Grazing Management Plans improve pasture selection by cattle and forage quality in sub-alpine and alpine grasslands

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Grazing Management Plans improve pasture selection by cattle and forage quality in sub-alpine and alpine grasslands

Marco Pittarello[1], Massimiliano Probo[2], Elisa Perotti[2*], Michele Lonati[1], Giampiero Lombardi[1], Simone Ravetto Enri[1]

[1] Department of Agricultural, Forest, and Food Sciences, University of Torino, Grugliasco, Italy
[2] Agroscope, Grazing Systems, Nyon, Switzerland

*corresponding author: Elisa Perotti
e-mail: elisa.perotti@agroscope.admin.ch
Agroscope, Grazing Systems, Nyon, Switzerland
Route de Duillier 50, CP 1012, 1260 Nyon 1, Switzerland

Abstract

Over the last decades, the reduction of manpower for herd management has led to an increase of continuous grazing systems (CGS) in the Italian Alps, which allow cattle to roam freely. Under CGS, due to high selectivity, livestock exploit grasslands unevenly, over- and under-using specific areas at the same time with negative effects on their conservation. To counteract these effects, a specific policy and management tool (i.e. Grazing Management Plan) has been implemented by Piedmont Region since 2010. The Grazing Management Plans are based on the implementation of rotational grazing systems (RGS), with animal stocking rate adjusted to balance it with grassland carrying capacity. A case study was conducted on alpine summer pastures to test the 5-year effects produced by the implementation of a Grazing Management Plan in grasslands formerly managed under several years of CGS on 1) the selection for different vegetation communities by cattle, 2) the abundance of oligo-, meso-, and eutrophic plant species (defined according to Landolt N indicator value), and 3) forage yield, quality, and palatability. A total of 193 vegetation surveys were carried out in 2011 and repeated in 2016. Cows were tracked yearly with Global Positioning System collars to assess their grazing selectivity, and forage Pastoral Value (PV) was computed to evaluate forage yield, quality, and palatability. Five years after RGS implementation, cow selectivity significantly decreased and the preference for the different vegetation communities was more balanced than under CGS. The abundance of meso- and eutrophic species increased, whereas oligotrophic ones decreased. Moreover, the abundance of moderately to highly palatable plant species increased, whereas non-palatable plant species decreased, with a consequent significant enhancement of the PV. Our findings indicate that the implementation of Grazing Management Plans can be considered a sustainable and effective management tool for improving pasture selection by cattle and forage quality in mountain pastures.

Keywords: mountain, GPS tracking, agricultural policies, livestock, Pastoral Value, vegetation community

Introduction

Mountain pastures provide a wide range of ecosystem functions and services for the society. For instance, Alpine pastures support food production, plant and animal diversity, carbon storage, nutrient cycling, regulation of climate and water quality, pollination, as well as aesthetic and recreational values (Harrison et al 2010, Silva et al 2010; Lonati et al 2015). However, a dramatic change in land-use and cover in the European Alps occurred in the last century due to deep socio-economic changes, resulting in a reduction of the area covered by sub-alpine and alpine pastures, which are nowadays among the main threatened ecosystems (Rutherford et al 2008; Orlandi et al 2016). The number of family farms, relying on herding to manage small herds and flocks, decreased and nowadays a smaller number of farms rear larger herds and flocks compared to the past (Probo et al 2013). Moreover, continuous grazing systems (CGS) spread and often replaced herding-based grazing management to reduce labour and capital inputs. Under CGS cows are allowed to roam freely, which results in an uneven spatial distribution of the grazing animals within pastures, i.e. widespread underuse of the steepest and most marginal areas and overuse of the flattest and most accessible ones (Probo et al 2014). As a consequence, grasslands are reducing their extension, as well as their herbage mass and nutritive value (Pittarello et al 2018), often evolving towards shrub and tree encroached communities, with negative effects on the provision of the abovementioned ecosystem services (Prévosto et al 2011).

To preserve pastoral environments, also by contrasting the negative impact of uneven grazing distribution, specific policies were adopted by the European Union, among which the Rural Development Program (RDP) 2007-2013. During the period of the program, EU supported the implementation of RDP agri-environmental measures in 1,5 Mio farms managing an area of over 63 Mio ha, with a total expenditure of about 37,000 Mln€ (ENRD 2019). Italy spent about 3,600 Mln€ to subsidize agri-environmental measures (ENRD 2019), which were implemented in different ways by regional administrations. In Piedmont Region (north-western Italy), regional government allocated 14.7 Mln€ to support grazing systems' extensification (Sistema Piemonte 2019). Among the good agricultural practices to improve the sustainability of extensive grazing system management, the implementation of Grazing Management Plans (GMP) was promoted, which enhances farm productivity while preserving biodiversity, soil, and landscape. GMP define a set of farm-specific and sustainable grazing management actions based on the concept that animal stocking rate has to balance the grassland carrying capacity (Argenti and Lombardi 2012). The carrying capacity of grasslands has been defined by Allen et al (2011) as the maximum stocking rate achieving a target level of animal performance, which can be applied over a defined period without grazing land deterioration. The implementation of rotational grazing systems (RGS) is the best and easiest way to achieve the abovementioned balance. Under RGS, pastures are subdivided in paddocks, which are grazed in rotation (Cavallero et al 2007; Lombardi et al 2011). The use of paddocks increases stocking density and grazing intensity, and changes livestock spatial distribution compared to CGS (Probo et al 2014). Indeed, in their research, Probo et al (2014) found a more homogeneous selection for different vegetation communities by beef cattle under RGS with respect to CGS. The RGS can also positively promote seed transportation and increase connectivity amongst different vegetation communities through a more homogeneous selection for different areas within each paddock, even the most inaccessible, steep, and at higher elevation (Bailey and Sims 1998). In another recent research, Perotti et al (2018) found that the 5-year implementation of a Grazing Management Plan had positive effects on plant diversity conservation leading to an increase in both species richness and Shannon diversity index.

However, to the best of our knowledge no research has focused on forage yield, quality, and palatability changes produced by the medium-term implementation of RGS in alpine pastures. Forage features of each single plant species for livestock can be expressed and synthetized by the Index of Specific Quality (ISQ), which summarizes the preference, morphology, structure, and productivity of different plant species (Daget and Poissonet 1971; Cavallero et al 2007). Considering both the abundance and the ISQ of each single plant species found within a vegetation community, the forage Pastoral Value (PV) can be computed to evaluate the overall forage yield, quality, and palatability of that vegetation community (Daget and Poissonet 1971). The PV is also related to nutrients, mainly nitrogen and phosphorous, available in the soil (Güsewell et al 2012; Gardarin et al 2014). Nutrient-poor grasslands have generally low PV and host mainly oligotrophic plant species, whereas nutrient-rich grasslands have higher PV and a dominance of meso-eutrophic plant species (Ravetto Enri et al 2017), if nutrient level is restricted under certain critical thresholds (Pittarello et al 2018).

Probo et al (2014) highlighted the beneficial effects produced by a 2-year RGS implementation on the selection for vegetation communities by cattle on sub-alpine and alpine pastures formerly managed under CGS. However, since cows have an accurate spatial memory (Bailey and Sims 1998), their short-term selection could have been influenced by historical resource selection strategies experienced under several years of CGS. Hence, the present study was carried out to compare on the medium term the selection for different vegetation communities by beef cattle under the two grazing systems and to evaluate the changes produced on grassland PV five years after the implementation of RGS. The specific objectives were: (1) to assess the selection for different vegetation communities by cattle under CGS and during 5-year RGS implementation, (2) to assess the changes in the abundance of different functional groups of plant species (i.e. oligo-, meso-, and eutrophic species and species characterized by different IQS), and (3) to measure forage PV changes along the 5-year timespan.

Material and Methods

Study area and grazing systems

The research was carried out in Val Troncea Natural Park, south-western Italian Alps (44°57′ N, 6°57′ E). Average annual temperature was approximately 4°C (Feb: −3.8°C; Jul: 12.6°C) and annual average precipitation was 703 mm (mean 2003–2015; data gathered from the meteorological station located at 2150 m a.s.l. - 44°98′N, 6°94′E). Dominant soils were gravelly and nutrient-poor over calcareous parent rock. The study area was 448 ha wide, ranging from 1900 to 2820 m a.s.l.

Vegetation was characterized by sub-alpine and alpine (*sensu* Ozenda 1985) grasslands, subjected to shrub-encroachment due to a decrease of grazing exploitation (Probo et al 2013). Dominant grassland species were *Festuca curvula* Gaudin, *Carex sempervirens* Vill., *Festuca nigrescens* Lam. non Gaudin, *Agrostis tenuis* Sibth., and *Poa alpina* L.. Shrublands were predominantly composed by *Rhododendron ferrugineum* L., *Juniperus nana* Willd., *Vaccinium myrtillus* L., and *Vaccinium gaultherioides* Bigelow.

One cattle herd of 80 AU (AU, Animal Units; Allen et al 2011) exploited the study area for several years from early June to late September under CGS, until 2010. From 2011 to 2015, following the directions of a specific Grazing Management Plan, the farmer implemented a RGS over the area, with four paddocks grazed in rotation by 105 AU from early June to late September (starting in paddock 1 and ending in paddock 4; Fig. 1). Grazing Management Plan prescriptions for the subdivision of the whole grazing area into four paddocks grazed in sequence took into account several features, such as vegetation cover, botanical composition, forage Pastoral Value, average phenological development of grassland communities, altitude, aspect, natural borders, water availability, and management facilities (Table 1). The number of animal units was increased according to vegetation carrying capacity, which was computed using Daget and Poissonet (1971) methodology, i.e. by multiplying forage PV with altitudinal and slope conversion coefficients and the grazable area.

Vegetation surveys and cattle tracking

To assess vegetation changes after 5 years of RGS, the grazable surface of the study area was subdivided into 150 X 150-m grid cells, for a total of 193 cells. At the centroid of each grid cell, a vegetation survey was carried out during summer 2011 (before the beginning of grazing, at the flowering stage of dominant graminoids) and it was repeated in 2016. Vegetation surveys were carried out with vertical point-quadrat method (Daget and Poissonet 1971), along a 10-m linear transect in which every plant species touching a steel needle was identified and recorded at every 50-cm interval. To account for occasional species, likely missing with the point-quadrat method, a complete list of all other species included within a 1-m buffer area surrounding the transect was also recorded (Iussig et al 2015). Species nomenclature followed Pignatti (1982).

Seven to thirteen randomly-selected cows were equipped with Global Positioning System (GPS) collars with an average accuracy of 5 m (Model Corzo Collars, Microsensory SLL, Fernàn Nunèz, Andalusia, Spain). Positions were recorded all along the grazing season at 15 min interval, to ensure sufficient battery life for the monitoring period. Animals were tracked during period 2010-2015, each year but during summer 2011, due to technical device failure.

Data analyses

The frequency of occurrence of each plant species recorded was calculated for each transect by dividing the number of occurrences by 20 points of vegetation measurements. Species Relative Abundance (SRA) of each plant species was computed by dividing its frequency of occurrence by the sum of frequency of occurrences values for all species in the transect and multiplying it by 100 (Pittarello et al 2017). The SRA can be used to detect the proportion of different species expressed in percentage. To all occasional plant species found within vegetation plots but not along the linear transects a SRA value = 0.3% was attributed (Tasser and Tappeiner 2005; Vacchiano et al 2016).

Landolt indicator value for soil nutrient content (hereafter N Landolt; Landolt et al 2010) was attributed to each plant species to assess the demand for nutrients. Plant species were pooled into three functional groups, i.e. oligotrophic species (i.e. plant species growing in nutrient-poor conditions; N Landolt = 1 and 2), mesotrophic species (i.e. plant species growing in moderate nutrient conditions; N Landolt = 3), and eutrophic species (i.e. plant species growing in fertile conditions; N Landolt = 4 and 5) (Nervo et al 2017).

To each plant species was also attributed the Index of Specific Quality (ISQ; Daget and Poissonet 1971), which ranges from 0 (low) to 5 (high). Plant species were pooled into three palatability groups according their ISQ: non-palatable (i.e. plant species with ISQ = 0 and 1), moderately palatable (i.e. plant species with ISQ = 2 and 3), and highly palatable (i.e. plant species with ISQ = 4 and 5).

Forage PV, which ranges from 0 to 100, was calculated for each transect of 2011 and 2016 on the basis of the SRA and ISQ according to the following equation (Daget and Poissonet 1971):

$$PV = \sum_{i=1}^{n} (SRA_i \cdot ISQ_i) \cdot 0.2$$

where ISQ_i is the ISQ value for the species *i* (Cavallero et al 2007).

Statistical analyses

A cluster analysis was performed using the SRA of each plant species to classify vegetation transects into vegetation types and vegetation ecological groups according to Cavallero et al (2007). Pasture types can be defined as herbaceous or mixed tree-shrub herbaceous communities characterized by the dominance of 1-2 (3) species and the constant presence of a variable number of common species having similar ecologically needs (Cavallero et al 2007). Pearson correlation was used to compute the similarity matrix and UPGMA (Unweighted Pair Group Method using Arithmetic Averages) as grouping method.

For each vegetation ecological group, preference and standardized indexes were calculated to evaluate cattle selection (Hobbs and Bowden 1982). Preference indexes were computed as the proportion of GPS fixes within a vegetation ecological group divided by the proportional area covered by that vegetation ecological group within the study area. A 95 % confidence interval with a Bonferroni adjustment (Manly et al 2002) was calculated for each preference index to determine if individual ecological groups were avoided, used indifferently, or preferred by cows. Values >1 for the lower confidence limit indicated preferential selection for a particular ecological group, while values <1 for the upper confidence limit indicated that cows used that particular ecological group proportionally less than its availability would suggest. If the value of 1 was within the confidence interval, it implied that cows used a particular vegetation ecological group in proportion to its presence. Standardized indexes are an alternative way to present the preference indexes so that they add to 1 (Manly et al 2002). Therefore, standardized indexes express the estimated probability of selection of a particular vegetation ecological group if all vegetation ecological groups were equally frequent.

Paired sample statistical tests were carried out to detect differences between 2011 and 2016 in terms of (1) SRA of oligotrophic, mesotrophic, and eutrophic plant species, (2) SRA of non-palatable, moderately palatable, and highly palatable plant species, and (3) forage PV of the whole pasture. The SRA and forage PV were tested for normality and homogeneity of variance through Shapiro-Wilk and Levene's tests, respectively. When assumptions were not verified, non-parametric Wilcoxon signed rank tests (Sokal and Rohlf 1995) were carried out instead of paired sample parametric *t*-tests.

Cluster analysis was performed using IBM SPSS Statistics 24.0 (IBM SPSS Statistics for Windows, v 24.0; IBM, Armonk, NY, USA) and paired sample statistical tests were carried out with PAST software (PAST 3.16; Hammer, Harper, & Ryan, 2001).

Results

The number of plant species recorded in 2011 and 2016 was 273 and 280, respectively. Vegetation surveys were classified into 17 vegetation types and 6 ecological groups (Table 2 and Fig. 2A).

Under CGS, snow-bed, eutrophic, and mesotrophic ecological groups were the most preferred by cows, whereas oligotrophic, pre-forest and shrub-encroached, and thermic ecological groups were avoided (Table 3). With the implementation of RGS, mesotrophic vegetation group became the most preferred group and it was increasingly selected over time according to both preference and standardized indexes. Snow bed were always amongst the preferred vegetation ecological groups, even though the preference index considerably decreased from CGS to RGS. Eutrophic vegetation group was the second most preferred group under CGS, whereas under RGS it was preferred only in 2012 and then avoided. Pre-forest and shrub-encroached vegetation group was avoided under CGS, whereas it resulted both preferred or indifferently grazed with the implementation of RGS depending on the year. Thermic and oligotrophic vegetation groups were avoided both under CGS and RGS, even if with the implementation of RGS an increasing trend of exploitation was almost always evident.

From 2011 to 2016, the SRA of oligotrophic plant species decreased (-5.5 % on average), whereas the SRA of mesotrophic and eutrophic plant species significantly increased (+2.6 % and +2.8 % on average, respectively) (Fig. 3A). Five years after the implementation of RGS the SRA of non-palatable plant species decreased (-1.8 % on average), moderately palatable species SRA increased (+1.8 % on average), and highly palatable plant species SRA did not change (Fig. 3B).

The forage PV of the whole study area significantly increased from 15.0 ± 0.58 (mean ± standard error) in 2011 to 15.8 ± 0.59 in 2016 ($P < 0.036$) (Fig. 2B).

Discussion

Our results suggest that the five-year implementation of a Grazing Management Plan was an efficient tool to improve pasture use by cattle and enhance forage quality in sub-alpine and alpine pastures.
Indeed, under CGS cows were free to roam over the whole pasture and consequently they highly selected few most-preferred vegetation groups, such as mesotrophic, eutrophic, and snow-bed vegetation communities. These ecological groups were characterized by a medium-high forage yield and quality, and they were typically located at the gentlest and most accessible sites. Meso- and eutrophic vegetation groups were situated at lowest elevations and they could offer a highly palatable vegetative regrowth in the second half of the grazing season (Probo et al 2014). Snow-bed vegetation group, even though placed at highest elevations (i.e. often above 2400 m a.s.l.) and with a low herbage mass due to the short vegetative cycle under harsh climatic conditions (Körner 2003), was the most preferred ecological group as it hosted a highly nutrient-rich forage (Björk and Molau 2007).
With the implementation of RGS, cattle selectivity decreased and the preference for different vegetation communities was more balanced. Indeed, even if the snow-bed vegetation group was always a vegetation group preferred by cattle, its selection markedly decreased over time. Moreover, eutrophic vegetation group shifted from preferred to avoided, likely as a consequence of the changed availability and palatability of different vegetation groups within each paddock. The RGS not only forced cattle to graze within paddocks having different proportions of vegetation groups, but it also imposed predefined grazing periods, thus encouraging animals to exploit vegetation communities having specific phenology and related forage quality and palatability. For this reason, in the rotation imposed by the RGS, the selection for the eutrophic group may have decreased due to an exploitation occurred often later than under the CGS. This later exploitation may have coincided with an advanced phenological stage and less palatable forage, above all for fast-growing eutrophic dominant species such as *Dactylis glomerata* L. For all these reasons, and considering also the increase in the selection for the pre-forest and shrub-encroached group, which was generally highly avoided during CGS, the present results confirmed the hypothesis according which the implementation of a Grazing Management Plan was an effective way to improve cattle distribution over a five-year timespan. Indeed, the implementation of RGS through Grazing Management Plans allows planning and optimizing the relationship between forage supply (yield and quality) and its consumption by grazing animals. The detailed study of forage resources on which Grazing Management Plan are based (i.e. mapping of the grazable area of different plant communities, based on botanical composition and the abundance of the individual plant species) allows to predict the temporal development of forage supply and to balance it with the stocking rate that will use it in a given period. This result can be achieved by optimizing the grazing length that a given number of animals belonging to certain categories (e.g. cattle, goats, sheep, horses of different ages, having different dietary needs and selectivity) will graze on the area of interest. Moreover, Grazing Management Plan can account for the integration of RGS with supplementary pastoral practices (i.e. strategic placement of drinking troughs and mineral mix supplements, arrangement of temporary night camp areas, etc..), which can additionally improve grazing distribution, botanical composition, vegetation structure, and forage quality (Probo et al 2013; Pittarello et al 2016a; Probo et al 2016).
A research conducted in the same study area (Perotti et al 2018) demonstrated that RGS increased the average soil nutrient content of the whole pasture over a five-year span. This result may explain the increase in abundance of medium-high nutrient demanding plant species (i.e. meso- and eutrophic) and the reduction of the abundance of nutrient-poor ones (i.e. oligotrophic). Indeed, nutrient-demanding plant species respond more efficiently to an increase in nutrient availability compared to nitrogen-poor ones (Chapin et al 1986). Moreover, the overall increase of nutrient content over the pasture may also explain the increase in the abundance of moderately to highly palatable plant species and the reduction of non-palatable ones. Indeed, plant species with a moderate and high ISQ are typically associated with moderate to high grazing and fertilization processes (Pittarello et al 2016b). Consequently, the increase in the abundance of these species enhanced the grassland PV. This index can theoretically assume values bounded between 0 and 100, but it actually ranges between 0 and 63 in western Italian Alps, with an average value around 20.7 (Cavallero et al 2007). Therefore, the increase of about 5 % (from 15.0 to 15.8) of PV in the five-year monitoring period was a non-negligible result for high-elevation grasslands, where environmental constraints (e.g. low temperatures and short growing season) slow down the ecological response of plant communities (Körner 2003).

In conclusion, the results extend the existing knowledge on the effects of the implementation of a RGS by assessing the improvement of the yield, quality, and palatability of forage for livestock. Previous research were mainly focused on ecological conservation results, such as plant diversity (i.e. species richness and Shannon diversity index), proportion of different vegetation functional groups' cover and redistribution of nutrients (Jacobo et al 2006; Perotti et al 2018), while agronomic aspects were not considered. Other than the scientific interest in the assessment of the agronomic effects produced on high elevation grassland communities, the importance of the present research relies also in the medium-term monitoring of the effects of EU policy measures aiming to enhance grazing management sustainability. Even though Piedmont region was a test area for GMPs and the regional government allocated for their implementation only 5.4 % out of the total expenditure for RDP agri-environmental measures (Sistema Piemonte 2019), the area potentially improved by large scale implementation of GMP would be much larger: grazing livestock use in the EU about 39,5 Mio ha of permanent grasslands (55 % of UAA), managed by 2,1 Mio livestock farms (Eurostat, 2019). Encouraged by our results, European Union policies should support GMP and promote RGS implementation as multifunctional tool aimed at the conservation, restoration, and improvement of sub-alpine and alpine grasslands.

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Figures

Figure 1 - Location of the four paddocks in Val Troncea, Western Alps, Piedmont, Italy (UTM zone 32 north, WGS84 datum).

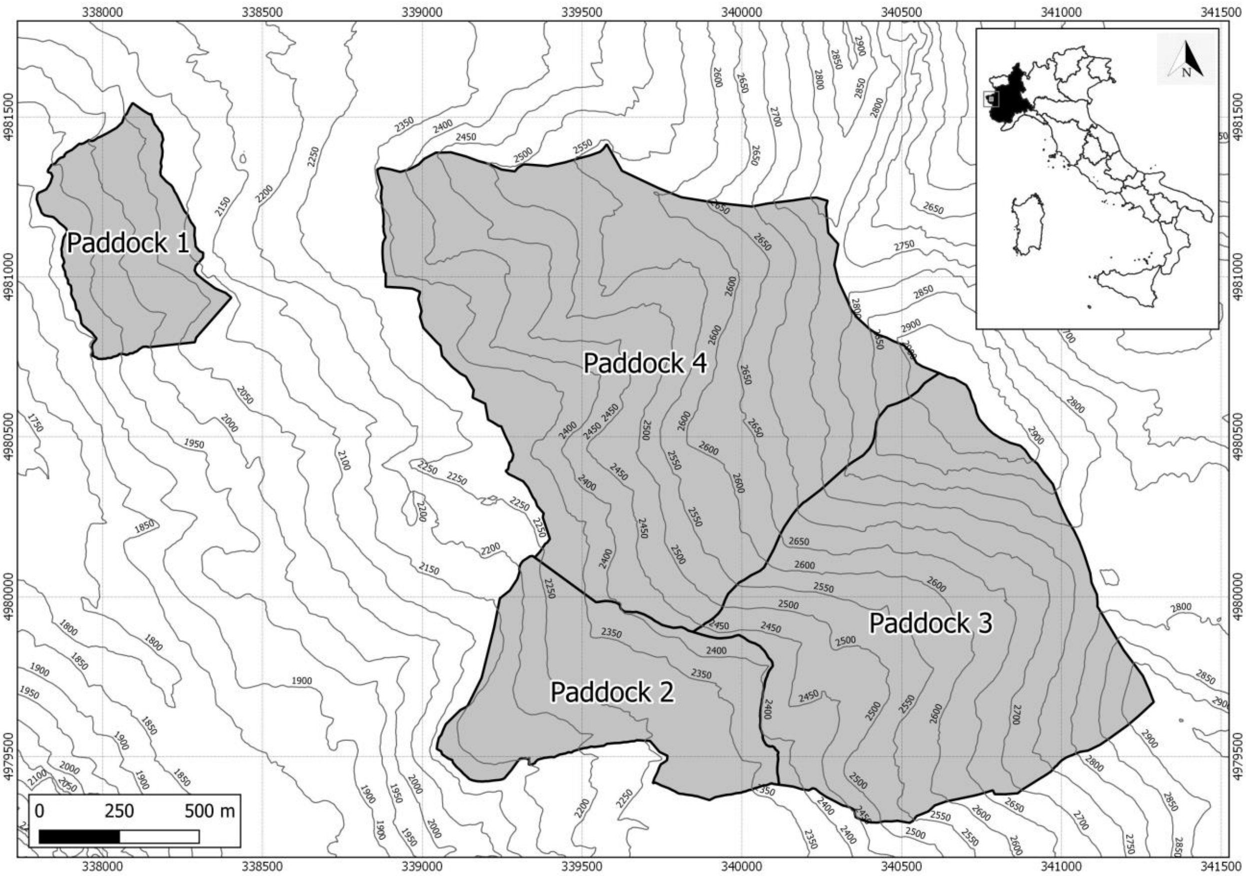


Figure 2 - Location of vegetation ecological groups (A) and forage Pastoral Value pattern in 2016 (B) across the four paddocks grazed under rotational grazing system (RGS) in Val Troncea

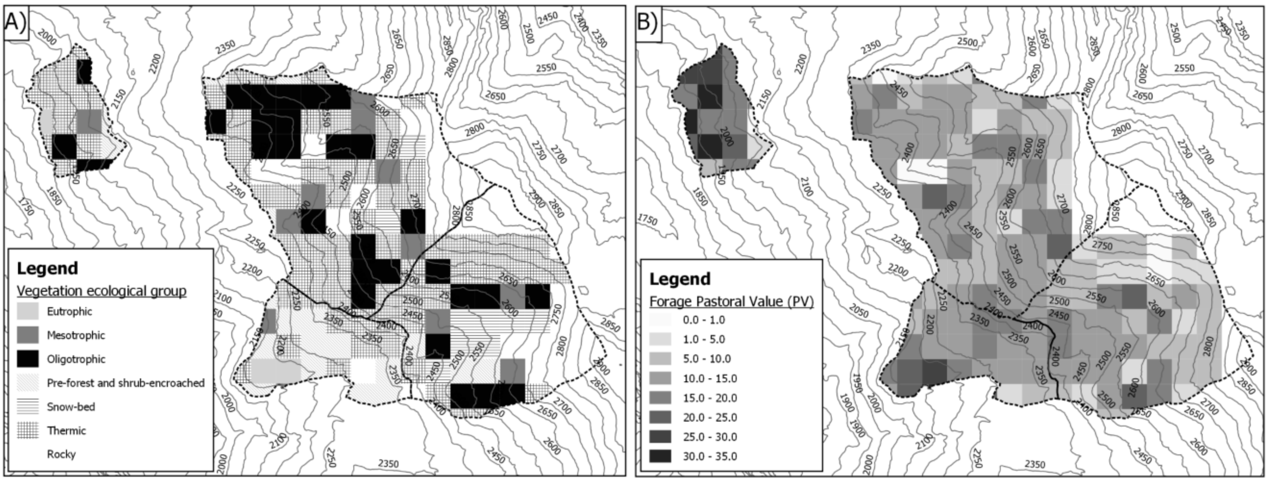
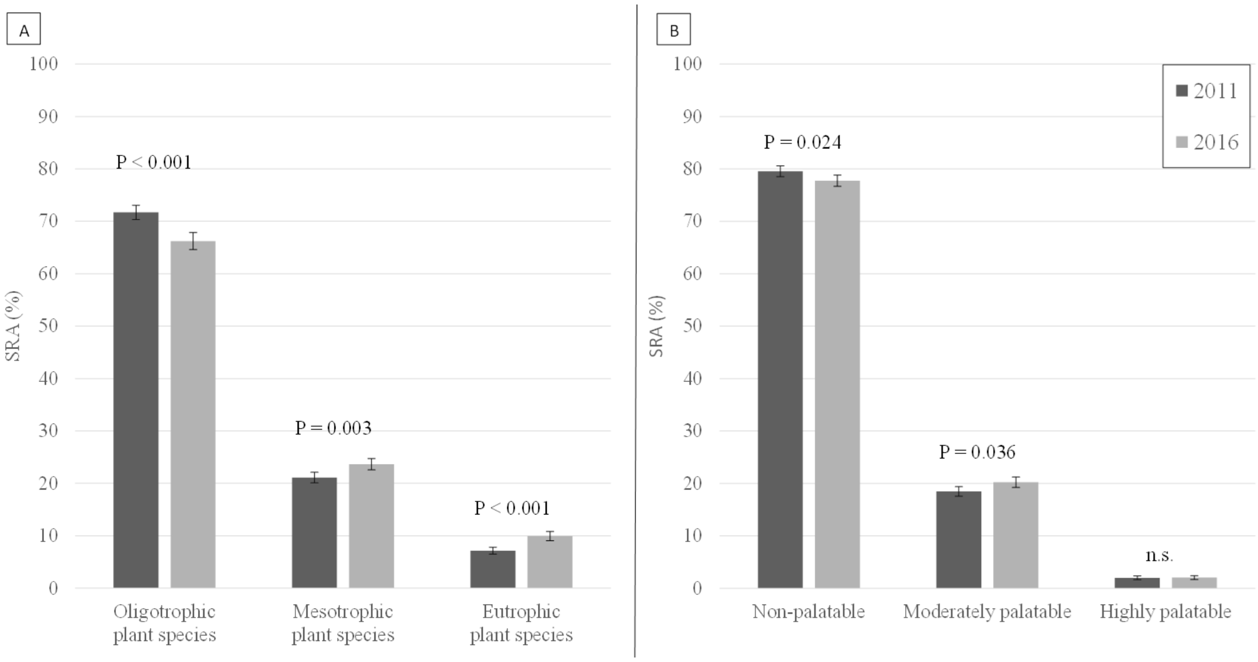


Figure 3 – Effects produced by the five-year implementation of a Rotational grazing system (RGS) on the Species Relative Abundance (SRA) of oligotrophic, mesotrophic, and eutrophic plant species (A) and of non-palatable, moderately palatable, and highly palatable plant species (B).



Tables

Table 1 - Area, topographic characteristics, average pastoral value, and length of the grazing period of the four paddocks grazed under a rotational grazing system by a herd of 105 Animal Units from 2011 to 2015 within the Val Troncea Natural Park

Paddock	Area (ha)	Grassland cover (%)	Shrub cover (%)	Bare ground and rock cover (%)	Average altitude (m)	Average slope (°)	Average Pastoral Value (2011)	Yearly days of grazing (average number from 2011 to 2015)
1	27.2	77.2	9.7	13.0	2020	24.5	19.1	27 ± 5.6
2	46.9	52.9	23.9	23.2	2256	25.6	14.9	24 ± 3.9
3	115.9	41.3	1.9	56.8	2637	27.8	9.4	32 ± 7.4
4	155.4	47.7	6.6	45.7	2489	26.4	11.0	32 ± 6.3

Table 2 - Vegetation ecological groups and vegetation types (labelled according to dominant species names) and area covered by each of them. Average forage Pastoral Value (PV) is also specified for each vegetation ecological group in 2011 and in 2016. Vegetation ecological groups and vegetation types follow Cavallero et al (2007) and species nomenclature follows Pignatti (1982).

Vegetation ecological groups	Vegetation types	Area (ha)	Area (%)	PV 2011	PV 2016
Thermic		139.6	32.1	11.7	12.4
	Carex rosae				
	Elyna myosuroides				
	Festuca quadriflora				
	Helianthemum nummularium				
	Helianthemum oelandicum				
	Sesleria varia				
Pre-forest and shrub-encroached		78.8	18.1	10.6	13.0
	Calamagrostis villosa				
	Juniperus nana				
	Vaccinium gaultherioides				
Oligotrophic		85.6	19.7	14.0	14.0
	Nardus stricta				
	Carex sempervirens				
	Trifolium alpinum and *Carex sempervirens*				
Mesotrophic		42.8	9.8	24.3	24.0
	Festuca gr. *rubra* and *Agrostis tenuis*				
Eutrophic		58.5	13.5	22.5	22.2
	Dactylis glomerata				
	Poa alpina				
Snow-bed		29.3	6.7	17.3	19.6
	Salix herbacea				
	Plantago alpina				
TOTAL		434.6	100.0		

Table 3 – Preference Index (PI) and Standardized Index (SI) for each vegetation ecological group under continuous (CGS) and rotational (RGS) grazing systems. Light brown cells and light grey cells indicate a significant (95% confidence interval with a Bonferroni adjustment) avoidance or preference for a specific vegetation ecological group, respectively. Orange cells indicate an indifferent selection for a vegetation ecological group.

Indexes	Vegetation ecological group	CGS	RGS				
		2010	2011	2012	2013	2014	2015
PI	Thermic	0.66	n.a.	0.86	0.71	0.83	0.95
	Pre-forest and shrub-encroached	0.35	n.a.	0.96	1.35	1.10	1.00
	Oligotrophic	0.75	n.a.	0.96	1.03	0.93	0.66
	Mesotrophic	1.30	n.a.	2.80	3.36	3.44	3.51
	Eutrophic	1.94	n.a.	1.08	0.74	0.91	0.87
	Snow-bed	2.83	n.a.	1.07	1.70	1.14	1.40
SI	Thermic	0.08	n.a.	0.11	0.08	0.10	0.11
	Pre-forest and shrub-encroached	0.04	n.a.	0.12	0.15	0.13	0.12
	Oligotrophic	0.10	n.a.	0.12	0.12	0.11	0.08
	Mesotrophic	0.17	n.a.	0.36	0.38	0.41	0.42
	Eutrophic	0.25	n.a.	0.14	0.08	0.11	0.10
	Snow-bed	0.36	n.a.	0.14	0.19	0.14	0.17