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# Assessment of management effect on grasslands characteristics in an area of the Apennines (North Italy)

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**Abstract.** In many regions of Europe, semi-natural grasslands not properly utilized face different threats, concerning changes in botanical composition and structural evolution, which can lead to a reduction of the qualitative value of forage biomass or, in the mid-long term, forest recovery. The present paper assesses various semi-natural grasslands within a mountain public property located in Tuscany (North Apennines, Italy) subjected to different types of utilization. Some of them are managed through cattle grazing during summer, whereas some others are only periodically mowed and utilization is performed only by wildlife occurring in the area. The paper analyses the importance of resource management and its impact on botanical composition and on qualitative value of forage production. Data collection of studied areas was conducted by means of vegetation assessment performed with a fast procedure that simplifies the botanical composition sampling. Results show the relevance of some environmental factors on grasslands evolution and on their composition (such as altitude and slope) and the importance of management on grassland quality and on level of shrub encroachment.

**Key words:** botanical composition, grazing, mowing, pastoral value, habitat improvement.

## INTRODUCTION

Grasslands are one of the most widespread land use in the world (Dixon et al., 2014) and in Europe they cover more than 50 million ha (Stypinski, 2011). They provide a great number of ecosystem services that go beyond the mere productive function traditionally acknowledged to these resources (Conant et al., 2017; Targetti et al., 2018). Rational management of grasslands and pastures can, in turn, maintain services related to soil protection, to preservation of landscape and endangered species linked to open spaces, to conservation of areas useful for wildlife, to enhancement of the environment for touristic activity (Hopkins & Holz, 2006; Komac et al., 2014; Primi et al., 2016; Hao et al., 2017; Bengtsson et al., 2019).

Nowadays, in many Italian regions, these resources are threatened by a reduction of utilization or abandonment (Argenti et al., 2011; Probo et al., 2013). This evolution is ongoing since the middle of the last century and it is particularly evident in mountain areas (Faccioni et al., 2019) where depopulation and ageing led to remarkable changes

in the employment of the agricultural territory and the landscape (Giustini et al., 2007; Orlandi et al., 2016). The causes of the abandonment of mountain agricultural and pastoral land are to be found in the socio-economic changes that have taken place in Italy and in many other European countries since the 1950s (Pittarello et al., 2020). In marginal areas, one of the most evident consequences of reduced utilization or land abandonment is the encroachment performed by shrubs and trees (Grau et al., 2019) and, consequently, the contraction of surface occupied by open habitats and grasslands (Urbina et al., 2020). Disappearance of grasslands presents a fundamental environmental significance (Rook & Tallowin, 2003), which is of extremely importance especially in mountain areas (Moudrý et al., 2009), where animal utilization can be represented not only by domestic herbivores, but also by wildlife, with consequent reduction of available forage biomass also for these animals' species (Ponzetta et al., 2010).

Taking into account the above-reported considerations, it is, therefore, necessary to protect the integrity and ecological quality of grasslands, as they are functional elements for maintaining biodiversity, both at local and territorial level (Gusmeroli et al., 2013). Following the progressive reduction of traditional agricultural practices, the landscape is slowly changing with a consequent increase in environmental uniformity (Burrascano et al., 2016) and such loss of heterogeneity can reduce its value as it is perceived by the general public (Lamarque et al., 2011). In this way, rational management performed by mowing or by animal grazing should be accurately carried out in order to optimize and to valorise the utilization of these resources, for forage production and/or for biodiversity conservation (Tälle et al., 2016). According to these issues, maintenance of grasslands is one of the key aims of European Agricultural policy (Viira et al., 2020) and to achieve this objective some mechanical interventions can be performed to maintain and recover grasslands and the ecosystem services they provide and to prevent them from afforestation ((Wahlman & Milberg, 2002), but they are time and money consuming (Cervasio et al., 2016), and, for this reason, the more suitable and sustainable management could be that carried out by direct animal grazing (Papanastasis, 2009). Thus, management and conservation of grasslands are really difficult to perform in mountain or marginal areas for technical and physical constraints present in these territories (Porqueddu et al., 2017).

As stated before, the possible manners to manage and maintain these resources are represented by mowing or grazing, and these two kinds of utilization can affect grassland traits in a very different way. Both of them can influence botanical composition (Tälle et al., 2016), by homogeneous herbage removal performed with cutting (Čop & Eler, 2019), or by higher animal intake on the most palatable species, which may decrease depending on management techniques and stocking rate (Mc Donald et al., 2020). Grazing effects on vegetation are also affected by species of animal grazing, as they are characterized by different impact on the herbaceous canopy in terms of selectivity and intensity (Osoro et al., 2017). Many studies were carried out to compare the two methods of grasslands utilization but conclusions on which is the best management choice were sometimes contradictory and site-specific (Tälle et al., 2016).

Following the previously reported issues, the main aim of the present paper is to compare, in an Apennine territory, some grasslands paddocks grazed by cattle with others subjected to periodical mowing, trying to understand the relationships between botanical composition or quality of pastures and type of management, and how some physical factors can affect botanical characteristics of areas under investigation.

## MATERIALS AND METHODS

Assessment of grasslands was carried out inside the regional forest of Rincine, a public property located in the province of Florence (Tuscany, North Apennines, Italy) with a total extension of approximately 1,448 ha. Grasslands occur on poor and shallow soils, mainly developed on sandstone, with reaction from neutral to acid. Climate is characterized by a mean annual temperature of 8.4 and by an average precipitation of about 1700 mm, with a remarkable amount of rain during summer (Viciani et al., 2010).

Grasslands survey was performed on 9 different areas, 3 of them were managed through Limousine cattle grazing during summer, whereas the lasting 6 were only periodically mowed, and eventually utilized only by wildlife and not by domestic livestock. The studied areas are located between 800 and 1,300 m asl, with a different surface (between 0.25 and 1.80 ha), with a general southern aspect and a slope ranging from mainly flat to about 35%. Sampled grasslands were inside a rectangular area delimited by vertices characterized by the following coordinates (decimal degrees): 43,869492 N/11,630492E and 43,878030N/11,650362E.

Data collection of botanical composition was carried out according to the simplified method proposed in pasture vegetation assessment for forest planning (Argenti et al., 2006). This procedure provides the composition of an herbaceous community by means of visual estimation of ground cover of six different botanical categories instead of detecting all the species through a complete vegetation analysis (Table 1). Categories chosen for botanical surveys according to this approach are the following:

**Table 1.** Botanical categories used for assessing grasslands, acronym and Specific Index of each category (SIc) according to Argenti et al. (2006)

| Botanical category | Acronym | SIc |
|---|---|---|
| Palatable grasses | PG | 1.95 |
| Not palatable grasses | NG | 0 |
| Legumes | LE | 2.99 |
| Species belonging to other botanical families | OT | 0.29 |
| Spiny or poisonous species | SP | 0 |
| Trees and shrubs | TS | 0.03 |

– palatable grasses
– not palatable grasses
– legumes
– species belonging to other botanical families
– spiny or poisonous species
– trees and shrubs.

The six categories were proposed in order to take into account their relevance to affect qualitative forage potentiality of a pasture and, in turn, to potential stocking rate of a pastoral area (Argenti et al., 2006). In fact, some of them are deeply correlated to a high quality of pasture, such as palatable grasses or legumes, while others can outline reduction of forage value (not palatable grasses) or irrational management related to underutilization (such as the presence of shrubs). According to these considerations, this simplified approach is useful not only to describe the actual state of the analysed pasture but also to identify possible ongoing evolution (Argenti et al., 2017).

Moreover, the proposed method permits the calculation, in a synthetic way, of the pastoral value (Daget & Poissonet, 1972), a parameter derived from the percentage presence of each species occurring in the canopy and which is directly related to carrying

capacity (Cavallero et al., 2007). According to the simplified approach utilized in this research, the pastoral value is calculated with the following formula:

$$PV = \frac{\sum SC_c \times SI_c}{5} \quad (1)$$

where $SC_c$ is the percentage occurence in the sward of each botanical categories previously defined, and $SI_c$ is a synthetic index that describes, for each category, its forage value (Bagella et al., 2013). Indices range between 0 (no forage interest) and 5 (excellent forage interest) and, following this method, the PV values range between 0 and 100 (Cavallero et al., 2002). SI for each of the six categories used to estimate pastoral value is reported in Table 1 according to values proposed originally by Argenti et al. (2006) and derived from about 1,000 botanical samples scattered in different mountain areas of Italy.

Results of survey were utilized to compare areas subjected to different management by means of ANOVA. Moreover, they were used to find out possible relationships among investigated variables and topographical features. All analyses were performed using statistical software SPSS (release 26, IBM, 2019).

## RESULTS AND DISCUSSION

Results of botanical assessment, according to different botanical categories, are reported for both grazed and mowed areas in Fig. 1.

In grazed areas, palatable grasses (PG) represent the most occurring category, with a cover of more than 50%, significantly higher than what detected in mowed areas. The same trend is observed for legumes, with higher value in areas utilized by animals which is more than three times with regard to what occurred in mowed sectors. Not palatable grasses (NG) are more frequent in grazed areas as well but difference in ground cover is less evident than what observed for palatable ones. On the contrary, occurrence of species belonging to other botanical families (OT) is significantly higher in mowed grasslands compared to those grazed, and the same is for shrubs and woody species (TS), with a percentage presence in mowed areas (roughly 13%) significantly higher than grazed ones (about 3%). Among observed categories, only presence of thorny or poisonous species (SP) is not significantly different among treatments.

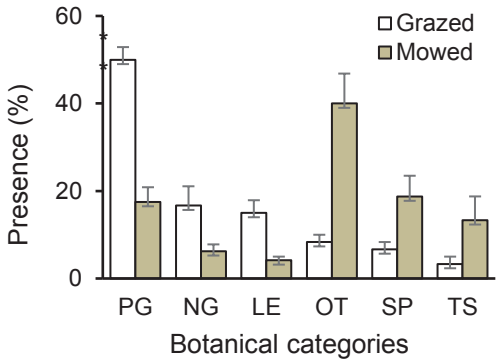


**Figure 1.** Botanical composition of assessed categories for grazed and mowed areas.
Significance: **: $P < 0.01$; *: $P < 0.05$; ns: not significant. Bars represent standard errors. PG: palatable grasses; NG: not palatable grasses; LE: legumes; OT: other botanical families; SP: Spiny or poisonous species; TS: trees and shrubs.

Grazing and mowing are the two considered an appropriate technique to recovery pasture after a long period of abandonment and it is often able to maintain also the botanical value of a grassland way

to utilize grasslands. Grazing is (Perotti et al., 2018), even if a previous mowing action is necessary before restoring direct animal utilization (Tardella et al., 2020). Management practices can affect vegetation, functional traits and related ecosystem services that are linked to grasslands (Targetti et al., 2013; Silva et al., 2019), even if the effects on botanical composition are not always stable (Sullivan et al., 2017) and depend on specific ecological features (Stammel et al., 2003). Mowing generally can produce a higher cover of forbs and our findings are consistent with previous researches (Valkó et al., 2012), even if very important characteristics of mowing that can affect botanical composition are frequency and period of cutting (Cervasio et al., 2016; Tälle et al., 2018). Our results highlighted higher presence of legumes in grazed areas compared to mowing, as grazing can favour species with a reduced height and characterized by a creeping growth, such as *Trifolium repens* (Cavallero et al., 2002). Ganjurjav et al. (2019) also highlighted a higher resilience of legumes to heavy grazing with respect to no utilization. On the other hand, in our situation, grasses (palatable or not) were favoured also by grazing as mowing was performed not every year, thus confirming what found by Catorci et al. (2011) in a similar Apennine environment, whereas other researches highlighted the importance of a continuous and regular cutting regime to efficiently affect botanical composition of grasslands (Socher et al., 2013). Pierik et al. (2017) highlighted also the importance of number of cuts on botanical composition and biodiversity, even if this issue is deeply correlated also to climatic conditions. The irregular management on mowed areas can explain the higher presence of shrubs and trees as well, as it is clearly documented the narrow relationship among reduced level of utilization and woody species development on grasslands and pastures (Urbina et al., 2020). According to these issues, assessment of vegetation inside a grassland is of extremely importance to identify how grazing or mowing can affect not only botanical composition but also ecosystem services they provide, which are remarkably affected by management (Johansen et al., 2019).

The pastoral value for different managements is reported in Fig. 2. Grazed areas presented an average value significantly higher than mowed ones (28.9 *vs*. 11.7 respectively) and this result is a direct outcome of previously analysed botanical composition, as grazed areas were dominated by the most relevant species from a qualitative point of view (palatable grasses and legumes). Pastoral value is usually calculated in order to obtain carrying capacity for a pasture (Argenti et al., 2017) but it can be also considered an index that represents the overall forage potentiality of a grassland (Pittarello et al., 2020) and in this way we used it to compare grazed areas to mowed ones that are not subjected to animal utilization. Grazing is acknowledged to maintain microenvironments of grasslands due to its patchy utilization (Funk et al., 2018) and to permit a proper plants turnover (Niu et al., 2016) and thus it can be considered a way to enhance conservation

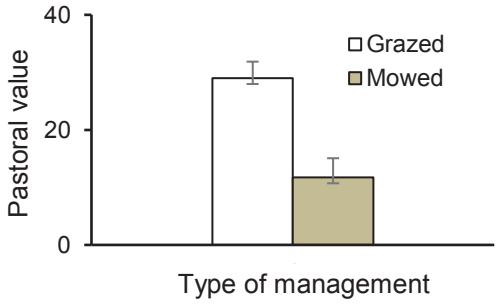


**Figure 2.** Pastoral value for grazed and mowed areas.

Significance: ** : $P < 0.01$; * : $P < 0.05$; ns: not significant. Bars represent standard errors.

of grasslands (Tälle et al., 2016). Adoption of specific management techniques is important also to improve the ecological status of a grassland: Perotti et al. (2018) reported a significant increase in floristic richness and diversity index after implementation for five years of rotational grazing.

Grazing was recognized also to favour some species belonging to grasses (Sebastià et al., 2008) and able, consequently, to improve directly grassland quality as reported by Hao & He (2019). Moreover, grazing can enhance the presence of specific clonal species with a reduced height and a prostrate growing structure, such as white clover, and this can contribute to improve forage value of the sward (Enriquez-Hidalgo et al., 2016). Results shown in the present work are also in line with the findings of Yoshihara et al. (2016) that highlighted the importance of grazing, when balanced in terms of stocking rate and animal pressure, to maintain a high level of forage quality in the long term. Other researches in the Apennines reported an improvement of pastoral value under grazing compared to mowing. Catorci et al. (2011) recorded an improvement of this parameter from 18 (in mowed areas) to 23 (in grazed areas). The different extent concerning our results can be reasonably attributed to the simplified way of calculation of pastoral value with respect to the original method, even if this approach was successfully adopted in other assessments on grasslands (Bolzan, 2009; Argenti et al., 2017).

The presence of different botanical categories was grouped in relation to different altitudinal classes in order to identify an eventual relationship with elevation (Fig. 3). Altitudinal classes were identified as follows: i) less than 1,000 m asl (Lower areas); ii) between 1,000 and 1,200 asl (Medium areas); iii) more than 1,200 m asl (Higher areas). It is evident the effect of elevation on different botanical categories: grasses presented a decreasing trend, more evident for palatable ones (PG) than for not palatable (NG). At the same time, legumes were extremely more frequent in lower areas with respect to those located at medium or higher elevations. In these areas, botanical classes with a greater occurrence were species belonging to other families (OT, remarkably reduced in lower areas), poison and spiny species (PS), and woody plants (TS).

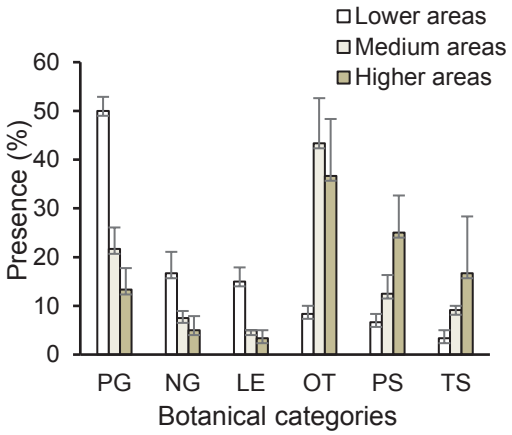


**Figure 3.** Botanical composition of assessed categories in relation to different altitudes. Bars represent standard errors. PG: palatable grasses; NG: not palatable grasses; LE: legumes; OT: other botanical families; SP: Spiny or poisonous species; TS: trees and shrubs.

Effects of some topographical features can be remarkably correlated to botanical composition or overall quality of the grasslands under investigation The most relevant regressions were those reflecting the effect of altitude on pastoral value, which is inversely correlated to elevation (Fig. 4), and the trend of percentage of woody species spread on grassland (trees and shrubs, TS) directly related to values of slope (Fig. 5).

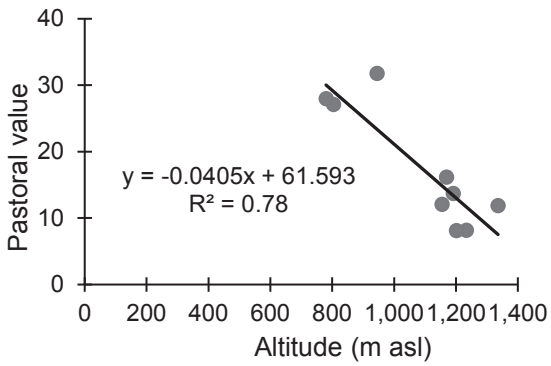


**Figure 4.** Regression between altitude and pastoral value.

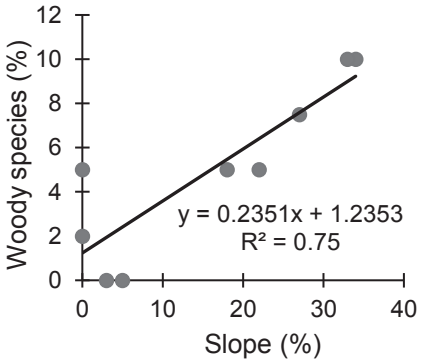


**Figure 5.** Regression between slope and presence of woody species.

Effects of different environmental factors on botanical composition and forage characteristics of grasslands are well documented in mountain areas (Gusmeroli et al., 2013) and in many cases, coupled with climatic features, topography and soil conditions, they are among the main key drivers able to describe distribution of grassland types on a wide territory (Dibari et al., 2016). Our data are consistent with previous researches. Argenti et al. (2020) reported the reduction of pastoral value, as a consequence of remarkable changes in vegetation composition, at increasing elevation in a rangeland mountain area. This can, in turn, affect the forage quality of herbaceous biomass that is highly related to botanical composition as affected by altitudinal location of pastures (Leiber et al., 2006). Moreover, Pornaro et al. (2019) recognized in alpine pastures a direct and significant correlation between pastoral value and crude protein content. Topographical characteristics can affect remarkably structural characteristics of grasslands, and, coupled with land utilization, can influence presence of woody species, and this is especially true for slope according to Tasser et al. (2007). On the contrary, elevation not always was considered significant in determining woody species cover, as reported by Parolo et al. (2011). Slope is thus considered one of the main drivers of accessibility of a grassland and it can influence type and frequency of management, both for grazing and mowing (Orlandi et al., 2016). Effect of slope is particularly evident in mountain and marginal regions, especially if characterized by reduced number of grazing animals. In this condition, steep slopes are the first areas to face a limited animal presence and to experience a relevant density of encroaching shrubs as a result of decreased animal pressure (Argenti et al., 2020). Also in our case the most significant effect induced by slope was the higher presence of shrubs and trees on steeper areas, confirming the findings of other researches (Homburger et al., 2015). Moreover, slope can influence soil characteristics and nutrient content and, consequently, it can induce changes in vegetation (Bennie et al., 2006).

Finally, the two most important botanical categories (PG and LE) were used as predictors to estimate PV, in single and multiple regressions (Table 2). Palatable grasses resulted more suitable than legumes to predict the pastoral value in single regression, both of them with highly significant determination coefficients ($R^2$). A combination of both predictors in a multiple regression was rather completely able to predict the total amount

Influence of these two main botanical categories on pastoral value is due to their high specific index, whereas other categories are not so relevant according to the reduced or null specific index that is not able to produce PV increasing (Pittarello et al., 2020). This could permit to further simplify data collection if the aim is just pastoral value evaluation, such as analysis performed in territorial planning with not specific pastoral assessment purposes (Paletto et al., 2012). Anyway, the extreme simplification in vegetation analysis can produce loosing of information and of thematic features of grasslands, such as grassland vegetation types, which are relevant for their characterization and accurate management and planning (Cavallero et al., 2007). The use of a simplified method should not be considered an alternative to the ordinary pasture assessment as already pointed out previously (Argenti et al., 2017) but it can represent a good agreement between opposite needs, *i.e.* simplification of the botanical survey and obtainable information that is acceptably accurate.

**Table 2.** Single and multiple regressions between PG and/or LE and PV. All determinant coefficients are significant with $P < 0.0001$

| Predictors | Equation | $R^2$ |
|---|---|---|
| PG | PV = 3.42 + 0.49 PG | 0.92*** |
| LE | PV = 7.02 + 1.34 LE | 0.82*** |
| PG and LE | PV = 3.43 + 0.33 PG + 0.59 LE | 0.99*** |

## CONCLUSIONS

Results of the study highlighted how mowing and grazing affected some features of grasslands, such as botanical composition and quality, in the case study. Grazing was superior in terms of occurrence of the most important forage categories, namely palatable grasses and legumes, and, in turn, of overall quality of herbaceous resources recorded by means of pastoral value. Mowing was recognized to be less useful to conserve a productive and efficient ground cover in grassland areas, but this was due to its occasional occurrence and to its irregular frequency, as in other conditions benefits of cutting were different than those observed in our survey.

The main constraints of mowing in our situation are due to the extremely marginal location of the areas, far from roads and rather problematic with regard to their accessibility. For these reasons, cutting or shrubs clearing are always difficult to perform and money consuming, and costs are often improved by the reduced surface of each open area.

Thus, especially in these conditions, grazing can represent the most efficient and economical way of utilization of grasslands, and availability of simplified methods to assess pastoral resources, such as that involved in this research, can help to provide information for different aims. In fact, one of the major findings of the research was the positive assessment of the fast procedure for vegetation sampling. This approach could be valuable in similar contexts, to attain data for pasture planning and management issues, such as for carrying capacity calculation, but also to evaluate the role of grasslands also under an ecological point of view, in order to obtain useful information for conservation purposes, such as those related to ecosystem services grasslands provide.

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