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

21
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29

30 Abstract

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

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

50 Introduction

51 Mountain pastures provide a wide range of ecosystem functions and services for the society. For instance, Alpine
52 pastures support food production, plant and animal diversity, carbon storage, nutrient cycling, regulation of climate and
53 water quality, pollination, as well as aesthetic and recreational values (Harrison et al 2010, Silva et al 2010; Lonati et al
54 2015). However, a dramatic change in land-use and cover in the European Alps occurred in the last century due to deep
55 socio-economic changes, resulting in a reduction of the area covered by sub-alpine and alpine pastures, which are
56 nowadays among the main threatened ecosystems (Rutherford et al 2008; Orlandi et al 2016). The number of family
57 farms, relying on herding to manage small herds and flocks, decreased and nowadays a smaller number of farms rear
58 larger herds and flocks compared to the past (Probo et al 2013). Moreover, continuous grazing systems (CGS) spread
59 and often replaced herding-based grazing management to reduce labour and capital inputs. Under CGS cows are
60 allowed to roam freely, which results in an uneven spatial distribution of the grazing animals within pastures, i.e.
61 widespread underuse of the steepest and most marginal areas and overuse of the flattest and most accessible ones
62 (Probo et al 2014). As a consequence, grasslands are reducing their extension, as well as their herbage mass and nutritive
63 value (Pittarello et al 2018), often evolving towards shrub and tree encroached communities, with negative effects on
64 the provision of the abovementioned ecosystem services (Prévosto et al 2011).

65 To preserve pastoral environments, also by contrasting the negative impact of uneven grazing distribution, specific
66 policies were adopted by the European Union, among which the Rural Development Program (RDP) 2007-2013. During
67 the period of the program, EU supported the implementation of RDP agri-environmental measures in 1,5 Mio farms
68 managing an area of over 63 Mio ha, with a total expenditure of about 37,000 Mln€ (ENRD 2019). Italy spent about
69 3,600 Mln€ to subsidize agri-environmental measures (ENRD 2019), which were implemented in different ways by
70 regional administrations. In Piedmont Region (north-western Italy), regional government allocated 14.7 Mln€ to support
71 grazing systems' extensification (Sistema Piemonte 2019). Among the good agricultural practices to improve the
72 sustainability of extensive grazing system management, the implementation of Grazing Management Plans (GMP) was
73 promoted, which enhances farm productivity while preserving biodiversity, soil, and landscape. GMP define a set of
74 farm-specific and sustainable grazing management actions based on the concept that animal stocking rate has to
75 balance the grassland carrying capacity (Argenti and Lombardi 2012). The carrying capacity of grasslands has been
76 defined by Allen et al (2011) as the maximum stocking rate achieving a target level of animal performance, which can
77 be applied over a defined period without grazing land deterioration. The implementation of rotational grazing systems
78 (RGS) is the best and easiest way to achieve the abovementioned balance. Under RGS, pastures are subdivided in
79 paddocks, which are grazed in rotation (Cavallero et al 2007; Lombardi et al 2011). The use of paddocks increases
80 stocking density and grazing intensity, and changes livestock spatial distribution compared to CGS (Probo et al 2014).
81 Indeed, in their research, Probo et al (2014) found a more homogeneous selection for different vegetation communities
82 by beef cattle under RGS with respect to CGS. The RGS can also positively promote seed transportation and increase
83 connectivity amongst different vegetation communities through a more homogeneous selection for different areas
84 within each paddock, even the most inaccessible, steep, and at higher elevation (Bailey and Sims 1998). In another
85 recent research, Perotti et al (2018) found that the 5-year implementation of a Grazing Management Plan had positive
86 effects on plant diversity conservation leading to an increase in both species richness and Shannon diversity index.

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

98 Probo et al (2014) highlighted the beneficial effects produced by a 2-year RGS implementation on the selection for
99 vegetation communities by cattle on sub-alpine and alpine pastures formerly managed under CGS. However, since cows
100 have an accurate spatial memory (Bailey and Sims 1998), their short-term selection could have been influenced by
101 historical resource selection strategies experienced under several years of CGS. Hence, the present study was carried
102 out to compare on the medium term the selection for different vegetation communities by beef cattle under the two
103 grazing systems and to evaluate the changes produced on grassland PV five years after the implementation of RGS. The
104 specific objectives were: (1) to assess the selection for different vegetation communities by cattle under CGS and during
105 5-year RGS implementation, (2) to assess the changes in the abundance of different functional groups of plant species

106 (i.e. oligo-, meso-, and eutrophic species and species characterized by different IQS), and (3) to measure forage PV
107 changes along the 5-year timespan.

108 Material and Methods

109 Study area and grazing systems

110 The research was carried out in Val Troncea Natural Park, south-western Italian Alps (44°57' N, 6°57' E). Average annual
111 temperature was approximately 4°C (Feb: -3.8°C; Jul: 12.6°C) and annual average precipitation was 703 mm (mean
112 2003–2015; data gathered from the meteorological station located at 2150 m a.s.l. - 44°98'N, 6°94'E). Dominant soils
113 were gravelly and nutrient-poor over calcareous parent rock. The study area was 448 ha wide, ranging from 1900 to
114 2820 m a.s.l.

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

120 One cattle herd of 80 AU (AU, Animal Units; Allen et al 2011) exploited the study area for several years from early June
121 to late September under CGS, until 2010. From 2011 to 2015, following the directions of a specific Grazing Management
122 Plan, the farmer implemented a RGS over the area, with four paddocks grazed in rotation by 105 AU from early June to
123 late September (starting in paddock 1 and ending in paddock 4; Fig. 1). Grazing Management Plan prescriptions for the
124 subdivision of the whole grazing area into four paddocks grazed in sequence took into account several features, such as
125 vegetation cover, botanical composition, forage Pastoral Value, average phenological development of grassland
126 communities, altitude, aspect, natural borders, water availability, and management facilities (Table 1). The number of
127 animal units was increased according to vegetation carrying capacity, which was computed using Daget and Poissonet
128 (1971) methodology, i.e. by multiplying forage PV with altitudinal and slope conversion coefficients and the grazable
129 area.

130 Vegetation surveys and cattle tracking

131 To assess vegetation changes after 5 years of RGS, the grazable surface of the study area was subdivided into 150 X 150-
132 m grid cells, for a total of 193 cells. At the centroid of each grid cell, a vegetation survey was carried out during summer
133 2011 (before the beginning of grazing, at the flowering stage of dominant graminoids) and it was repeated in 2016.
134 Vegetation surveys were carried out with vertical point-quadrat method (Daget and Poissonet 1971), along a 10-m linear
135 transect in which every plant species touching a steel needle was identified and recorded at every 50-cm interval. To
136 account for occasional species, likely missing with the point-quadrat method, a complete list of all other species included
137 within a 1-m buffer area surrounding the transect was also recorded (Iussig et al 2015). Species nomenclature followed
138 Pignatti (1982).

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

143 Data analyses

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

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

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

159 Forage PV, which ranges from 0 to 100, was calculated for each transect of 2011 and 2016 on the basis of the SRA and
160 ISQ according to the following equation (Daget and Poissonet 1971):
161

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

162
163 where ISQ_i is the ISQ value for the species i (Cavallero et al 2007).
164

165 Statistical analyses

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

172 For each vegetation ecological group, preference and standardized indexes were calculated to evaluate cattle selection
173 (Hobbs and Bowden 1982). Preference indexes were computed as the proportion of GPS fixes within a vegetation
174 ecological group divided by the proportional area covered by that vegetation ecological group within the study area. A
175 95 % confidence interval with a Bonferroni adjustment (Manly et al 2002) was calculated for each preference index to
176 determine if individual ecological groups were avoided, used indifferently, or preferred by cows. Values >1 for the lower
177 confidence limit indicated preferential selection for a particular ecological group, while values <1 for the upper
178 confidence limit indicated that cows used that particular ecological group proportionally less than its availability would
179 suggest. If the value of 1 was within the confidence interval, it implied that cows used a particular vegetation ecological
180 group in proportion to its presence. Standardized indexes are an alternative way to present the preference indexes so
181 that they add to 1 (Manly et al 2002). Therefore, standardized indexes express the estimated probability of selection of
182 a particular vegetation ecological group if all vegetation ecological groups were equally frequent.

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

189 Cluster analysis was performed using IBM SPSS Statistics 24.0 (IBM SPSS Statistics for Windows, v 24.0; IBM, Armonk,
190 NY, USA) and paired sample statistical tests were carried out with PAST software (PAST 3.16; Hammer, Harper, & Ryan,
191 2001).

192 Results

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

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

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

210 The forage PV of the whole study area significantly increased from 15.0 ± 0.58 (mean \pm standard error) in 2011 to 15.8
211 ± 0.59 in 2016 ($P < 0.036$) (Fig. 2B).

212 Discussion

213 Our results suggest that the five-year implementation of a Grazing Management Plan was an efficient tool to improve
214 pasture use by cattle and enhance forage quality in sub-alpine and alpine pastures.

215 Indeed, under CGS cows were free to roam over the whole pasture and consequently they highly selected few most-
216 preferred vegetation groups, such as mesotrophic, eutrophic, and snow-bed vegetation communities. These ecological
217 groups were characterized by a medium-high forage yield and quality, and they were typically located at the gentlest
218 and most accessible sites. Meso- and eutrophic vegetation groups were situated at lowest elevations and they could
219 offer a highly palatable vegetative regrowth in the second half of the grazing season (Probo et al 2014). Snow-bed
220 vegetation group, even though placed at highest elevations (i.e. often above 2400 m a.s.l.) and with a low herbage mass
221 due to the short vegetative cycle under harsh climatic conditions (Körner 2003), was the most preferred ecological group
222 as it hosted a highly nutrient-rich forage (Björk and Molau 2007).

223 With the implementation of RGS, cattle selectivity decreased and the preference for different vegetation communities
224 was more balanced. Indeed, even if the snow-bed vegetation group was always a vegetation group preferred by cattle,
225 its selection markedly decreased over time. Moreover, eutrophic vegetation group shifted from preferred to avoided,
226 likely as a consequence of the changed availability and palatability of different vegetation groups within each paddock.
227 The RGS not only forced cattle to graze within paddocks having different proportions of vegetation groups, but it also
228 imposed predefined grazing periods, thus encouraging animals to exploit vegetation communities having specific
229 phenology and related forage quality and palatability. For this reason, in the rotation imposed by the RGS, the selection
230 for the eutrophic group may have decreased due to an exploitation occurred often later than under the CGS. This later
231 exploitation may have coincided with an advanced phenological stage and less palatable forage, above all for fast-
232 growing eutrophic dominant species such as *Dactylis glomerata* L. For all these reasons, and considering also the
233 increase in the selection for the pre-forest and shrub-encroached group, which was generally highly avoided during CGS,
234 the present results confirmed the hypothesis according which the implementation of a Grazing Management Plan was
235 an effective way to improve cattle distribution over a five-year timespan. Indeed, the implementation of RGS through
236 Grazing Management Plans allows planning and optimizing the relationship between forage supply (yield and quality)
237 and its consumption by grazing animals. The detailed study of forage resources on which Grazing Management Plan are
238 based (i.e. mapping of the grazable area of different plant communities, based on botanical composition and the
239 abundance of the individual plant species) allows to predict the temporal development of forage supply and to balance
240 it with the stocking rate that will use it in a given period. This result can be achieved by optimizing the grazing length
241 that a given number of animals belonging to certain categories (e.g. cattle, goats, sheep, horses of different ages, having
242 different dietary needs and selectivity) will graze on the area of interest. Moreover, Grazing Management Plan can
243 account for the integration of RGS with supplementary pastoral practices (i.e. strategic placement of drinking troughs
244 and mineral mix supplements, arrangement of temporary night camp areas, etc.), which can additionally improve
245 grazing distribution, botanical composition, vegetation structure, and forage quality (Probo et al 2013; Pittarello et al
246 2016a; Probo et al 2016).

247 A research conducted in the same study area (Perotti et al 2018) demonstrated that RGS increased the average soil
248 nutrient content of the whole pasture over a five-year span. This result may explain the increase in abundance of
249 medium-high nutrient demanding plant species (i.e. meso- and eutrophic) and the reduction of the abundance of
250 nutrient-poor ones (i.e. oligotrophic). Indeed, nutrient-demanding plant species respond more efficiently to an increase
251 in nutrient availability compared to nitrogen-poor ones (Chapin et al 1986). Moreover, the overall increase of nutrient
252 content over the pasture may also explain the increase in the abundance of moderately to highly palatable plant species
253 and the reduction of non-palatable ones. Indeed, plant species with a moderate and high ISQ are typically associated
254 with moderate to high grazing and fertilization processes (Pittarello et al 2016b). Consequently, the increase in the
255 abundance of these species enhanced the grassland PV. This index can theoretically assume values bounded between
256 0 and 100, but it actually ranges between 0 and 63 in western Italian Alps, with an average value around 20.7 (Cavallero
257 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-
258 negligible result for high-elevation grasslands, where environmental constraints (e.g. low temperatures and short
259 growing season) slow down the ecological response of plant communities (Körner 2003).

260 In conclusion, the results extend the existing knowledge on the effects of the implementation of a RGS by assessing the
261 improvement of the yield, quality, and palatability of forage for livestock. Previous research were mainly focused on
262 ecological conservation results, such as plant diversity (i.e. species richness and Shannon diversity index), proportion of
263 different vegetation functional groups' cover and redistribution of nutrients (Jacobo et al 2006; Perotti et al 2018), while
264 agronomic aspects were not considered. Other than the scientific interest in the assessment of the agronomic effects
265 produced on high elevation grassland communities, the importance of the present research relies also in the medium-
266 term monitoring of the effects of EU policy measures aiming to enhance grazing management sustainability. Even
267 though Piedmont region was a test area for GMPs and the regional government allocated for their implementation only
268 5.4 % out of the total expenditure for RDP agri-environmental measures (Sistema Piemonte 2019), the area potentially
269 improved by large scale implementation of GMP would be much larger: grazing livestock use in the EU about 39,5 Mio
270 ha of permanent grasslands (55 % of UAA), managed by 2,1 Mio livestock farms (Eurostat, 2019). Encouraged by our
271 results, European Union policies should support GMP and promote RGS implementation as multifunctional tool aimed
272 at the conservation, restoration, and improvement of sub-alpine and alpine grasslands.

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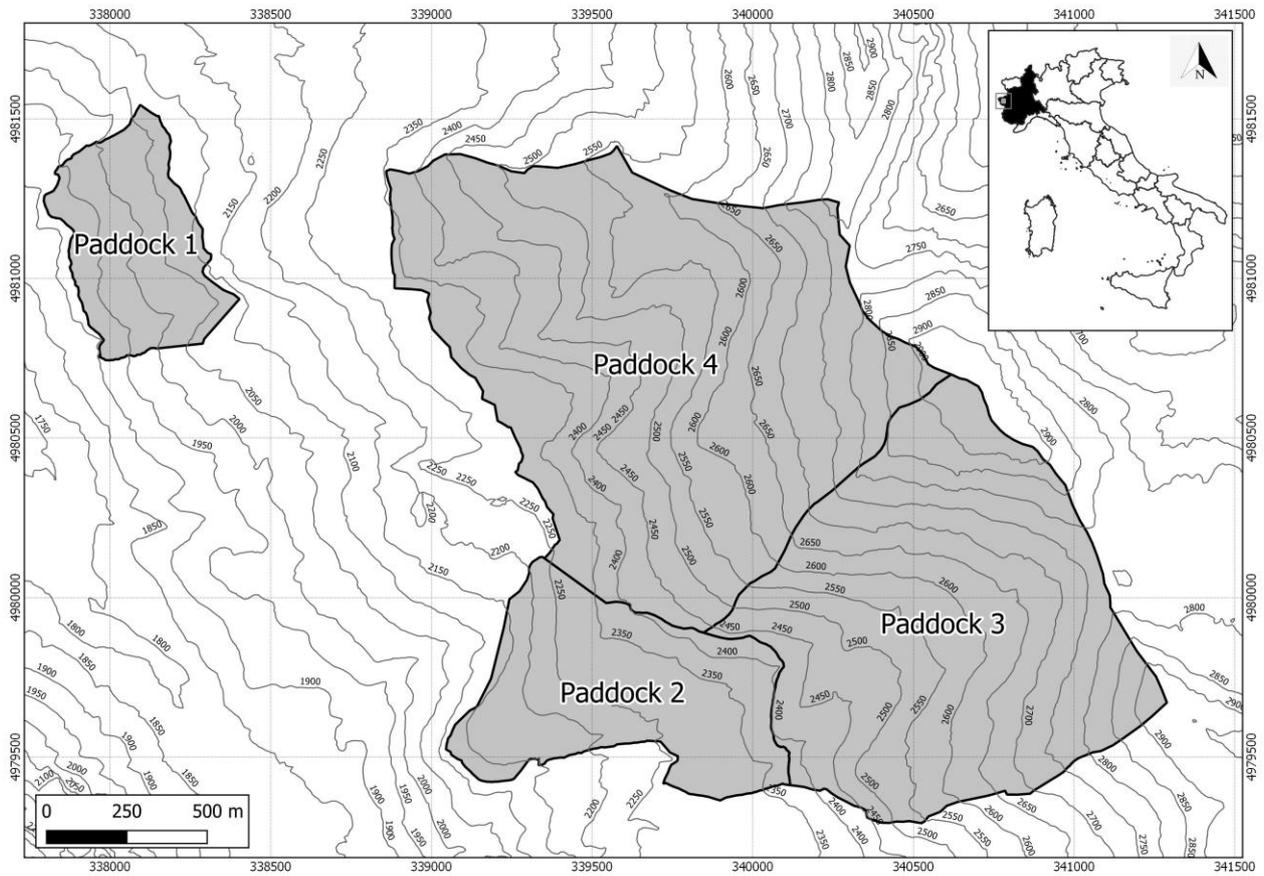
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371 Figures

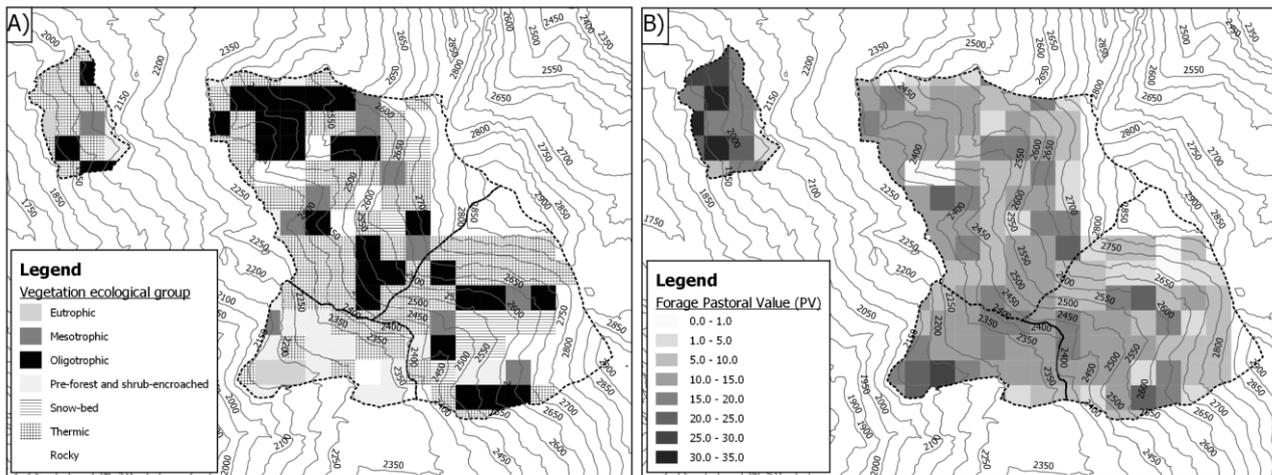
372 Figure 1 - Location of the four paddocks in Val Troncea, Western Alps, Piedmont, Italy (UTM zone 32 north, WGS84 datum).



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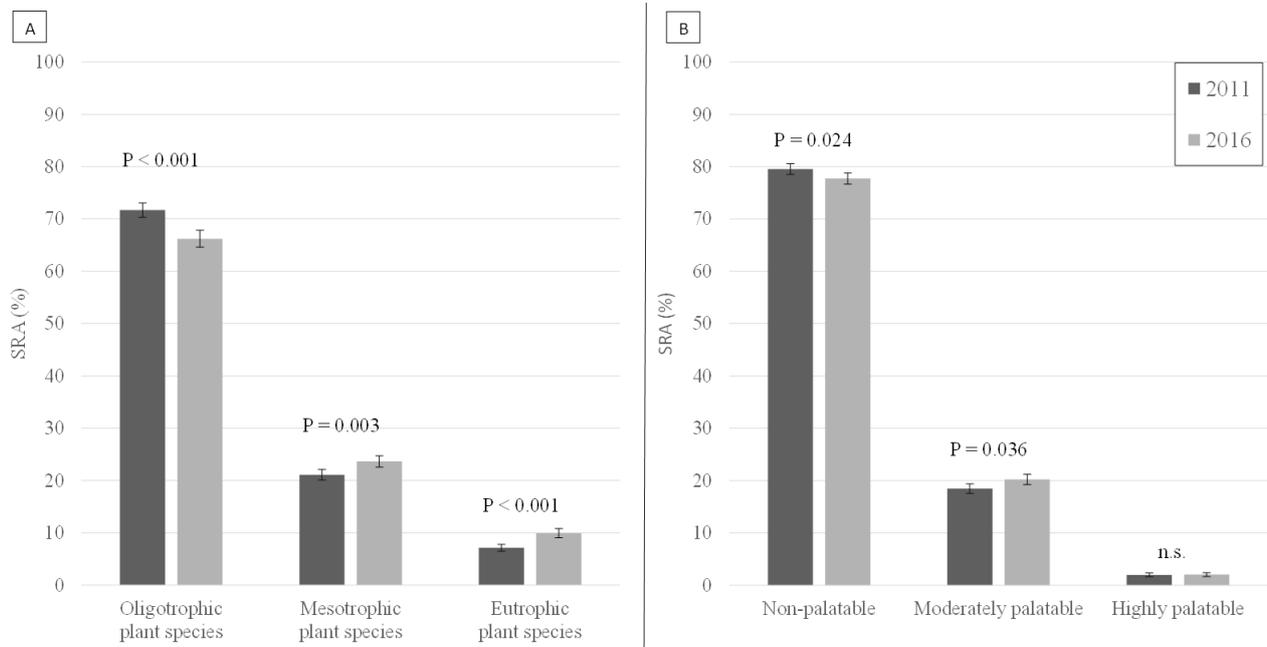
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Figure 2 - Location of vegetation ecological groups (A) and forage Pastoral Value pattern in 2016 (B) across the four paddocks grazed under rotational grazing system (RGS) in Val Tronca



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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).



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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

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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	<i>Carex rosae</i> <i>Elyna myosuroides</i> <i>Festuca quadriflora</i> <i>Helianthemum nummularium</i> <i>Helianthemum oelandicum</i> <i>Sesleria varia</i>	139.6	32.1	11.7	12.4
Pre-forest and shrub-encroached	<i>Calamagrostis villosa</i> <i>Juniperus nana</i> <i>Vaccinium gaultherioides</i>	78.8	18.1	10.6	13.0
Oligotrophic	<i>Nardus stricta</i> <i>Carex sempervirens</i> <i>Trifolium alpinum</i> and <i>Carex sempervirens</i>	85.6	19.7	14.0	14.0
Mesotrophic	<i>Festuca gr. rubra</i> and <i>Agrostis tenuis</i>	42.8	9.8	24.3	24.0
Eutrophic	<i>Dactylis glomerata</i> <i>Poa alpina</i>	58.5	13.5	22.5	22.2
Snow-bed	<i>Salix herbacea</i> <i>Plantago alpina</i>	29.3	6.7	17.3	19.6
TOTAL		434.6	100.0		

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393 **Table 3 – Preference Index (PI) and Standardized Index (SI) for each vegetation ecological group under continuous (CGS) and**
 394 **rotational (RGS) grazing systems. Light brown cells and light grey cells indicate a significant (95% confidence interval with a**
 395 **Bonferroni adjustment) avoidance or preference for a specific vegetation ecological group, respectively. Orange cells indicate an**
 396 **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

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