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Effects of Grazing in Natural Regeneration at Tree Line region in Lamtang National Park, Nepal

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Abstract

Livestock grazing in the form of transhumance activities is common practices in the mountainous region of Nepal. Such grazing activities can impact on natural regeneration of tree species. Being grazing practices as major occupation, not enough research has been carried out on impacts of grazing and management of grazing area in Nepal. This study was conducted with an aim to assess the effects of grazing in natural regeneration in tree line region of Lamtang National Park (LNP). Transect method was carried out for study after identifying different grazing intensities in field. Data were analyzed to study phyto-sociological characteristic (species richness, Shannon-Wiener Diversity Index and density) of vegetation, health of seeding, soil characteristic and disturbance index in grazing region. ANOVA, Kruskal-Wallis test and linear regression were performed to elucidate the relationship between vegetation attributes and grazing intensities. The relationship was further analyzed using post-hoc test i.e., Tukey post hoc test for normal data and Dunn test for skewed data. The result shows that *Abies spectabilis* has set the upper altitudinal limit in all sampling areas i.e., ungrazed, least grazed and moderately grazed area at 3803 m, 3827 m and 3860 m respectively. Moderately grazed area had the higher tree richness, diversity, density and natural regeneration. The density of seedlings was also higher in moderately grazed area. Only 18.3% of seedlings were found to be healthy in moderately grazed area which is comparatively lower than in ungrazed area (69.8%). Soil parameters such as Bulk density, Moisture content, pH and Nitrogen showed the variation with grazing intensities. The linear regression analysis showed the insignificant decrease ($p=0.18$) and insignificant increase ($p=0.08$) in seedling density with increase in disturbance score in ungrazed and least grazed area respectively. However, for the moderately grazed area, there is significant increase ($p=0.02$) in seedling density with increase in disturbance score. As moderate forest grazing helps to maintain the natural regeneration, grazing management is recommended in the higher Himalayan region.

Keywords: *Regression analysis, seedling sapling ratio, seedling density, seedling health, soil parameters,*

Introduction

Livestock grazing in mountainous rangeland is one of the common practices around the world. In Nepal, animal husbandry is one of the major occupations in mountain areas where, livestock are being grazed for forage and fodder in forest and rangeland (Gurung et al., 2009). Livestock in high hills and mountains are mostly managed under a migratory system in Nepal known as transhumance. Transhumance is a form of livestock production in which the livestock are moved between fixed points to utilize seasonal availability of grazing resources over a year (Nyssen et al. 2009). There is definite spatio-temporal movement of herds throughout the year. During the movement, around four months between June to September, grazing takes place in periphery of treeline region during summer season (Aryal et al., 2014). In high mountainous regions, the alpine treeline ecotone is an important altitudinal boundary of vegetation where grazing practices are regular. There is abrupt decline in vegetation where the forest meets grassland/rangeland creating unique ecosystem. The grazing practices along with climate stress have major effect in such area.

The chronological disturbance has exhibited the reducing diversity level due to grazing for long period of time (Hofgaard, 1997). Higher grazing intensity can have significant effects on herbaceous species biomass, grass composition, number of seedlings, age category, basal cover, and woody plant diversity. It can bring out undesirable change on the condition of rangeland (Mathewos et al., 2023). For the maintenance and preservation of biodiversity, natural regeneration is important. It's a process of reproducing new plants in the community that determines the composition of the species and its stability in the near future (Napit, 2015). Natural regeneration of tree depends upon exclusive interaction of biotic and abiotic factors in specific environment. The major biotic factors are: accessibility of seeds, interactions between different plant species, the frequency of herbivore seed predators, pathogenic microbes, intra- and interspecific competition, structure of vegetation etc. (Gordon & Rice, 2000).

Grazing is an important biotic factor that poses a serious impact to biodiversity and regeneration via different ways i.e. defoliation through eating, physical damage such as animal trampling, soil compaction and mineralization by deposition of urine and faeces (Lempesi et al., 2017). Seed survival is greatly impacted by the trampling of seedlings and soil compaction by animal activity and seed predation is considered as the limitation to regeneration and migration (Cairns & Moen, 2004). But, if grazing is controlled, it can be sustainable. It enhances the tree growth by reducing the biomass of grasses and sedges (Gratzer et al., 1999). Natural regeneration can be promoted at moderate level of grazing intensity (Darabant et al., 2007). Despite of having large grazing area in mountain region and grazing practices as major occupation, a limited research has been carried out on impacts of grazing and management of grazing area in Nepal. LNP is one of the areas where transhumance is practiced for long period of time as has more than 300 sq. km of rangeland area for grazing. Thus, this study aims to explore the impacts of grazing in regeneration in Lamtang region.

Materials and Methods

Study area

Lamtang National Park lies in Central Himalayan region comprising core area of 1,710 sq. km and 420 sq. km of buffer zone in Nuwakot, Rasuwa, and Sindhupalchowk district. It is distinguished as having high climatic and altitudinal variations (alt. 792 m –7,245 m asl). Seasonal climate is dominated by the southerly monsoon, which occurs between June and September. Plant communities extend from upper tropical forest of *Shorea robusta* to hill forest of *Pinus roxburghii*, Rhododendrons and *Alnus nepalensis,* temperate oak forests and northern alpine scrub. The Park consists of more than 1,000 plant species of which 21 species are endemic. The faunal species found in the park includes 46 species of mammalia, 345 species of birds, 11 species of herpetofauna, 30 species of fishes, 10 species of spiders, 58 species of butterflies (DNPWC, 2023). The local population of the park is culturally and ethnically heterogeneous. The three main ethnic groups are the Tamang, Yolmo, and Bhotia. Animal husbandry is the major source of livelihood followed by agriculture and tourism. Herders in Lamtang have a trans-human mode of lifestyle.

The study was carried out in Vrana, tree line ecotone situated between Lauribinayak and Cholangpati near to Chandanbari Cheese Factory at (28.094609°, 85.376936°) in LNP (Figure 1). The numbers of livestock have increased in recent years due to establishment of the Chandanbari Cheese Factory. It exists between the altitudes of 3771 m to 3860 m and consists undulated rocky terrain mostly covered with algae and mosses. The site is dominated by *A. spectabilis* with rhododendron under the canopy and few herbs and mosses. The particular place was chosen considering the seasonal pattern of grazing history.

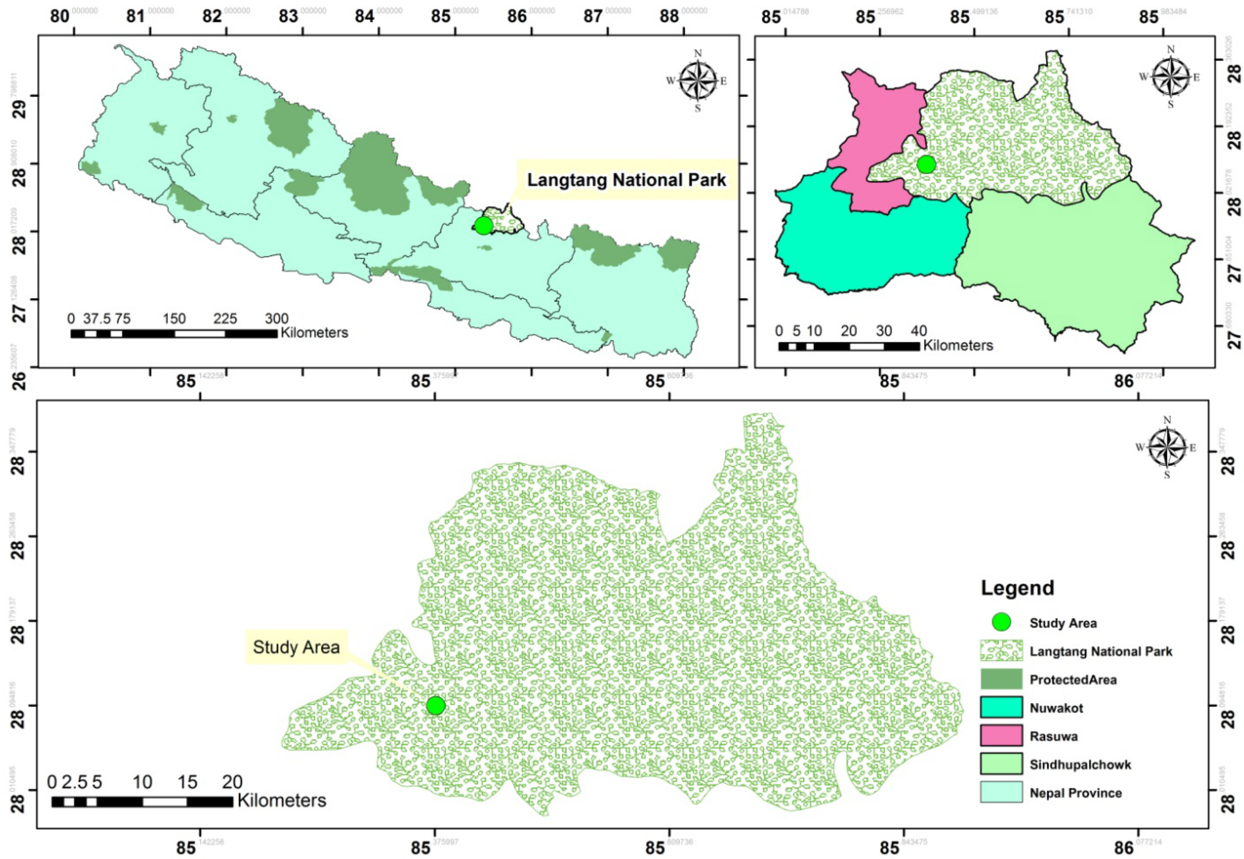

Figure 1: Map of Study Area

Field Methods

The study area (Vrana), was selected considering the seasonal pattern of grazing history where every year grazing takes place for 5-6 months. Based on grazing intensity as defined by Kikoti et al., 2015 (Table 1), moderately grazed area, least grazed area and ungrazed area were selected where detailed investigation on the natural regeneration of trees was conducted.

Table 1: Grazing intensity classes and their interpretation

S.N.	Grazing Intensity Class	Interpretation
1.	0	No grazing
2.	1	1%- 20% (least grazed)
3.	2	21%- 60% (moderately grazed)
4.	3	61%- 100% (heavily grazed)

The study was designed following Potthoff, 2009. In north to south direction, two transects of 170 m in length and 10 m in width were set to record the characteristics of tree and sapling layers on the three grazing intensities. Transects were spaced to encompass the upper altitudinal limits of the tree species. The upper altitudinal limits of the tree were the 1st point in the study. The transects were then divided into 17 segments of 10 m in length, each thus creating, 10 m x 10 m plots. All trees, irrespective of size, were identified, counted, and their heights (height of tallest stem per individual) were estimated in 10 m x 10 m plots. Each 10 m x 10 m plot was divided into four equal plots, and in each plot, a 1 m x 1 m quadrat was placed where regenerants were studied.

The regeneration status was determined following Shankar (2001) that classifies regeneration as: i) 'good', if seedling > sapling > adult; ii) 'fair', if seedling or sapling > adult; iii) 'poor', if species survives in only sapling stage but not as seedling; iv) 'none', if a species is an absence in both in sapling and seedling stage; v) 'new', if a species has no adult but only sapling or seedling or both.

The soil sample was collected from the depth of 0-10 cm, 10-20 cm and 20-30 cm and made a composite sample for lab analysis. As described in Marques et al., 2001, by measuring percentage of trampling area and dung number in each 10mx10m quadrat, the degree of trampling and dung count were assessed.

Lab analysis

Soil samples analysis was carried out following the standard method described in Trivedi & Goel (2015). (Table 2).

Table 2: Soil Sample Analysis Method

S.N.	Parameters	Unit	Standard Method
1.	pH	-	pH meter YSI 1200
2.	Bulk Density	g/cm^3	Oven dry
3.	Organic matter	%	Walkley- Black titration
4.	Nitrogen	%	Kjeldahl digestion method
5.	Phosphorus	Kg/ha	Bray II (SS1 UV 2101 Spectrophotometer)
6.	Potassium	Kg/ha	Normal ammonium acetate method

Data analysis

At growth stage with <2 cm diameter were classified as tree seedling, plants with diameter 2-4 cm were classified as saplings and at growth stage with 4-9 cm diameter were classified as poles (Miligo et al., 2011).

Health of the seedlings was categorized to one of the three categories i.e. perfect health (buds exists and are healthy), semi-healthy (no terminal bud, lateral buds), browsed (missing most lateral buds and terminal buds) as described by Pour et al., 2012.

By measuring the percentage of trampling (in area) and dung (in area) in each 10 m x 10 m quadrat, the degree of trampling and dung count were assessed (Marques et al., 2001). The disturbance index value was calculated according to the class of trampling percentage (%) (Table 3). Similarly, disturbance index for dung was calculated according to the count of dung percentage (%) (Table 4). Finally, the disturbance score considered here as the total score for the grazing intensity class, disturbance index of dung count and disturbance index of trampling.

Different phyto-sociological parameters such as richness, diversity and density were calculated for tree species. The parameter i.e. density (Zobel et al. (1987) was also calculated for seedlings, saplings and poles. Species diversity was calculated by using Shannon Weiner Index (H) (Shannon & Weiner, 1963) and species richness by counting the total number of species per sampling unit under a given grazing intensity (Pielou, 1966).

Table 3: Disturbance index for trampling

S.N.	Trampling (%)	Disturbance index value	Disturbance intensity
1.	0	0	Low
2.	0-30	1	Medium
3.	>30	2	High

Table 4: Disturbance index for dung count

S.N.	Dung count (%)	Disturbance index value	Disturbance intensity
1.	0	0	Low
2.	0-5	1	Medium
3.	>5	2	High

Before analysis of data, normality of data was studied through Shapiro-Wilk test. One- way ANOVA was carried out for normal data and Kruskal test for non- normal data to elucidate the relationship between vegetation attributes and grazing intensities. The relationship was further analyzed using post- hoc test i.e. Tukey post hoc test for normal data and Dunn test for skewed data. Linear regression was carried out to establish the relationship between disturbance score and seedling density across different grazing intensities.

Results and Discussion

Grazing plays an important role in the establishment of seedlings. Livestock returns to the tree line area during the mid-summer monsoon season. This cycle repeats every year and regulates the forest regeneration since the browsed area lacks healthy seedlings. Wildlife species like Musk deer had little impact on the study area as no major signs of other wildlife were witnessed. All together two tree species (*Abies spectabilis* and *Betula utilis*) were observed in ungrazed area and least grazed area. In moderately grazed area, additional one species, *Sorbus microphylla* was spotted. *A. spectabilis* was most commonly occurring plant species in entire studied area. Considering the tree line, in ungrazed area, the upper altitudinal limit of *A. spectabilis* was 3803 m whereas in least grazed and moderately grazed areas, it was 3827 m and 3860 m respectively.

Vegetation characteristics

The calculated diversity index of 2.43 shows the highest diversity for moderately grazed area followed by ungrazed area with 1.87, which is slightly higher to that of least grazed area with diversity index of 1.83. There was a significant difference (H = 6.3764, df = 2, p-value = 0.04125) found across different grazing intensities. The post- hoc Dunn test indicated that the difference was observed between the least and moderately grazed area (p=0.025). No significant difference was observed between least grazed and ungrazed (p=0.961) area as well as between the moderately grazed and ungrazed area (p=0.083).

A. spectabilis, B. utilis and *S. microphylla* were the tree species found in the study area and the upper altitudinal limit was created by *A. spectabilis* in all the study areas. The observed variation in altitudinal limit resembles the conceptual model proposed by Cairns & Moen (2004) which mentioned the low upslope migration potential of tree line in low animal activity and highest migration potential of the tree line at intermediate levels of animal activity. According to local herders, moderately grazed area was found to be grazed from longer period of time with various intensities and intervals compared to that of least grazed and ungrazed area. Higher species richness in moderately grazed area here, accepted the theory of intermediate-disturbance hypothesis.

Similarly, in many cases grazing alters the competitive hierarchy and supports the species abundance of those that might otherwise be rare or excluded (Callaway, 1997). Comparable result was observed in Manaslu Conservation Area by Thapa et al. (2016) in which result agrees with intermediate-disturbance hypothesis. In case of diversity index, ungrazed and least grazed area were recognized for lower diversity. A similar finding reported by De Gabriel et al. (2011) who found lower diversity at the site where sheep grazing was absent. There is little impact on the most unproductive communities but the larger impact on the productive grassland of Scotland after the cessation of deer grazing (Virtanen et al., 2002). The transport of seeds induced by grazing might influence diversity (Olff & Ritchie, 1998). The slightly higher diversity in the ungrazed area was due to the higher evenness despite being the same species richness.

The tree density was found to be higher in moderately grazed area followed by least grazed area and ungrazed area (Figure 2). Kruskal test showed significant difference (H = 7.9021, df = 2, p-value = 0.01923) across different grazing intensities. The post-hoc Dunn test indicated the difference between least and moderately grazed area (p=0.0363) as well as between moderately grazed and ungrazed area (p=0.148). No difference was observed between least grazed and ungrazed area (p=1).

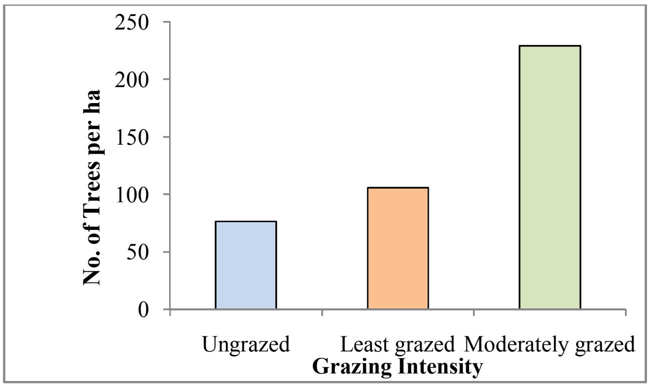

Figure 2: Tree density per hectare area

The density of trees has changes with respect to grazing intensity. Grazing and trampling support to create micro-habitat for the tree species reducing the density of herbs, ultimately reducing the competition for water and nutrients (Castro et al., 1999). As well as, grazing intensity seems to depend on herbivore density, i.e., only medium grazing pressure allowed massive regeneration (Chauchard et al., 2007). Though the species richness of ungrazed and least grazed area were similar, but the abundance of *B. utilis* were higher in the ungrazed area; which was the north-facing tree line (windward side in Nepal). The similar observation was made by Shrestha et al. (2007) where the dominance of *B. utilis* was observed in trans-Himalayan north-facing tree line.

Soil Parameters

Among the seven soil parameters, only four parameters (Bulk density, Moisture content, pH and Nitrogen) showed the variation in different grazing intensities (Table 5). Intensity of grazing significantly alters the soil attributes. Forest area, compared to other lands, has loose soil due to the decomposition of fallen litter. However, presence of animals brings about the changes in soil compactness. The increasing bulk density from ungrazed to moderately grazed area may have attributed by grazing. Brady & Weil (2008) and Warren et al. (1986) also reported that grazing significantly altered the bulk density. Similarly, moisture content also increases with grazing. Increased livestock deposition enhances organic matter which, in turn increases the decomposition rate of soil microbes making soil more porous and hence increases the water holding capacity (De Gryze et al., 2006). In addition, litter content also acts as mulch by both adding organic matter through decomposition and shading soil from direct exposure of solar radiation. The shades reduce the loss of moisture through evaporation (Jeddi & Chaieb, 2010).

The soil was acidic across different grazing intensities which might be due to the active rain that leached out basic cations making the soil acidic (Brady & Weil, 2008). On the other hand, the acidic soil in the least grazed area may be due to the acids released by the decomposition of organic residues i.e. litter from forest vegetation (KC et al., 2013). Similar finding was reported by Yates et al. (2000) who found the alteration of pH due to grazing. In contrast to the finding, the study carried out by Milchunas et al. (1988) and Akhzari et al. (2015) reported no relation exist between grazing and pH.

Grazing either increase or decrease organic matter or have no effect on it (Zarekia et al., 2012). High amount of organic matter in ungrazed area might be due to the decomposition of plant residues which in turn favors high microbial activity (Jeddi & Chaieb, 2010). The increase in organic matter in moderately grazed area was attributed to the deposition of dung and urine by livestock. Organic matter returns back to the soil in the form of manure after been grazed. Also, the movement of livestock results in the better mixing of the plant remains. Al-Seekh et al. (2009) reported no any significant difference in the amount of organic matter with different 30 grazing intensities. However, Pappas & Koukoura (2013) reported medium grazing intensity to enhance organic matter at higher altitude. Nitrogen shows similar trend with organic matter since large amount of nitrogen is bound to organic matter (Kalu et al., 2015). In case of the phosphorus, excreta enhance its content and there is more mobility of phosphorus due to trampling (Zarekia et al., 2012). Baron et al. (2001) also observed the positive change in phosphorus due to grazing. Although, availability of nutrients in moderately grazed and ungrazed areas has increased, the decrease in potassium may be due to increased nutrient consumption by plants (Xu et al., 2016).

Table 5: Impacts of grazing on various soil parameters with mean ± SD

Grazing Intensity	BD (g/cm3)	MC (%)	pH	OM (%)	N (%)	P (Kg/ha)	K (Kg/ha)
Ungrazed	0.52 ± 0.05	29.38 ± 2.64	5.29 ± 0.49	8.74 ± 0.69	0.40 ± 0.09	30.68 ± 7.11	170.06 ± 70.77
Least grazed	0.67 ± 0.07	38.44 ± 5.57	4.73 ± 0.13	8.29 ± 1.41	0.32 ± 0.09	24.04 ± 2.94	256.08 ± 159.12
Moderately grazed	0.82 ± 0.08	40.77 ± 2.63	4.38 ± 0.58	8.82 ± 0.97	0.47 ± 0.08	34.00 ± 13.56	149.52 ± 3 1.43
p- value	6*10-5***	0.001**	0.02*	0.4	0.03**	0.03	0.01
Test	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	Kruskal	Kruskal

Health of the seedlings

The number of perfect health seedlings was greater in the ungrazed area where no seedlings were found browsed. Whereas, a large number of browsed seedlings observed in moderately grazed area followed by least grazed area. 69.8% of the seedlings observed to be perfect health, 30.2% to be semi-healthy and absence of browsed seedlings in ungrazed area. Whereas, 51.4% of seedlings were found to be perfect health, 28.8% of the seedlings were found to be semi-healthy and 19.8% were found to be deformed in least grazed area. Similarly, 18.3% of seedlings were found to be healthy in moderately grazed area which is comparatively low, 34.8% were found to be semi-healthy and 46.9% were found to be deformed.

The browsed seedlings were the clear indication of the effect in their health. Seedlings were usually grazed and deformed in the moderately grazed area, which does not guarantee for the future of forest if this continues for the long term (Pour et al., 2012). If the process of being eaten repeats every time, this might affect forest regeneration. The browsing observed was expected to affect the growth forms of tree species through the browsing of both terminal and lateral twigs and buds which reduces the growth rate of seedling. The reduction in the growth rate of seedling will have more influence from browsing since it takes a longer time to escape the effect (Mcevoy et al., 2006). In general, complete exclusion of forest from grazing would only facilitate the quick recovery of degraded forests (Teich et al., 2005). In the study carried out by Wilson (1990) and Harrington (1976) in which the effect of goat browsing was considered. Wilson (1990) reported random browsing by goats eventually killed it whereas Harrington (1976) reported though the random browsing was repeated it mostly influenced the twigs not the leaves, only a few plants were killed. If the browsing continues, it not only endangers the sustainability of forest ecosystems, but also increases the challenges for sustainable forest management.

Effects of grazing on regeneration

A. spectabilis was dominant plant species in entire studied area representing good regeneration status in all three grazing zones. There was no regeneration of *S. microphylla,* where *B. utilis* were present only in ungrazed and moderately grazed area (Table 6).

With different grazing intensities, the natural tree species regeneration changes. The density of regeneration showed the maximum density of seedlings in moderately grazed area followed by least grazed area and ungrazed area (Figure 3). The dominance of seedlings is obvious where there were large groups of trees along with dense branches and foliage that reaches the ground. The majority of seedlings were established under this condition since foliage protects the seeds from being grazed. Similar findings were observed by Milchunas et al. (1988). Newton et al. (2013) result supported this fact that the fallen branches or trunks protect the young ones from disturbance such as grazing within the protective microsites.

Table 6: Regeneration Status of Vegetation

Grazing Area	Seedling	Sapling	Poles	Result
For *A. spectabilis*				
ungrazed area	66	10	8	Seedling>sapling>pole (good)
Least-grazed area	169	25	2	Seedling>sapling>pole (good)
Moderately-grazed area	156	10	9	Seedling>sapling>pole (good)
For *B. utilis*				
ungrazed area	15	1	2	Seedling>sapling<pole
Least-grazed area	0	0	0	Absent (none)
Moderately-grazed area	21	1	1	Seedling>sapling=pole
Total				
ungrazed area	81	11	10	Seedling>sapling>pole (good)
Least-grazed area	169	25	2	Seedling>sapling>pole (good)
Moderately-grazed area	177	11	10	Seedling>sapling>pole (good)
Note: The number of seedling, sapling and poles in the table represent the total number in transect. i.e. number per 34 sq. m.				

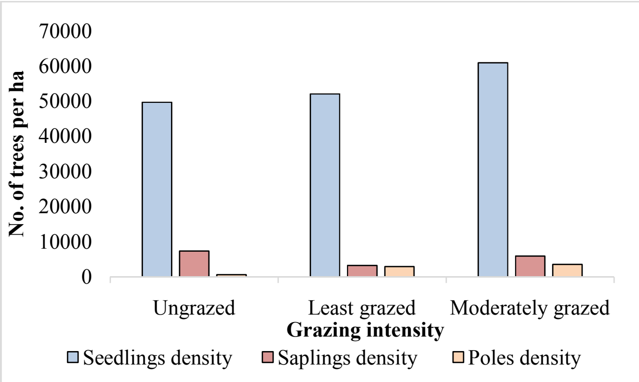

Figure 3: Density of regeneration

The finding shows that moderate level of grazing had been facilitating to sustain the species of *A. spectabilis.* The result supported Buffum et al. (2009) who found that moderate intensities of forest grazing can be sustainable as long as the grazing intensities are controlled since a moderate level of grazing facilitates the area without a negative impact on natural regeneration. Similarly, a mechanism like grazing, trampling, and dung promotes the area. The fleece supports the area through nitrogen fixation whereas grazing and trampling facilitate to create micro-habitat for the vegetation. Also, livestock grazing helps in the canopy opening, facilitating the gap opportunistic plant species (Pekin et al., 2014).

Apart from *A. spectabilis*, remaining two species *S. microphylla* and *B. utilis* grazing may not have supports its growth. Although grazing supports the dispersal of seeds, it prevents seedlings from developing into saplings (Wassie et al., 2009). A similar observation was made by Mcevoy et al. (2006) where greater numbers of saplings were found in ungrazed forest than in grazed forest of NW Spain. Smit et al. (2006) reported the destructions of newly grown seedlings, which in turn influences the lower density of saplings in the Swiss Jura Mountains. This result is similar in case of *B. utilis*. Although, a good number of seeding was observed, very few have reached the sapling phase. Kikoti et al. (2015) found the lower density of seedlings in a moderately grazed area compared to that of ungrazed and least grazed area. This shows restricted seedlings recruitment probably due to the effect of grazing, leading to the negative impacts on natural regeneration pattern in the montane forests of northern slopes of Mount Kilimanjaro. The long period of grazing and change in microclimate by grazing limits the existence of some common as well as rare species (Song et al., 2020). This may have resulted in absence of regeneration in *S. microphylla.*

The high proportion of poles in moderately grazed area was an indication that after the new recruitment reached to the certain height, it escapes the effect of grazing thus would not affect their growth (Mcevoy et al., 2006). The smaller number of poles individuals compared to the seedlings and saplings were may be due to the extraction of fuelwood and fodder by local people. In a similar study, a lower proportion of seedlings conversion to poles was reported by Baboo et al. (2017) since the fuelwood and fodder extraction by local people was a major problem. Similarly, in the study carried out by Sagar & Singh (2004), lower proportion of seedlings conversion to poles was accounted for anthropogenic pressures. They also reported the lower recruitment of poles and accounted for the influence to be illegal harvest of poles, density-dependent mortality of seedlings and grazing.

Relationship between seedling density with disturbance score

The linear regression analysis showed the insignificant decrease in seedling density with increase in disturbance score in ungrazed area (Figure 3a). However, the result was opposite (Figure 3c) in case of moderately grazed area. There is a significant increase in seedling density with increase in disturbance score. Least grazed area also showed insignificant increase in seedling density with increased disturbance (Figure 3b). Dung count, trampling and grazing had resulted in an increase in seedling density following the grazing intensity (Pollock et al., 2013). Grazing supports the establishment of the seedlings providing the microsites which otherwise might not be able to compete with established vegetation (Shaw et al., 2010). It mentions structural heterogeneity to be the lowest at heavily or ungrazed area and to be the highest structural heterogeneity at moderate levels of grazing (Augustine et al., 2012). Also, the variation in the spatial distribution of the quantity of dung influences in the community composition (Valdés-Correcher et al., 2019). However, the variation must be large enough. The apparent decrease in disturbance might be the reason for the ungrazed area and least grazed area not to be significant (Valdés-Correcher et al., 2019).

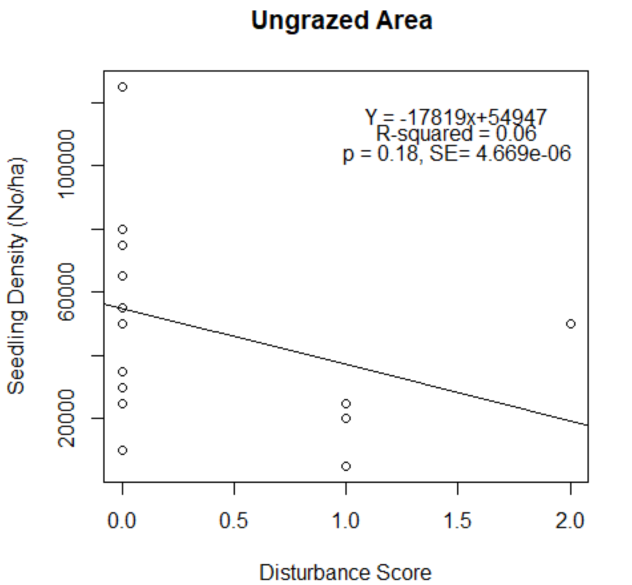

Figure 4a: Linear regression between seedling density and disturbance score (ungrazed area)

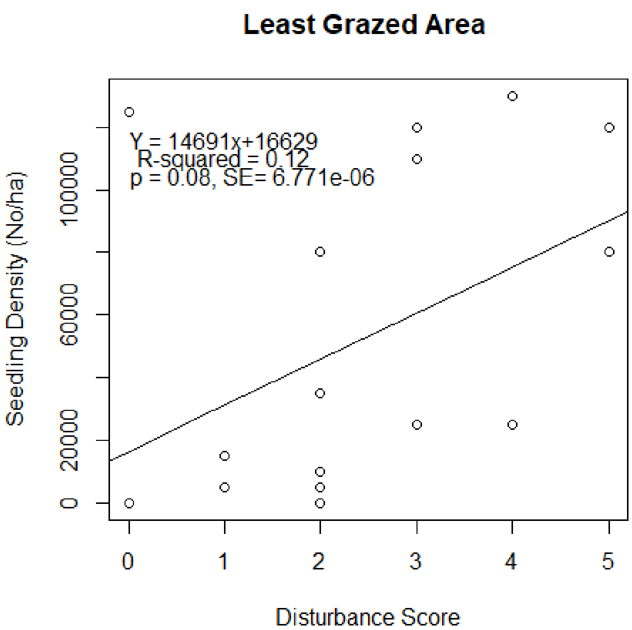

Figure 4b: Linear regression between seedling density and disturbance score (least grazed area)

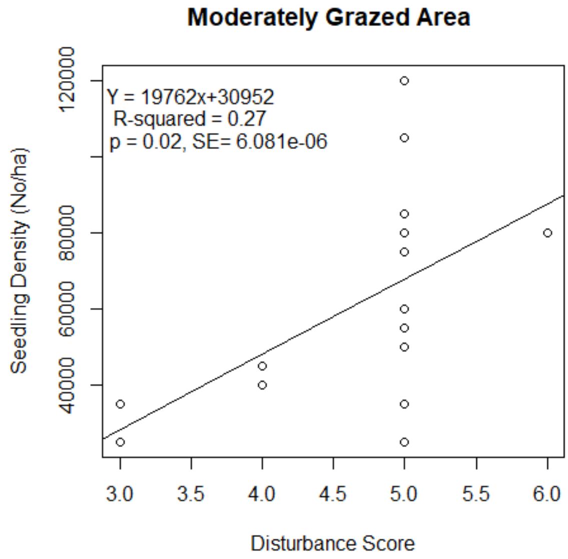

Figure 4c: Linear regression between seedling density and disturbance score (moderately grazed area)

Although these results suggest that grazing has importance in shaping the community composition of plants species, there are also other unexplored factors such as fire effect, below ground competition of seeds, canopy cover, micro climate, climate change etc. that need to be researched along with grazing. This study provides a general idea of effect of grazing in limited area of high-altitude region. However, for more generalization of the result, this type of study needs to be conducted in a large scale.

Conclusion

Grazing was found as an important factor for natural regeneration. Effects of grazing in natural regeneration were studied through relationship between seedling density and disturbance score of grazing. The natural regeneration was higher in moderately grazed area. The species richness, diversity, and density of trees were also found to be higher in moderately disturbed forest. Further, soil characteristics also got altered by grazing. Forest grazing can be sustainable as long as grazing intensity does not impact its natural community composition. Moderate level of grazing facilitates the regeneration of *A. spectabilis* but not all the species respond similarly to the disturbance. Hence, different level of grazing intensities needs to be plan for areas with different species composition.

Since livestock herding is the major occupation in high altitude areas of Lamtang National Park, the findings of the present study carried are expected to influence the decisions regarding grazing management and serve as a baseline for long term monitoring of treeline ecology.

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Data availability statement

Our research is primary research. Most of the data collected and used in analysis are available with us in excel file. We have not put them in any internet platform yet. But we are able to provide dataset on request.