



## **Determination of browse production, browsing capacity and implications on bush encroachment and livestock feed resources in rangelands of Southern Ethiopia**

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**Key words:** Leaf biomass; canopy volume; browsing height, Goat, Kudu

### **Abstract**

Rangelands covering about 61 to 67% of the total land area of Ethiopia have herbaceous and woody vegetation layers. Browse production, browsing capacity and implications on bush encroachment and livestock feed resources have not been investigated in the Borana rangelands of Ethiopia in contrast to the many studies of biomass production and grazing capacity of the herbaceous layer. Thus, the objective of this research was to determine browse production and browsing capacity and the implications on bush encroachment and livestock feed. Eighty-six rangeland sites were identified to collect data on woody vegetation species, density, plant height, heights of maximum canopy diameters, heights of first leaves or potential leaf bearing stems, and maximum and minimum canopy diameters using plots of 20 m x 20 m or 10 m x 10 m at each site. The browse production and browsing capacity were analysed using biomass estimation from canopy volume model and browsing capacity equation. The mean browse production at peak of the growing season varied from 516 to 14,914 kg ha<sup>-1</sup> with a browsing capacity ranging from 8.27 ha and 0.21 ha BU<sup>-1</sup> (browser unit), respectively. The mean woody vegetation density varied between 783 to 8,800 plants ha<sup>-1</sup> while the mean evapotranspiration tree equivalent (ETTE), which is a measure of the status of a woody community in terms of potential moisture use, ranged from 2,421 to 58,951 with a high degree of bush encroachment with increasing ETTE. The woody plants that contributed more to browse production and bush encroachment were mainly the acacia species. While the increase in the woody vegetation results in higher browse biomass production, the high degree of bush encroachment, which lowers the production of the herbaceous layer affects the grazers. Thus, appropriate bush management needs to be implemented while taking into consideration the feed needs of the browsing and grazing animals

### **Introduction**

Rangelands, which are usually defined as uncultivated land that will provide the necessities of life for domestic and wild grazing and browsing animals, include grasslands, savannas, shrublands, woodlands, wetlands, and deserts. They are among the most important terrestrial ecosystems in the world, occupying 54% of the world's terrestrial area (ILRI et al. 2021). Globally, rangelands contribute about 70% and over

95% of the feed needs of domestic and wild ruminants, respectively (Holechek et al. 2014). Likewise, Ethiopia has a vast area of rangelands, 61-67% of the total land area, which is primarily used for extensive livestock production and the rangelands in Ethiopia are also rich in biodiversity, mineral, water, energy resources, cultural heritages, untapped tourist attractions, and socio-anthropological values (Getachew et al. 2024). The vegetation structure of the Ethiopian rangelands includes 50% woody-browse plants; 35% open grasslands, and 15% open bush-grassland savanna. These rangelands particularly in southern Ethiopia are experiencing increasing bush (Ibrahim, 2019). Bush encroachment, which is the spread of woody vegetation into grass-dominated areas, has led to changes in the livestock species the pastoralists keep. The number of browsing animals like camels and goat is increasing while the number of grazers like cattle and sheep is decreasing (Hassan et al. 2023). Compared to the research undertaken to determine the production and grazing capacity of the herbaceous layer, the studies undertaken to determine browse production and browsing capacity is scant. Thus, the objective of this study was to determine browse production, browsing capacity and implications of bush encroachment and on livestock feed resources.

### Methods

As the Borana rangeland is very vast, the woody vegetation assessment was undertaken following a road transect sampling technique. The effect of the roadside was avoided by moving more than 50 meter from the edge of the road. Data was collected from 86 rangeland sites throughout the three sub-basins of the Borana zone, and the woody vegetation data was collected in most instances at an interval of 10-20 km. The woody vegetation was assessed at the peak of the growing season using a plot of 20 m x 20 m or 10 m x 10 m at each of the sites, and all live woody plants within the 400 or 200 m<sup>2</sup> plots were counted by species to determine density.

All live plants rooted in the plot were counted, and multi-stemmed plants were counted as a single plant. The measurement consisted of the following: (i) maximum height, (ii) height where the maximum canopy diameter occurs, (iii) height of first leaves or potential leaf-bearing stems, (iv) maximum canopy diameter (2 dimensions), and (v) base diameter of the foliage at the height of the first leaves (2 dimensions). The canopy volume of each woody plant was calculated using the Biomass Estimates from Canopy Volume model (Smit, 1989,1996). The number of evapotranspiration tree equivalent (ETTE) ha<sup>-1</sup> was subsequently calculated from the leaf volume estimates (1 ETTE mean leaf volume of a single-stemmed tree with a height of 1.5m = 500 cm<sup>3</sup> leaf volume, Smit, 1989). The ETTE is a measure of the status of a woody community in terms of potential moisture use. To measure the heights and diameters of the woody plants, two calibrated aluminium poles of 2 and 4m were used. Dimensions of those woody plants too tall to measure with poles were taken using a dimension meter (Smit 1996). Estimates of the browsing capacity for the most important woody plants based on leaf DM were made from the leaf DM estimate, using the formula proposed by Smit (1999).

$$\text{ha BU}^{-1} = \frac{\text{DM} \times p \times f}{r}$$

BU = Browser unit defined as the metabolic equivalent of an average kudu with a mass of 140 kg (Dekker 1997)

DM = Total leaf DM yield ha<sup>-1</sup>

p = Phenology (0= no leaves, 1.0 = peak biomass)

f = Utilization factor

r = Daily browse DM required per BU (3.5 kg day<sup>-1</sup>)

The estimated leaf phenology for the various plant groups can theoretically vary from 100% (p= 1) in the case of evergreen to 0% (p=0.0) during winter for the early deciduous group. However, there are indications that browsers may utilize the tips of shoots and twigs even if no leaves are present. Accordingly, the allocated leaf phenological values ranged from 0.2 (lowest leaf yield) to 1 (maximum leaf yield).

Furthermore, each woody plant was assigned a leaf carriage score to determine leaf phenology: where, 0= no leaves, 1= 1-10% of full leaf carriage, 2= 11-40 % of the leaf carriage, 3= 41-70% of the full leaf carriage, 4 = 71-100% of full leaf carriage (Smit 1994). A utilization factor ranging from 0.1 to 0.3 depending on the palatability of each of the woody species as perceived by the pastoralists was used in this study.

## Results

The woody vegetation density (plants ha<sup>-1</sup>) ranged from 700 to 11,200 with an average range of 783 to 8,800 while the ETTE ha<sup>-1</sup> varied from 2,271 to 73,425 with an average value ranging from 2,421 to 58,951. The results clearly indicate a high degree of bush encroachment in the sampled sites. The higher the ETTE value, the higher the degree of bush encroachment. The browse production (kg ha<sup>-1</sup>) at the peak of the growing season varied from 503 to 22,766 with an average value ranging from 516 to 14,914. The browsing capacity varied between 8.47 ha BU<sup>-1</sup> and 0.003 ha BU<sup>-1</sup> with a mean range of 8.27 to 0.21 BU ha<sup>-1</sup>. Generally, the results indicate that with an increase in the amount of browse production, the land size required to support a browser unit for a year will decline. Removing the unpalatable woody plants, the browse production and the associated browsing capacity will decline. Acacia species are the most important woody species contributing to browse production and bush encroachment, and they varied from site to site.

## Discussion/ Conclusions/Implications

Bush encroachment, one of the major problems in Sub-Saharan Africa, leads to an increase in plant cover by woody species and a decrease in grass cover, grass production, and the grazing capacity of the rangelands which corresponds with the findings of previous studies in the study area (e.g., Ayana, 2007; Chaun et al. 2018). The availability of forage/browse that can support the different livestock species is the most important factor influencing habitat selection by large herbivores (McNaughton, 1987). However, there is variability from locality to locality in terms of browse production and browsing capacities (Jarman and Sinclair, 1979). Different bush control techniques are applied by government and non-government organizations in the area. The pastoral communities own both grazers and browsers, and the number of browsers has increased in recent years. While the increase in the woody vegetation results in higher browse biomass production, the high degree of bush encroachment lowers the production of the herbaceous layer, and decreases forage for grazers. The study implies that appropriate bush management needs to be implemented while taking into consideration feed needs of the browser and grazers animals.

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## **Pasture land use and planning: An example from the Mogod soum of Bulgan province, Mongolia**

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**Key words:** Pasture use; pasture land planning; pasture carrying capacity; pure pasture; pasture irrigation; affected pasture land; soum, bag

### **Abstract**

The pressure on soil and vegetation of pastureland has drastically increased in recent years and the tendency to desertification has increased due to overgrazing and non-rotational grazing. We aimed to evaluate the possibility of developing a pastureland use plan based on suitability assessment and citizens' survey of pasture use and its future, as well as an assessment of the current condition of the pastureland, in Mogod soum<sup>6</sup> of Bulgan province. Our study shows that as of 2020, Mogod soum contains a total of 243,789 ha of pastureland that includes 1,073 camps. Camp registrations show that these comprise 366 camps used for winter, 402 for spring, 272 for winter-spring, 28 for summer-autumn, 2 for autumn and 3 all-season camps. Some 28,500 ha of pastureland (11.7 per cent of the total) is affected or changed of which 68.7 % is affected moderately and 31.3% strongly; rodents are widespread on 6,499 ha, overlapping both moderately and strongly affected pastures. Over the total soum pasture area the total number of livestock exceeds the carrying capacity by 3.7 times, indicating the dire need to take immediate actions to improve pasturelands in the region. It is planned to use 19.8% of the total pasturelands in summer and autumn, 18.6% in spring, 51.3% in winter and spring and 10.3% in winter under a rotational use scheme, with livestock numbers reduced to the appropriate seasonal carrying capacity. For improvement of affected areas, we plan 3.6% for fallowing, 7.8% for rotational use only, 2.6% for rodent control, and 88.6% for seasonal rotation without exceeding the carrying capacity.

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<sup>6</sup> A small administrative unit within a province, further divided in 'bag', the smallest administrative unit.

### **Introduction**

Since the last century, land that was used solely for agricultural purposes is now being used for various purposes. In recent years the pressure on the soil and vegetation of agricultural land has increased dramatically due to overgrazing on pastureland, with negative effects of grazing including pastureland degradation and increased tendency for desertification.

Therefore, we need a plan that balances the two factors: (i) increase the economic benefits of using the land and livelihood improvements of the residents and (ii) encouraging appropriate use of land based on the natural resources and conditions of the area and their relationships. Right balance aimed at maintaining the sustainability will ensure creation of wealth in the area and better life quality for the residents.

### **Methods**

The current situation of the Bulgan province of the Mogod soum's pasture land was determined, and pasture land plan was developed based on the land suitability assessment and local citizens' opinion. We used the methods outlined in the Methodical Instructions for Monitoring the State and Quality of Pastureland (MoCU, Order 34 of 2019) as well as reports related to Mogod soum's pastureland use, unified land fund, land cadastral database, surface water inventory, pasture condition and its state quality control and photo monitoring activities.

### **Results**

The "2020 report of the United Land Fund" shows that Mogod soum has pasture land totalling more than 237,000ha, which is 97.3% of the total agricultural land. The report further indicates that 35.6% or 84,533.4 hectares of pasture lands belong to summer-autumn pastures, and 64.4% or 152,750.5 hectares of pasture lands belong to winter-spring pastures as shown in Figure1. There is a difference of 6,037.7 hectares compared to the result of the study of the unified land fund report. In this study, pasture area was calculated as pure pasture used by livestock.

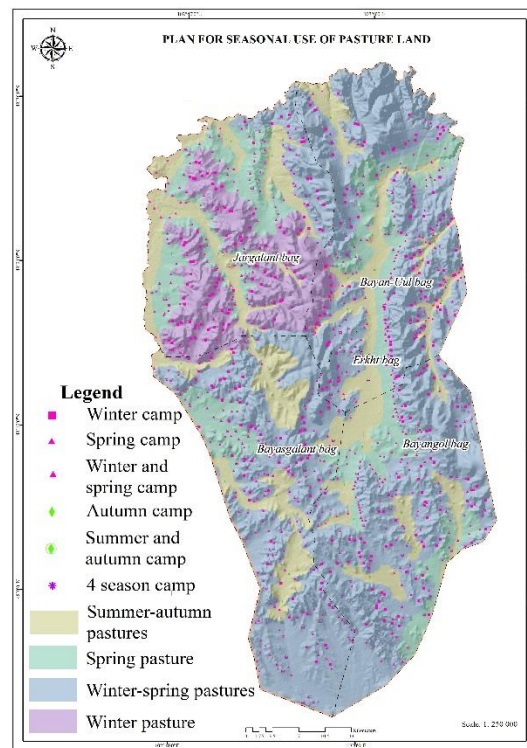


Figure 1. Plan for seasonal use of pasture land

Pasture lands affected by use: Based on the analysis and quality comparison of the Mogod soum's pasture land pasture quality inspection reports, as well as the survey of soum citizen opinions, 28,500 hectares of pasture land were affected (11.4 percent of the total pasture land). The degradation of pastureland in Mogod soum is related to the rapid growth of animal husbandry and non-rotational use throughout a year. About 68.7% or 19,558.2 ha of changed or affected pasturelands are moderately grazed, and 31.3% or 8,899.0 ha are strongly grazed and rodents are spread in 6,498.5 ha of pastures, which coincides with moderately and strongly grazed pastures as shown in Figure 2.

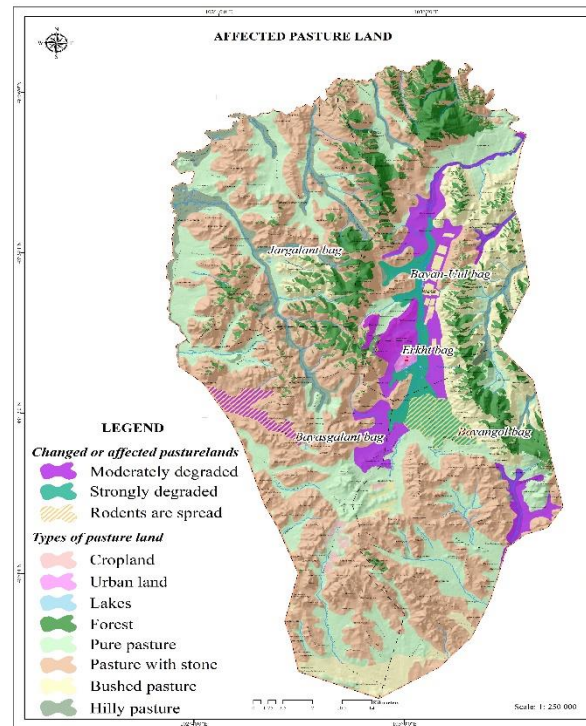


Figure 2. Affected pasture land

Carrying capacity of pasture in Mogod soum: The carrying capacity of pasture was calculated by the “Integrated method for calculating the carrying capacity of livestock pastures”, which was approved in 2019, and is being implemented nationwide.

The total number of livestock is compared with the total soum pasture area, the carrying capacity of the pasture is exceeded 3.7 times the maximum limit. Taking further actions to improve pasture lands in Mogod soum is necessary.

Pasture land improvement, and conservation plan: As the number of livestock increases in Mogod soum, traditional types of grazing pastures are lost, and the number of winter and spring shelters increase dramatically.

Therefore, based on the suitability assessment of the pastures and citizens’ opinion and features of the surface landscape, seasonal pastures are planned for 4-year use, that allows the use of 19.8% of total pasture lands in summer and autumn for all 4 years, 18.6% in spring only in year 1 and 3, 51.3% in winter and spring in year 2 and 4, and 10.3% in winter for year 1 and 3. In this way, it is possible to use the pasture with seasonal rotation and reduce the carrying load of the pasture to maintain the appropriate number of livestock for that season.

Plan for affected pastures: In accordance with regeneration capacity of pastures, measures like summer and autumn pastures to be alternated between months and seasons, rest periods, taking improvement measures, and fighting rodents in the pastures are planned.

Table 1. Modified Pasture

№	Measures to be taken on the pasture	Area, ha	Normal condition	Affected degree		
				Overgrazed strongly	Overgrazed moderately	
1	Rest pasture	11,659.7		8,899	2,760.7	
2	Rotational timely grazing	16,797.5				16,797.5
3	Seasonal rotation according to carrying capacity	221,369.3	221,369.3			
4	Destroy pests and rodents	6,498.4		3,737.7	2,760.7	

It is planned to take measures to improve pastures covering all soum pasture land. For rest pastures 3.6%, for replacement pastures 7.8%, for rodent control 2.6%, and for seasonal rotational pastures 88.6% of total grazing measures are planned as shown in Table 1.

Measures for seasonal rotation according to carrying capacity: This measure is planned for 221,369.3 hectares of pastures in normal condition. To sustainably use and protect pasture land for a long period of time, it is necessary to herd animals suitable for the carrying capacity of the pasture, and to use it with seasonal rotation and sell the surplus animals to the market. Thus, it is advisable to introduce to the herders the right practices and methods to use pastures in groups under contract and ensure its proper practices. The following actions are required:

- Adjusting the number of animals to the carrying capacity of the pasture;
- Optimizing the herd structure;
- Separating long legged animals and male animals into remote herds;
- Improving the quality of animals and intensifying the sale of male and female animals.

Rest measures: Rest pastures are planned 2,556.5 hectares of spring pastures in the area of Suuj Ukhaa, which is a strongly overgrazed pasture, 6,342.5 ha of pastures along the Khulj, which is summer and autumn pasture, and 2,760.7 hectares of pastures in Ikh Khujirt and Suuj khundii are moderately overgrazed spring pastures.

It is necessary to calculate the load to be 10 percent lower than the possible bearing capacity, and it is necessary to make a long migration to rest when visiting the pasture. When making a long distance migration, we planned to move along the Bumbat river and Rashaantyn khoshuu.

Alternative use measures: Total of 1,679,765 hectares of moderately degraded pastures, so these pastures will be released from use during the growing season until the vegetation cover recovers. The load should be calculated at less than 10% of the potential capacity and should be used during the growing season of plants for 2 years in a row.

Measures to control pasture pests and rodents: Total of 6,498.5 hectares of pastures are planned to be controlled by voles. During the implementation of the measure, it is planned to use many methods, such as poison spraying, biological control, fumigation, and water pouring, based on the characteristics and capabilities of the ammunition.

## Discussion

By implementing the above plan for 5-7 years, the following results are expected:

1. Herders in Mogod soum will adapt the rotational use of pastureland.
2. By letting 3.6% of pasture rest as per plan, and 7.8% used by rotation, and fight against rodents on 2.6% of the pasture, the floral cover of the pasture will be rehabilitated causing more types of plants to emerge, thus the pasture will be restored naturally.

3. At the end of the implementation period, a study on affected pastureland conditions and quality shall be conducted and compared to the data before the implementation of the plan.
4. AS a result of implementation of the plan, severely degraded pasture conditions should be restored bringing its level up to medium level of degradation.
5. Implementing the plan requires close cooperation of the local government and herders to reduce the number and types of animals and keep it suitable to the carrying capacity of the pastureland.

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