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Restoration of shrub-encroached grasslands through the modification of cattle grazing patterns

Probo M.[1*], Lonati M.[1], Bailey D.W.[2], Gorlier A.[1], Iussig G.[1], Pittarello M.[1], Lombardi G.[1]

[1]University of Turin, Department of Agricultural, Forest and Food Sciences, Via Leonardo da Vinci 44, Grugliasco, 10095, TO, Italy.

[2]New Mexico State University, Department of Animal and Range Sciences, Las Cruces, NM 88003, USA.

*E-mail: massimiliano.probo@unito.it

Abstract

Throughout the last decades, agricultural abandonment in European mountain areas has caused changes in traditional livestock management with consequences for semi-natural grassland use and vegetation. In the Western Italian Alps, continuous extensive grazing has become the simplest and the most common system for managing large cattle herds. As a result, limited grazing in many rugged locations has led to an extensive shrub-encroachment of semi-natural grasslands in the sub-alpine and alpine belts. A study was conducted to assess if the provision of mineral mix supplements (MMS): 1) increases the use of steep and shrub-encroached locations by beef cows, and 2) helps restore meso-eutrophic grassland vegetation around supplement-deployment sites. During the summer grazing season, MMS were placed within 10 steep and shrub-encroached areas in two adjacent pastures (364 ha and 366 ha), and 12 cows were tracked with GPS collars. For each supplement site, a paired control site was identified, and vegetation surveys were performed in the surrounding areas of both sites. Placement of MMS increased the use of areas within 12 m of supplement locations compared to corresponding control areas. Cattle use of areas within 100 m of the MMS sites was also greater than expected by chance. The use by cattle, associated with trampling, grazing and faecal deposition, reduced the cover of shrub and oligotrophic herbaceous species and increased the average nutrient *N* value and forage pastoral value of the new vegetation types established around MMS sites two years after their use by cattle. Strategic placement of MMS appears to be a sustainable practice to restore sub-alpine and alpine shrub-encroached grasslands. Nevertheless these results must be considered preliminary as a longer period is needed to evaluate the long-term effectiveness of this practice for the restoration of semi-natural grasslands.

Keywords: beef cows, continuous grazing, dwarf shrubs, feed blocks, GPS-tracking, sustainable restoration practice.

Introduction

Over the past decades, agricultural abandonment in European mountain areas has caused changes in the use of semi-natural grasslands, their management, and the composition of their vegetation, with extensive shrub and tree encroachment over large areas (MacDonald *et al.* 2000). In the Western Italian Alps, both a marked decrease in the number of livestock farms, cattle herds, workers per farm, and an increase in the average number of animal per herd have occurred. Consequently, traditional livestock management has been deeply modified. Since the decline in herding, continuous extensive grazing has become the simplest and the most common system for managing large herds (Probo *et al.* 2013). Higher stocking densities with these larger herds than in the past and the natural predilection of free-ranging cattle for flatter terrain have generally increased grazing in these areas and limited the use of steeper areas. As a consequence, limited grazing of many rugged locations in the sub-alpine and alpine belts has resulted in natural successional phenomena with changes in vegetative cover and composition. Herbaceous oligotrophic species and dwarf shrubs have encroached large areas of semi-natural grasslands, leading to a decrease in forage yield, pastoral value, and extent of meso-eutrophic habitats characterized by high plant and animal diversity (Cavallero *et al.* 2007) and to an increase in landscape homogeneity.

For these reasons, in many European countries the conservation and restoration of semi-natural grasslands have become an important agri-environmental issue. Such conservation and restoration have been mainly carried out by manual or mechanical shrub-clearing, mowing, prescribed burning and grazing management (Ascoli *et al.* 2009). Livestock can play an important role in the restoration process because trampling, grazing, seed transport and nutrient redistribution through faecal deposition can alter the cover and structure of vegetation as well as botanical composition (Olff and Ritchie 1998).
Strategic placement of mineral mix supplements (MMS) has been used to entice cattle into traditionally undergrazed areas in American rangeland systems (Bailey and Welling 2007). To our knowledge, the strategic placement of MMS has not been evaluated as a tool to restore semi-natural shrub-encroached grasslands. Modification of the grazing patterns of cattle through strategic placement of MMS could be a more sustainable restoration practice than manual or mechanical shrub-clearing or fencing, as it is less costly, has lower labour inputs, and could be more easily carried out on rugged alpine locations.
The objective was to assess if MMS could: 1) increase the use of steep and shrub-encroached locations by cattle and 2) help restore meso-eutrophic vegetation around supplement-deployment sites. It was hypothesized that: 1) providing MMS on steep and shrub-encroached locations would result in greater cattle use of areas around placement sites compared to similar control sites, so that 2) cattle trampling, grazing and faecal deposition would reduce the cover of shrub and oligotrophic herbaceous species and increase the cover of meso-eutrophic herbaceous species.

Materials and methods

The study was conducted in Val Troncea Natural Park (latitude 44° 57’ N, longitude 6° 57’ E), which is a protected area representative of the changes that have occurred on grasslands in the Western Italian Alps. Grasslands were mainly dominated by *Festuca curvula* Gaudin, *Carex sempervirens* Vill., and *Trifolium alpinum* L. and the shrub vegetation layer was predominantly composed by *Rhododendron ferrugineum* L. (alpenrose), *Juniperus nana* Willd. (dwarf juniper), *Vaccinium myrtillus* L. (bilberry), and *Vaccinium gaultherioides* Bigelow (northern bilberry), that have rapidly encroached wide areas of grasslands after the decline in agro-pastoral activities. The study area was selected within the two cattle farms still operating in the Park, and consisted of two pastures: Troncea (366 ha) and Meys (364 ha). Elevations ranged from 1 950 to 3 000 m and slope averaged 29 %. The Troncea pasture was grazed from 12 July to 29 September 2010 by 119 beef cows, predominantly of the Piedmontese breed, with some of the Valdostana Red Pied and Barà-Pustertaler breeds. The Meys pasture was grazed from 8 July to 20 August and from 7 September to 2 October 2010 by 150 beef cows of the Piedmontese breed. Both groups included heifers and non-lactating cows, varying in age from 1 to 15 years.
During the summer grazing season (early July to early October) of 2010, cows were offered MMS *ad libitum*. The MMS was placed at 10 sites, six in the Troncea pasture and at four in the Meys pasture. Supplement-deployment sites were positioned within the 10 largest patches of shrub-encroached grassland types and they were on steep areas with an average slope of 48.6 ± 3.4 % (mean ± SE). Within each site, MMS was supplied in 5-kg blocks, which were placed 5 m apart in pairs. Each pair of MMS blocks was considered as a treatment site and was paired with a control site having the same soil cover, vegetation features and distances from water sources with respect to MMS sites.
Seven randomly-selected cows per farm were tracked with global position system (GPS) tracking collars (GPS Model Corzo, Microsensory SLL, Fernán Núñez, Andalusia, Spain). Positions were recorded every 15 min, with an average accuracy of 6 m.
Botanical composition was determined using the vertical point-quadrat method (Daget and Poissonet 1971) along cross-shaped transects. One transect was placed at each control and supplement site, with the centre of the cross positioned in the exact middle of the pair of MMS blocks. Twenty vegetative transects were measured in early July 2010, in order to test the homogeneity of vegetation between supplement and control sites before the use of MMS by cattle. Transects were 12.5 m long across each of the four sides of the cross. In each transect, at every 50-cm interval, plant species touching a steel needle were identified and recorded. In early July 2012, the extent of areas, which had been modified by cattle around MMS locations, were visually estimated, following the sharp fine-scale fragmentation of the original dense shrub cover. A new cross-shaped transect was placed within each of these changed vegetation areas, with the purpose to evaluate vegetation differences between supplement and control sites. In 2010 and 2012, percentage of shrub, herbaceous, and bare ground cover was visually estimated within a 1-m buffer around the transect line.

Use by cattle of areas within 12 m of MMS placement sites was assessed. It is likely that cattle consumed supplement when they were inside the 12-m buffer because placement sites were located on steep slopes that cattle typically avoid. A visit to an MMS site was then defined as the location of a GPS collar within 12 m of the placement site, in accordance with Bailey *et al.* (2001). The number of visits to each supplement and control site was calculated for each tracked animal. Frequency of visits to supplement sites was calculated as the total number of the visits over the number of days cows were tracked (visits day^{-1}). The number of GPS locations for each collared cow within 100 m of the MMS sites was also computed to quantify the use by cattle of areas near placement sites (Bailey and Welling 2007). The area of the minimum convex polygon was calculated for each cow (Ganskopp 2001). Distribution of the number of visits per cow to MMS and control sites was tested for normality using the Kolmogorov-Smirnov test. Because neither raw data nor log-transformed data were normally distributed, use within 12 m of supplements was compared to corresponding control areas using the non-parametric Wilcoxon signed-rank test (Sokal and Rohlf 1995). Pearson χ^2 test was used to test if the number of locations for each cow within 100 m of the MMS sites differed from expected frequencies based on the average cattle use in the minimum convex polygon area.
For each plant species recorded in the vegetative transects the frequency of occurrence (f_i = number of occurrences/100 points) was calculated. Species relative abundance was calculated according to Daget and Poissonet (1971) and was used to detect the proportion of different species. The demand of each plant species for nutrients was estimated according to the Landolt nutrient value (index *N*, Landolt 1977) and each plant species was classified as oligotrophic (N = 1, 2), mesotrophic (N = 3), and eutrophic (N = 4, 5). An indirect vegetation *N* index ($N_{average}$) was calculated to evaluate the overall effect of fertilization produced by the cattle (Probo *et al.* 2013). Each species was also classified according to the Index of Specific Quality (ISQ) (Cavallero *et al.* 2007). In each transect, forage pastoral value (PV), a synthetic value summarizing forage yield and nutritive value ranging from 0 to 100, was calculated (Daget and Poissonet 1971). Kolmogorov-Smirnov test for normality and Levene test for homogeneity of variance were used to evaluate the distribution of vegetation variables. Variables not normally distributed were subjected to a log(x + 1)-transformation that normalized the data. A Pearson correlation was used to estimate the association between overall number of visits to supplement sites (all tracked cows pooled together) and the following variables measured in the changed vegetation areas: extent of the area, shrub cover, average vegetation *N* index, and forage pastoral value. Soil cover and vegetation variables between supplement and their control sites were compared using paired-samples *t* tests (Sokal and Rohlf 1995).

Results

One collar per farm failed, so tracking data were obtained from 6 collared cows for each pasture. During the study, 92 % (11 out of 12) of collared cows visited MMS, and 90 % of MMS sites (nine out of 10) were visited by collared cows. Visits per cow to MMS sites (4.09 ± 0.913 visits) were greater ($P < 0.01$) than those to paired control areas (1.13 ± 0.332). Sites with MMS were visited approximately once every six days (0.16 ± 0.031 visits day^{-1}). Minimum convex polygon areas were 320.5 ± 7.61 ha. Number of GPS locations within 100 m of the MMS sites (288 ± 54.0) was greater ($P < 0.001$) than the expected number of locations based on average cattle use of the minimum convex polygon area (205 ± 24.8). The overall number of cattle visits to supplement sites (ranging from zero to 53 visits) was strongly related ($r = 0.806$, $P < 0.01$) to the extent of changed vegetation areas measured in 2012, which ranged from 0.0 to 98.9 m^2 (45.2 ± 9.51 m^2).
No statistical differences in variables of visually estimated cover were detected between MMS and control sites in 2010. Two variables of cover around supplement-deployment sites differed from corresponding control sites in 2012: shrub cover was lower ($P < 0.001$) at the MMS sites (12.1 ± 7.20 %) than at the control sites (55.6 ± 4.50 %) and the percentage of bare ground was higher around MMS sites ($P < 0.001$).
No differences in vegetation variables were detected between the MMS and control sites in 2010. It was assumed, therefore, that supplements and control sites had roughly the same vegetation and ecological features before cattle used the MMS. In 2012, a reduction ($P < 0.001$) in both frequency and relative abundance of shrub species was detected near MMS placement sites. Oligotrophic herbaceous species cover declined ($P = 0.05$) at MMS sites, whereas no differences in relative abundance were detected between supplement and control sites. No changes in mesotrophic species were detected around MMS locations. Percentage of eutrophic species on the total of species was higher ($P < 0.01$) around supplement-deployment sites, although their frequency did not increase significantly. An increase in average vegetation *N* index ($P < 0.01$) and forage pastoral value ($P < 0.01$) was detected around supplement-deployment sites. These two

vegetation variables were also related ($P < 0.05$) with the overall number of cattle visits to MMS sites (r = 0.740 and r = 0.658, respectively).

Discussion

Cattle regularly travelled to the MMS and the data support the hypothesis that strategic placement of MMS on steep and shrub-encroached locations can increase cattle use up to 100 m from placement sites. Considering that supplement placement areas were historically underused and located in extremely steep and rugged terrain, these results are promising and suggest that cattle can be successfully used on similar landscapes and vegetation mixes.
Cattle impacts on cover around placement sites were localized and never exceeded 100 m^2. Near sites of MMS placement, cattle trampling and grazing reduced shrub cover. Two years after MMS placement, bare ground gaps created by cattle were mostly not covered by herbaceous vegetation, showing that recolonization by herbaceous vegetation is a slow process.
The forage pastoral value approximately doubled near MMS sites. The strong correlation between cattle visits to MMS and forage pastoral value provides additional evidence that targeted grazing by cattle may be useful for restoring shrub-encroached grasslands in this region. The vegetation N index increased near MMS placements and was correlated with cattle visits to the MMS. This may be a result of the deposition of faeces and urine which can increase nutrient availability in the soil.
Nonetheless, the vegetation data do not allow validation of all the restoration hypotheses made about changes in herbaceous species. Cover of oligotrophic species decreased but that of mesotrophic and eutrophic species did not increase on the areas of bare ground. Vegetation changes observed in this study were short-term. Long-term studies are needed to determine if strategic placement of MMS can result in sustained reductions in shrub cover and subsequent establishment of desired herbaceous vegetation in these steep and high altitude alpine grasslands.

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