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in

Molina Alcaide E. (ed.), Ben Salem H. (ed.), Biala K. (ed.), Morand-Fehr P. (ed.).
Sustainable grazing, nutritional utilization and quality of sheep and goat products

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 67

2005
pages 33-38

Tools for sustainable management of mountain pastures: Application to three protected natural areas in Northern Spain

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SUMMARY – This paper describes some examples taken from a wide research project whose main objective is to provide decision tools for the sustainable grazing management of protected natural areas. The study was carried out in 3 Natural Parks, located in Northern Spain (Guara, Izki and Gorbeia), that have different agro-climatic situations and livestock utilisation regimes. Special attention is paid to the methodology used to study livestock-vegetation interactions. Several farming systems with different animal species, production regimes, breeding and grazing calendars, stocking rates, etc., are present in these areas. All these conditions determine the establishment of different plant communities, which were characterised in terms of botanical composition, biomass availability and nutrient quality. The patterns of evolution of these parameters in grazed and non-grazed areas are mentioned in the paper. The elaboration of a "grazing cartography", including physical (orography, climate, etc.) and biological (animals and vegetation) maps, is described. The wide range of situations analysed by GIS can allow constraint factors and possible indicators for sustainable grazing management to be determined. Likewise, an evaluation of alternative farming practices, compatible with economic and environmental objectives, is possible. Thus, this methodology could constitute a useful tool for both conservation and production purposes in these areas.

Key words: Sustainability, grazing management, mountain systems, decision support tools, GIS.

RESUMÉ *– "Outils pour la gestion durable des pâturages de montagne : Application à trois zones naturelles protégées au nord de l'Espagne". Cet article rapporte des exemples d'un projet de recherche qui a pour objectif d'obtenir des outils d'aide à la décision pour une gestion durable des espaces naturels protégés. L'étude concerne trois Parcs Naturels situés au Nord de l'Espagne (Guara, Izki et Gorbeia) avec différentes situations agro-climatiques et différents régimes d'utilisation. Une attention spéciale est portée à la méthodologie utilisée pour étudier les interactions animaux-végétation. Plusieurs systèmes d'élevage avec différentes espèces animales, races, calendriers de pâturage et d'élevage, charges, etc. sont présents dans ces zones. Toutes ces situations conditionnent l'établissement de différentes communautés végétales qui sont caractérisées en termes de composition botanique, biomasse disponible et qualité nutritive. Dans cet article, on discute les évolutions possibles de ces paramètres dans les zones pâturées et non pâturées. L'élaboration d'une cartographie des activités de pâturage intégrant les aspects physiques (orographie, climat, etc.) et biologiques (la végétation disponible et son utilisation par les animaux) est décrite. La diversité des situations analysées permettra, en utilisant la technologie SIG, la détermination des contraintes de l'utilisation pastorale et des indicateurs possibles nécessaires à une gestion durable des pâturages. En plus, cette méthodologie permettra l'évaluation des différentes pratiques et sera un outil de travail autant pour la production animale que pour la conservation des habitats.*

Mots-clés : *Gestion durable, conduite de pâturage, systèmes de montagne, outils d'appui à la décision, SIG.*

Introduction

Preserving landscape biodiversity is a major goal of environmental policies in European countries. Mountain pastures have traditionally been maintained by livestock, but the abandonment of large grazing areas have implied economical and social consequences as well as changes in the vegetation, reduction of biodiversity, degradation of traditional landscapes and higher risk of environmental hazards, such as forest fires.

As mountain farming systems are dynamic and imply complex relationships between physical and biological elements, their management requires adequate strategies, which should take into account both the expected animal performance on the available pasture types, and the impact of grazing on

vegetation characteristics. The analysis of data concerning land use, grazing management and vegetation dynamics using GIS (Geographic Information Systems) can constitute an appropriate tool to study these systems. It allows the understanding of relationships between most factors involved and to diagnose specific situations. This information is necessary to develop utilisation guidelines, making compatible the exploitation and conservation of natural resources.

This paper describes a methodological framework to study the issues described above through some examples taken out from a wide 3 year-long research project whose main purpose is to provide decision tools for the sustainable management of protected natural areas.

Material and methods

The study was carried out in 3 Protected Natural Parks located in the north of Spain (Guara in Aragón and Izki and Gorbeia in the Basque Country) (Fig. 1), which have different agro-climatic conditions and livestock utilisation regimes. The three areas constitute a diverse range of mountain situations: Mediterranean (850 mm annual rainfall with dry summers in Guara), transition (1000 mm annual rainfall in Izki) and Atlantic (2000 mm annual rainfall with snow in winter in Gorbeia).

Fig 1. Location of the three Protected Natural Parks

These mountain systems are dynamic and depend on the vegetal-animal interactions, altogether with the human activities. Several farming systems with different animal species, production regimes, breeding and grazing calendars, stocking rates, etc., are present in these areas. All these conditions determine the establishment of different vegetation communities, which have different characteristics in terms of botanical composition, biomass availability and nutrient quality.

Due to the large extension of the Parks and the diversity of farming systems, a scale of work was selected both to be representative of the park and easy for sampling purposes. Therefore, some representative "study areas" were included in the study in each Park. The six study areas selected in Guara were pastures that ranged from 140 to 3000 ha, and were grazed either by sheep, cattle or mares. Two areas of 102 and 227 ha were selected in Izki, grazed collectively by sheep, cattle and mares, and finally the four areas considered in Gorbeia ranged from 44 to 93 ha and were grazed collectively by sheep, cattle and mares and goats.

The methodology used implied a multidisciplinary approach, which concerned three main research activities summarised in Fig. 2.

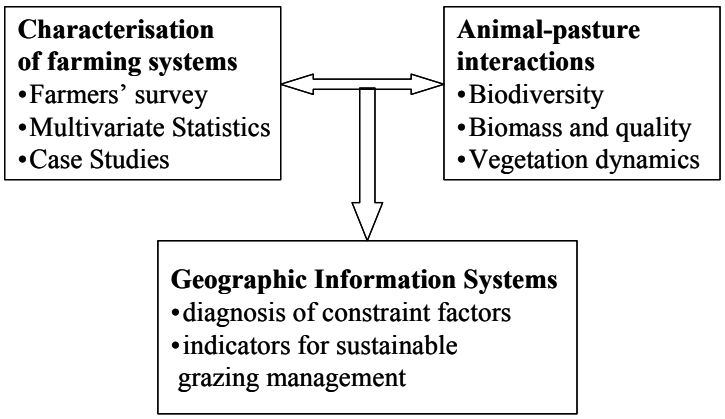

Fig. 2. Objectives and methodology.

Characterisation of farming systems and grazing management

A structured questionnaire collecting information concerning family composition, labour force, land use, herd composition, general management, with special focus on grazing management, was designed in order to determine the main characteristics of farming systems. Opinions and attitudes of farmers towards the Park regulations were also collected. Multiple Correspondence Analysis and Cluster Analysis were carried out to typify farms using indicators about farm size, land use, location of grazing resources in the Park and stocking rate (Bernués et al., 2002). From the groups obtained, case studies will be selected in the future to carry out an in-depth dynamic analysis of grazing management.

Data were collected from farms using grazing areas inside each Park. Due to the differences in the number of farmers and stocking rates, the sample was different in each case: (i) in Guara, all the farmers using grazing areas inside the Park were interviewed, n=62; (ii) in Izki, all farmers that grazed the "study areas" were included, n=6; while (iii) in Gorbeia, 70% of the farmers using "study areas" (attending to species and number of animals) were included, n=40. In order to extrapolate results, in following months more questionnaires will be made to farmers located out of the "study areas".

Vegetation characterisation and the effects of grazing

Botanical inventories were carried out to characterise vegetation, using the point-intercept method (contacts every 10 cm on a 10 m transect). Experimental plots were located in each study area to determine the effect of grazing on the evolution of vegetation. In each of them, a representative area of 10x10 m was fenced in early spring, in order to avoid animal grazing thereafter. Different measurements of herbaceous and bushy vegetation were recorded outside (grazed area) and inside the plots (non-grazed areas) at the beginning and end of the grazing season. The study started in 2001 and will be performed throughout four grazing seasons.

The necessity for a simple, rapid and non-destructive methodology to estimate the pasture availability, led us to use indirect measurements for both herbaceous and shrubby vegetation. For the herbaceous component of pasture, biomass was estimated measuring herbage height. For the study of shrubby vegetation, a fixed transect was delimited inside and outside the fenced areas. Bush biomass has been frequently related to volume, so it was calculated after measuring all individual shrubs in the transect (height, length and width), assuming an elliptic-based cylindrical shape. Predictive models were obtained by linear regression for both herbage and shrub biomass (Casasús et al., 2002).

Besides, the weight and body condition score of all animals grazing in the "study areas" were recorded immediately before and after the grazing season. In this way, the actual role of grazing can be evaluated in terms of animal performance, dietary energy supplied by pasture and its contribution to annual energy requirements.

Analysis of land use by livestock

The grazing areas were used in different time periods during spring, summer and autumn and by different animal species under diverse grazing regimes. Due to the differences in stocking rates and grazing management, the utilisation of land was very different between and even within parks, and its study needed to be adapted. In Guara individual flocks and herds were more isolated and the surfaces they used were better delimited, even when they grazed on communal ranges, and thus the information concerning grazing areas and stocking rates were individually collected in the questionnaires. In Izki and Gorbeia, animals from different owners grazed together in communal areas, and therefore stocking rates were estimated *in situ* by fixed transects and a more extended study of beef-cattle habitat utilisation was carried out using a scan-sampling method (Mandaluniz and Oregui, 2003; Mandaluniz et al., 2003).

All animal data (stocking rates, species, grazing periods, etc.) and vegetation information was digitalised using Arc Info and processed with Arc View 3.2. Other maps concerning several physical variables, vegetation classes, infrastructures, etc. were added, and a series of thematic maps were generated. Relationships were established between grazing activities and stocking rates and other variables of physical (altitude, slope, pasture types, distance to rivers) or "human" origin (distances to infrastructures, villages, etc). Taking into account these relationships, a Grazing Potential Index was developed, in order to predict the potential use of all grazable areas.

Preliminary results and discussion

One of the main characteristics of the farming systems was the large heterogeneity in size, species composition, reproductive management, land availability, etc., both between and within parks (Bernués et al., 2002; Urarte, 1988). In general, the utilisation of communal pastures was very important and farms are quite extensive, both in terms of herd/flock size, and of rangeland utilisation.

The predictive equations for both herbage and shrub biomass were accurate enough to allow for an estimation of the biomass by only measuring sward height and shrub volume respectively (Albizu et al., 1999; Casasús et al., 2002). Preliminary results from two years indicated that grazing controlled herbage biomass on rangelands (changes of +1180 and -210 kg DM/ha in non-grazed and grazed areas, respectively), produced a higher proportion of green material (33% and 57% at the end of the second year in non-grazed and grazed areas, respectively) and maintained or even decreases shrub density and volume (Casasús et al., 2003).

The study of animal performance in Gorbeia Natural Park revealed that there were important differences according to animal age and physiological stage and the grazing period considered. All animal types gained weight to some extent in the summer, with lower gains in lactating and late pregnant cows as opposed to dry cows, heifers or calves. A lower performance was observed in the autumn, which was associated to the reduction of forage quality and availability.

Finally, actual and potential land use by livestock was analysed. In Guara Natural Park only 53.2% of the available surface was grazed, and the average stocking rate was very low (0.15 livestock units per hectare, LU/ha), which implied that most of the territory was under-exploited (Asensio, 2004). This was related mainly to the low livestock censuses, and the fact that in certain areas some physical and human factors limited grazing use. According to these relationships, the potential use of all pastures in the Park was predicted by defining a Grazing Potential Index based on pasture types, slope, altitude and distance to roads, villages, rivers and other water points. This index allowed to find areas of medium, high and even very high grazing potential which were not actually grazed (Fig. 3), an information that can be very valuable for those who decide and design management strategies for these areas.

On the other hand, all the *Livestock Encouragement Areas*[1] of Gorbeia (average stoking rate 0.77 LU/ha) were grazed in different degrees depending on the area and animal preferences (Marijuán,

[1] Livestock Encouragement Areas: extensive livestock and forest maintenance or improvement zones. The objective of these areas is to improve pastures in areas where the slope is less than 30% and to improve forest in areas where the slope is more than 30% and are under erosion risk (Natural Resources Arrangement Plan).

1996). The study of the effects of both biotic (vegetal availability and its nutritive value) and abiotic factors (water availability, orography, etc.) allowed to determine the constraints of each animal species for grazing (Mandaluniz and Oregui, 2003; Mandaluniz et al., 2003). In this sense, cattle selected positively open pasture due to its higher herb availability, and only selected heather-gorse-fern community when herbage availability decreased because of its higher cover of shrubs, which limited accessibility. All these constraints meant a diversified utilisation of these mountain areas, which implies a different evolution of the vegetation.

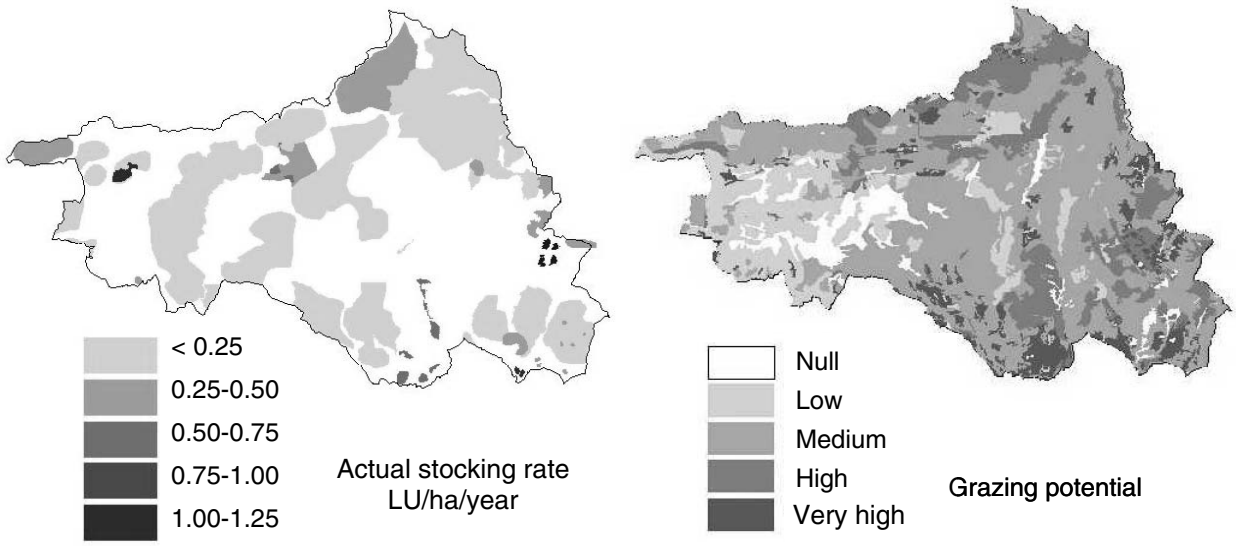

Fig. 3. Actual and potential use of grazing areas by livestock in Guara Natural Park.

Conclusions

The particularities of mountain grazing systems need that specific methodologies are developed for the study of these areas. They are areas of free access and where we can find different animal species, which makes difficult the analysis of land use and of animal-pasture interactions. On the other hand, the study of herbaceous and shrub vegetation in extensive rangelands requires quick and easy sampling methods which are adapted to the specific objectives of each work, and suitable time-space scales in order to obtain representative results.

The preliminary results presented here show that the diagnosis of farming systems, the study of animal-pasture interactions, and the analysis of land use with adequate methodologies, can be very useful tools to determine constraint factors for production systems and land use, and also to provide indicators for sustainable grazing management.

Acknowledgements

This work has been financed by project RTA 02-086-C2-2 of the Spanish National Institute of Agricultural and Alimentation Research and Technology (INIA)

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