extended the variety of sources for my research again.

For research question 1) I additionally utilized geo-spatial datasets from the Google Earth Engine, the Carpathian Countries Integrated Biodiversity Information System (CCIBIS), ResourceWatch from the World Resources Institute, and the Land Monitoring Service (LMS) from the European Union's Earth Observation Programme Copernicus.

After the collection of all relevant and available literature on the research topic, I extracted all the important information concerning the research questions and analysed them using the qualitative content analysis method.

4.5 Data analysis

4.5.1 Qualitative content analysis

Qualitative content analysis is a systematic method for analysing informational contents of texts and documents in an objective and replicable manner (Forman & Damschroder, 2007; Khirfan et al., 2020). It is a flexible method as it can be done inductively and deductively (Cho & Lee, 2014).

For this research I chose to utilize the inductive approach to content analysis as it is more appropriate when the existing knowledge about a subject matter is fragmented or limited (Cho & Lee, 2014; Elo & Kyngäs, 2008). This suits this thesis as the subject matter of this exploratory research has not been the focus of an extensive number of pre-existing studies.

As part of the inductive approach I selected the units of analysis (scientific papers and grey literature), which has already been done by the systematic literature review and drew categories from the reading of the texts. With this approach I adhered to the inductive qualitative content analysis as described by Elo & Kyngäs (2008). The categories I further divided into main category, generic category, and sub-category, as illustrated by Elo & Kyngäs in their research, and can be seen in Table 10 in the analysis section. The categories themselves will then provide the means by which to analyse the topic (Elo &

Kyngäs, 2008). The overall analysis resulted in 97 sources providing relevant information and being referenced in the thesis.

4.6 Methodological limitations

With the chosen methodology comes a set of inherent limitations. As my research will focus on the collection of secondary data it won't have an established close familiarity with the data or control over the data quality (Bryman, 2012). Additionally, getting access to important data might be difficult (Igwe & Odii, 2020). Combined with a systematic literature review these methodological approaches to research can be particularly time-consuming (Khirfan et al., 2020; Okoli & Schabram, 2010). According to Bryman (2012), another limitation of systematic literature review is the potential "bureaucratization of the process of reviewing the literature, because it is more concerned with the technical aspects of how it is done than with the analytical interpretations generated by it" (p. 108).

Qualitative content analysis exhibits on the other hand exhibits the possibility of its categorization becoming exceedingly complex (Cho & Lee, 2014). Combined with a missing established procedure of analysis this could lead to confusions for a novice researcher (Cho & Lee, 2014). Lastly, content analyses in general run the risk of being deemed atheoretical with a focus more on data that is measurable rather than theoretically significant (Bryman, 2012).

5. Results

5.1 The current state of FLA in Europe

Estimations of the overall FLA in all of Europe vary greatly as quantitative data on land-use statistics before the 1970s are limited and not always reliable, especially in former soviet countries (Alcantara et al., 2013; Kuemmerle et al., 2011; Lasanta et al., 2015; Ustaoglu & Collier, 2018). The numbers range from 20 million hectares to over 50 million hectares (Alcantara et al., 2013). Regardless of the actual number, the abandonment of farmland is an ongoing issue that shows clear signs of continuation in the future. According to Yang (2020) and Navarro and Pereira (2012), between 10 and 29 million ha of additional agricultural land is estimated to be abandoned by 2030, with approximately 1 million ha being abandoned by small scale farmers and shepherds every year (Helmer et al., 2015). The majority of areas that face this risk are mountainous and similarly marginal areas (Navarro & Pereira, 2012), although areas with exceptional yield potential face FLA as well (J. Terres et al., 2013). Figure 2 illustrates the distribution of these high abandonment risk areas in Europe, which bears a striking resemblance to the European Commission's classification of utilized agricultural areas as less favourable areas, as seen in Figure 3.

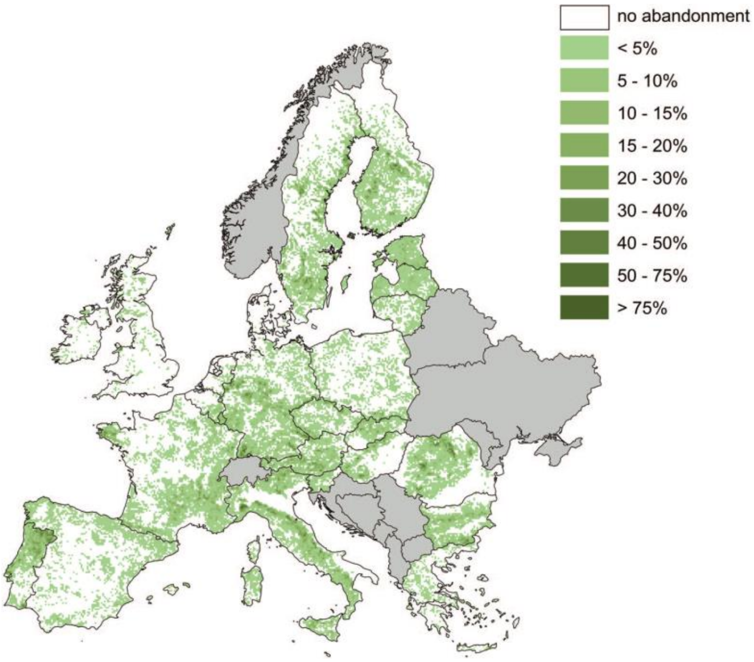

Figure 2. Areas with high risk of abandonment. Grey areas have no data (Navarro & Pereira, 2012).

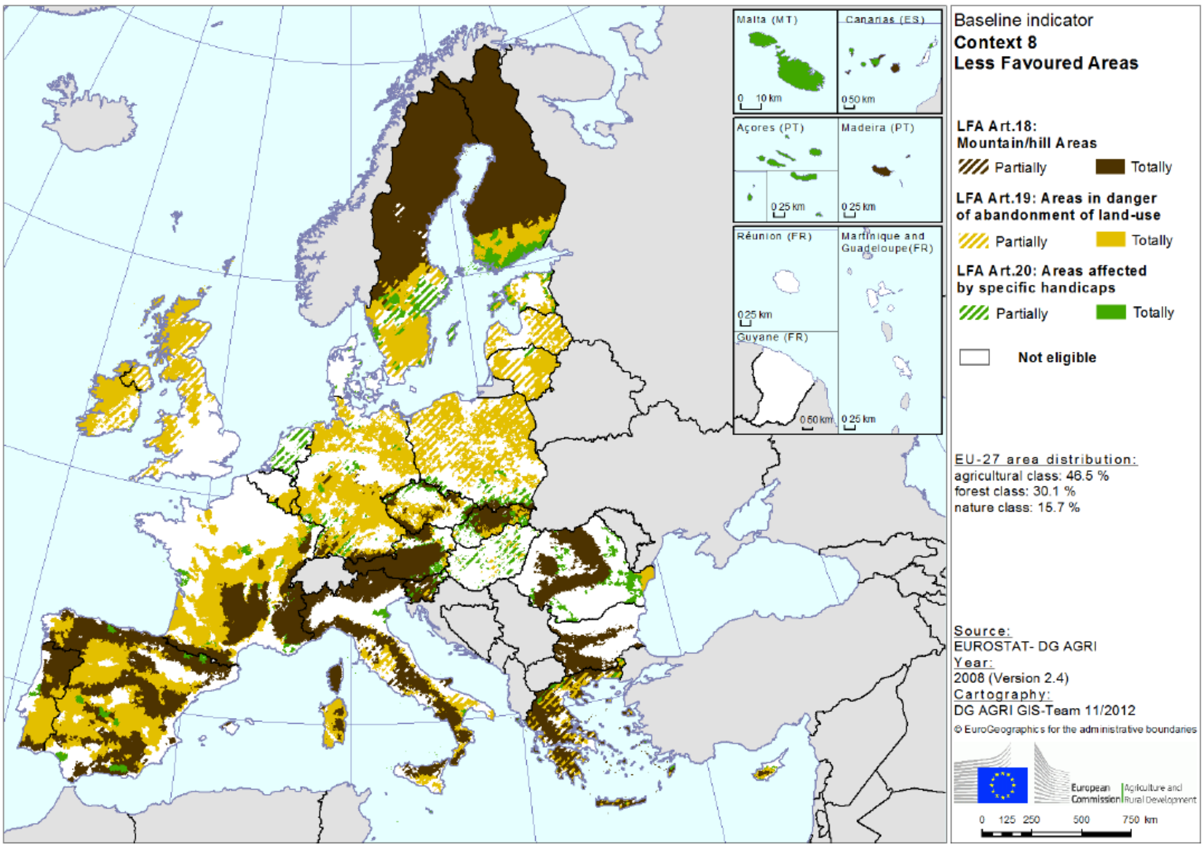

Figure 3. Less favoured areas. The European Commission differentiates between three types of less favourable areas: mountain areas, areas in danger of abandonment of land-use, areas affected by specific handicaps (*Rural Development in the EU: Statistical and Economic Information Report 2012*, 2012).

According to the European Commission, less favoured areas make up around 54% of the total utilised agricultural areas with the majority of it being in danger of abandonment (*Rural Development in the EU: Statistical and Economic Information Report 2012*, 2012). The following section will establish if such abandonment has taken place within the borders of the project areas of RE chosen for this thesis.

5.2 Amount of abandoned farmland

During the research, the methods that I employed did not enable me to acquire information about the amount of abandoned farmland used in two of the three project areas of RE chosen for this thesis (Southern Carpathians and Danube Delta). Out of the supplementary sources, only the team leader of the Central Apennines project answered my inquiry and subsequently agreed to calculate the amount of abandoned farmland within the project. The finished calculation revealed that around 44.000 ha of the total 525.000 ha of the rewilding area is made up of abandoned agricultural land, which is around 8% (Team leader Central Apennines, personal communication, August 22, 2021).

In addition to contacting RE directly I attempted to employ geospatial datasets from Google Earth Engine, the CCIBIS, ResourceWatch from the World Resources Institute, and the Land Monitoring Service (LMS) from the European Union's Earth Observation Programme Copernicus in order to calculate the same area as well as the FLA areas in the other two projects.

In the Google Earth Engine I utilised the 'Copernicus Global Land Cover Layers: CGLS-LC100 collection 3' data set which shows land covers ranging from deciduous broadleaf closed forest to shrubland to cropland. However, it neither shows abandoned farmland nor indicates if land covers like shrubland or herbaceous vegetation were previously cropland.

The dataset 'CLC2018' from Copernicus' LMS provided similar land cover information for the three project areas, but also with no information on abandoned farmland.

The CCIBIS on the other hand visualised area types such as old growth forests, protected areas, and Natura2000 sites. This enabled me to locate the Tarcu mountains where the project area of the Southern Carpathians is located as well as regional nature reserves and Natura2000 sites. Nevertheless, the CCIBIS did not include abandoned farmland within their dataset.

Lastly there was the 'Global Land Cover (IPCC Classification)' dataset from ResourceWatch which showed land covers such as forest, shrubland, and agriculture. This dataset provided the option to view the different landcovers from 1992 to 2015, thereby illustrating the possible transformation of agriculture to shrubland or forest. However, without coordinates of the exact location and borders of the project areas, it was not possible for me to calculate the amount of agriculture that has been abandoned prior to or after the establishment of said project areas. Neither the organisations website, nor the team leaders of the projects or scientific papers provided me with the necessary data. The only information I was able to obtain about the location of one of the project areas, Central Apennines, comes from an article on the organisations website which showed a map illustrating the 5 corridors the project established, as seen in Figure 4.

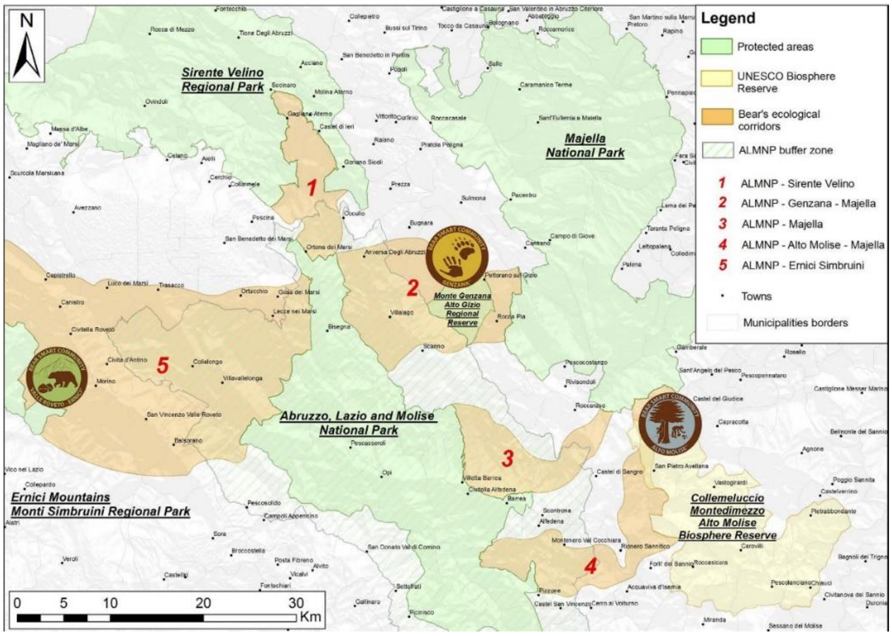

Figure 4. Map of the wildlife corridors in the Central Apennines rewilding area (*New Partnership to Address Climate Change and Enhance Biodiversity in the Central Apennines*, 2021).

Nonetheless, neither the article nor the map provides coordinates of the 5 corridors necessary for the mentioned calculation using ResourceWatch. For the Central Apennines I did however receive the calculated amount of FLA from the team leader of the project, as mentioned above.

5.3 Areas with higher ecological integrity

The missing coordinates for any of the project areas limited the research on the amount of areas with higher ecological integrity as well. As an alternative, it was possible, through geospatial images, to visualize protected areas with higher ecological integrity in the region of the rewilding projects.

In the Central Apennines, the only project area with a clear visual image of its location (Figure 4), the 5 corridors are connecting and overlapping with the following protected areas:

- Sirente Velino Regional Park
- Majella National Park
- Abruzzo, Lazio, Molise National Park
- Monte Genzana Alto Gizio Regional Reserve
- Collemeluccio Montedimezzo Alto Molise Biosphere Reserve

For the Southern Carpathians, the CCIBIS enabled the image of the Tarcu mountain range (in blue), which is the area in which the rewilding project is located, as seen in Figure 5.

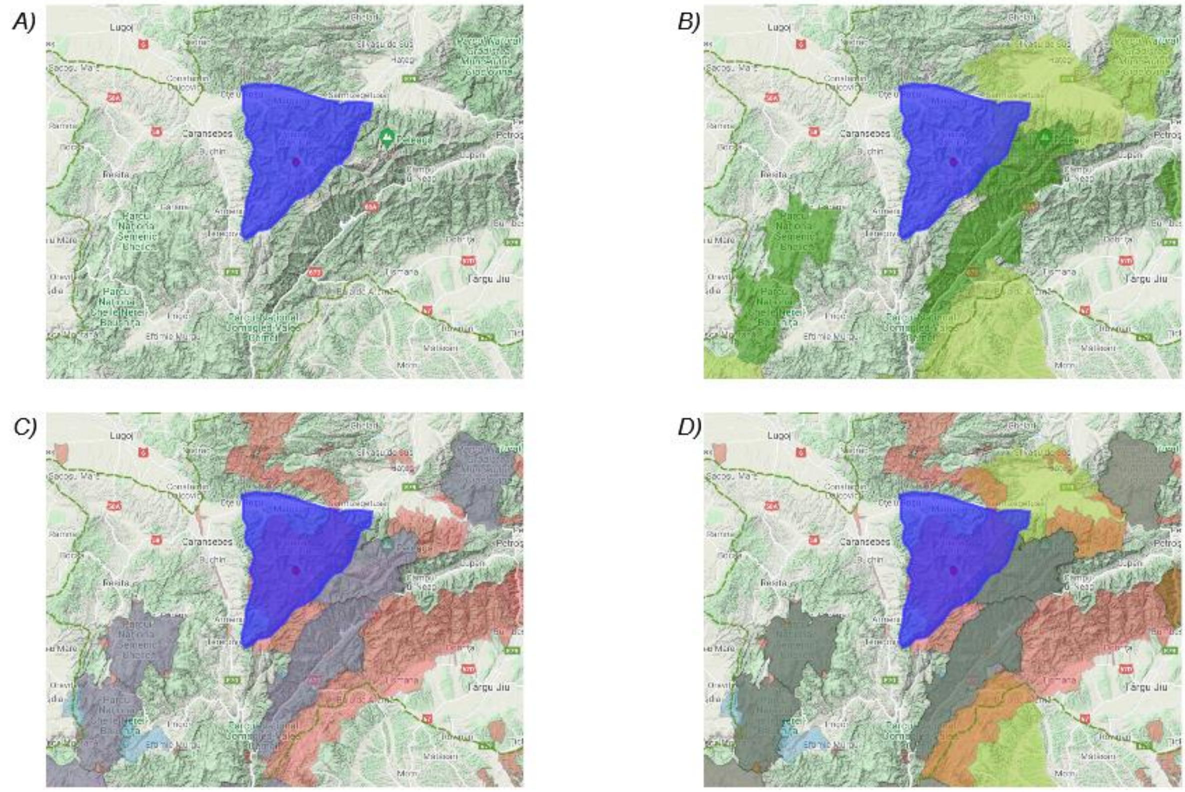

Figure 5. Geospatial images of the Tarcu mountain (blue) in the Southern Carpathian Mountain range. Tarcu mountain range (A), protected areas (B), Natura2000 sites (C), all together (D) (*CCIBIS*, n.d.). Scale 1: 1 160 000.

Image B includes national parks/national nature parks, national park buffer zones, nature reserves, man and biosphere reserves, landscape parks/regional landscape parks, protected landscape areas/natural parks (*CCIBIS*, n.d.). The protected areas overlapping with the Tarcu mountain range are the Tara Hategului Dinosaurus Geopark to the Northeast, classified as a protected landscape/natural park and the Retezat National Park to the East, classified as both a man and biosphere reserve and a national park/national nature park. Image C shows Natura 2000 sites divided into special areas of conservation (habitats) and special protection areas (birds), which both overlap with the Tarcu mountain range (*CCIBIS*, n.d.). Image D showcases the combination of all 3 types of areas.

Lastly, for the Danube Delta, as seen in image A of Figure 6, the Delta covers an area that stretches from the Northern part of Romania’s Black Sea coast into Ukraine and marginally into Moldovia. Image B illustrates the Natura 2000 sites (blue lines) within the delta. And lastly, image C is a map of the Danube Delta Biosphere Reserve with its different zones.

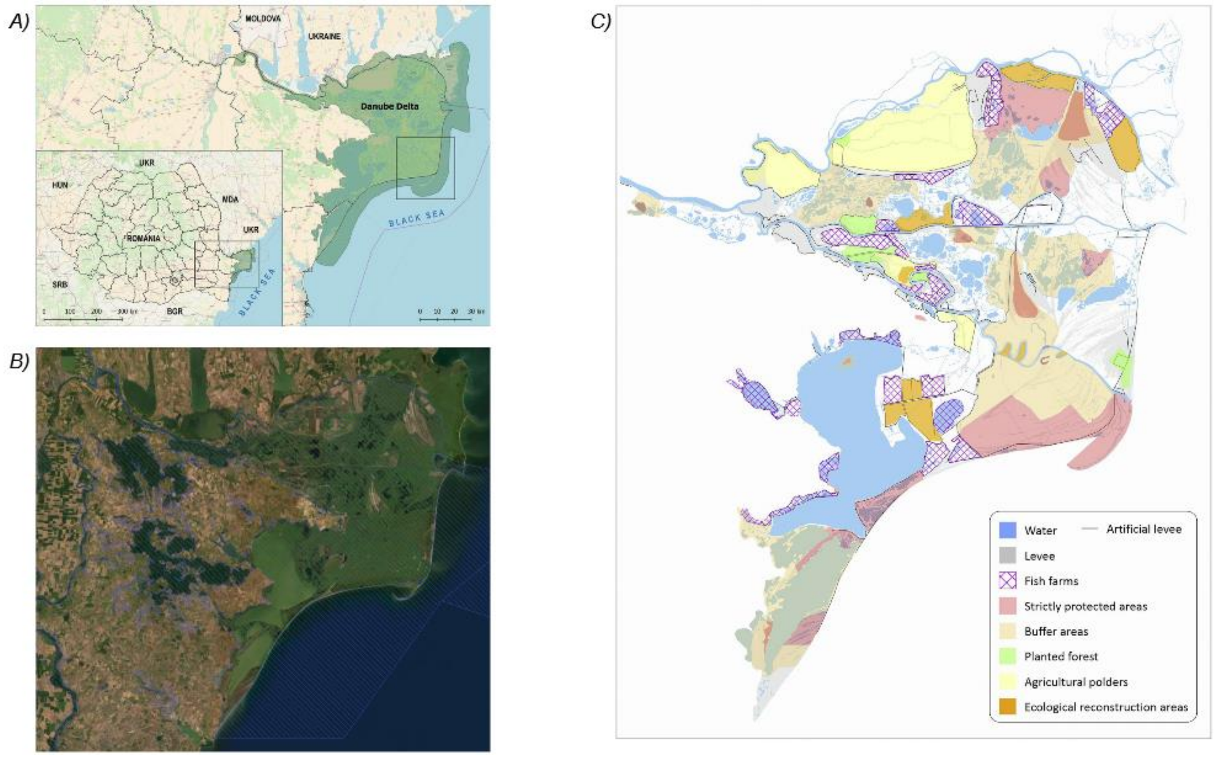

Figure 6. Geospatial images of the Danube Delta. Danube Delta (A) (Spînu et al., 2018), Natura2000 sites (B)(*Natura 2000 Network Viewer*, n.d.), Danube Delta Biosphere Reserve (C) (Tănăsescu & Constantinescu, 2020).

All three project areas illustrate various degrees of protection within their supposed borders which influence the impact rewilding can have on biodiversity in the region.

5.4 Impact of rewilding

After the review process it has become clear that there does not exist a consensus in the scientific community about the possible positive or negative outcomes for biodiversity if rewilding is applied on abandoned farmland. Furthermore, the academic papers focused more on passive and trophic rewilding than on active and Pleistocene rewilding. In accordance with those findings this result section will centre on passive and trophic rewilding as well and leave out active and Pleistocene rewilding.

According to Plieninger et al. (2014), letting abandoned farmland go fallow without any human intervention or management, which is passive rewilding, will result in a decrease of biodiversity as ecosystems dependent on low-intensity farming practices will experience habitat loss, a decrease in landscape patchiness, and possibly the invasion of non-native plants. The passive rewilding of abandoned farmland will further lead to an increased homogeneity of landscape forms through the dominance of shrubs and forests which negatively affects the diversity of flora and fauna that are reliant on open grassland (Ceaușu et al., 2015; García-Ruiz et al., 2020). This potential decline in open landscape biodiversity is counteracted, however, through the increase in the diversity of forest-dwelling flora and fauna, which would experience a boost through the expansion of forest cover (Navarro & Pereira, 2012). Overall, the passive rewilding of abandoned farmland will lead to species that benefit from it and species that will experience a disadvantage (Carver, 2019; Ceaușu et al., 2015; García-Ruiz et al., 2020; Navarro & Pereira, 2012). In a study conducted by Navarro and Pereira (2012), 60 species of birds, 24 species of mammals, and 26 species of invertebrates were identified to show an increase in numbers after passive rewilding of abandoned farmland, while at the same time around 101 species were identified as disadvantaged by the process. Despite these similar numbers, according to Carver (2019) and Ceausu et al. (2015), passive rewilding of abandoned farmland brings more benefits than disadvantages for biodiversity as wildlife habitats are improved and the available resources for wildlife populations and ecosystems increase through the expansion of vegetation cover.

One aspect of passive rewilding of abandoned farmland that clearly negatively affects biodiversity is the increased risk of wildfires (García-Ruiz et al., 2020; Johnson et al., 2018; Navarro & Pereira, 2012; Plieninger et al., 2014). This risk is, however, reduced if trophic rewilding is implemented on abandoned farmland. Large grazing herbivores consume vast amounts of wildfire fuel (grass), reduce and change the plant density and composition, and create habitat heterogeneity on a large scale with interchanging zones of high and low flammability, thereby impeding the spread of wildfires (Bakker & Svenning, 2018; Cromsigt et al., 2018; Johnson et al., 2018; Navarro & Pereira, 2012). A comprehensive list of effects on fire regimes of large grazing herbivores from Johnson et al. (2018) can be seen in Table 9.

Table 9. Effects of large grazing herbivores on fire regimes. Evidence types are manipulative experiments (E), modelling of relevant data (M), and correlational or observational (C). 'Strength' of evidence is rated on a 3-point scale (3 = strongest) (Johnson et al., 2018).

	Evidence	
Effect	**Type**	**Strength**
Less biomass consumed by fire in *grazed areas*	E, M	3
Fire temperatures and flame height are lowered because of reduction of fuel loads by *grazers* (and possibly *browsers*)	E, M	2
Fire-induced mortality of sensitive plants is reduced in *grazed* areas	E	2
Fire severity is possibly increased in areas *grazed* by cattle, because of increased fuel loads from unpalatable shrubs	C	2
Rate of fine spread is reduced because of reduction of fuel loads by *grazers* (and possibly *browsers*)	E, M	2
Area of landscape burned is reduced because short-grass patches created by *grazers* ('grazing lawns') impede the spread of fires	E, C, M	2
Area burned is reduced because *grazing* lowers fuel loads and breaks fuel continuity	M, C	2
Return interval of fire is lengthened because of increased woody cover and smaller herbaceous fuel loads due to *grazing*	M, C	2
Number of potential fire days is reduced because of reduced fuel loads due to *grazing*	M	1
Number of potential fire days may be increased in tussock grassland because *grazers* selectively remove live shoots, increasing the proportion of dry dead fuels	M	1

Furthermore, the reintroduction of large herbivores, or other large keystone species (carnivores), brings benefits to biodiversity through their potential in mitigating or even preventing impacts of invasive species that may establish themselves in abandoned farmland (Bakker & Svenning, 2018; Derham et al., 2018). Depending on the type of invasive species, reintroduced carnivores can predate on them and herbivores can feed on them (plants) or prevent their domination (other herbivores) through competition for the same food source (Derham et al., 2018). In addition, trophic rewilding of abandoned farmland also creates benefits for arthropod communities as the open landscapes vital for their existence are retained (van Klink & WallisDeVries, 2018). It is exactly trophic rewilding that is predominantly implemented in the projects of RE. The Southern Carpathians project is famously reintroducing the European Bison to the mountain range around the Tarcu mountains, thereby providing the area with a long-lost large grazing herbivore (*Rewilding Europe | Making Europe a Wilder Place*, n.d.; Tănăsescu, 2019; van de Vlasakker, 2014; Vasile, 2018). In the Danube Delta project, trophic rewilding plays an even bigger role as RE has been reintroducing several large grazing herbivores into the area, such as the Water Buffalo, Kulan (wild donkey), Konik horses, and the Tauros (*Annual Review 2019*, 2020; *Rewilding Europe | Making Europe a Wilder Place*, n.d.; Stokstad, 2015). This follows RE's conviction that grazing herbivores play a major role in the restoration of Europe's biodiversity, as can be seen in one of their mission statements: "Rewilding Europe recognizes natural grazing as one of the key ecological factors for naturally open and half-open landscapes, upon which a large part of Europe's biodiversity is dependent" (*Annual Review 2015*, 2016, p. 8).

There are studies, however, that indicate that trophic rewilding with a focus on introducing large grazing herbivores have a negative impact on biodiversity in areas of low nutrient abundance and plant production, such as abandoned farmland (Bakker et al., 2006; Proulx & Mazumder, 1998). According to Bakker et al. (2006) and Proulx and Mazumder (1998), large grazing herbivores only exhibit positive impacts on biodiversity if they are reintroduced into nutrient-rich areas with high plant productivity such as wilderness areas and reserves. Overall, there is consensus that trophic rewilding brings about increases and stability of biodiversity when applied in already established biosphere reserves and protected areas which have a higher ecological integrity in comparison to abandoned farmland (Bakker et al., 2006; Proulx & Mazumder, 1998; Schulze et al., 2018).

Still, there persists a level of uncertainty when it comes to the claims of rewilding's impact on biodiversity as the data is in general limited and the support for either a positive or negative outcome mixed (Andriuzzi & Wall, 2018; Bakker & Svenning, 2018). Furthermore, any documented or projected success in increasing biodiversity through rewilding (passive or trophic) will vary from project to project as it is dependent on factors such as geographical location, climate, species, spatial temporal scales, landforms and land use (Bakker & Svenning, 2018; Carver, 2019; Navarro & Pereira, 2012).

6. Analysis

Following my data collection I compiled the categories I induced from my content analysis of the literature I reviewed for this thesis. The categories and their subdivisions can be seen in Table 10. They provide the means by which to analyse the state of FLA in Europe, the amount of abandoned farmland and areas with higher ecological integrity within the project areas of RE and the impact of rewilding on biodiversity.

Table 10. Categories for qualitative content analysis. Own work.

Main category	Generic category	Sub-category
FLA in Europe and RE	Drivers	Climate
		Income
		Urban migration
		Fall of Soviet Union
	State of FLA	20 – 50 million ha so far
		10 – 29 million ha more until 2030
		Mountain and other marginal areas
	Project areas	Geospatial datasets
		Rewilding Europe contacts
		Central Apennines results
		Protected areas
Impacts of rewilding on biodiversity	Passive rewilding	Expansion of vegetation cover
		Increase of wildfire risk
		Benefits for forest species
		Disadvantages for open landscape species
		Opportunity for invasive species
		Determining rewilding progress
	Trophic rewilding	Reintroduction of large grazing herbivores
		Reduction of wildfire risk
		Benefits for nutrient-rich areas
		Containment of invasive species
		Determining rewilding progress

6.1 Abandoned farmland and protected areas within *Rewilding Europe*

Section 5.1 already covers the initial part of the first research question with 1 million hectares of farmland being estimated to experience abandonment every year, leading to possibly 30 million hectares to be abandoned by 2030. With estimations such as these it is safe to say that the current state of FLA in Europe is worrying. As established by section 5.4, there are benefits but also considerable risks to the local biodiversity connected to FLA, as abandoned farmland can be regarded as passive rewilding. My focus in this section will therefore lie more heavily on the second part of the first research question, namely the chosen project areas of RE and to what degree they are made up out of abandoned farmland and/or ecologically more integral areas.

The research conducted through literature review and geo-spatial datasets did not yield any tangible results on the amount of abandoned farmland in the selected project areas. The only avenue of research that produced results was the inquiry to the organisation itself and even there only one of the three rewilding projects (Central Apennines) provided me with data. However, this overall lack of information about FLA, did shine a light on the limitations of research on FLA in general as I was unable to ascertain the desired data despite applying multiple approaches throughout my research.

As the background section on abandoned farmland revealed, FLA has been a problem for many decades and is projected to continue to pose a variety of challenges, be it for biodiversity, agricultural productivity, or rural to urban migration. Despite that, relevant data on FLA is not readily available. This is exacerbated the further back in time one aims to go for the research. Because I anticipated challenges in my research my exploratory research design benefited me in this context as I was able to incorporate geospatial mapping programmes into my research.

Programmes such as Google Earth Engine, CCIBIS, and the European Union's Land Monitoring Service provided me with visual data on various land cover types (cropland, shrubland, forest, etc.) but they did not include abandoned farmland. The only programme that did was ResourceWatch through their 1992-2015 timescale. However, without the corresponding coordinates for the borders of the project areas, I was unable to calculate the amount of agriculture that has turned into shrubland, forest, or other non-farming land covers in that time period. Concerning the aim of this research, these mapping tools turned out to be inefficient. This indicates a problem in the research field of FLA as these programmes and datasets made up the majority of programmes and datasets utilized in the academic papers reviewed for this thesis. There might be other geospatial mapping programmes available that provide the sought-after information on FLA. However, further research would be necessary to find and test them.

The research that has been done on abandoned farmland so far seems to focus more on overall land cover changes that may only indicate farmland being abandoned instead of providing actual data on the phenomenon. Furthermore, research is being done on the quantitative amount of total abandoned farmland in Europe and calculations on how much farmland will be abandoned in decades to come. Future FLA trends receive a higher priority than the specific amounts, as can be seen in Figures 2 and 3 which visualize agricultural areas in danger of abandonment instead of present figures. However, the reasons for this lack of information on this topic might not be lack of interest or low priority but instead the difficulty in assessing abandoned farmland in general. Getting a clear picture of the exact amount of abandoned farmland across Europe requires the cooperation of various governmental institutions who may have diverging definitions of what constitutes abandoned farmland. In addition, the methods of reporting and the funds allocated to the relevant agencies may differ across nations, resulting in varying degrees of comparable data. According to Eurostat, difficulties in the assessment of FLA derives mainly from problems with data availability and resolution as it requires data on a very detailed scale

(*Archive: Agri-Environmental Indicator - Risk of Land Abandonment - Statistics Explained*, n.d.). Furthermore, varying levels of geographic reporting between European member states creates processes that consume a lot of time while preventing the creation of comparable results (*Archive: Agri-Environmental Indicator - Risk of Land Abandonment - Statistics Explained*, n.d.).

Because the geospatial mapping programmes did not provide me with the required data as well, I adhered to the exploratory research design again and changed my methodological approach one more time. As a final measure to access relevant data on the amount of abandoned farmland I contacted RE directly. Both the contact form on their website as well as the messages to the team leaders of the three project areas yielded no tangible answers, except the Central Apennines team leader. Through LinkedIn messages, and as mentioned in the results section, I was provided with the rough estimate that around 8% of the rewilding area (44k ha out of 525k ha) 'might' constitute abandoned agricultural land (Team leader Central Apennines, personal communication, August 22, 2021). In the team leaders own assessment, these numbers are much lower than expected (Team leader Central Apennines, personal communication, August 22, 2021).

As the research was unable to produce similar data on the other two project areas it remains difficult to ascertain if numbers from them correspond with those from the Central Apennines project. If further research would reveal numbers in a similar range, one could confidently estimate that abandoned farmland is not as prominently utilized as the strategy of RE indicates. For the Central Apennines project it clearly shows that the local RE team has not prioritised abandoned farmland in the choice of land-cover types for the establishment of their rewilding area. This can be seen as a missed opportunity for the improvement of local biodiversity given the results on the impact of rewilding on biodiversity when applied on abandoned farmland. However, the existence of abandoned farmland in the vicinity of the project area would have to be determined through further research to confidently declare negligence on the side of the Central Apennines team. How extensive this possible oversight could be, will be more clear in the next section where I analysis the impact of rewilding on biodiversity.

6.2 Benefits and conservation/restoration potential of rewilding

6.2.1. Impacts of rewilding on biodiversity

There is no overarching consensus within the scientific community regarding the overall impact of rewilding on biodiversity when applied to abandoned farmland or areas with a higher ecological integrity. Furthermore, it is highly dependent on the type of rewilding as well, which in the case of this thesis are passive and trophic rewilding. The other two variants of rewilding mentioned (active/ecological and Pleistocene rewilding) have not come up during research in a relevant degree and have therefore not been given further consideration.

Passive rewilding

Passive rewilding, which is comparable to FLA, clearly illustrates the contentious assessment of its impact on biodiversity by the scientific community. The proponents of this approach (like Carver, 2019; Ceausu et al., 2015; Navarro & Pereira, 2012) claim that letting landscapes, especially previous agricultural land, rewild on their own without any human intervention brings benefits to the local biodiversity as species that thrive in forests and shrubland will increase due to their habitat expansion. In contrast, the opponents of it (like García-Ruiz et al., 2020; Plieninger et al., 2014) state that letting farmland go fallow removes habitats for species that depend on farming landscapes, opens the possibility for the invasion of non-native species, and increases landscape homogeneity as well as the risk for wildfires. However, as Carver (2019) and Ceausu et al. (2015) point out, passive rewilding and its expansion of vegetation cover does result in more available resources for local wildlife overall, giving passive rewilding, arguably, more benefits than disadvantages. Nevertheless, these assessments solely focus on the impact of passive rewilding when applied on nutrient-poor areas such as abandoned farmland and not areas with a higher ecological integrity. The assessments produced by the research on trophic rewilding, on the other hand, do consider both types of landscapes.

Trophic rewilding

The introduction of large grazing herbivores (the most common use of trophic rewilding within projects of RE) brings positive impacts to landscapes as they mitigate/prevent invasive non-native species, retain a mosaic landscape by preserving open landscapes, and reduce the risk of wildfires. However, these benefits are, according to the scientific community, only distinctly visible when trophic rewilding is performed in nutrient-rich landscapes (areas with a higher ecological integrity).

When it comes to areas of lower nutrient abundance (like abandoned farmland), the scientific community is as contentious about the impact of trophic rewilding as they are on the impact of passive rewilding. Nevertheless, I am going to argue that the benefits of trophic rewilding (when focused on grazing herbivores) clearly outweigh the disadvantages when applied on nutrient-poor areas. I base this claim on the impact grazing herbivores have on the mitigation/prevention of wildfires.

As established in section 5.4, passive rewilding can lead to an increase of wildfires due to the expansion of shrubland and other vegetational covers which produce fuel for wildfires. Wildfires serve their own ecological purpose and certain species of flora and fauna depend on their occurrences. Still, an increase of wildfire incidents beyond the ecological average in a given landscape presents a danger to local biodiversity. Areas that are prone to both naturally occurring wildfires and FLA, such as Mediterranean mountain ranges (e.g. Central Apennines), experience a particular increase in risk. However, an increase in wildfire risk is presumably not going to be constrained to Mediterranean mountain ranges. Due to anthropogenic climate change it is estimated that weather patterns around the world will be subjected to irreversible changes that are most likely detrimental to local ecosystems (Anderson et al., 2012). Dry weather periods and heat waves are expected to appear more frequently in regions more used to temperate climates (Rummukainen, 2012), which would include mountain ranges and lowlands in central, north, and eastern Europe, such as the Southern Carpathians and the Danube Delta. In addition, with approximately 1 million hectares of farmland being abandoned every year in Europe it is reasonable to assume that wildfires will pose a bigger threat to biodiversity in the future.

This would make trophic rewilding with a focus on large grazing herbivores highly relevant as it provides a method for wildfire reduction that is sustainable and highly beneficial for local biodiversity. However, definitively determining the promised positive progress of rewilding remains a difficult task.

6.2.2. Determining rewilding progress

As shown, the impact of rewilding on biodiversity has both positive and negative outcomes, depending on what type of rewilding is applied and in what type of area, be it abandoned farmland or areas with a higher ecological integrity such as biosphere reserves. If one where to establish a new rewilding project, a choice would have to be made between the two types of areas. One would be confronted with the question of which type of rewilded area brings more benefits to the local biodiversity. Is it worth more to increase biodiversity through rewilding in an area which has already a high ecological integrity or should one rather strive towards improving an area of low ecological integrity such as abandoned farmland and bring it up to medium levels? RE probably faced that decision when choosing its project areas.

Unfortunately, evaluating the progress of rewilding in order to determine which area has more potential for an increase in biodiversity and therefore ecological integrity is a difficult endeavour. The problems lie in the insufficient knowledge about possible outcomes and the difficulty in monitoring and reporting rewilding projects (Perino et al., 2019; Torres et al., 2018). To overcome this challenge, Torres et al. (2018) devised a scaling framework designed to evaluate rewilding progress. The framework, as seen in Figure 7, considers both the pressures of direct human forcing on the particular ecosystem (H axis) and ecological integrity (E axis) (Torres et al., 2018). Changes in the human management of ecosystems will result in changes in the rewilding score.

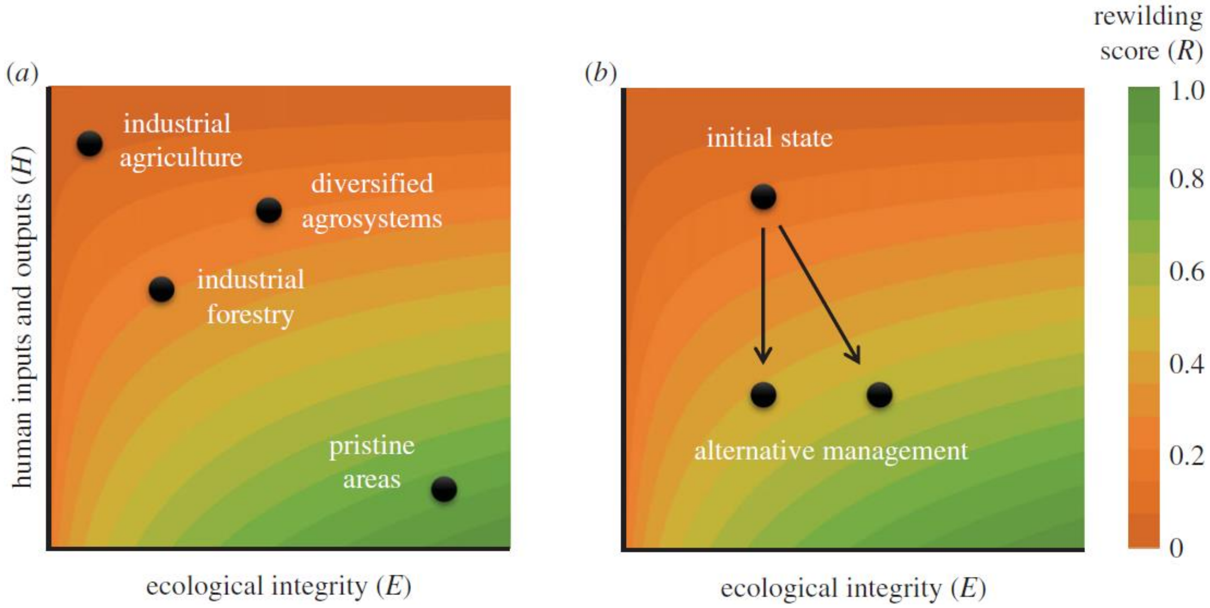

Figure 7. Framework for measuring rewilding progress (Torres et al., 2018).

The best possible score of 1.0 is practically impossible to achieve as even minimal human input raises the rewilding score on the H axis. This is unavoidable as anthropogenic influences can be found in every corner of the world, no matter how remote. Because of that, Torres et al. (2018) states that for a more sensitive restoration target, one should aim for “gradual increases in the natural condition of ecosystems at lower and intermediate scores” (p. 12) instead of defaulting for achieving the highest score possible. If the first research question would have resulted in accessible data (the amount of abandoned farmland and ecologically integral areas in the project areas) this framework would have laid the groundwork for further research into RE and their rewilding projects. Additionally, through the conduction of field work one could have collected primary data on the human inputs and outputs as well as the ecological integrity of the ecosystems of the project areas. By looking at the data through this framework the research could determine RE’s adherence to utilizing areas with low ecological integrity (abandoned farmland) for their rewilding projects.

Both types of landscapes have benefits when used for rewilding so a possible alternative to the binary decision process between abandoned farmland and ecologically integral areas would be to combine the two instead of looking at them individually. Based on the findings of this research, applying rewilding on a biodiverse area that is potentially surrounded by abandoned farmland could constitute benefits for biodiversity across the board. The core area with established ecological integrity would be able to secure its biodiversity and possibly expand while the surrounding (buffer) zone of abandoned farmland would get additional benefits from the borderless connection to it. In addition, reintroduced large grazing herbivores would potentially provide a reduction in wildfires for the abandoned farmlands while enhancing biodiversity more directly in the more nutrient-rich ecological core areas. Furthermore, their grazing would retain the existing open landscapes and keep the encroaching forests and possible invasive species at bay, ultimately sustaining a mosaic landscape that benefits a larger amount of flora and fauna.

Based on the assumption of protected areas experiencing a higher ecological integrity due to their protective status, as stated in section 3, the Central Apennines project can be identified as such an undertaking. As seen in Figure 4, the five areas that make up the rewilding project are situated in the buffer zones of national parks, regional parks, regional reserves, and biosphere reserves. In addition to enlarging the already established protected areas through their position in their buffer zones the five rewilding areas also connect the protected areas with each other, effectively creating corridors. This improves the dispersal and exchange of species across the region which is a vital benefit for local biodiversity. This could also counteract their minimal inclusion of abandoned farmland in their project area mentioned above. However, the Central Apennines project does not focus on introducing large grazing herbivores but instead prioritises increasing the number of large carnivores such as the Marsican brown bear and the Apennine wolf through active rewilding (old fence removal, bear proof bins, speed limit reduction, etc.) (*Annual Review 2013*, 2014). Based on the benefits that (trophic) rewilding can bring to areas such as the Central Apennines, this RE project has the potential to improve its impact on biodiversity if it were to implement additional rewilding approaches with a focus on grazing herbivores.

7. Discussion

7.1. Are *Rewilding Europe* and Rewilding panaceas for biodiversity loss and rising FLA?

As the previous results and analysis sections have demonstrated, neither RE as an environmental organisation nor the concept of rewilding as a conservation/restoration method provide a flawless solution to these two crises. Rewilding as a concept is divided up into a myriad of different approaches that all have their own focus and narrow applicability. The two versions of rewilding that this thesis decided to focus on (passive and trophic) showcase clear benefits to local biodiversity but it is dependent on the type of rewilding as well as the type of landscape it is being utilized on as the wrong combination can lead to negative impacts instead. However, with the benefit of wildfire reduction, it could be argued that trophic rewilding exhibits more benefits than disadvantages, no matter the landscape type, and would therefore be a prime candidate for a more widespread use on the European continent.

Fortunately, trophic rewilding is the rewilding method used the most by RE. Unfortunately, it seems that RE is more focused on using it in areas which are already experiencing a higher level of ecological integrity than ones which would fall under the category of FLA. This research was not able to conclusively proof this assumption due to limited data on FLA in Europe and missing information from RE concerning the exact location and borders of their project areas. However, based on the numbers provided by the team leader of the Central Apennines project and the overabundance of protected areas present within the presumed project areas, RE is arguably focusing more on rewilding areas with a higher ecological integrity than areas that contain abandoned farmland. Based on Torres et al.'s (2018) assessment on rewilding progress this can be seen as a wasted opportunity as abandoned farmland constitutes favourable areas for rewilding.

This is not to say that both RE and rewilding have not contributed at all to the prevention of biodiversity decline and FLA. Both are working on improving these issues. Nevertheless, while the assessment of both rewilding and RE was impeded by the obstacles encountered during the research, more opportunity for access to the data on RE's part and more research on the part of rewilding could lead to an improvement on their positive impacts on biodiversity and FLA.

7.2. Limitations

As mentioned above, it was the missing data on FLA in Europe combined with the unavailability of the exact coordinates of the location and borders of the project areas of RE that prohibited this research from reaching a definitive conclusion on the amounts of abandoned farmland and areas with higher ecological integrity present within the project areas. The geo-spatial datasets and monitoring programmes are of a sophisticated nature and contain extensive data on landscape types ranging from wheat fields to forests and wetlands. It is with the help of these kind of datasets and programmes that FLA risk maps can be created, such as seen in Figures 2 and 3. Nevertheless, a clear assessment on the precise areas of FLA was not attainable. This could hint at the possible difficulty of such an assessment process in general as the majority of land abandonments is occurring in marginal areas (Alcantara et al., 2013) and especially on small agricultural land parcels (Navarro & Pereira, 2012), which would make the documentation of such data more difficult.

In addition, the problem with geo-spatial datasets extended to RE as well. The detailed review of their publications and websites revealed missing information or data on abandoned farmland or areas with higher ecological integrity within their project areas. The only information this research was able to obtain was the percentage of *presumed* abandoned farmland within one of the three project areas under investigation, the Central Apennines.

Lastly, and perhaps most importantly, the impact of rewilding and its varying approaches on biodiversity is highly debated within the scientific community. This impeded the assessment of the method's applicability in the biodiversity and FLA crisis. More research into rewilding is therefore needed. However, this undertaking is not effortless as the assessment of rewilding is in itself a demanding task due to the flexible nature of rewilding concerning its outcomes and goals. In addition, appraising rewilding progress is complicated as well due to the aforementioned flexibility of the restoration method and the longevity of the process in general. Fortunately, there are frameworks being worked on to alleviate these issues such as the one from Torres et al. (2018) considered in 6.2.2. which represents a step forward in the endeavour to improve rewilding research and assessment.

7.3. What does the future hold?

What the science behind rewilding and the assessment of FLA needs is an expansion of research into these topics. This entails both new data and findings on the impact of rewilding and spread and drivers of FLA, as well as the avoidance of scientific 'cul-de-sacs'. This thesis contributed to this objective.

Through the meticulous review of scientific and grey literature, utilisation of geospatial land monitoring programmes, and outreach to professional rewilding practitioners, I was able to highlight the lack of methodological approaches available for research that aims to investigate the amount of FLA in concrete terms and in specific locations. As the scientific literature on this topic did not provide me with this information, my research has been able to explore this knowledge gap. Potential future researchers who aim to investigate a similar subject, will have the advantage of avoiding coming to the same conclusion on the amount of abandoned farmland and the spatial data on it. By providing them with this information on the lack of said data they will be able to go beyond this research and further enhance the knowledge on the topics of FLA and rewilding respectively. Another improvement that research on this topic unquestionably requires is a more detailed and concrete mapping of FLA. For this to exist the geographical reporting on FLA amongst European member states needs to be streamlined through more extensive and finer mapping. If the pandemic were to be solved in the near future, it would be even possible to carry out fieldwork to collect the necessary geo-spatial data oneself.

Filling the aforementioned knowledge gap would benefit the advancement of rewilding as a conservation/restoration method and aid rewilding projects and organisations in establishing new rewilding areas. However, if one were to decide to use rewilding in a specific location or not, the positive impact on biodiversity should not be the only aspect of rewilding worthy of consideration. There exists a multitude of research that focuses on impacts of rewilding that go beyond biodiversity. Allowing revegetation through passive rewilding can improve the water quality as well as the water holding capacity of the soil (Carver, 2019; García-Ruiz et al., 2020; Navarro & Pereira, 2012). The reduction of water run-off further aids in the decline in soil erosion as increased vegetation protects and secures the soil (Carver, 2019). In addition, passive rewilding of abandoned farmland is estimated to increase the sequestration and storage of carbon from the atmosphere (Bakker & Svenning, 2018; Carver, 2019; García-Ruiz et al., 2020). Trophic rewilding with large grazing herbivores on the other hand holds the potential benefit for combating climate change through their prevention of encroaching forest cover which has a lower albedo effect than open grassland (Bakker & Svenning, 2018; Cromsigt et al., 2018). Through the consumption, digestion, and afterwards dispersal of various grasses and woody plants through dung and urine, grazing herbivores also contribute to the cycling of nutrients (Andriuzzi & Wall, 2018; Cromsigt et al., 2018).

Further socio-economic impacts of rewilding exist as well and should, together with the ones above, be taken into consideration during any decision-making process concerning the implementation of rewilding approaches on abandoned farmland or areas with high ecological integrity. In addition, these positive impacts could also have further positive ramifications for biodiversity. They would, however, need to be meticulously researched before taken into consideration.

8. Conclusion

This thesis highlights the impact that rewilding can have on biodiversity when applied on two distinct types of landscapes, abandoned farmland and areas with a higher ecological integrity. The overall positive impacts that both passive and trophic rewilding create within each landscape type gives credence to their effectiveness in combating biodiversity decline. However, possible negative effects should be taken into account as well as the scientific community has not reached an overarching consensus on the viability of rewilding as a solution to the biodiversity crisis.

While rewilding may constitute a feasible method for addressing the biodiversity decline, it has no discernible effect on the ongoing trend of FLA. Rather, this thesis illustrates how the increasing amount of abandoned farmland in Europe can be utilized instead for something positive by providing space for rewilding projects.

This thesis further analyses how far this is reflected within three project areas of RE. It is within this area of investigation that the research reveals a considerable knowledge gap within the scientific community and RE concerning FLA assessment. Neither scientific literature, geo-spatial land monitoring programmes and datasets, nor RE publications include relevant information on definitive amounts of abandoned farmland within the chosen project areas or Europe in general. The research is further impeded through missing project area coordinates from RE. As converting abandoned farmland into ecologically intact areas plays a vital part in RE's overall strategy in reversing biodiversity loss, solving these aforementioned deficiencies is of outmost importance in order to comprehensively assess the application of rewilding within RE.

In order to fully appraise the viability of rewilding as a restoration and conservation method further research would need to be done which incorporates the evaluation of rewilding progress and positive and sustainable effects rewilding might have that go beyond biodiversity, as mentioned in section 7.3.

Despite these uncertainties and the FLA knowledge gap, rewilding and RE show promise in the struggle of halting or even reversing the decline in biodiversity. With more expansive research into rewilding and its impacts and minor adjustments within RE, both the conservation/restoration method and the environmental organisation will significantly contribute to making our society more sustainable now and in the future.

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10. Appendices

10.1. Wildlife areas of *Rewilding Europe*. Own work.

Wildlife area	**Region**
Southern Carpathians	Romania
Danube Delta	Romania, Ukraine, Moldovia
Oder Delta	Germany, Poland
Rhodope Mountains	Bulgaria
Greater Côa Valley	Portugal
Velebit Mountains	Croatia
Central Apennines	Italy
Swedish Lapland	Sweden

10.2. Objectives of *Rewilding Europe* (*Annual Review 2012*, 2012).

Rewilding Europe objectives	
1	A total of at least 1 million ha (10,000 km2) of land will be 'rewilded' by the initiative and its partners, across 10 places covering different geographical regions of Europe, including different landscapes and habitats.
2	A substantial wildlife comeback (in particular for keystone or flagship species) will take place in the 10 rewilding areas, supported by re-introductions where appropriate or necessary, serving as the starting point for complete, functional ecosystems.
3	In each of the 10 rewilding areas, sufficient "in-situ" breeding facilities for wildlife will be established, for a variety of wildlife species that can be used for re-introductions or re-stocking of these areas.
4	Because of a growing demand for wildlife in these rewilding areas, European wildlife will develop a 'market value', providing new business opportunities - for management partners, landholders, hunting associations and the like.
5	In each of the 10 rewilding areas, 'rewilding' will become a competitive form of land (and sea) use; through supporting and building of rewilding enterprises, the economic prospects of local people and/or communities will be improved.
6	Magnification of success: the 10 rewilding areas serve as inspiring examples for other areas in Europe. This should ideally lead up to 100 other 'rewilding' initiatives launched across Europe affecting a total of 10 million ha (100,000 km2).
7	"Wild nature & natural processes" will be accepted and adopted as one of the main management principles for nature conservation in Europe, in particular in the larger landscapes that have a conservation status (especially the wilder, large Natura 2000 areas).
8	Through the work of Rewilding Europe, and the communication & outreach thereof, a sense of 'Pride of the Wild' will be created among a very broad audience in Europe, who will also again be able to enjoy these wild values.
9	A science-based and practical, tailor-made monitoring system will be established to oversee progress on the objectives of Rewilding Europe, both at the central level and in the rewilding areas.
10	The concept of the 'Joy of the Wild' will have reached out to at least 350 million European citizens, using different kind of media, outdoor and indoor exhibitions, computer and mobile applications, etc.