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Environmental impacts of farm land abandonment in high altitude/mountain regions: a systematic map of the evidence

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Abstract

Background: Environmental impacts of farm land abandonment can be viewed as either an opportunity for ecological restoration to a state prior to agricultural establishment, or as the loss of an on-going process of land management and an associated threat to biodiversity. Whether land abandonment poses an ecological opportunity or threat depends upon the agricultural history and the presence of ecological systems that depend upon regular management for their existence. In Europe, many ecosystems have developed in the presence of agriculture and the loss of continued management resulting from land abandonment can have significant negative ecological impacts. Around 56 percent of the utilised agricultural area (UAA) of the EU is classified as 'less-favourable areas' and much of this is mountainous. The small-scale and extensively managed farmlands that are common in mountain areas are particularly vulnerable to marginalisation and abandonment. The work herein will form the first systematic synthesis of the evidence of impacts of farm land abandonment in mountain areas across the globe.

Methods: This review will take the form of two interrelated systematic maps, cataloguing the existing evidence across a wide range of variables such as setting, methodology, scale, measured outcomes etc. Mapping will be undertaken both at abstract-level at a coarse scale and at full text-level at a finer scale. Literature databases, organisational web sites, and search engines will be used to collate all of the available literature regarding the impacts of agricultural land abandonment. All studies investigating farmland abandonment in mountainous regions with an appropriate comparator and measuring an appropriate outcome will be included. Outcomes will be coded in a partly iterative process but will include; natural hazards (fire-/flood risk, land/mud slides), soil (fertility, erosion), water (chemistry, eutrophication, sediment load, hydrology), ecosystem functioning (biodiversity, abundance, invasive species presence), socio-economics (e.g. health, wellbeing, employment). The systematic map outputs will be in the form of searchable databases of relevant and obtainable (full text only) literature, coded by subject, methodology and study design, and internal validity.

Keywords: Agriculture, Abandonment, Mountains, Alpine, Remote, Farming, Socio-economic impacts, Environmental impacts

Background

Farm land abandonment can be simply defined as the cessation of agricultural activities on a given surface of land, yet there is no common precise definition of agricultural farmland abandonment in the literature [1]. Farm land abandonment occurs when income or resource generation cease to be economically viable or sustainable and the possibilities of adapting via changes in farming practices have been expended [2]. According to a study by Ramankutty and Foley [3], global abandonment of croplands has occurred over an estimated 1.47 million km^2 between 1700 and 1992. Meanwhile, Pointereau et al. [1] estimate that 9.09 Mha of agricultural land have been abandoned across 20 European countries between 1990 and 2000. Data cited for France for the period 1992 and 2003 show that grassland represented 57% of abandoned agricultural land; cropland 30% and vinyards and hedges/groves each 6%. However, the lack of a standardised definition of aban-

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doned agricultural land, and the difficulty of matching this to available datasets, means that accurate estimates of abandoned area are lacking.

Land abandonment has a number of well-studied drivers, including environmental (e.g. reductions in soil fertility), economic (e.g. market globalisation) and socio-political (e.g. rural depopulation) causes [4].The environmental impacts of farm land abandonment can be viewed as either an opportunity for ecological restoration to a state prior to agricultural establishment, or as the loss of an ongoing process of land management and an associated threat to biodiversity. Whether land abandonment poses an ecological opportunity or threat depends upon the agricultural history and the presence of systems that depend upon regular management for their existence. In Europe, many ecosystems have developed in the presence of agriculture and the loss of continued management resulting from land abandonment can have significant negative ecological impacts [4]. Pointereau et al. [1] suggest that abandonment of intensive agriculture often results in ecological benefits for the affected parcel of land, whilst abandonment of low intensity agricultural is more likely to result in a negative ecological impact owing to the role of such agriculture in maintaining systems classified as "high nature value" (HNV). From a soci-economic perspective, the abandonment of agricultural land is usually regarded as detrimental owing to implied loss of employment and income in rural areas.

Around 56 percent of the utilised agricultural area (UAA) of the EU is classified as 'less-favourable areas' by the Common Agricultural Policy (CAP). According to MacDonald *et al.* [2], much of this is mountainous, and a report in 2004 identified mountainous regions as constituting 39.9 percent of the area of the 15 Member States at the time [5]. Mountain areas, however, are difficult to define. For the purposes of examining farm land abandonment, mountainous areas are defined by their unfavourable topography, remoteness and extreme climate. Mountainous areas are typically described by elevation and/or slope, but this can vary significantly between countries. For example, Austria defines mountain areas as being above 700 m or above 500 m if slope is greater than 20 percent, whilst Spain more strictly defines them as being above 1000 m, over 20 percent slope and a 400 m elevation gain relative to surrounding land. Some definitions include low altitude areas where temperature contrasts reflect those in the high altitude Alps, such as Sweden and Finland. Other definitions use ruggedness assessed from satellite imagery e.g. [6].

The small-scale and extensively managed farmlands that are common in mountain areas are particularly vulnerable to marginalisation and abandonment [7]. A report from the Cross-Compliance Network identified mountainous areas as key areas at threat from farmland abandonment [8]. The causes of farmland abandonment in mountainous areas are expanded upon in more detail in Pointereau et al. [1] to include; steep slope, distance from the farm to the field, low accessibility, poor soils, land used as alpine pastures, small farms, high cultivation costs and small field size.

Resilience and adaptability in farming systems in mountain regions is limited for a number of reasons, including remoteness, climate and physical constraints, and the aversion to risk-taking, traditional cultural values and limited skill sets often held by the local population [2]. Limitations to the adaptability of mountain regions have been compounded by the historical paucity of agricultural research in these areas and a bias towards lowland regions e.g. [9].

A limited review of CAB Abstracts focusing on land abandonment was published in 2007 [10]. A systematic review is currently underway on the subject of land abandonment in the Mediterranean [11]. A conceptual review of several case studies of land abandonment and EU policies responding to the problem for mountain areas was published in 2000 [2]. The work herein will form the first systematic synthesis of the evidence of impacts of farm land abandonment in mountain areas across the globe. This systematic map of the literature will identify and catalogue all available evidence from a wide variety of sources, including the grey literature. Here we set out our methodology.

Objective of the review

Primary question

The primary question of this systematic review will be;

What are the environmental impacts of farm land abandonment in high altitude/mountain regions?

This review will take the form of a systematic map, cataloguing the existing evidence across a wide range of variables such as setting, methodology, scale, measured outcomes etc. Mapping will be undertaken at two levels. Coarse-scale mapping will be undertaken on all identified abstracts, whilst fine-scale mapping will be undertaken on all available full texts.

The map databases that we will produce will catalogue the focus and location of relevant articles on the subject of agricultural land abandonment in high altitude/mountain regions. We anticipate that these maps will form a vital resource for researchers to identify subsets of this literature for further systematic review, and to identify knowledge gaps in the primary research.

The question has the following components:

Population: All mountainous* agricultural lands (global scope).

Exposure: Abandonment of agricultural land management. This definition is in

accordance with that of Coppola [12] and Pointereau et al. [1] and specifies the cessation of all agricultural activity.

Comparator: Before-after land abandonment (temporal comparator), or un-abandoned nearby surrogate (spatial comparator).

Outcome: All outcomes relating to environmental and socio-economic impacts, including but not restricted to; natural hazards (fire-/flood risk, land/mud slides), soil (fertility, erosion), water (chemistry, eutrophication, sediment load, hydrology), ecosystem functioning (biodiversity, abundance, invasive species presence), socio-economics (household income, gender equity, health, wellbeing, employment).

*Due to the difficulties in defining a *mountainous* region and the differences in definition between institutions, we will include any studies that make reference to a study site that is mountainous (including synonyms, e.g. uplands) or that has limited accessibility (e.g. of farming machinery) due to topography (i.e. altitude or slope).

By mapping the literature at abstract AND full text levels we hope to identify significant details about the availability of certain groups of studies. Scoping has suggested that a potentially large body of research has been carried out in the Loess Hilly Plateau in China on soil erosion. Preliminary scoping suggests that many of these articles may be published in Chinese language journals with restricted access; a potentially systematic limitation to the synthesis of the entire body of available evidence. Comparisons between the two levels of maps will highlight these potential deficiencies in the full text map and will allow users of the full text map to avoid outcomes that may be particularly susceptible to such restrictions.

No language restrictions will be employed in this systematic map. However, searches will be undertaken only using English search terms, since inclusion of all languages in such a global study would be impractical. In order to identify whether evidence exists that may have been missed by this limitation, during coding we will extract author email addresses. Following full-text coding we will then invite authors to participate in a simple online survey asking several questions: (1) if they are aware of non-English language research and research that may have gone un-catalogued by databases searched herein that has been published in this topic within their country/language/research area; (2) requesting that they give examples of such studies against which the search can be tested. The results of this survey will be compared with the two maps to identify where potentially missed studies may lie. To our knowledge, such involvement of primary researchers has not previously been undertaken in CEE systematic reviews and will strengthen any conclusions made concerning knowledge gaps in the evidence base.

Methods

Search strategy

Search terms

Scoping was undertaken in order to identify suitable relevant key terms to be included in the finalised search string. These terms include aspects of the exposure (farm land abandonment) and the population (high altitude/mountain regions) and are displayed in Table 1. Outcome terms were not included in the search string because of the size of returns based only on exposure and population terms, which was deemed to be manageable. Furthermore, the aim of the map is to document the available literature, including the forms of outcomes measured in the evidence base. Outcome documentation will therefore be an iterative process, and all relevant outcomes will be coded. No language restrictions will be put in place: automated language translation software will be used to complement the review teams' abilities.

Databases

The search aims to include the following online databases which cover the breadth and depth of available literature on the topic:

1) ISI Web of Knowledge (inc. ISI Web of Science and ISI Proceedings)
2) Science Direct
3) Directory of Open Access Journals
4) Copac
5) Agricola
6) CAB Abstracts
7) CSA Illumina/Proquest
8) GreenFile

Table 1 Summary of outputs from scoping study for search terms using web of knowledge

	Search string	WoK hits
Exposure terms	((grassland OR farm* OR cropland OR agricultur* OR land OR *field OR pasture) AND (destock* OR abandon*))	26,325
	AND	
Population terms	("high altitude" OR "higher altitude" OR "high ground" OR "higher ground" OR *alpine OR montane OR mount* OR elevat* OR highland OR hill* OR upland OR plateau OR mesa OR tableland OR slope OR aspect OR remote* OR massif OR sierra OR steep OR rugged)	2,579

* indicates a wildcard in search term (i.e. any character(s) permitted).

Where databases cannot accept the full search strings detailed in Table 1, search strings will be modified according to the database help files. All database searches and outcomes will be recorded in a Search Record Appendix.

Search engines

The following internet search engines will be used to identify relevant grey literature. The first 150 hits from each engine will be screened (based on sorting by relevance of results where possible).

Google Scholar http://scholar.google.co.uk/.

Scirus http://www.scirus.com/.

Dogpile http://www.dogpile.co.uk/.

Where search engines cannot accept the full search strings detailed in Table 1, search strings will be modified according to the search engine help files. All search engine searches and outcomes will be recorded in a Search Record Appendix.

Specialist sources

The following specialist organisations will be searched for relevant grey literature using manual searches of their websites and automatic search facilities using key terms (such as abandon*).

Alterra http://www.wageningenur.nl/en/Expertise-Services/Research-Institutes/alterra.htm

Centre for Ecology and Hydrology http://www.ceh.ac.uk/.

National Farmers Union http://www.nfuonline.com/home/.

Global Environment Centre http://www.gec.org.my/.

Greenpeace http://www.greenpeace.org.uk/.

Joint Nature Conservation Committee http://jncc.defra.gov.uk/.

Macaulay Land Use Research Institute http://www.macaulay.ac.uk/.

National Soil Resources Institute http://www.cranfield.ac.uk/sas/nsri/.

Natural England http://www.naturalengland.org.uk/.

Royal Society for the Protection of Birds http://www.rspb.org.uk/.

Society for Ecological Restoration http://www.ser.org/.

DEFRA http://www.defra.gov.uk/.

Environment Agency http://www.environment-agency.gov.uk/.

PBL Netherlands http://www.pbl.nl/en/.

German Federal Ministry of Ag http://www.bmelv.de/EN/Homepage/homepage_node.html.

Thunen Institute http://www.ti.bund.de/en/.

ETH Zurich http://www.ethz.ch/index_EN.

European Environment Agency http://www.eea.europa.eu/.

EC Ag and Rural Dev site http://ec.europa.eu/agriculture/.

IEEP http://www.ieep.eu/.

JRC Institute for Env Sustainability http://ies.jrc.ec.europa.eu/.

JRC Institute for Prospective Tech Studies http://ipts.jrc.ec.europa.eu/.

United Nations Environment Programme http://www.unep.org/.

Food and Agriculture Organisation http://www.fao.org/index_en.htm.

Convention on Biological Diversity http://www.cbd.int/convention/.

World Wildlife Fund http://www.wwf.org.uk.

Associations des Populations des Montagnes du Monde http://www.mountainpeople.org.

Mountain Partnership http://www.mountainpartnership.org.

The International Centre for Integrated Mountain Development http://www.icimod.org.

Where organisational website search facilities cannot accept the full search strings detailed in Table 1, search strings will be modified according to the search help files (where provided), or a small subset of key terms will be searched individually. All organisational website searches and outcomes will be recorded in a Search Record Appendix.

Search comprehensiveness assessment

The comprehensiveness of the above search strategies will be assessed in a number of ways. Firstly, key bibliographies from relevant reviews e.g. [2] will be compared to the search results to check that all relevant articles have been identified through searches. Secondly, search results will be compared with a list of includable studies, identified by subject experts prior to the review (see Table 2). We will post questions on social media (www.academia.edu, www.researchgate.net and www.linkedin.com) to alert the research community to this systematic map and to request that subject experts submit studies that they feel may not be readily accessible or catalogued by the most common academic databases. In addition, authors of unobtainable articles will be contacted by email to request the submission of other pertinent articles in addition to the unobtainable literature. These studies will be used in addition to the articles highlighted in Table 2 to test the comprehensiveness of our search strategy.

Study inclusion criteria

Study selection according to the predefined inclusion criteria detailed below will proceed according to a three stage, hierarchical process: titles, abstracts and finally full texts will be assessed against the inclusion criteria. If there is any doubt over the presence of a relevant inclusion criterion (or if information is absent) the articles will be retained for assessment at a later stage. Title-

Table 2 List of key includable articles identified by subject experts for checking the comprehensiveness of the search strategy

1. Cammeraat, E.L.H., A. Cerda, and A.C. Imeson, *Ecohydrological adaptation of soils following land abandonment in a semi-arid environment.* Ecohydrology, 2010. **3**(4): p. 421–430.
2. Catorci, A., G. Ottaviani, and S. Cesaretti, Functional and coenological changes under different long-term management conditions in Apennine meadows (central Italy). Phytocoenologia, 2011. **41**(1): p. 45–58.
3. Cocca, G., et al., Is the abandonment of traditional livestock farming systems the main driver of mountain landscape change in Alpine areas? Land Use Policy, 2012. 29(4): p. 878–886.
4. Deleglise, C., G. Loucougaray, and D. Alard, Effects of grazing exclusion on the spatial variability of subalpine plant communities: A multiscale approach. Basic and Applied Ecology, 2011. **12**(7): p. 609–619.
5. Durak, T., *Long-term trends in vegetation changes of managed versus unmanaged Eastern Carpathian beech forests.* Forest Ecology and Management, 2010. **260**(8): p. 1333–1344.
6. Ferlan, M., et al., *Comparing carbon fluxes between different stages of secondary succession of a karst grassland.* Agriculture Ecosystems & Environment, 2011. **140**(1–2): p. 199–207.
7. Fonderflick, J., et al., *Avifauna trends following changes in a Mediterranean upland pastoral system.* Agriculture Ecosystems & Environment, 2010. **137**(3–4): p. 337–347.
8. Garcia-Ruiz, J.M. and N. Lana-Renault, *Hydrological and erosive consequences of farmland abandonment in Europe, with special reference to the Mediterranean region - A review.* Agriculture Ecosystems & Environment, 2011. **140**(3–4): p. 317–338.
9. Gellrich, M., et al., Agricultural land abandonment and natural forest re-growth in the Swiss mountains: a spatially explicit economic analysis. Agriculture, Ecosystems & Environment, 2001. **18**(1): p. 93–108.
10. Kampmann, D., et al., *Agri-environment scheme protects diversity of mountain grassland species.* Land Use Policy, 2012. **29**(3): p. 569–576.
11. Knapp, B.A., A. Rief, and J. Seeber, Microbial communities on litter of managed and abandoned alpine pastureland. Biology and Fertility of Soils, 2011. **47**(7): p. 845–851.
12. Lesschen, J.P., L.H. Cammeraat, and T. Nieman, Erosion and terrace failure due to agricultural land abandonment in a semi-arid environment. Earth Surface Processes and Landforms, 2008. **33**(10): p. 1574–1584.
13. Marriott, C.A., et al., Impacts of extensive grazing and abandonment on grassland soils and productivity. Agriculture Ecosystems & Environment, 2010. **139**(4): p. 476–482.
14. Nikolov, S.C., *Effects of land abandonment and changing habitat structure on avian assemblages in upland pastures of Bulgaria.* Bird Conservation International, 2010. **20**(2): p. 200–213.
15. Nunes, A.N., et al., *SOIL EROSION AND HYDROLOGICAL RESPONSE TO LAND ABANDONMENT IN A CENTRAL INLAND AREA OF PORTUGAL.* Land Degradation & Development, 2010. **21**(3): p. 260–273.
16. Obrist, M.K., et al., *Response of bat species to sylvo-pastoral abandonment.* Forest Ecology and Management, 2011. **261**(3): p. 789–798.
17. Peco, B., et al., *Effects of grazing abandonment on functional and taxonomic diversity of Mediterranean grasslands.* Agriculture Ecosystems & Environment, 2012. **152**: p. 27–32.
18. Tocco, C., et al., *Does natural reforestation represent a potential threat to dung beetle diversity in the Alps?* Journal of Insect Conservation, 2013. **17**(1): p. 207–217.
19. Uematsu, Y., et al., Abandonment and intensified use of agricultural land decrease habitats of rare herbs in semi-natural grasslands. Agriculture Ecosystems & Environment, 2010. **135**(4): p. 304–309.
20. Waesch, G. and T. Becker, Plant diversity differs between young and old mesic meadows in a central European low mountain region. Agriculture Ecosystems & Environment, 2009. **129**(4): p. 457–464.
21. Zimmermann, P., et al., Effects of land-use and land-cover pattern on landscape-scale biodiversity in the European Alps. Agriculture Ecosystems & Environment, 2010. **139**(1–2): p. 13–22.

and abstract- level assessment will not assess the presence of a comparator, which is typically not explicit. Since titles and abstracts in grey literature do not conform to scientific standards, assessment will proceed immediately to full text assessment. Consistency checks will be undertaken using a subset of 100 abstracts by two reviewers independently of one another. Screening decisions will then be compared using a Kappa test of agreement [13]. A score of greater than 0.6 indicates substantial agreement. Any disagreements will be discussed and any terms that need redefining or expansion will be adapted accordingly.

The following aspects of the systematic review question will form inclusion criteria when assessing potentially relevant literature:

Relevant population(s): Any high altitude or mountainous region, any region with restricted access due to ruggedness, any region with agricultural difficulties or limits on agricultural advancement or adaptability due to slope, altitude or ruggedness [global scope]

Types of exposure/ intervention:	Abandonment of agricultural land or reinstating of agricultural activity in agricultural land following abandonment
Types of comparator:	Before land abandonment and/ or an un-abandoned control site
Types of outcome:	All outcomes, including but not restricted to; soil chemistry (including carbon and GHG flux), soil erosion, water chemistry, hydrology, natural hazards, biological diversity and abundance, presence of invasive species, socio-economics (including health, wellbeing, employment)
Types of study:	Both observational and experimental field studies. Experimental field studies (i.e. simulated abandonment) must investigate continued abandonment over a period in excess of one year.

Map coding

Mapping will be undertaken in two stages to produce two interrelated databases. One database will map studies

Table 3 Coding tool for the systematic map

Coding variables	Details/examples
Author	
Full reference	
Publication type	e.g. book chapter, journal paper, conference paper, thesis, organisation report
Holding institution	Organisation/body holding access to article
Article access issues	i.e. open access, subscription only
Study year	Time period of experimentation/observation
Study length	Time over which study undertaken
Study timescale	Period between intervention and study
Study description	Brief description of study
Intervention description	Full description of intervention and final state
Intervention time period	Years intervention in place
Comparator description	Full description of comparator
Comparator appropriateness	Brief description of how well matched the comparator is to the intervention population
Comparator type	i.e. spatial, temporal, both
Replication	Unit of replication (e.g. patch, farm, landscape)
Spatial scale	i.e. landscape scale, single farm, multiple farm, whole farm, within field
Sources of potential bias	Brief description of potential sources of bias in study results
Methodological detail	Level of methodological detail; low (very little detail, significant information missing), medium (some detail missing but generally sufficient), high (very high level of detail, no obvious information lacking)
Study country/ies	
Study region	
Mountain descriptor	Quoted description of mountain type, e.g. alpine
Altitude	
Farming system	e.g. organic farming, conventional farming, integrated farming, intensive grassland, extensive grassland, tillage, ploughing, non inversion tillage, minimal tillage
Broad outcome group	i.e. soil, water, natural hazard, ecosystem functioning
Outcome focus	e.g. water chemistry, butterfly
Measured outcome	e.g. total suspended solids, Simpson's diversity index
Experimental design	i.e. observation, experimentation
Additional details	i.e. multiple outcomes studied, multiple articles of one study, multiple experiments in one article

using abstracts at a coarse scale (i.e. study location, population descriptor, measured outcome, study design, and comparator type).

A second database will expand on this information by extracting summary details for each study where a full text is available, producing a fine-scale. Coding of full texts will be undertaken using key words describing various aspects of study design and setting. Key variables of interest were identified through scoping activities and discussion with subject experts. Coding options within these key variables were then compiled in a partly iterative process, expanding the range of options as they were encountered during scoping. The finalised coding tool for the full text map is displayed in Table 3.

Studies may be coded with multiple keywords within each coding variable where appropriate, for example one study in multiple countries. The coding will be undertaken by one reviewer, with a subset of 10% of the coding carried out independently by a second reviewer and cross checked. Discrepancies will be discussed and coding moderated accordingly to reflect any clarification.

Critical appraisal of study internal validity

Coding will be used to describe the internal validity (IV) of each included study. This will be assessed using the following coding variables; *study length*, *study timescale*, *comparator appropriateness*, *comparator type*, *replication*, *sources of potential bias* and *methodological detail*. A judgment based on this critical appraisal will be made by placing each study into one of three categories; low, high, or unclear IV. For each study a short descriptive explanation for this judgement will be given for transparency.

Systematic map database

The systematic map outputs will be in the form of two databases of studies (at abstract and full text levels) that will describe the nature and location of evidence on the review topic. These databases will be easily searchable and freely accessible. The maps may form the basis for further primary research by identifying key knowledge gaps, and may also form the basis for further secondary research as a starting point for the synthesis of information in focused systematic reviews.

Competing interest

The authors declare that they have no competing interest.

Authors' contributions

NH, DS and AP conceived the review question. NH undertook pilot research. NH drafted the protocol text with support from DS and AP. All authors read and approved the final manuscript.

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