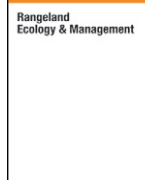




Contents lists available at ScienceDirect

## Rangeland Ecology &amp; Management

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Original Research

Structure of Stockmen Collaboration Networks Under Two Contrasting Touristic Regimes in the Spanish Central Pyrenees<sup>☆</sup>Hugo Saiz<sup>a,b,c,\*</sup>, Maite Gartzia<sup>d</sup>, Paz Errea<sup>a</sup>, Federico Fillat<sup>d</sup>, Concepción L. Alados<sup>a</sup><sup>a</sup> Instituto Pirenaico de Ecología (IPE)—CSIC Campus de Aula Dei, Zaragoza 50059, Spain<sup>b</sup> UMR 6553 Ecobio, CNRS—University of Rennes 1, Rennes Cedex 35042, France<sup>c</sup> Departamento de Biología y Geología, Física y Química Inorgánica, Universidad Rey Juan Carlos, Móstoles 28933, Spain<sup>d</sup> IPE—CSIC Campus de Jaca, Jaca, Huesca 22700, Spain

## ARTICLE INFO

## Article history:

Received 3 September 2015

Received in revised form 28 September 2016

Accepted 29 September 2016

Available online xxxxx

## Key Words:

agropastoral practices

collaboration networks

Ordesa-Monte Perdido National Park

socioeconomic systems

ski resorts

## ABSTRACT

Ecosystem management is a difficult task because it must conciliate the ecological, economic, and social dimensions of socioecological systems. In those systems, the action of any single component can have an effect on the others and result in a critical impact on the organization of the entire system. This study examined the collaboration networks among stockmen within two traditionally agropastoral regions in the Spanish Central Pyrenees, which in the past 30 yr included touristic activities: one under the influence of a national park and centered on ecotourism and the other in a region where there are ski resorts and local stockmen have turned to snow tourism. Our hypotheses were that economic regime affects the structure of the networks, and the type of collaboration (e.g., for economic reasons) influences the collaborations among stockmen. We built stockmen collaboration networks by connecting breeders within the same pastoral partnerships and calculated the importance of collaborations (links density), the occurrence of collaborative subgroups (network modularity), and the existence of collaborations between stockmen in different regions (Krackhardt Ratio). In addition, we identified the distribution of links among types of pastoral partnerships. The network under the influence of the National Park presented higher link density and modularity than did the network influenced by ski resorts, where the presence of nonlocal stockmen is higher. Furthermore, economic partnerships played a major role connecting stockmen. In the study area, differences in the collaboration networks between the two regions suggest that changes in the economic trend in the past 30 yr has influenced the collaborative structure of the stockmen. We discuss possible reasons behind these differences and propose some recommendations that could help to strengthen the collaborative bounds between stockmen in the area.

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## Introduction

Ecosystem conservation is one of the most important challenges of our time. Global change driven by human activities has altered the natural balance and modified earth processes significantly (Rockström et al., 2009). Those changes have created several threats to the preservation of ecosystems including global warming and biodiversity loss, which are among the most important issues that governments must face to preserve the ecological value of the environment (Vitousek, 1994; Vitousek et al., 1997; Sala et al., 2000). However, finding a balance

among the conservation of ecosystems, economic development, and preservation of social values (i.e., sustainable development, Hopwood et al., 2005) can be difficult. Ecosystem management covers only one part of social-economical systems (SESs), which combine ecological, economic, and social dimensions of human systems (Millenium Ecosystems Assessment, 2005; Ostrom, 2009). In SES, an effect on any single component can spread to the others and have a significant impact on the entire organization of the system (Holling, 2001; Young et al., 2006). Thus, to develop more effective conservation strategies, all different dimensions of SESs have to be assessed simultaneously (Fiksel, 2006). Particularly, in recent times the importance of the social dimension to address the resilience of SESs has been highlighted (Davidson, 2010; Berkes and Ross, 2013). For instance, considering the collaborative structure among the inhabitants in SES is central for the system resilience, as differences in the social organization of the system can have significant effects on the success of management practices (Berkes et al., 2000).

Management practices are particularly important in mountainous regions. In mountain areas, human activities have led to the development of

<sup>☆</sup> The study was made possible by the financial support of projects FW7 ENV.2009.2.1.3.2 from the European Community and 125/2010 from Organismo Autónomo de Parques Nacionales of Ministerio de Agricultura, Alimentación y Medio Ambiente.

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<http://dx.doi.org/10.1016/j.rama.2016.09.007>

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Please cite this article as: Saiz, H., et al., Structure of Stockmen Collaboration Networks Under Two Contrasting Touristic Regimes in the Spanish Central Pyrenees, Rangeland Ecology & Management (2016), <http://dx.doi.org/10.1016/j.rama.2016.09.007>

a wide variety of ecosystems that are nowadays considered biodiversity hotspots (Lomolino, 2001; Korner and Spehn, 2002) and whose environmental value is recognized (mountain ecosystems are included within the European Habitat Conservation Strategy, Consejo de las Comunidades Europeas, 1992). Furthermore, those areas have been inhabited for centuries and are presented as examples of sustainable SESs that preserve traditional economic activities, mainly agropastoral practices; together with the ecological value of the ecosystem (Jodha et al., 1992). For example, in the Spanish Central Pyrenees, the persistence of traditional pastoral habits such as transhumance (i.e., periodic movement of livestock between summer and winter pastures) led to the development of singular plant communities that have both high biodiversity and productivity (Ruiz and Ruiz, 1986; Caballero et al., 2011). Thus, traditional mountain human systems are good examples of sustainable development, where ecological, economic, and social dimensions of the SES are balanced.

In Europe, however, industrial development near cities at the beginning of the 20th century led to massive migration from rural to urban areas (Mather, 2001; Pinilla et al., 2008; Alados et al., 2014). This dramatic reduction in human labor had a profound impact on mountain SESs, especially on the conservation of mountain pastures. In the Spanish Central Pyrenees, land abandonment and the loss of sustainable pastoral practices have reduced pasture area due to changes in land use (García-Ruiz et al., 1996; Gartzia et al., 2014, 2016b) and “shrub encroachment” (i.e., increase in the density of local shrubs in pastures to the detriment of herbs and grasses (Van Auken, 2000; Komac et al., 2011). For example, the substitution of pastures by shrublands and forests has been associated with the decrease in livestock numbers in the area (Gartzia et al., 2014). In addition, the loss of mountain pastures might be accelerated in the near future as they are among the most vulnerable habitats to global climate change (Huber et al., 2006).

Livestock management is one of the main factors responsible for maintaining the ecological value of mountain pastures (Zervas, 1998; Kohler et al., 2004). Livestock grazing influences the growth of the consumed plants, modifies species cover, and changes the composition and structure of plant communities (Milchunas and Lauenroth, 1993; Van Auken, 2000). Furthermore, pastoral ecosystems have been recognized as important providers of ecosystem services (Oteros-Rozas et al., 2013). For example, livestock grazing can increase the productivity of an ecosystem and transforms a dispersed, low-energy resource (grass) into a concentrated, high-energy resource (livestock meat, Frank et al., 1998). In addition, pastoral activities also help to preserve and transmit traditional local knowledge in mountain SES (e.g., location of water points and grazing paths, regulation of grazing intensities, Hassanein and Kloppenburg, 1995), which helps to accelerate the reorganization of the system after major disturbances (Berkes et al., 2008). Therefore, to preserve mountain pastures and their associated ecosystem services, the conservation of sustainable agropastoral activities is essential.

Traditionally, in the Spanish Pyrenees livestock production has involved a communal grazing system in which stockmen collaborate to expand grazing pastures and to preserve their pastoral value (Caballero et al., 2011). Today, this collaborative structure has led to the creation of different livestock partnerships whose duties include from economic to sanitary tasks (e.g., optimize the marketing of products, obtain quality designations for the livestock, manage veterinary examinations, España Ministerio de Agricultura, Pesca y Alimentación, 2003). Remarkably, the implementation of Common Agricultural Policy (CAP, Consejo Europeo, 2005) has led to the apparition of several partnerships specialized in maximizing the capture of subsidies (Veysset et al., 2005; García-Martínez et al., 2009). However, changes in mountain SES as depopulation and the reduction in agropastoral practices might modify this collaborative system and, ultimately, influence the viability of mountain pastures. Thus, economic and social dimensions of traditional mountain SES have to be reconciled to preserve the ecological value of mountain pastures.

In this study, we evaluate the collaborative structure of stockmen in two regions in the Spanish Central Pyrenees. This mountainous area has

been traditionally driven by agropastoral activities, but with the decline of livestock in recent times, inhabitants have supplemented livestock management with other economic activities associated with tourism. One region has supplemented agropastoral practices with ecotourism activities under the influence of a national park. On the other hand, the other region has incorporated snow tourism activities organized around the development of big ski resorts. We studied the collaborative structure in the area through the analysis of their stockmen collaboration networks (SCNs). In these networks, stockmen connect among them considering the different economic and cultural partnerships they belonged to. We hypothesize that analysis of the SCNs unveils valuable information about the organization of stockmen in our SES. For example, differences in the current economic trends between regions or the specific type of partnerships considered to represent the collaboration could have a reflection in the stockmen collaborative structure. We expect that the analysis of SCNs improves our knowledge about the social dimension in the Spanish Central Pyrenees.

## Methods

### Study Area and Data Collection

The study was conducted in the Central Pyrenees within the province of Huesca in northern Spain. The study area lies within the alpine mountain range (sensu, the zone above 1 500 m, Fillat et al., 2012) with a maximum elevation of 3 340 m. The climate is heterogeneous and strongly influenced by elevation, ranging from alpine in mountain grasslands to sub-Mediterranean at low elevations. Average annual temperature ranges from 5°C (Goriz Refuge at 2200 m, data from 1976 to 2005) to 12.4°C (Salinas de Bielsa at 760 m, data from 1961 to 1967), and average annual precipitation ranges from 1657 mm (Goriz) to 1307 mm (Salinas de Bielsa). Historically, grazing activities, which have involved moving livestock from mountain grasslands in summer to the Middle Ebro valley in winter, have driven the local economy (Daumas, 1976; Caballero et al., 2011). However, at the beginning of 20th century, urban development led to rural depopulation in the area, resulting in a reduction of grazing activity and the substitution of pastures and cultivated areas by shrublands and forests (García-Ruiz et al., 1996; Lasanta and Vicente-Serrano, 2007; Alados et al., 2014).

We selected two regions in the Spanish Central Pyrenees: Sobrarbe and Alto Gállego counties (Fig. 1). Although both regions differ in their population densities (Table 1), their population trends in the 20th century have been similar (strong decrease until 1980s, when population stabilized, Alados et al., 2014). Furthermore, both regions have experienced the same changes in agropastoral activities, with a substitution of sheep livestock by cattle (sheep livestock decreased from 1.4 individuals [ind]/ha in 1940 to 0.2 ind/ha in 2000, while cattle increased from 0.05 ind/ha to 0.14, data from Archivo Histórico de Huesca and Delegación Provincial de Huesca), principally because the cost of managing cattle is smaller (in the study area, livestock can reach the most remote pastures while cattle are concentrated in the most accessible ones, Gartzia et al., 2016a). Together with changes in shepherding, in recent times stockmen in both regions have supplemented pastoral practices with other sources of income mostly linked to services sector (see Table 1). However, these sources differed among regions.

On one hand, Sobrarbe includes six municipalities (Torla, Broto, Fanlo, Puertolas, Tella-Sin, and Bielsa) encompassing the area in and around Ordesa-Monte Perdido National Park (OMPNP, see Fig. 1). OMPNP was created in 1918 and expanded to its current limits in 1982 (15 608 ha). The presence of OMPNP has induced the rise of ecotourism in recent years, resulting in the development of campsites and rural houses (see Table 1). On the other hand, Alto Gállego includes five municipalities (Sallent del Gállego, Panticosa, Hoz de Jaca, Biescas, and Yésero), which comprise two ski resorts (Formigal and Banticosa, see Fig. 1). In the Central Pyrenees, between 1965 and 1976, five alpine ski resorts and associated tourist infrastructures were built, which led to

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