MOUNTAIN HAY MEADOWS: ASSESSING THE LOSS OF SURFACES AND ECOSYSTEM SERVICES IN IBERIAN AREAS

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Abstract:. Hay meadows, agro-ecosystems established and maintained by human secular actions of extensive management, are disappearing all over Europe, especially in mountain areas where they represent key High Nature Value Farming systems for biodiversity and ecosystem services. In recent times, also mesophile hay meadows in South-West Europe, a European priority habitat registering a poor conservation status, have lost significant part of their area. This disappearance is due to abandonment, intensification or urbanisation, driven by changes in land management and rural socio-demographic decline. This study is aimed at assessing the loss of mountain hay meadows in the North of the Iberian Peninsula and its consequences for ecosystem services, focusing on selected pilot areas currently protected as Natura 2000 sites. A diachronic analysis of these habitats was carried out through detailed land use mapping for three different periods, from the 1960s to the present, representing areas covered by hay meadows over time. Once identified, land use changes during the time under consideration have been quantified and analysed, as well as the drivers responsible for those changes. The conceptual framework of the Millenium Ecosystem Assessment was then applied to identify and discuss the most relevant consequences of change on ecosystem services. Results showed that, over the last 60 years, some study areas have lost up to 74% of hay meadows progressively, although at a higher rate in the latest years. A relationship between abandonment and slope and distance to inhabited areas has been also observed. Findings suggest that the observed abandonment process may lead to a loss of biodiversity (domesticated species) and impacts in the supply of strategic ecosystem services such as genetic resources, safe and healthy food products, traditional knowledge or fire risk protection. Interactions between hay meadows loss, ecosystem services, demographic processes and agricultural structural changes are finally discussed.

Keywords: Mountain hay meadows, loss, South-West Europe

Introduction

Despite their high botanical and faunistic value (especially lepidoptera and other insects important for pollination), hay meadows are disappearing in Europe. According to the Habitats Directive, in south-west (SW) Atlantic Europe, the habitats coded as 6510 Lowland hay meadows *(Arrhenatherion*) and 6520 Mountain hay meadows *(Triseto-Polygonion bistortae*) correspond to mountain hay meadows. This general process is also affecting hay meadows in the SW Atlantic Europe, due to changes in land management, intensification, and abandonment, although their traditional management is still conserved in mountains of north-west Portugal, the Cantabrian coast and the Pyrenees. In the Iberian area, some previous studies have outlined the changes experienced by these agroecosystems in recent times (Prince *et al.*, 2012; García Manteca *et al.*, 2018; Ascaso Martorell *et al.*, 2018). Thus, this research faces questions as: What has been the evolution of hay meadows in mountain areas of the Iberian Peninsula in recent decades? How much surface has disappeared, why and at what rate? How do these changes affect biodiversity and ecosystem services?. In order to answer them, this study was focused on different Iberian mountain territories of the RN2000 to analyse the evolution of hay meadows from the 1950s to the present day and the possible causes of these changes, in order to propose corrective or palliative measures to the trend of abandonment. In view of this, the consequences that these changes have on biodiversity and on the most relevant ecosystem services provided by mountain meadows are identified.

Materials and methods

The study was carried out in 6 different pilot areas included in 4 protected areas of the RN2000 (Table 1). They are all mountain areas that belong to two well-differentiated biogeographic regions. Two provinces are involved in the *Atlantic Region*: the *European Atlantic*, where the space PICOS DE EUROPA is located (site code ES1200001), and the *Pyrenean*, where the RIO ÉSERA is located **(**ES2410046). In the *Mediterranean Region*, on Portuguese territory are located ALVÃO/MARÃO (site code PTCON0003) and MONTESINHO/NOGUEIRA (PTCON0002). For the time intervals, three different dates have been chosen for each pilot zone, within the availability of photographic means for each area (Table 1).

Table 1. Basic information of the pilot zones and periods chosen for the analyses

NATURA 2000 SITE´S NAME	SITE CODE	PILOT ZONES	ALTITUDE	BASELINE YEAR	INTERMEDIATE YEAR	LAST YEAR
PICOS DE EUROPA	ES1200001001	Sotres	800 - 1,400 m	1956	2006	2017
PICOS DE EUROPA	ES1200001001	Fuente Dé	800 - 1,400 m	1956	2006	2017
PICOS DE EUROPA	ES1200001001	Soto de Sajambre	800 - 1,400 m	1956	2006	2017
RÍO ÉSERA	ES2410046	Benasque	800 - 1,400 m	1957	1986	2016
MONTESINHO/NOGUEIRA	PTCON0002	França	650 - 1,450 m	1958	1978	2017
ALVÃO/MARÃO	PTCON000003	Vila Pouca	600 - 1,100 m	1995	2005	2017

Available cartographic data and the photo-interpretation of historical photographs have been used, corrected in some cases with surveys to the inhabitants of these areas and social actors. The mapping units have been adapted to the *Corine Land Cover* (hereinafter CLC) legend by adding a code to distinguish, in the *grassland* unit, *tooth meadows* (231) from *hay meadows* (232). The information thus obtained has been analysed using Geographic Information Systems (GIS) tools to obtain quantitative and cartographic data on land use changes. For the cartography produced, a reference scale of 1:10 000 was used, with a minimum polygon size of 625 m^2. For the particular area of Picos de Europa, it was also assessed the effect of the slope and ease of access on the abandonment of hay meadows: a Digital Slope Model (DSM) has been constructed in degrees (based on the 25 m resolution DEM) and *a cumulative access cost area* has been developed from each 25 x 25 m cell to the nearest road, track or village. For this purpose, the layers of Spain's 1:25,000 National Topographic Base (NGI BTN25) have been used and weighted with the slope of the terrain.

Finally, adopting the conceptual framework of the Millenium Ecosystem Assessment (MA, 2003), we analysed ecosystem services (ES) in the studied sites taking into account their importance (according to an ordinal scale of four categories: Very high, High, Moderate and Low) and trends (Fast growth, Growth, Steady, Mixed or non-defined trend, Decrease and Fast decrease) over the last 60 years. This assessment was carried out by building qualitative matrices. Results from the diachronic analyses and prior knowledge/data from phytosociological and socioeconomic studies and samplings in the pilot areas were used (García Manteca *et al.*, 2017; Guzmán Otano *et al.*, 2017; Reiné *et al.*, 2014; Honrado *et al.*, 2017; Aguiar & Azevedo, 2011; Pires *et al.*, 1994), complemented with previous results from Spanish and Portuguese ES national assessments (EME, 2011; Aguiar *et al.*, 2009).

Results and discussion

In five of the six studied pilot zones there was a very significant reduction of hay meadows (Table 2): between 30% and 74% of the area occupied by hay meadows in the 50´s has disappeared, as well as the crops in the case of the Atlantic mountain pilot zones. The higher rate of disappearance has occurred during the last period analysed, which suggests that the process of change is accelerating in recent times. Part of the surfaces lost have been converted into tooth meadows (not mown), whereas other part has been abandoned; this second process has supported the natural succession and the replacement of part of the meadows by shrub communities and young forests. Particularly, the average slope of hay meadows in the Picos de

Europa area has decreased over time, from almost 18° in 1956 to 13.4° in 2017, which indicates that the process of abandonment has more intensely affected the areas of high slope. In the same way, the effective distance to the hay meadows has been decreasing over the years, and is now much shorter than in 1956, which means that the meadows furthest from villages and infrastructure have been lost to a greater extent.

Table 2. Evolution of surfaces occupied by hay meadows in the pilot zones.

	Area (ha)			% of change		
Location	**1956**	**2010**	**2017**	**1956_2010**	**2010_2017**	**1956_2017**
Soto de Sajambre	138.1	86.5	36.2	-37.3	-58.2	-73.8
Sotres	173.1	132.4	56	-23.5	-57.7	-67.6
Fuente Dé	155.6	117.2	54.8	-24.7	-53.3	-64.8
Location	**1956**	**1986**	**2016**	**1956_1986**	**1986_2016**	**1956_2016**
Benasque	1545.9	1672.3	1076.9	8.2	-35.6	-30.3
Location	**1995**	**2005**	**2017**	**1995_2005**	**2005_2017**	**1995_2017**
Vila Pouca	316.3	353.5	307.4	11.8	-13	-2.8
Location	**1958**	**1978**	**2017**	**1958-1978**	**1978_2017**	**1958_2017**
França	291.4	292.3	138.1	0.3	-52.8	-52.6

A number of consequences arise from these processes in the studied areas. *Supporting* ES are clearly decreasing due to surfaces reduction: primary production of forage, one of the most important service, decreases associated to higher grazing and changes in traditional fertilization, and the provision of habitat worsens. *Regulating* services of high importance and irreplaceable in these areas, as forest risk control and pollination, tend to decrease in supply. Concerning *provisioning* services, genetic resources and agrobiodiversity is the fundamental ES currently threatened: the traditional use of native seeds has almost disappeared and local autochthonous cattle and sheep breeds also suffer a strong decrease, although diversity of plant and wild animal species typical of hay meadows remain steady for the moment. Animal products experience a certain decline, softened by the use of local eco-labels and quality marks that still provide good added value to some of them (as cheeses, for example). Finally, in general *cultural* ES are being improved (scientific knowledge and educational, aesthetics and inspiration, sense of identity and place, cultural heritage), except for the traditional knowledge, which is quickly disappearing.

The drivers responsible for these changes are all growing or steady in the pilot zones since the last decades. As described before, major direct drivers (pressures) consist of land use changes, over and under exploitation (mainly abandonment), while the indirect drivers influencing the direct ones concern in most of the cases socio-demographic changes (depopulation, aging), the effect of the EU Common Agricultural Policy, mechanization, and urbanization of mountain rural communities. In the case of Spain, changes in land use and hay meadows since 1956 in the studied areas are mainly the result of two parallel and inseparable processes of a socio-economic and demographic nature. The first one is the different agricultural policies implemented in Spain over the last 60 years, with their corresponding effect (structural adjustment) on traditional extensive livestock farms in these mountain areas. The second one is the socio-demographic processes linked to the loss and ageing of the rural mountain population, accompanied by cultural changes in the population that still lives in these areas. Some potential responses to these processes have been identified as potential tools to try to reverse or smooth the loss of hay meadows and the good traditional extensive practices of farmers in these mountain:

–The implementation of a new CAP and Rural Development Programmes beyond 2020 is an opportunity to redefine certain 2nd Pillar CAP aids such as agro-environmental ones, specifically aimed at maintaining and recovering these areas and the good agricultural practices linked to them. It should also support accessibility to these meadows and formulas to increase plots efficiency for owners and exploiters.

–Protected Areas and N2000 sites can implement their own conservation or restoration measures on these habitats according to the rate of deterioration, loss or threat of these meadows: from education and environmental awareness campaigns to farmers and local population, to direct mowing actions.

–Fire risk prevention and climate change mitigation plans should pay attention to the importance of maintaining these types of open herbaceous environments that act as risk buffers around populated mountain areas and rural infrastructure.

–Favouring the markets of bio-based agricultural products and eco-labels specifically linked to the productions coming from these meadows (meat, milk, cheese) is one of the best options to increase their profitability and added value. Supported by specific programs of research and conservation of genetic material, these productions can also include native local seeds with accredited traceability to satisfy new emerging uses (restoration, civil works, landscaping, urban environment, etc.).

Conclusions

Diachronic analyses of the evolution experienced by hay meadows in 6 mountain pilot areas of Spain and Portugal belonging to Natura 2000 sites shows a considerable loss of their surfaces over the last 60 years. This reduction is being mainly caused by land use changes, over and under exploitation (mainly abandonment), as well as socio-demographic dynamics and agricultural structural changes. This process is leading to a loss of biodiversity (domesticated species at the moment) and a decrease in the supply of strategic ES: genetic resources, safe and healthy food products, traditional knowledge and fire risk protection.

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