ENCYCLOPAEDIA OF HIMALAYAS

EDITED BY

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Western Himalayas

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PREFACE

World renowned 'Himalayas' are not only a great mountain range having the privilege Highest Peaks in the world.

A barrier to snowy winds from Mongolia and middle Asia to the south Asia, many great rivers originate from the Himalayas. A legendary range in Ancient Indian literature—many myths, realities and maxims are associated with Himalayas.

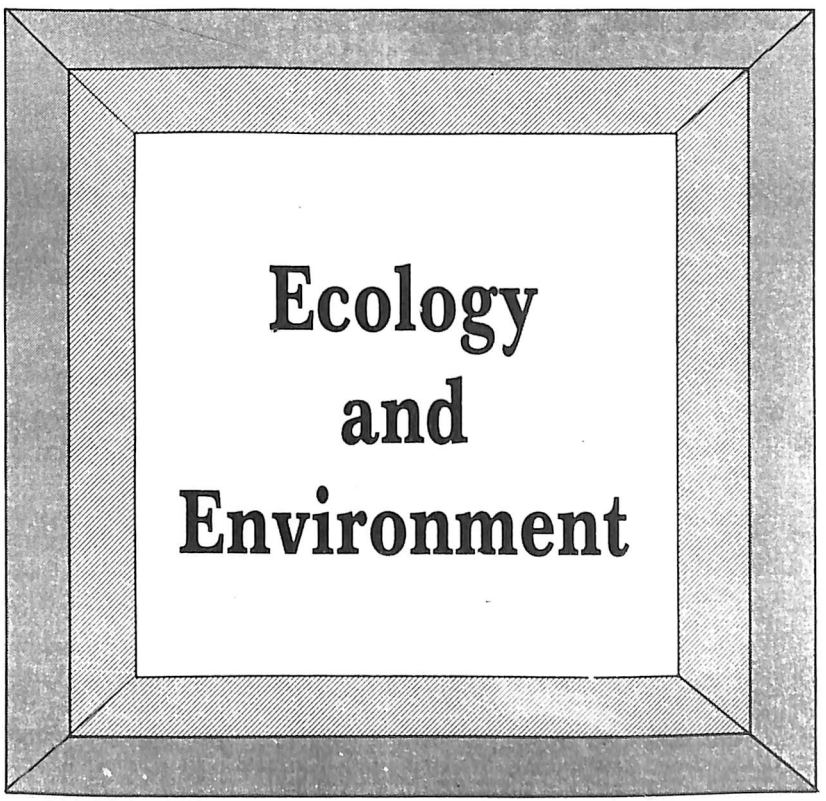
The present work in four volumes is encyclopaedic in nature which elaborately discusses all the major aspects viz. Geography, Economy, Fauna and Flora, Tourism, species, history and culture etc. Based on authoritative information, the four volumes, are grouped as follows:

- Understanding Himalayas
- Eastern Himalayas
- Eastern Himalayas
- Central Himalayas
- Western Himalayas.

I am thankful to all the learned authors and scientists whose writings are cited or substantially made use of in the present encyclopaedia. I am also grateful to Mr. J. L. Kumar, Managing Director, Anmol Publications Pvt. Ltd., New Delhi for undertaking the publication of this project.

This work will prove a standard reference for the students, scholars and teachers in the field of geography, economics, environment, and sociology of the Himalayan regions.

—Kadambari Sharma


Ecology
and
Environment

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Ecology and Environment

Kashmir Himalaya

The overall energy budget for Yusmarg meadowlands indicated that 38 and 42% of total net production disappeared, respectively from fenced and grazed sites, and rest of the energy remained locked in the vegetational compartments. The highest energy conserving efficiency values were obtained in summer in fenced and 8.23% in grazed meadowland. On the while, the energy conserving efficiency value in fenced region was about six times greater than that in grazed meadowland. Within an ecosystem the first step in the process of energy flow is the capture of solar energy by the green plants. The productivity potential of different ecosystems, depends much on the efficiency with which the vegetation accumulates this energy in the net primary production which forms the ultimate source of the caloric needs of all the animals and men.

The energy conserving efficiency of primary producers is the ration of output to input in an unit area over a definite period. The studies presently made are based on fenced and grazed meadowlands, both situated at Yusmarg.

The energy conserving efficiency has been calculated by the following formula:

Energy conserving efficiency (%) = Energy captured/m^2/t/½ Solar radiation/m^2/t x 100 t = period of solar radiation and energy captured. The net dry matter production as obtained in different months were converted into energy values by multiplying them with the caloric values of the plant material.

In this investigation only half of the solar radiation was used for calculating efficiency because 50% of the total radiation is not usable by plants in photosynthesis; Terrien *et al.*, 1957; Bray, 1961. Hence efficiency of energy captured is defined here as the per cent of half the total solar radiation reflected in the total net production.

The green shoot captures the energy but the material so synthesized is distributed to other parts as well. Therefore, in order to get the energy conserving efficiency of dominant, other species and entire community, for fenced and grazed sites, the total plant biomass was taken into consideration on unit area and time basis.

The data reveal that the average caloric values were 3251.13 to 3876.69 cal g^{-1} dry weight in the fenced and 3155 to 3717.74 cal g^{-1} dry weight in herbage of the grazed meadow. Ovington *et al.* have reported the caloric values for maize field, prairie, savannah, oakwood ecosystems in Minnesota as 4525, 4127, 4817, and 4865 cal g-1 dry

weight, respectively. Thus, the energy content of the present herbage seems to be lower. It is observed that the intensity of grazing influences the pattern of energy flow through the vegetation components of fenced and grazed sites. Out of the total energy fixed 42.91 Kcal m^{-2} day^{-1} is transferred to underground system in the fenced; while in grazed, 5.11 Kcal m^{-2} day^{-1} is accumulated in the aboveground parts and 5.67 Kcal m^{-2} day^{-1} in the fenced, and 0.66 and 3.88 Kcal m^{-2} day^{-1} in the grazed meadow. Singh *et al.* have summarized data from a number of grazing lands to elucidate the energy flow pattern in the vegetation compartments. Accordingly a tropical canopical grazing land ecosystem captures energy at a mean rate of 12.38 ±6.93 Kcal m^{-2} day^{-1}. Minimum energy fixation occurs in strongly water limited grazing lands of semiarid zone. During the rainy season, the energy capture efficiency is usually several times higher as compared to the post-monsoon season. Billore has noted that the values are affected with the intensity of grazing.

In the present study, the energy conserving efficiency of the total community was maximum in summer. The values were less when estimated annually. The efficiency of gross production in perennial herbaceous forest communities ranges between 2.0% and 3.5%. These figures would be doubted if the incident amount of photosynthetically active radiation is taken as a basis. In the tropical grass-lands, some earlier authors have determined the highest energy conserving efficiency values in February in completely protected and in open grazed and in August in semi-protected grasslands. On the whole, the energy conserving efficiency value for completely protected site was about four times greater than in semi-protected and open grazed site. In the present study the energy conserving efficiency value in fenced was also about six times greater than that in grazed meadowland.

The overall results indicated that 31 and 42% of the total net production disappeared respectively form fenced and grazed sites and in the rest energy remains locked in the vegetational compartments. Such studies were also conducted by Billore for the grazing lands of Ujjain; the values were more or less same, but some differences occurred which may be due to their different edapho-climatic and floristic influences.

Agriculture

This section deals with problems of development and management of sub-montane grass lands comprising the region of Siwaliks and the out hill ranges of Western Himalaya. It excludes the temperate and alpine grasslands. The upper limit of the tropical and subtropical regions is 2,100 m alt. which also is the transition zone from dry and moist Sal type and *Pinus roxburohii* type of forest to the oak-conifer forest zone. The altitudinal distribution of the various forest types, their ecological succession and parallelism with grassland has been discussed elsewhere.

Ecology of grass covers: The submontane region has been included under the agricultural zone 1, the main grass cover being *Themeda-Arundinella* type. Gupta and Nanda described the ecological succession of the Western Himalaya and the synecology of the grass covers for the Garhwal region. The topography is essentially mountaineous. Anthropogenic influence in this zone due to dense settlements and migratory animal population from

high altitudes during winters is very strong. cutting, grazing and lopping of the forest vegetation have marked effect on the land-scape. The general tendency is to clear forests and *benap* lands for agriculture. Field terraces are made even on steep slopes. Irrigated terraces are only maintained properly with soil and water conservation measures while the unirrigated terraces where occasional cultivation is practised are at low level of management. Steep slopes provide condition for high degree of natural erosion and are the areas primarily for perennial vegetation mainly for grasslands. Plants like *Carissa spinarum, Euphorbia royleana, Cotinus Coggyria,* all immune to grazing are commonly seen. Grasslands throughout the country, except for the alpine altitudes and the extreme arid area are considered to be biotic or bio-odaphic in origin and show various stages of ecological succession depending on the nature of the soil and the extent of grazing and other biotic factor. No where, .these represent the "climatic climax" in the Clementsian terminology

Climate: The climate of the region is characteristic of the tropical deciduous forest and forest of *Pinus roxburghii.* It is usually warm with heavy precipitation during the monsoon. Physiologically dry months range between 3-4 in the Siwaliks to 1-2 in the outer hills. Accordingly to Labroue *et al* these represent the typical bixeric bioclimates of the northwest India.

Soils: The tract falling in the Siwalik zone belongs to the quarternary era where the rocks are loose and soft in nature. Recent excavations have revealed that the area was once the bed of vast ocean in which were found Elephants, Rhinoceros, etc. The outer hills are comparatively of late age and were formed during the Tertiary era. These consist of mainly quartzites, phyllites, limestone and shales. There is wide range of soils in the sub-montane and foot hills commonly classified as "Bhabar and Terai soils" and "brown forest soils".

Botancial composition and human influences: The botanical composition of the grasslands for the Garhwal region and the Western Himalaya has been described elsewhere. *Heteropogaon* type is associated with the submontane zone subjected to cutting and burning of slash. This species contributes to 63 per cent of the botanical composition under protection. Associated grasses are *Bothriochloa pertusa, Arundinella setosa* and *Chrysopogon fulvus,* etc. It occurs as low as Terai region where tall grasses are subjected to burning. In as Terai region where tall grasses are subjected to burning. In the Bhabar region its forms a distinct community with *Eulaliopsis binata.* The *Arundinella* type is primarily associated with the *Pinus roxburghii* type of forest where it contributes to nearly 66 per cent to the botanical composition under protection. Other main grasses associated are *Arundinella setosa, A. nepalensis, Heteropogon contortus* and *Chrysopogon fulvus.* The *Cenchrus ciliaris* type is primarily restricted to alluvial flats in Jammu region where it contributes to 62 per cent of the botanical composition. The associated grasses are *Cynodon dactylon, Bothriochloa pertusa, Saccharum spontaneum, Imperata cylindrica* and *Sporobolus marginatus.* The most important species for development and management of grasslands in the region is *Cenchrus ciliaris* in the Siwalik zone upto 500 m and *Chrysopogon fulvus* on the Siwaliks and the outer hill ranges upto 2,100 m. However, *Eulaliopsis binata* is another grass for the region with is

primarily the source for fibre and paperpulp. The Chir pine needles and the heavy forest litter in the dry zone is very much susceptible to fires which are both accidental and international. Chir pine needle being acidic in nature also do not allow luxuriant growth of grass cover. Otherwise a thick grass cover is evident both in the dry and moist sal type of forests. In addition to unrestricted grazing, this factor modifies the ecological succession to a great extent.

Problems of development and management: Main problems of development have been classified as below:

1. *Protection*: Where human settlements have agriculture as the main profession land holdings are very small and the people do not allot land for fodder. There is a high incidence of continuous grazing with the result that the perennial grasses have almost disappeared giving place to tough obnoxious weeds such as *Lantana camara, Euphorbia royleana,* etc. Soil erosion has taken place from community lands which are "Gochar lands," being everybody's property is no man's responsibility. Protection improvement and management of such lands is the major problem.
2. *High cost of development:* The grasslands with protection tend to progressive ecological succession where shrubs and weeds invade the area quickly. Weed eradication along with soil conservation measures is costly and uneconomic with the present standards of secondary productivity.
3. *People's participation in socialistic and democratic management of community lands:* In almost all the areas, deferred grazing is an immediate necessity till the grasslands improve with the desired species. Curtailment in grazing rights is very much desirable. This could be achieved only with the active participation of the villagers, since reduction in cattle population is more a social and politico-religious problem.

Socio-economic surveys in the submontane zone have shown that on an average a household keeps 6 animals comprising of 1 buffalo, 2 bullocks and 3 cows. Goats and sheep are dominant in the inner hill ranges. Only about 25 per cent of the cows are in milk and rest are dry. The milk yield is poor. On an average, a cow and a buffalo give 112 and 734 litres of milk respectively during their location period. The animals are kept for dung which is the primary source for manure in the fields are hardly any farmer supplement the FYM with fertilizers. Animal husbandry occupies the leisure time of the farmer, particularly the house wife. Forest grazing is the rule. Tree leaves are extensively lopped for cattle feeding during winter and summer, independently or mixed with agricultural residues or hay conserved on tree tops from the forest or community lands. Only buffaloes are stallfed while dry cows and other animals are left for grazing on hill slopes. Cultivation of forages such as Berseem, Leucerne, Oats, etc. is seldom practised. Though a perfect health cover is essential for higher production, these facilities are seldom available in remote areas. The animals have long generation interval with high age at maturity. In addition to grazing by sedentarised population, these regions support heavy migratory livestock population of *Gujjars, Jads, Bhotias* and *Marchayas*. The forest vegetation, in addition to grazing, is disturbed for temporary hutments made by these nomads.

4. *Proper grazing system:* Deferred-cum-rotational grazing can not be introduced and successfully carried on even for a year. The leguminous component in the existing grazing systems is confined only to low quality annuals. People do not take to stall-feeding except for heavy milch animals like buffalo.

5. *Poor site conditions:* Steep slopes, shallow soil depth, bouldry and gravelly nature of the land, intense soil erosion and low fertility status of the soils in addition to their acidic nature, pose additional problems of development. Indiscriminate cutting of trees and their lopping destroy the normal protective and productive forests of the nearby region. Therefore, these lands require sylvi-pastoral management for fuel and fodder species. The fires, cause dessication of soils, kill the microflora and hamper progressive ecological succession.

Development and management practises for increased production: Scope for the development of community lands for fodder production is tremendous to improve the economy of the hill region. Besides fuel and fodder, these can sustain several plant based small-scale industries such as fibre and paper pulp, sericulture, soft wood, resins, turpentines, drugs and aromatic oils, etc. Following steps are suggested for increased production and exploitation of the potential.

1. *Enclosure including Soil and Water Conservation Measures:* Stone wall fencing has proved to be most economical and effective for enclosing grasslands from overgrazing in some parts of Western Himalaya though 4 strand barbed wire with angle iron posts have proved most economical in arid zone. Experience has shown that stone wall fencing is economical if the lead for stone is within a range of 30 m otherwise angle iron posts with barbed wire is most economical since the material could be recycled and need very little maintenance cost. Live hedges with *Agave americana* and *Euphorbia caducifolia* could also be tried. Experiments conducted at Bhatta indicate that the above ground production of grasses increased from 21 q/ha to 87 q/ha simply by enclosure for 2-3 years.

Contour trenching at 8m interval with vegetative bunds of hybrid napier recorded a maximum yield of 119 quintals/ha of natural grass and 42 quintals/ha of napier. The vegetative cover showed marked change under closure. *Heteropogon contortus* was gradually replaced by *Arundinella* cover during the period of 5 years. Thus there was a progressive succession in the range.

2. *Brush control:* Closure for grazing initiates progressive ecological succession and thus rapid growth of brush and weeds. The common shrubs recorded are *Lantana camara, Euphorbia royleana, Berberis asiatica, Rhus cotinus, Carissa spinarum* which compete for soil moisture and nutrients. Area occupied by *Lantana camara* only is over 30 per cent in some cases. The number of bushes varies from 21,000 per ha in protected grasslands to 12,500 in unprotected lands. It has been shown that grass production is higher in brush free grassland against grassland with brush indicating adverse influences on grass production. Broadcast of Picloram @ 15 kg/ha around bushes or 0.4 per cent stump application of 2-4 5T ester or amine has proved effective to control bushes. Our studies have shown that spray of Tordon K21 on cut stumps with coarse nozzle completely removes *Lantana* bushes.

3. *Fertilization and manuring :* Studies conducted at Indian Grassland & Fodder Research Institute, Jhansi and Central Arid Zone Research Institute, Jodhpur have shown increase in forage production with the addition of fertilizers, similar results are recorded for the sub-montane regions also. Soil Survey of hilly grasslands have shown nitrogen deficient soils while phosphate and potash very with soil and rainfall. At places due to high rainfall soil becomes acidic and P_2O_5 gets locked in unavailable form. Application of phosphorus is recorded as less beneficial as compared to nitrogen. Erasmus recorded that 20 kg of nitrogen per ha gave maximum yields over control in *Chrysopogon-Heteropogon* grasslands with a net profit of Rs.92 per ha. For acidic soils addition of 3-5 m tonnes of lime per ha is necessary. Higher doses of nitrogen may be applied only keeping possibilities of ultimate benefits. Studies in Himachal Pradesh have shown that with 100 kg Nitrogen/ha two cuttings gave significantly higher yields.

4. *Choice of species and method of seeding hill grasslands*: Since sylvi-pastoral management for such lands gives the maximum benefit mixtures of grasses legume herbage and trees are recommended. Success will depend upon several factors such as choice of species, soil working, time of sowing and seeding, seed rate and method of sowing. The list of species for the Siwalik region and the outer hill ranges is as below:

Siwalik hill range upto 1,500 m

Grasses:Bothriochloa pertusa, B.intermédia, Cynodon dactylon, Cenchrus ciliaris, Chrysopogon fulvus, Eulaliopsis binata, Heteropogon contortus.

Legumes: Atylosia scarabaeoides, Alysicarpus vaginalis, Clitoria ternatea, Phaseolus trilobus, Stylosanthes humilis, Medicago denticulata, Dolichos axillaris.

Trees: Dalbregia sissoo, Acacia, catechu, A. arabica, Albizzia lebbek, Anogeissus latifolia, Bauhinia purpurea, Bombax ceiba, Bridelia retusa, Cassia fistula, Cordia obliqua, Ehretia laevis, Emblica officinalis, Ficus sp., Garuga pinnata, Grewia oppositifolia, Holoptelea integrifolia, Litsaea polyantha, Mallotus phillipensis, Melia azadirach, Milletia auriculata, Morus alba, Ougenia oojenensis, Putranjiva roxburghii, Terminalia tomentosa, Trema orientalis, Zizyphus Xylopyra.

Outer hill ranges above 1500 m

Grasses: Arundinella nepalensis, Bromus intermis, Chrysopogon fulvus, Dichanthium annulatum, Themeda quadrivalvis.

Legumes: Desmodium uncinatum, Glycine javanica, Lespedeza stenocarpa, Lotus corniculatus, Medicage sativa, Trifolum pratense, T.repens, Trigonella sp. and Vicia villosa.

Trees: Acer villosum, Bauhinia retusa, Cedrela serrata, Celtis caucasica, Cornus macrophylla, Euonymus hamiltonianus, Ficus roxburghii, Grewic opposiiifilia, Morus serrata, Olea cuspidata, Popaius ciliata, Pyrus pashia, Quercus incana, O.dilztata, Robinia pseudoacacia, spermadictyon suaveolens, Ulmus wallichiana.

The grasses forming the major plant community of natural pastures are relatively low yielders as compared to the exotics. *Setaria Sphacelata* gave 91 percent higher yield than

Pennisetum orientale, the highest yielder among the local grasses. A number of exotic grasses are under trial at Dehradun. Artificial seeding, reseeding and plantation through rooted slips and tussocks are often necessary for quick regeneration of superior grasses; with only exclosure the process of recoupment is slow.

Grasses: For effective seeding light soil working is important along the contours though conventional method of sowing is limited to broadcast or line sowing. For the montano region line sowing on steep slopes is not easily accomplished; broadcasting grass seeds with light soil working with a rake ensures successful germination. 1-2 cm seeding depth has given optimum germination. Seed rate is 3-4 kg/ha. Use of unhusked seeds give higher percentage germination over husked seeds. Though premonsoon sowing gives assured establishment of grasses, strong competition from surrounding herbage during monsoon adversely effects forage production. Dry sowing of course has an added significance regarding time availability for such operations. Planting of rooted slips/tussocks give high and early production, thus compensating for the money and time spent in preparation of slips in nursery. As grass seeds are light and small they need be mixed with moist sand and $CuSO_4$ so that they are not blown away with the wind of eaten away by insects, white ants and rodents.

Grass seeds when sown in nursery beds during March-April, will give rooted slips for planting in July. Planting of rooted slips at 1x1 m distance with first effective rains ensures quick establishment. After spot planting, a saucer of 20 cm diameter is made around the plants. From soil conservation view point also this method has an added advantage since the soil is not disturbed over a vast area.

Legumes on community lands are relatively low and of poor quality. It has been estimated that protein content of grasslands could be raised from 2% in pure grass cover to 6% in herbage mixed with legumes. Among the various exotic legumes introduction of *Stylosanthes humilis, Glycine javanica, Dolichos axillaris, Centrosema pubescens and Desmodium* sp. have shown good prospects. Use of clovers, *Medicago and Melilotus* has proved successful in some parts of the submontane regions. Broadcast sowing of pelleted scarified legume seeds before monsoon have been recorded to have excellent establishment. The technique of soil working, broadcast sowing, spot sowing for legumes, are similar to those given for grasses. In order to have successful growth establishment, legume seedlings raised in polythene bags were found to be effective in this region since competition surrounding herbage is minimised. Grasses and legumes are raised side by side in alternate strips or spots in such a way that 25 per cent of the area is covered with legumes in mixture with grasses. Since the strata of the rock dip vertically and give rise to frequent changes in soil types, from shallow stony to deep clay soil, mixed pastures are successful. Utilization of field bunds in the Siwalik and terrace risers in outer hill ranges for forage- Singh and Srivastava recorded planting of *Eulaliopsis binata* alongwith *Eucalyptus hybrid* on field bund in the Siwaliks as most economic. A total income from and *Eucalyptus* on bund is estimated at Rs. 1,350/-per ha. important grass used is *Saccharum munja*. Some of the grasses and legumes recommended on different habitats are:

Contour& field bunds	*Terrace faces*
Pennisetum purpureum	*Phalaris truberosa*
Eulaliopsis binata	*Paspalum dilatum*
Setaria sphacelata	*Eragrostis curvala*
Chrysopogon fulvus	*Chrysopogon fulvus*
Dichanthium annulatum	*Themeda anathera*
Chloris gyana	*Arundinella nepalensis*
Cenchrus ciliaris	*Apluda mutica.*
Erianthus munja	

Yield potential is recorded in table below :

Yielf od somē indigenous grasses on terrace faces At Bhatta

1.	*Chrysopogon fulvus*	—	7.5 tonnes/ha
2.	*Themeda losea*	—	7.6 tonnes/ha
3.	*Pennisetum orientale*	—	16.5 tonnes/ha
4.	*Arundinella nepalensis*	—	13.0 tonnes/ha
5.	*Apluda mutica*	—	13.8 tonnes/ha

Other potential sites which could lbe used for forage production are; (i) Grassed waterways, (ii) river and stream banks and (iii)landslide and cut road faces where only cutting of grasses could be allowed after establishment. Dalal et al recorded under conditions of Dehradun. *Panicum repens* to be the best for grass waterways. However, mixture with legumes like *stylosanthes gracilis* and *Calpogonum orthocarpum* would improve the forage quality. Kudzu provides a good cover on a variety of habitats which can be used as forage when cut. Average yields are 18725, 17725, 13150, 11200 and 4900 kg/ha on pond spillway, nursery, class III, land, roadside slips and torrent banks respectively in the region of Dehradun.

Grazing Management: Scarcity of fodder during the rainy season is hardly felt though the quality of forage is poor. Five cattle units per ha has been estimated to be sufficient under ordinary circumstances otherwise eight cattle units can safely be grazed. Peculiar socio-economic conditions prevailing in the region make it difficult to control or reduce cattle unit grazing. Therefore, grazing contain necessary legumes to make it acceptable to cattle during winter and summer scarcity period.

Under the continuous grazing system, while the grass is growing actively, cattle prefer it to legume, promoting new palatable grass growth and allowing the legume to build up a bulk of feed for later use. This process is assisted by the fact that some of the legumes are relatively unpalatable when young. Rotational grazing of grasses at 2-4 weeks interval is helpful. Yield and persistence of tropical legumes is improved if grazed at 8-12 weeks interval. If the grazing of a grass-legume mixed rangeland is delayed for 8 weeks or more, the grasses will be past its best and cattle will tend to ignore it and concentrate on legume. Under these conditions, grass content is fully utilized while on the other hand shorter durations tend to weaken legume and may essentially eliminate them.

After the grass shed their seeds, there is a drop of 70-80 per cent in their protein level necessary to maintain their body weight.

The legumes on the other hand retain their protein level for a longer period even after the crop is standing in the field for 6 months. A protein level of 12-13 per cent may still be expected. Digestibility and voluntary intake of mature legume is much greater than in mature grass. If a range contains half grass and half legume during autumn, it will provide feed of best quality readily acceptable to cattle until new growth comes in March-April.

Table: Crude protein content of some grasses of the submontane region at different tiems of cutting

Grass	*%of Crude Protein during*		
	May/June	*July/Aug.*	*Sept./Oct.*
Chrysopogon fulvus	8.95	9.60	5.10
Heteropogon contortus	7.44	7.44	4.44
Rothriochloa intermedia	8.12	9.12	8.91

Deferred rotational system of controlled grazing in preferred to continuous controlled grazing. Rotational system entails elaborate demarcation of paddocks and a very careful management which at present in the region is still not possible. However, some elementary form of this system may be practised as being done in some parts of Himachal and Garhwal. These lands are managed as *Ghasnis* under 3 practices viz, (i) enclosure from grazing for 12 months and use it as hay land, (ii) exclosure for six months from June to November, cutting the grass and then grazing from December to May, and (iii) grazing all the year round. However, the grazing is not carried on the basis of carrying capacity i.e.not controlled grazing. Even then the practices nos. (i) and (ii) have been found to be better than continuous grazing. The air dry forage yield recorded under all the three practices is 3.32, 2.89 and 0.16 mt/year/ha respectively. Though the maximum quantity of crude protein in the grasses is available during Aug./Sep., this is no time for drying the grass, and, therefore, methods for forage conservation both as silos and hay making need to be popularised.