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Changes in vegetation structure and hydrological function in response to rangeland rest

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Abstract: An experiment was carried out to evaluate the effects of grazing rest on the vegetation structure, the hydrological function, and the ecological status in grasslands of regular condition for cattle. The study area is located at 4,095 meters above sea level, in the Cordillera Blanca peasant community, Ancash Region, Peru. The experimental design was factorial 2 x 2 in blocks, where the factors were: a) two grazing systems P1: uncontrolled grazing on communal usufruct lands and P2: rest or total exclusion of grazing, and b) three years of monitoring from 2011 to 2013. At the end of the study, the vegetation structure changed according to the regime of the rangeland use, where rest favored the increase of local gramineae species, but unfavorable for herbs, pseudogramineae, and shrubs. Resting increased the vegetation cover, the accumulation of biomass and mulch on the ground with respect to grazing ($P < 0.01$). The hydrological function improved with the application of rest compared to grazing, which was reflected in a higher infiltration capacity and soil moisture content ($P < 0.01$). The ecological processes improved with resting compared to grazing expressed by the increase of the ecological status of the pasture, in response to the improvement of the components that determine its value, such as forage species and vigor ($P < 0.01$).

Key words: rest; continuous grazing; native plants; hydrologic function; ecological status

1 Introduction

Overgrazing is considered to be one of the main causes of vegetation and soil degradation (Distel, 2013). Rest is a grassland improvement strategy that includes limiting grazing in areas used for animal consumption for one year or more (Flores, 1999). This technology is used to eliminate or reduce the negative effects of overgrazing by promoting the natural restoration of flora in degraded grassland ecosystems (Yayneshet et al., 2009). Many studies have reported that the biological integrity of grasslands has improved due to maintaining the advantages of local plants and reducing the invasion of other species, which is conducive to increasing vegetation coverage (Weinert&Williams, 2018).

Liu.Shao (2014) and Merritt & Bateman (2012) pointed out that greater vegetation coverage means greater infiltration and accumulation of available water in the soil, thereby improving the ecological status of grasslands. However, the response of natural vegetation to grazing is also influenced by a number of other factors, such as the evolutionary history of plants, morphological and physiological characteristics, and the structural and functional status of systems

(Deboring et al., 2008; Ruppert et al., 2015). Grassland plants have various mechanisms to adapt to changes caused by grazing conditions. For example, the emergence of basal meristems and their ability to vegetatively reproduce promote their survival during grazing and subsequent reproduction (Milchunas et al., 1988).

On the other hand, the impact of overgrazing has been widely studied in grassland ecosystems and represented in models based on plant succession theory. It can lead to grassland degradation, a process that can be reversible by regulating animal load (Distel, 2013). Alternative stable state models identify discontinuous and irreversible changes in the same niche (locations with specific physical characteristics that determine the structure and function of ecosystems). Under this approach, the role of external controls (such as extreme weather events) and internal controls (plant-plant and animal-plant interactions) in regulating ecosystem dynamics is emphasized, based on the concepts of "resilience" and "ecological threshold" (Distel, 2013).

Under the conditions of Pune, Peru, there has been little research on the impact of short-term (<5 years) rest on vegetation and soil. Therefore, the purpose of this study is to assess the impact of rest on the vegetation structure, hydrological response, and ecological status of the perennial grass dominated grassland in the Cordillera Blanca farmer community in Ankash for a period of three years.

2 Materials and methods

2.1 Study area

This study was conducted at two grassland ecological sites dominated by perennial grasses, located in the usufruct area of the Cordillera Blanca farmer community in the Ankash region of Peru, known as Sillacancha and Cotocancha, with an altitude of 4095 meters (Fig. 1). The study area is 1.6 km from the buffer zone of Huascarán National Park, and corresponds to the Pajonal Altoandino wet classification based on the description of the northern and central Andes ecosystems (Josse et al., 2009), characterized by an average temperature of 12 ° C, cold and dry winds. From 2011 to 2013, the average annual precipitation values for the study years were 823.5, 953.8, and 849.6 millimeters, respectively (SENAMHI, 2015).

The soil chemical characteristics of these two departments show that the PH value is 4.53, the electrical conductivity is 0.11ds/m, the cation exchange capacity is 9.12meq/100g, the phosphorus content is 3.4ppm, the potassium content is 24ppm, and the organic matter content is 4.2%. The soil of these two departments is sandy loam soil, with signs of moderate interlayer erosion. The climate, altitude, grazing intensity, and topographic characteristics of the two grazing lands are similar. However, at the beginning of the experiment they were different in soil moisture level (Sillacancha: 8%; Cotocancha: 14%) and surface stoniness (Sillacancha: 25%; Cotocancha: 2%).

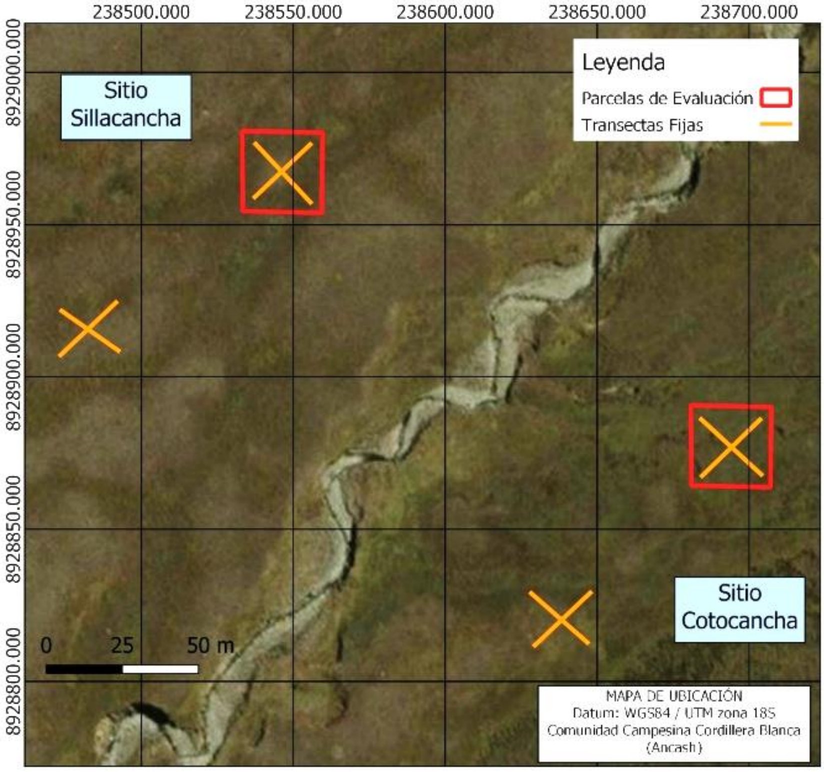

Fig.1. Location and distribution of the experimental area

The physiographic characteristics corresponded to a slightly sloping to steep topography, with a slope varying between 2 to 5% and very shallow and superficial soils (0-25 cm). Vegetation cover was 77% for the Sillacancha sector and was dominated by the association Calamagrostis macrophyla. Scirpus rigidus, while the Cotocancha sector had a vegetation cover of 85% dominated by Festuca humilior - Stibra brachiphylla. At the beginning of the experiment, the study area showed signs of deterioration due to overgrazing because both ecological sites have a long history of overgrazing with cattle and sheep as part of the management of communal usufruct lands, so the average condition of both ecological sites was poor for sheep and regular for cattle. As the value of the exponential increases, the influence of the height of the furthest points is considerably reduced, giving prevalence to the known heights closest to the point at which the calculation is made.

2.2 Experimental processing

These treatments are a combination of the following factors: a) two grazing systems (P1: uncontrolled grazing on land with public use rights, hereinafter referred to as grazing P2): complete rest or exclusion of grazing within three years, hereinafter referred to as rest) and b) a three-year evaluation from 2011 to 2013. Due to the grazing characteristics of these public use rights areas (uncontrolled, with different numbers of vaccines and sheep, no fences, according to herdsman standards), it is not possible to estimate the carrying capacity per hectare.

In order to limit all grazing activities for rest, a 25m x 25m experimental area was constructed at each location (Sillacancha and Cotocancha), including 9 thin lines and 1.8 m high columns. In order to monitor the vegetation within each experimental area and adjacent usufruct grassland areas, a permanent cross section of 30 meters was installed as a sampling unit for vegetation and soil. The distance between the permanent fixed cross section of the right of use area and the experimental plot is approximately 50 meters. A total of 4 cross sections were installed throughout the experiment.

2.3 Measure

Temporal changes in vegetation structure were evaluated by functional groups (gramineae, pseudogramineae, herbs, and shrubs), vegetation coverage, cumulative biomass, and percentages of cumulative coverage. The functional group was obtained based on an annual vegetation survey (Parker, 1951) conducted at the end of the rainy season (April-May). This is the time when plants produce botanical seed in greater quantities, so the presence of flower heads is helpful for their identification (Elzinga et al., 1998). The vegetation survey includes recording the presence of plants, mulch, moss, exposed soil, eroded roads, and rocks on grasslands, as they are intercepted at intervals of 0.5 meters by permanently fixed cross sections with 100 count points on each cross section (Elzinga et al., 1998). Subsequently, the floristic composition of perennial grassland biological species was divided into functional groups such as the percentages of gramineae, pseudogramineae, herbaceous, and shrubby families.

The vegetation coverage rate is estimated based on a vegetation census, which represents the total number of plants discovered with the help of a census loop of a total of 100 count points on each cross-section (Parker, 1951; Kent, 2012). Through manual cutting and plant separation methods, biomass and cover are estimated four times a year, corresponding to the onset of the rainy season, heavy rain, and transition to drought and complete drought (Kent, 2012). Due to the extension of the experimental plot (625 meters), they conducted sampling at five random points, bounded by a metal quadrant of 1 meter, as in the adjacent usufruct area, ensuring that the sampling points were not the same as those considered in previous years. Next, extract all the mulch contained within the quadrant, namely, aging material, litter, and organic matter. Then, all plant biomass was extracted by cutting at ground level, mainly foliage contained within the quadrat (Kent, 2012). Both mulch and biomass, collected in the field, were taken to the Grassland Utilization Laboratory of National Agrarian University La Molina (UNALM) for dehydration at 105 °C for 24 hours to obtain the amount of dry matter expressed in Kg-MS-ha-1(AOAC, 1980). The annual values of biomass and accumulated mulch resulted from the average of the four annual estimates.

The hydrological function of the grassland is evaluated by temporal changes in infiltration rate and soil water content. The infiltration rate was estimated by using an infiltration meter, taking two samples per treatment 4 times per year corresponding to the beginning of the rainy season, full rain, transition to dry and full dry through the flooding method (Bouwer, 1986). Soil moisture was estimated together with infiltration measurements, including five soil samples taken at a depth of 15 centimeters. Subsequently, wet soil samples were transferred to an oven, dried at 105 ° C for 24 hours, and the soil moisture percentage for each treatment was calculated based on weight differences (Pierson et al., 2002).

Temporal variation in the ecological status of the pasture was evaluated based on the percentage of forage species (desirable and undesirable plants), vegetation cover and vigor of the key species Festuca humilior, according to a score to determine the condition of the pasture for cattle based on vegetation censuses (Parker, 1951). The botanical species found were classified taxonomically and according to their desirability for cattle consumption: desirable, less desirable and undesirable. Subsequently, the pasture condition score was estimated from Formula 1 (Flores, 1999).

Formula 1: score(0-100%)=0.5(%D)+0.2(%1F)+0.2(%CV)+0.1(%IV)

Where:

%D: percentage of desirable species for cattle.

%IF: percentage of forage species (desirable + undesirable).

%CV: vegetation coverage

%IV: percentage of vigor index of the key plant for cattle, Festuca humilior

2.4 Statistical analysis

The experimental design used for statistical analysis is a set of factors, including the grazing system (P1: grazing and P2: rest) and a three-year evaluation from 2011 to 2013. It is blocked by each grassland site to control differences in soil moisture and surface rock quality in the two study areas (Sillacancha and Cotocancha). Shapiro-Wilk test was used to verify the normality of the dataset, and Bartlett test was used to verify the applicability of the model. To separate the mean from the parameters studied, a significance limit test DLS (α=0.05) was used. All relevant statistical tests were processed using SAS V.9.2 software (SAS Institute, 2004) under the linear additive model of Formula 2.

Formula 2: $Y_{ijk} = u + P_i + A_j + (P{*}A)_{ij} + S_k + e_{ijk}$

Where:

Y_{ijk}: It is the response obtained with the i-th grazing system, j-th period and k-th pasture site;

u: It is the effect of the general average;

P. : Is the effect of the i-th grazing treatment;

A. : It is the effect of the j-th period;

$(P{*}A)_{ij}$: The interaction of the i-th grazing system for the j-th period;

S. : It is the effect obtained with the k-th pasture site (Sillacancha or Cotocancha);

e_{ijk}: It is the experimental error.

3 Results

3.1 Temporal variation in vegetation structure

Compared to the fastest rate of change for grasses and herbs, the rate of change for the functional groups of Pseudogramineae and shrubs is relatively slow (Fig. 2). Table 1 shows the results of the plant components (%) obtained through processing. Compared to grazing (p=0.0001), with the application of rest time, the proportion of grassland was significantly higher than that of grazing (p=0.0001), and there was no significant difference between the three year evaluations (p=0.8853). However, there were significant differences between the interaction of grazing system and years of evaluation (P=0.0438). In grazing, the highest proportion of grass was in 2011 (61.783%), and gradually decreased in 2012 (59.665%) and 2013 (55.057%). At rest, the proportion of grass maintained a growth trend with the passage of 2011 (71.728%), 2012 (75.147%), and 2013 (76.527%).

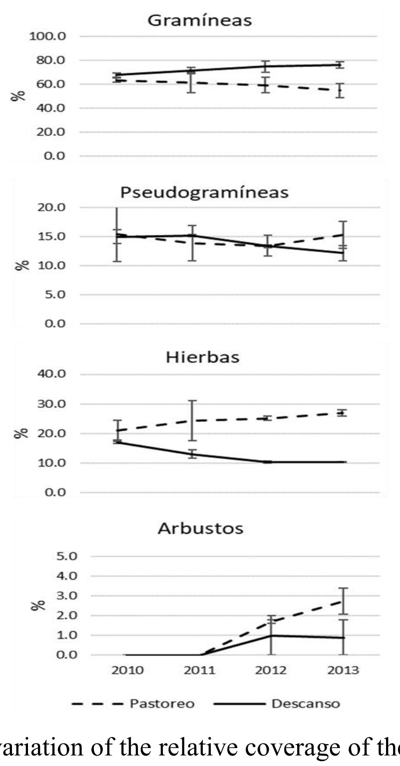

Fig. 2. Temporal variation of the relative coverage of the functional groups

When comparing the two grazing systems (p=0.6337) and the three-year evaluation (p=0.7099), the proportion of pseudograsses was very similar. In both cases, they were functional groups and did not show the greatest changes year after year, indicating that there was no interaction between the two factors (p=0.619). However, the proportion of weeds in grazing (14.505%) was numerically higher than that in rest (13.907%). The impact of grazing systems on the proportion of weeds was different, with grazing (24.412%) significantly higher than rest (12.716%) (p=0.0002). Throughout the experiment, grazing kept the proportion of weeds at a high level and had an increasing trend; on the contrary, there is a downward trend in rest. The evaluation year had no effect on the proportion of Chinese herbal medicines in the grassland (p=0.95), and for herbal medicines, there was no interaction between the grazing system and the evaluation year (p=0.1047).

Shrubs were a minor component of the vegetation (about 1%), which is characteristic of high Andean grasslands, and they appeared from the second year of evaluation. For both sectors, the grazing system had no influence on the percentage of shrubs in the pasture (P = 0.0918). As the years of evaluation passed, the level of shrub encroachment increased without reaching high or predominant levels: 0.0.0% (2011), 1.4.0.4% (2012) and 1.8.0.9% (2013), being significantly higher during the last two years of study (P = 0.0107). There was no interaction between grazing system by year on the proportion of shrubs in the pasture (P = 0.2369).

The levels of vegetation cover, biomass accumulation and mulch were influenced according to the temporal variations of the functional groups in response to the natural recovery of the vegetation (Fig. 3). We found that the grazing system did not influence the level of vegetation cover (P = 0.0793); however, vegetation cover was numerically higher in rest (85.0 . 1.3%) than in grazing (74.4 . 3.8%). The year of evaluation also had no influence on pasture vegetation cover (P = 0.6973), which was demonstrated by the absence of interaction between both factors (P = 0.5687).

Biomass accumulation was statistically lower in grazing (1 142.2 . 341.5 Kg-MS-ha-1) than in rest (1 684.7 . 613.9 Kg-MS-ha^{-1}) (P = 0.0001). The year of evaluation had an influence on biomass accumulation (P < 0.0001) with a tendency to increase as the years 2011 (907.7 . 52.0 Kg-MS-ha^{-1}), 2012 (1 142.7 . 267.6 Kg-MS-ha^{-1}) and 2013 (2 825.4 . 667.1 Kg-MS-ha^{-1}) respectively elapsed. There were significant differences between the interaction of grazing system by year on plant biomass accumulation (P = 0.006). Under grazing, the values found for the amount of biomass for the years 2011, 2012 and 2013 were: 855.7 . 64.1, 875.0 . 75.6 and 2 158.2 . 580.4 kg-MS-ha^{-1}, respectively. At rest, the amount of biomass found for the year 2011 was 959.7 . 91.2 Kg-MS-ha^{-1} and this progressively increased in the following years 2012 (1 410.3 . 161.4 Kg-MS-ha^{-1}) and 2013 (3 492.5 . 227.9 Kg-MS-ha^{-1}).

The coverage accumulation of grazing (277.995.6 kg-Ms·ha-1) was statistically lower than that of rest (426.1.128.2 Kg-Ms·ha-1) (p=0.005). Overall, the evaluation year had an impact on coverage accumulation (p<0.0001), with an increasing trend in 2011 (218.3.73.1 kg-Ms·ha-1), 2012 (360.7.51.7 Kg-Ms·ha-1), and 2013 (663.0.127.1 Kg-MS-ha-1). The grazing system has no interaction with the vegetation deposited on the grassland every year (p=0.4674).

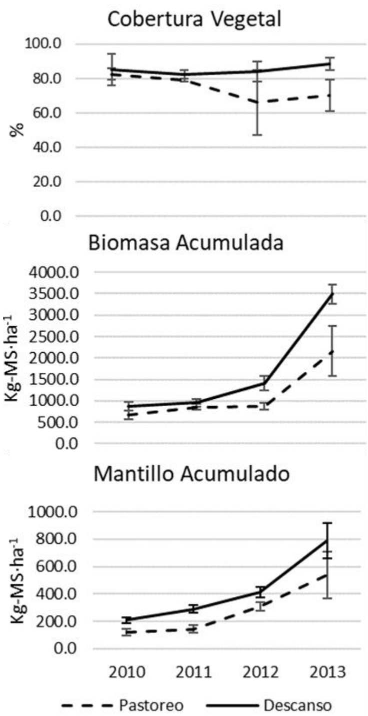

Fig. 3. Temporal changes in vegetation cover, accumulated biomass, and accumulated cover

3.2 Time variation of hydrological function

The hydrological function is influenced by the vegetation cover, biomass, and coverage accumulation level on the grassland surface (Fig. 4). The infiltration rate of grazing (0.12. 0.01 cm/min) was statistically significant compared to rest (0.19. 0.02 cm/min) ($p<0.0001$). The evaluation year affected the infiltration rate ($p<0.0001$), and with the passage of 2011 (0.14. 0.03 cm/min), 2012 (0.17. 0.04 cm/min), and 2013 (0.19. 0.05 cm/min), the infiltration rate showed an upward trend. The interaction between grazing systems has a significant difference in soil infiltration rate every year ($P=0.0003$). In grazing, the infiltration rates in 2011, 2012, and 2013 were 0.11.0.01, 0.13.0.02, and 0.14. 0.02 cm/min, respectively. During rest, the penetration rate in 2011 was 0.17. 0.02 cm/min, and gradually increased in the following 2012 (0.22. 0.02 cm/min) and 2013 (0.24. 0.02 cm/min).

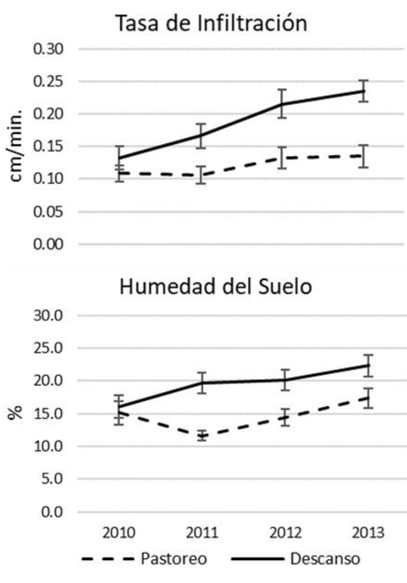

Fig. 4. Time variation of hydrological function

The soil moisture of grazing (14.7.12%) was statistically lower than that of rest (19.6.13%) ($p<0.0001$). The evaluation year had an impact on soil moisture ($p<0.0001$), and with the passage of 2011 (15.7.4.0%), 2012 (17.3.2.8%), and 2013 (19.9.2.5%), soil moisture showed an increasing trend. There was a significant difference in the interaction between grazing systems on soil moisture every year ($p=0.0041$), The penetration rates in 2011, 2012, and 2013 were 11.7. 0.7%, 14.5% .1.2 and 17.4.1.5%, respectively. At rest, the penetration rate in 2011 was 19.7.15%, and gradually increased in the following 2012 (20.1.5%) and 2013 (22.3.16 cm/min).

3.3 Temporal changes in grassland ecological conditions

The final impacts of these two grazing systems and assessment years were summarized in the ecological status estimation to address changes in ecological indicators that determine the grazing system and assessment year (Figure 5). The grazing system affected the forage value ($P=0.008$), with grazing significantly lower than rest (84.21.3%). The evaluation year had no effect on the forage value of grassland plants ($P=0.4596$), which was demonstrated in the absence of interaction between the two factors ($P=0.3082$).

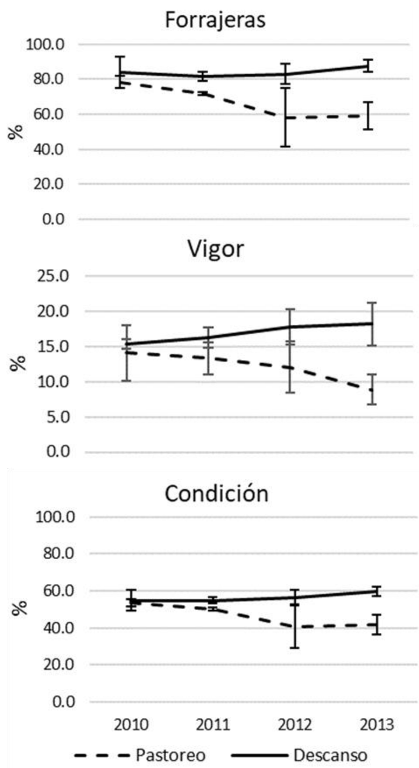

Fig. 5. Temporal changes in grassland ecological conditions

The grazing system affected the vitality of the key plant, the tall Festuca Humilior ($P=0.0004$), and compared to other plants, the vitality of tall Festuca Humilior was significantly reduced (16.9.7%) (12.1.1%). The evaluation year had no effect on the vitality of the tall Festuca Humilior plant ($P=0.578$), and there was a significant difference in the interaction between grazing systems on plant vitality every year ($P=0.035$). In grazing, the plant vitality discovered in 2011, 2012, and 2013 were 13.4.2.3%, 12.1.3.7%, and 8.9.2.1%, respectively. During rest, the plant vitality in 2011, 2012, and 2013 were 16.3.1.5, 17.8.2.5, and 18.2.3.0, respectively. Finally, the grazing system affected the ecological status of the grassland ($p=0.0157$). Compared to grazing (46.5.31%), rest time had a better response to the score determining the ecological status of the grassland (56.5.1%). The evaluation year had no effect on the ecological status of the grassland ($p=0.6438$), which was demonstrated by the lack of interaction between the two factors ($p=0.2677$).

4 Discussion

The results indicate that the vegetation structure of grasslands is strongly influenced by management practices, and these effects become more pronounced over time (Yates et al., 2000). However, information on the self positioning of local plant species in the study area is still unclear; As found, the impact may be due to changes in the local environment (soil moisture, daytime temperature changes, duration of sunlight, etc.), as well as the duration of the experiment until a response from the ecosystem is found (Loydi&Distel, 2010).

Continuous grazing leads to a decrease in perennial gramineae plants, which affects their persistence and competitiveness against other plant functional groups such as herbaceous plants, pseudogramineae plants, and shrubs (De Villalobos&Zalba, 2010). Due to the influence of grazing, the vitality of grass decreases, making the plant community open to accommodate and gradually expand low-end invasive species that are not very attractive to livestock, such as Caesaretosa baccharis and Pulvinnata acacine (Loydi&Distel, 2010). This led to an increase in species diversity at the end of the study (Zhang et al., 2017), as evidenced by the Shannon Weaver index (H '). Grazing: 3.76, resting: 3.18 (Table 1).

Table 1. Plant composition by treatment (%)

Grupo Funcional	Clave	Especie	Deseabilidad Vacuno	Pastoreo				Descanso			
				2010	2011	2012	2013	2010	2011	2012	2013
Arbusto	Baca	*Baccharis caespitosa*	Indeseable	0.0	0.0	1.7	1.8	0.0	0.0	1.0	0.9
	Mapi	*Margirycarpus pinnatus*	Indeseable	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
Gramínea	Acpu	*Aciachne pulvinnata*	Indeseable	1.0	3.5	3.4	3.6	1.0	1.0	0.0	0.0
	Caan	*Calamagrostis antoniana*	Poco Deseable	6.7	7.8	7.6	5.4	17.0	16.2	15.2	15.1
	Cama	*Calamagrostis macrophylla*	Deseable	15.4	14.8	14.3	13.5	19.0	21.2	21.0	20.8
	Cavi	*Calamagrostis vicunarum*	Poco Deseable	0.0	0.9	1.7	2.7	0.0	2.0	2.9	3.8
	Fehu	*Festuca humilior*	Deseable	25.0	24.2	22.5	22.5	19.0	19.2	21.0	22.6
	Mufa	*Muhlenbergia fastigiata*	Poco Deseable	9.6	7.0	5.9	5.4	1.0	1.0	4.8	4.7
	Stibra	*Stipa brachiphylla*	Poco Deseable	5.8	3.5	4.2	1.9	11.0	11.1	10.2	9.5
Hierba	Alpi	*Alchemilla pinnata*	Poco Deseable	3.8	3.5	5.0	6.3	2.0	3.0	1.9	1.9
	Gaco	*Galium corunborum*	Indeseable	1.9	3.5	5.0	6.3	0.0	0.0	0.0	0.0
	Gese	*Geranium sedifolia*	Poco Deseable	0.0	0.9	1.7	1.8	0.0	0.0	0.0	0.0
	Gewe	*Geranium weedeli*	Indeseable	1.9	1.7	1.7	2.7	0.0	0.0	0.0	0.0
	Hyta	*Hypochoeris taraxacoides*	Poco Deseable	2.9	5.2	3.4	3.6	2.0	1.0	1.9	1.9
	Plase	*Plantago sericeae*	Poco Deseable	2.9	3.5	3.4	2.7	4.0	3.0	2.9	2.8
	Platu	*Plantago tubulosa*	Poco Deseable	1.9	0.9	0.0	0.0	3.0	1.0	0.0	0.0
	Wenu	*Werneria nubigena*	Poco Deseable	5.8	5.2	5.0	3.6	6.0	5.1	3.8	3.8
Pseudo gramínea	Caec	*Carex ecuadorica*	Poco Deseable	7.7	5.2	3.4	4.5	6.0	5.1	3.8	3.8
	Elal	*Eleocharis albibracteata*	Poco Deseable	0.0	0.0	0.8	0.9	0.0	0.0	0.0	0.0
	Sciri	*Scirpus rigidus*	Deseable	5.8	6.1	5.9	6.3	7.0	8.1	7.6	6.6
	Siju	*Sisyrinchium junceum*	Poco Deseable	0.0	0.9	1.7	2.7	1.0	1.0	1.0	0.9
	Xysu	*Xyris subulata*	Deseable	1.9	1.7	1.7	0.9	1.0	1.0	1.0	0.9
Índices de Vegetación		Diversidad Shannon – Wiener		3.58	3.75	3.76	3.76	3.34	3.20	3.19	3.18
		Dominancia Gramíneas		0.54	0.54	0.54	0.50	0.55	0.55	0.58	0.58

On the other hand, rest is beneficial for the persistence and advantages of perennial gramineae to cope with all grazing restrictions (De Villalobos&Zalba, 2010). This situation enhances the vitality of the grass by thickening the tree crown on the soil and stimulating the production of plant seeds, which is crucial for promoting grassland recovery. Our findings are consistent with the report by Lezama et al. (2014), who found that continuous grazing led to a decrease in grassland proportion and the emergence of other plant functional groups represented by perennial and one-year species, such as herbs, pseudograsses, and shrubs. Zhang et al. (2017) determined that in resting fields, the proportion of grass increases, or in some cases remains unchanged.

Rest is beneficial for the further growth and development of vegetation, as evidenced by the high vegetation coverage rate. Vegetation coverage can protect soil from erosion, prevent nutrient loss, and improve the accumulation of organic matter (Liu&Shao, 2014). In this regard, Yayneshet et al. (2009) agree that greater increase in vegetation cover in resting pastures is attributed to the elimination of defoliation by livestock and the intact growth of plant communities for several years.

Due to the protection of grazing, the grassland shows good recovery potential. Rest enables vegetation to accumulate more biomass as part of its life cycle, which also facilitates the release and deposition of senescent substances in the soil, improving the level of cover layer (Liu&Shao, 2014). In this regard, Rong et al. (2014) agreed to recommend resting as a way to enhance ecosystem capacity, thereby generating more biomass and cover to update nutrient cycling and improve organic matter storage.

There is sufficient evidence to indicate the relationship between the soil protection level generated by vegetation and the hydrological function of grasslands (Jia et al., 2006). The vegetation on the soil plays a protective role in erosion, evaporation, and radiation. Due to promoting frequent removal of plant biomass, continuous grazing reduces vegetation coverage by limiting the storage and availability of water in the soil (Shi et al., 2013). On the other hand, the increased vegetation coverage due to rest improves the hydrological function of grasslands evaluated by soil infiltration rate and humidity. These results are similar to those obtained by Jia et al. (2006) and Shi et al. (2013), who demonstrated the decisive role of vegetation cover in restoring grassland hydrological function, where resting fields have sufficient soil moisture.

Over time, uncontrolled grazing reduces the value of components defining grassland ecological conditions, such as the number of species required for cattle, feed value, vegetation coverage, and the vitality of the key plant tall Fescue (Call&Roundy, 1991). On the contrary, rest enhances the value of ecological conditions to minimize the negative effects of grazing, such as defoliation, trampling, and physical disturbance to the soil (Yates et al., 2000), which increases the vitality of the key local plant tall Fescue and benefits the quantity of feed species required for cattle.

Our results will indicate that under stable vegetation conditions, the ecological status of grasslands can undergo reversible changes, as only the evacuation of animals can improve the condition of grasslands (Distel, 2013). At the beginning of the experiment, the grassland ecosystem may not have exceeded the critical threshold for irreversible grazing degradation. If so, just resting may not be enough to transition to the ideal state (Distel, 2013). Although the ecological condition remained normal after three years of rest, the improvement trend is quite obvious, which makes us infer that it is possible to improve the ecological condition of the grassland by extending the rest time. Our results are consistent with Yayneshet et al. (2009) and Weinert&Williams (2018), who reported that through the implementation of rest, grassland conditions improved in the medium term.

5 Conclusion

This study indicates that grassland grazing management is a factor that leads to short-term changes in vegetation structure, hydrological function, and ecological conditions. Continuous grazing has led to a significant decrease in vegetation coverage, thereby harmfully altering the indicators that determine the hydrological function and ecological status of grasslands. Rest enables natural restoration of grassland ecosystems, therefore, compared to uncontrolled grazing, the impact of rest on all assessed attributes is always advantageous. Our results indicate that more specific studies need to be designed to evaluate the impact of increased vegetation biomass on bearing capacity, conduct different grazing experiments to evaluate the response of grasslands under different management schemes, and ultimately conduct long-term studies to evaluate the impact of rest on the quality of herbivorous nutrition and animal nutrition.

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Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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