Journal for Nature Conservation 20 (2012) 162–169

Contents lists available at SciVerse ScienceDirect

Journal for Nature Conservation

journal homepage: www.elsevier.de/jnc

Changes in the vegetation composition of hay meadows between 1993 and 2009 in the Picos de Europa and implications for nature conservation

Heather E. Prince[a,*], Robert G.H. Bunce[b,c], Rob H.G. Jongman[b]

[a] University of Cumbria, Rydal Road, Ambleside, Cumbria LA22 9BB UK
[b] Alterra, PO Box 47, 6700 AA, Waganingen, The Netherlands
[c] Estonian University of Life Sciences, Kreutzwaldi 64, 51014 Tartu, Estonia

ARTICLE INFO

Article history:
Received 5 July 2011
Received in revised form
20 December 2011
Accepted 10 January 2012

Keywords:
Biodiversity loss
Herb-rich grassland
Indicator species
Northern Spain
Resource loss
Stratified random sample

ABSTRACT

The Picos de Europa are a range of predominantly Carboniferous Limestone and Sandstone mountains mainly in the Cantabrian region of northern Spain. The highest peaks are precipitous and reach 2600 m. There are complex gradients between Lusitanian, Alpine and Mediterranean environmental zones, as well as variable soil types. In combination with the long history of traditional agricultural management, a wide range of diverse habitats and species is present. The herb-rich hay meadows have long been recognised as having a high nature conservation value but, as elsewhere in European mountains, such grasslands are threatened by changing agricultural practices. Accordingly, in 1993, 92 quadrats were recorded using a restricted list of indicator species from stratified random samples. The authors repeated the sample in 2009. Changed land use had only occurred in approximately 3% of meadows, however, farmyard manure was no longer used, probably because of shortage of labour. Statistical analysis of the vegetation data showed a range of significant changes consistent with the increased use of slurry, as well as re-seeding of some fields. The grass swards had not only become denser, with fewer species present, but there was also a loss of sensitive indicators especially of calcareous conditions and open vegetation. By contrast, competitors had increased and the vegetation had become simpler, with the balance of vegetation types shifting to more nutrient rich conditions. These changes have mainly occurred in the more fertile meadows used for silage. The core of about 35% of herb-rich meadows, mainly cut for hay, has remained relatively stable but the results show that they are at risk if the current trend continues. If management practices that form the core of traditional agriculture are not maintained, one of the most important resources of herb-rich meadows in Europe will be lost.

Introduction

A wide range of diverse habitats and species is present in the Picos de Europa mountains of northern Spain. The hay meadows have long been recognised as having particular botanical significance and a high nature conservation value (Farino 1987, 1988; Goldsmith & García 1983; Rivas-Martinez et al. 1984). The exceptional plant diversity results from the combination of pedogenic and climate factors interacting with centuries of management by man. Traditionally, the practice of altitudinal transhumance enabled the species-rich meadow areas to produce hay in the spring and summer, which provided fodder for overwintering livestock (Bunce et al. 1998; Ruiz & Ruiz 1986). The mountain hay meadows of the Picos de Europa are still mainly managed using traditional agricultural practices, although these are changing because of the introduction of silage, particularly on less steep fields. In Spain, there is no available literature on the changes over time in the species structure of mountain grasslands, hence the present paper. This study assesses changes in the vegetation composition of hay meadows and interprets these in the light of changing agricultural practices. The conservation importance of the species-rich mountain hay meadows in this region is also emphasised.

Over the last 50 years, the status of many Spanish cultural landscapes has changed because of differences in management systems and social factors. The pace of these changes has accelerated since Spain joined the European Union (EU) in 1986, but especially in the last ten years. Spanish agriculture had already moved away from self-sufficiency before the accession to the EU, but the Common Agricultural Policy (CAP) with its subsidy incentives has accelerated this process (Hindmarch & Pienkowski 2000). Agricultural development in the Picos de Europa has been slower than in other parts of Europe. However, some noticeable changes have occurred. There has been a decline in the local equivalent of pollarding ash trees (*Fraxinus excelsior* L.), which produces the distinctive "candelabra"

* Corresponding author.
E-mail address: Heather.Prince@Cumbria.ac.uk (H.E. Prince).

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doi:10.1016/j.jnc.2012.01.002

shape indicative of the traditional agriculture. There has also been a shift from the traditional cattle breed (*Tudanca*) to high output Charolais and Limousin for beef, and Friesian and Swiss Grey for milk. These foreign breeds are ill suited to the swards on steep mountain pastures and therefore they are rarely taken to higher altitudes in the valley (Waterhouse 1996). In combination with a decline in the farming population and reduced land management, less cutting or burning has led to scrub encroachment on the steeper slopes. The need for a higher productivity in meadows and pastures has been met through silage production and an increasing use of slurry. The former also allows earlier and more frequent cutting, which prevents plants from setting seed (Farino 2009; Frame 2000).

The reduced area of hay meadows raises concerns over the loss of floristic biodiversity and its associated fauna (Baura et al. 2006; Hopkins et al. 2000). The remaining meadows on steeper slopes tend not to be fertilised and have lower land management pressure due to a variety of social factors, especially the aging population.

Cultural landscapes, such as those in the Picos de Europa, in which component ecosystems have developed over many centuries in response to management practices, are now recognised as being of major conservation importance (Bergland 1991; Pedroli et al. 2007; Selman, 1994). Mountain hay meadows in Europe are under threat mainly because of changes in traditional management systems (Bunce et al. 2004). Species richness is higher in less fertilised meadows and there is evidence that there are also more species in meadows that are cut less frequently in the Italian Alps (Marini et al. 2008) and Norway (Losvik 2001). Their conservation importance is recognised by their presence in the list of Annex 1 habitats in the EU Habitats Directive. Both lowland and upland hay meadows are listed but the Picos de Europa meadows fit better into the latter category. Hay meadows are rare habitats in Britain and a priority habitat in the UK Biodiversity Action Plan (Jefferson 2005; O'Reilly 2010). Agricultural intensification, involving ploughing and re-seeding and a shift from hay-making to silage production, has taken place over the last 50 years and has been linked to losses in species-rich upland hay meadows. Many meadows continue to exhibit a decline in floristic richness, despite recent conservation initiatives, including voluntary agri-environment schemes (Jefferson 2005). A more recent initiative is seeking to restore and enhance hay meadows in the North Pennines Area of Outstanding Natural Beauty (AONB), U.K., through 'Hay Time' (North Pennines AONB Partnership, 2011) by harvesting seed from species-rich meadows and spreading it on sites that have lost species and by providing detailed habitat management advice. Bunce et al. (1998) suggested that an option for nature conservation in the Picos de Europa is to introduce agri-environmental measures similar to those in other parts of Europe (cf. 'Ecological Compensation Areas' in Switzerland (Hofer et al. 2011)).

Changes in the floristic diversity and composition of hay meadows are caused by several management factors. The present study reports changes in mountain meadows and pastures over almost 20 years and interprets these in terms of known drivers.

Location

The Picos de Europa mountains in northern Spain, are a range covering approximately 600 km^2. The highest peaks reach 2600 m and consist of precipitous Carboniferous Limestone cliffs, screes and grasslands. At lower altitudes the mountains and valleys also include Carboniferous Sandstones and Shales which have gentler slopes, though some cliffs are also present. There are also some smaller areas of conglomerates giving local variations in soil conditions. The western side of the massif is hyper-oceanic, because of the Atlantic influence, with a gradient towards the east caused by a progressively stronger Mediterranean influence; especially in the valleys and on south facing slopes. This gradient is reflected in the transition between the European Environmental Zones (Metzger et al. 2005) from Lusitanian in the west, to Alpine South in the highest mountains and Mediterranean mountains on the lower slopes, especially in the east. The range forms the highest part of the Cantabrian chain which extends almost 400 km south west from the Pyrenees. It is geographically isolated from other mountains in the Iberian Peninsula, as reflected by the number of endemics, some of which are in common with the Pyrenees. Otherwise the region contains a complex mixture of phytogeographical elements including Alpine, Atlantic, Lusitanian and Mediterranean species as well as many plants with wide ranges throughout Europe. A correspondingly wide range of habitats is also present.

Methods

The initial botanical survey, using the nomenclature of the Flora Europaea (Tutin et al. 1993), took place in April 1993 and a replicate survey was completed in May 2009 (a seasonal difference of three weeks) and covered the Deva valley, Cantabria, Picos de Europa.

A detailed field survey of meadows was undertaken by Charlotte Mason College in 1992, to ground truth the maps and to identify all the area of meadows in the valley. Base maps showing meadow delineation were used (*Mapa Topografico de Espana Camaleño* (81–1) and *Potes* (81–2)). 23 groups of meadows were identified by geographical proximity. The sample of quadrats thus comprised 23 stratified random square kilometres, with four random points in each square (a total of 92 quadrats). The meadow altitudes vary from 290 m to 1085 m, a range of 795 m. In 2009, map detail was further enhanced by employing 'Sigpac' (http://sigpac.mapa.es/fega/visor); as used by the Cantabrian Regional Government; which enabled a combination of aerial photography and maps to be used to locate the sites, which were predominantly on limestone; although some were located on calcium-rich sandstones and shales.

Sampling

Each point on the map was the central point for a 4 m^2 quadrat (Bunce & Shaw 1973) with a 5 m minimum distance from any track or field boundary. Notes of location and field sketches were made in 1993 to facilitate replication. 86 indicator species with minimal taxonomic challenges were selected; following research by Farino (1992) and through discussions between the authors; with an estimation of percentage grasses, percentage moss and percentage bare ground. The indicator species were selected as representative of the full species complement in order to cover the valley in the limited time available. Some key species for conservation were also included.

Species abundance was categorised on the Braun–Blanquet scale of 1–5: 1: 1 individual present; 2: <5% cover; 3: 5–25% cover; 4: 26–50% cover; 5: 51–100% cover. For calculations of comparative abundance, a median percentage was used (1: 1%; 2: 2.5%; 3: 15%; 4: 37.5%; 5: 75%) to pick up the species of low frequency.

In 1993, a pilot study of eight quadrats in which all species were identified was used to assess the reliability of indicator species as a measure of meadow composition. The results confirmed that indicators were reliable and could be used to determine the status of meadows, as the additional species recorded were common species and widespread in a number of different open habitats.

The co-ordinates of the point and the altitude were recorded on maps in 1993. In 2009 the points were located using a Global Positioning System (GPS). The mean height of the vegetation was estimated, and grazing and application of farmyard manure were also noted. In 1993 the following environmental variables were