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Meadows species composition, biodiversity and forage value in an Alpine district: Relationships with environmental and dairy farm management variables

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ABSTRACT

Alpine meadows have been exposed to relevant management shifts in the last decades, with changes in plant species composition and biodiversity losses often occurring in favor of augmented foraging capabilities, especially in marginal rural contexts. In this study, we analyzed the relationships among the plant species composition, biodiversity and forage value of meadows and two sets of variables, environmental and management ones, in a dairy district of the Central Italian Alps. Results indicate that management variables could only explain limited variability of the meadows under study: for instance, the number of cuts per year is available to justify the plant species composition and biodiversity of such coenoses. Moreover, the environmental variables better described the variability of responses, due to the harsh environmental constraints of the area under examination, located at high altitudes. The shared effects of the two sets explained larger variance than the management set alone, due to the complex relationships of environmental and management factors in the context. The forage value of meadows, an indicator of hay quality, was found negatively associated with the Shannon Index. This behavior highlights a known dilemma which especially refers to high altitude communities as the ones under study, clearly highlighting trade-offs between their production and biodiversity. Some *taxa* as *Anthriscus sylvestris*, *Heracleum sphondylium* and others critically unbalance the species composition of meadows, thus their overall biodiversity, at low altitudes. This finding, explainable by the late first cuttings commonly adopted by all farmers, suggests the eutrophication of coenoses. The management choices inspected did not reflect on the wide variability of meadows, but indeed they made possible to understand how this farming system should be deeply revised, with respect to environmental constraints and meadows' fodder capabilities.

1. Introduction

Meadows and pastures have always been the forage basis for livestock breeding in the Alps and they characterize Alpine landscapes (Ellenberg, 1988; Fava et al., 2010; Monteiro et al., 2013). In general, meadows ensure feed supplies for the critical periods of vegetative rest, whereas pastures support cattle feeding in summer. In the last decades, these two semi-natural agroecosystems have gone through widespread degradation processes, as a result of profound socio-economic shifts (Bätzing, 2003) and of deep changes with respect to farming strategies. In particular, two main kinds of alteration have involved meadows: the land abandonment (Gellrich et al., 2007; Hopkins and Holz, 2006), and the intensification of livestock systems (Andrighetto et al., 1993; Strijker, 2005; Guerci et al., 2014).

Generally, land abandonment issues concern the most marginal parcels, mainly the steeper ones, which are less accessible and more difficult to manage. Often these have been converted to grazing (Rudmann-Maurer et al., 2008) and, in parallel, labor diminished in parcels with lower yields (Tasser and Tappeiner, 2002). In other contexts, such as several arid mountain regions, grasslands have been abandoned due to changes in the irrigation regimes, as modernization and rationalization of agriculture led to the exclusion of these marginal areas with poor accessibility, with the consequence of decreased productivity and land use conversion (Werner, 1995; Riedener et al., 2014). Another general issue, the severe urbanization rates within the Alpine valley floors, due to the conversion of grasslands towards other cropping systems or human settlements beside the total land abandonment, was investigated by Monteiro et al. (2011) among others. These

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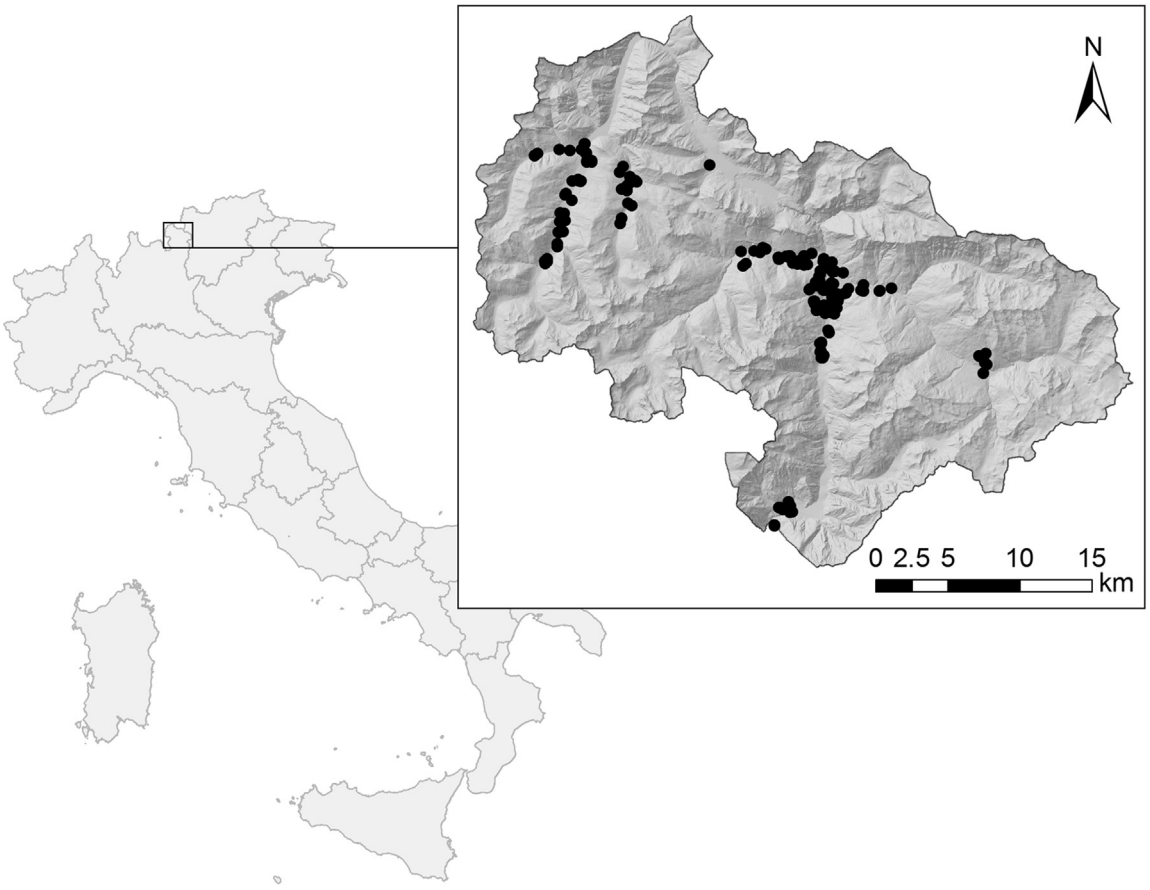

Fig. 1. Overview of the surveyed meadows (dots) within the boundaries of the Alta Valtellina Upland Authority.

trends are recognized as major multidimensional issues; in fact, the loss of grasslands threatens centuries of traditional land use and it impacts their relevant ecological and economical values at the same time (Monteiro et al., 2011; Poschlod and WallisDeVries, 2002), especially regarding the need of food supply (Ceballos et al., 2010), the lack of forage production (Liu et al., 2006) and the loss of intrinsic biodiversity (Niedrist et al., 2009) among other effects. These dynamics have such remarkable impact that Alpine species-rich grasslands have been placed among the most threatened ecosystems in Europe (FAO, 2008; Gusmeroli et al., 2012).

The intensification of livestock systems, instead, had consequences within the most accessible and productive meadows. Alpine farms have become larger and more modern (Streifeneder et al., 2007) and often specialized breeds such as Holstein Friesian and Brown Swiss substituted traditional cattle, the latter more prone to tolerate constrained environments as the Alpine one (Scotton et al., 2014). Cattle have reached high standards of milk production/productivity, while feeding rations earned higher energy and protein contents, often by purchasing concentrates from plain areas (Sturaro et al., 2009), with the drawbacks of opening nutrient cycles (Penati et al., 2011). Increasing stocking rates have characterized most of the enlarging farms, and nitrogen loadings have significantly increased (Gusmeroli et al., 2012; Van der Hoek et al., 2004) as sometimes happened for the number of cuts (Scotton et al., 2014). These factors have provided an undeniable increase in hay biomass yield, although they have exerted strong negative effects on such ecosystems (Plantureux et al., 1987), especially in the case of unbalanced cutting frequencies with respect to fertilizer doses (Dietl and Lehmann, 2004). This has caused the eutrophication of coenoses, the loss of biodiversity and the appearance of nitrophilous species (Marini et al., 2008), mostly penalizing other species linked to traditional management (Prosser, 2001). In the extreme cases, new typologies of meadows have appeared showing untypical plant species composition (Scotton et al., 2014), which seem far from traditional ones that have connoted Alpine landscapes in centuries (Ellenberg, 1988). Besides, landscape-scaled alterations such as the homogenization of landscape matrices and the fragmentation of grasslands occurred (Tscharntke et al., 2005), thus shifting biodiversity patterns and altering management strategies as hay-making processes and livestock grazing practices.

The restoration of such degraded grasslands, together with the preservation of their extension, is the primary condition for the maintenance of viable farming systems in the Alps. This requires accurate knowledge of vegetation and its determinants, which are partly natural (environmental constraints) and partly anthropogenic (management choices and techniques). The knowledge of vegetation and its determinants is also the prerequisite to guide management strategies towards the sustainability of farming processes and to ensure the production of good quality forage.

In this research we evaluated the relative importance of environmental and management factors in the explanation of plant species composition, biodiversity and forage value variability of meadows in a marginal context of the Italian Alps. Until now, few studies have been devoted to this topic, probably due to the difficulties of field investigations and data interpretation. Naturalistic studies have mainly focused on plant species composition and biodiversity of meadows, while agronomic studies have mostly investigated their productivity. In this work, we tried to combine these two approaches, with the aim to respect multi-functionality, which is one of the peculiar characteristics of grasslands.