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A simple model to support grazing management by direct field observation

Matteo Barcella*, Federico Filipponi, Silvia Assini

Department of Earth and Environment Sciences, Sec. Landscape Ecology, University of Pavia, Via S. Epifanio, 14, 27100 Pavia, Italy

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ABSTRACT

In the framework of grassland conservation, extensive grazing represents a management tool which is both cheaper than mechanical management and produces a highly diverse landscape mosaic, thus addressing economic and conservation purposes. The understanding of the key ecological processes involved in grazing systems is a basic step towards the sustainable application of such a system. The aims of this study were: (1) assessment of the grazing pressure and the grazing damage in a fenced cattle pasture; (2) identification of the environmental factors driving the grazing pressure; (3) development of a mathematical model (based on multivariate linear regression analysis) explaining the grazing pressure in the area; and (4) modeling of a grazing pattern scenario that would result from manipulation of an environmental variable.

Management facilities were found to be the main factors driving the behavior of grazing cattle and, consequently, the distribution of undergrazed and overgrazed areas, with the highest grazing pressure close to drinking troughs.The search for new foraging areas promotes a better distribution of animals in the pasture as shown by the increase in grazed area frequented by cattle during the season.

Grazing pressure modeling is a potentially effective low cost methodology to support biodiversity preservation and the efficient use of pastures in specific situations, such as habitats listed in Directive 92/43/EEC. It can be extended to studies at a Pan-European scale by using recently developed data sources and instruments. Pasture management based on the application of our model could be used to optimize grazing patterns without costly repositioning of fences.

1. Introduction

Grazing is a key issue for range management as well as for nature conservation (Sternberg et al., 2000; Watkinson and Ormerod, 2001; Ebrahimi et al., 2010). Range managers emphasize the sustainable maximization and profitability of livestock production, while conservationists seek to maintain high biodiversity (Tilman et al., 1996; Noy-Meir, 1998). Both plant and animal biodiversity depend critically upon the level of grazing (Watkinson and Ormerod, 2001). Too much grazing can lead to land degradation and to the loss of biodiversity, while too little grazing can lead to succession from grassland to woodland and the loss of grassland habitat.

Semi-natural dry and mesophilous grasslands are among the most species-rich plant communities in Europe and contain a large number of rare and endangered species. Calcareous grasslands are protected under European Habitat Directive 92/43/EEC (Habitat 6210). These plant communities remain stable only when subject to low intensity or extensive management (grazing or mowing). At the same time, extensive grazing is cheaper than mechanical management and also produces a highly diverse landscape mosaic, answering economic and conservation purposes (Finck et al., 2002). Large-scale pasture landscapes could thus be seen as a suitable strategy to preserve biodiversity under the framework of current agricultural policy and with limited financial resources (Finck et al., 2002). In contrast to traditional forms of agricultural practice, the objective of large-scale pasture landscapes is to combine both economic and ecological requirements (Härdtle et al., 2002).

Conservation of montane grasslands, in particular at high altitude, is only possible by extensive grazing. It generally requires stocking levels that are lower than the carrying capacity of the grasslands in order to ensure that a significant proportion of the annual sward production remains undergrazed (Crofts and Jefferson, 1999). It is essential to take into account several features of the pasture in order to establish a grazing typology suitable for

* Corresponding author.
E-mail address: matteo.barcella@unipv.it (M. Barcella).

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the maintenance of herbaceous communities without turf damage. Not only level of grazing, but also duration and animal species involved are important (Grant et al., 1996; Hulme et al., 1999; Humphrey and Patterson, 2000; Ausden, 2007). Establishing an appropriate grazing regime for biodiversity conservation is based on several parameters, such as stock type, grazing periods, stocking rates, duration of grazing, and grazing system. These parameters often show complex interactions. In particular, it can be quite difficult to define the correct stocking density in order to avoid scrub invasion and overgrazing (Pihl et al., 2001).

Grazing pressure, a measure of the amount of vegetation that a given number of grazing animals is expected to obtain from a grassland area during their grazing time, directly influences vegetation. It is therefore a crucial parameter for controlling the effects and consequences of the stocking rates on sward composition and structure.The standard measure of grazing pressure is the number of livestock unit days/ha per year (Ausden, 2007). This value is calculated on the basis of grazing area, herd size and grazing duration. If grazing pressure exceeds the carrying capacity of the grassland, it will result in a damage to the ecological and productive character of the sward indicating overgrazing (Crofts and Jefferson, 1999). Overgrazing involves excessive nibbling and trampling, causing both soil erosion and variation in species-richness and structural diversity, such as a loss of tall herbs and an increase in invasive thorny species of little appeal to livestock (Calaciura and Spinelli, 2008).

One important determinant of how grazing affects the vegetation is the spatial pattern of pasture use (Weber et al., 1998; Güsewell et al., 2007). Free-ranging cattle tend to graze some parts of the pasture more intensively than others due to variation in the quantity and quality of available herbage (Bokdam and de Vries, 1992; Matejková et al., 2003; Lamoot et al., 2005). The concentration of grazing on nutritious vegetation patches can lead to local overgrazing and to insufficient management in the remaining pasture area (Jewell et al., 2005). Furthermore, if different parts of the pasture are used for grazing and resting, an excessive concentration of nutrients in resting areas may promote nutrient leaching and water pollution (Boddey et al., 2004; McGechan and Topp, 2004). For all these reasons, spatial heterogeneity in pasture use can limit the use of grazing as a tool for conservation management (Middleton and van Diggelen, 2006).

Solid methods for recording, and knowledge of factors influencing the spatial patterns of the stocking rate are thus important and often underestimated parts in research on cultural landscapes, sustainable grazing systems and landscape management. Previous studies on the activity and spatial site-use of grazing animals have mainly focused on economically orientated pasture systems (e.g. Owens et al., 1991; Hart et al., 1993; Dumont et al., 2002).

The principal novelty of the present study is the use of direct field observation to assess grazing pressure and its spatial distribution. Compared to the use of GPS/GIS technologies (such as radio collars), data acquisition in the field allows collection of data from a far greater number of animals, reducing the error that occurs when few GPS collars are used to model animal location (Turner et al., 2000). Many GPS collars should be used to obtain data from many animals with presumably higher costs. Since data from field observations may be less precise than data collected by instruments due to human error and limited observation times, pasture damage and its spatial distribution were also evaluated in relationship to grazing pressure.

The present study aimed at (a) assessing the grazing pressure and the related grazing damage in the studied cattle pasture; (b) identifying the environmental factors driving grazing pressure; (c) developing a mathematical model to describe the grazing pressure in the area; and (d) predicting scenarios based on the position of the management facilities.

We address the following questions: (1) What is the spatial distribution of grazing pressure and grazing damage and are they related in the studied cattle pasture? (2) Which are the main factors driving the spatial pattern of the grazing pressure in the considered pasture? (3) Is it possible to obtain a more sustainable spatial pattern of grazing pressure by changing the position of management facilities of pastures?

2. Materials and methods

2.1. Study area

The study area is located on Mt. Chiappo (1699 m, 44°41′12.15″N, 9°12′05.85″E) in the province of Pavia (Lombardy Region, North Italy). Mt. Chiappo is in the Pavese Apennine, the northern foothills of the Tosco-Emiliano Apennine, an area of about 1100 km^2. The Bioclimatic Map of Europe (Rivas-Martinez, 2004) classifies the study area as Temperate oceanic submediterranean (Toc).

We carried out our study in the pasture located on the southwest side of Mt. Chiappo, which has a surface of 236 ha (Fig. 1). This area is fenced off and grazed by an average of 180 cattle from one herd, all free to roam throughout the area. The cattle are of the “Piemontese” breed and an extensive grazing system is used. Three drinking troughs are present in the lowland portion of the pasture. The stocking rate in the pasture has prevented the further spread of shrub species on the steep slopes, but it has also caused the appearance of bare soil lumps due to trampling in the

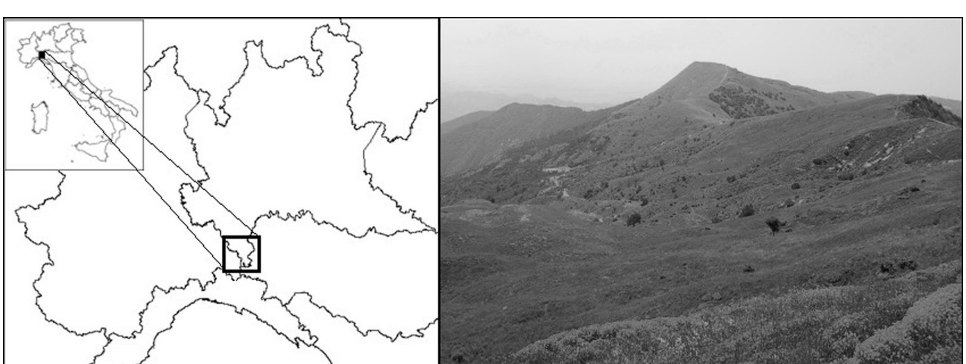

Fig. 1. Study area. Cattle pasture located on the south-western slope of Mt. Chiappo (PV).