CHAPTER 6

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6.1. Introduction

In highly heterogeneous landscapes, as in the Himalayan alpine region, where physical, edaphic, biological attributes of ecosystem and nature and intensity of grazing often vary over short distances, a landscape scale analysis assumes importance for managing grazing for direct benefits to the people through animal husbandry on one hand and global environmental benefits on the other. Within Himalaya, broadly, two zones could be differentiated: (a) the alpine meadow area grazed over a short period of time (during summers) by the migratory livestock of transhumance/nomadic communities (b) forests and pastures around permanent settlements at lower altitudes grazed by the livestock all through the year. There are only a few studies on ecology of grazing in Himalayan alpine region. Past studies have concentrated on effect of grazing in selected Himalayan alpine ecosystems in central Himalayas. These studies provide limited information on ecosystem structure and function variation in the landscape in relation to variation in grazing regime. Further, attempts to understand ecosystem structure, function and management in relation to grazing in the cold desert region of the Himalayas are altogether lacking. A wider objective of this study is to look at the differentiation of landscape and ecosystem in relation to grazing in upper catchment of Spiti watershed covered in cold desert region and to undertake intensive ecological studies in selected landscape segments.

6.2. The objectives of the study were:

1. Characterization of ecosystems and microhabitats in pastoral landscape subjected to grazing by migratory graziers.
2. Comparison of community structure, productivity and soil physico-chemical characteristics in different ecosystem types.
3. Comparison of biomass removal and recovery patterns in different ecosystem types.
4. Analysis of strengths and weaknesses of resources uses in traditional migratory pastoral land use.

6.3. Foraging Behaviour of Livestock

Studying the foraging process is perhaps the most important aspect of understanding plant-animal interactions. Diet selection is the most important aspect of foraging behavior and a key process affecting both the grazing animals nutritional status and successional processes in plant communities. Therefore, by preferring some plants and avoiding others, ruminants have a profound effect on the competitive interactions of plants and consequently on the structure and function of ecosystems.

In the present context, an attempt has been made to study the foraging behavior of three different domestic animals viz. Yak, Horse and Zomo (a crossbreed between Yak and Cow) in the Trans-Himalayan cold desert region. The two plant communities studied were the Caragana-Festuca-Forb community (CaFD), found in the dry habitat on sloping land and the Carex dominated community (CrW) occupying the wet habitats, occurring as moist depressions. The CaFD community occupied the larger area and can be characterized as the general vegetation of the region (alpine scrubs).

The three animal species together grazed upon 30 plant species out of 67 plant species sampled in the landscape, excluding the rare ones. Out of these 30 species that were foraged, 5 grasses, 5 sedges, 19 forbs and only one was a shrub species. Zomo and yak foraged 20 species compared to 25 species by horse. The average foraging period was longest for yaks (10.9 hours) and shortest for the Zomos (7.5 hours). There were not much difference in the foraging period of yak (10.9 hours) and horses (9.1 hours). All animals spent maximum time in Caragana-Festuca-Dry community.

The dry intake per day (DMI) averaged across the grazing season for zomos, yaks and horses were 2.62 kg, 44.9 kg and 3.31 kg respectively. All the three animals increase their DMI with the progress of sampling months. Yaks covered wide area of the grazing landscape and even reached some high and remote locations that were inaccessible to horses and zomos and therefore, they have high mobility rate. Also, to compensate for the higher daily intake they increased their foraging time and search cost in comparison to the horses and zomos. Horses, even when not
interfered by herding like zomos, restricted themselves to the gentle slopes. Their lower foraging movement indicates that they are able to sustain on the diet of lower quality and that they even increased even the number of species grazed in compensation.

All the animal types show more preference to CaFD plant community in comparison to CrW community despite of higher shoot biomass of the latter community. In addition, this trend did not differ as the season progressed and varied marginally without any significant shift. This is perhaps the indication that the dry community (CaFD) has more nutritious grasses and forbs in comparison to CrW, which is exclusively dominated by sedges. Also, the area covered by the CaFD community is more than double the CrW community. The bite rate across the sampling months was constant for all the animals and for each community. However, across the communities their bite rates differ remarkably, with much lower bite rates in the CaFD community than the CrW community. This shows the response of all the animal types towards the morphology of the vegetation found in these communities. But utilization of various plant categories did not show much difference in the three animals, except in yaks, which showed preference for the grasses.

Diet selection could be expressed by using the selection ratios. The selection ratios are lowest for sedges despite their significant contribution to the diets of all the animal types. This is because of their higher fraction in the community biomass. If these indices are followed then we can suggest that all the three animal types tried to increase certain fraction of some species in their diet. Levin’s response breadth is a good estimate of diet breadth in animals and it depicts that zomos have wider (0.71) response breadth than yaks and horses, as they show intermediate value (0.52 and 0.50).

Under the free ranging condition and minimal grazing management practices, yaks are better adapted to this environment as found in the cold dessert of Spiti- Himalayas. Due to little differences in the foraging behavior of the three animal types and as their diet overlaps, these animals are likely to compete for resources in the condition shortage of forage, especially in the case of zomos and horses due to higher degree of similarity in their in diet composition.
Vegetation composition, diversity and productivity of alpine pasture communities

The present study deals with the dynamics of vegetation pattern and processes in relation to grazing in the cold desert region of Spiti-Himalayas. If efforts are to be made to ensure that resources are managed sustainably, it is important to understand the utilization pattern of meadows and the potential effect of this utilization on biodiversity and productivity. Although few preliminary ecological studies are available for the region, there is lack of knowledge on the effects of small scale migratory grazing on ecosystem structure, function and management in the cold desert region.

Generally, dry sites were more species rich compared to wet sites. Among the different plant-groups, maximum number of species belonged to forbs while shrubs were represented by only two species viz. *Caragana versicolor* and *Lonicera zanskarensis*. Grasses were virtually absent in the wet sites that were dominated by 2-3 sedge species. Among the different life forms observed in the area, shrubs were represented by *Caragana versicolor* and *Lonicera zanskarensis* with low density but very high cover and biomass. In the forb category *Cicer microphyllum*, *Cousinia thomsonii*, *Lindelofia stylosa* and *Polygonum tuertosum* were more abundant. The more abundant grasses were *Festuca valesiaca*, *Festuca kashmiriana* and *Piptatherum munroi*. Sedges were represented by *Carex curta*, *Carex alpina*, *Carex maritima* and *Kobresia royleana*.

An ordination for all the sites was done by using the DCA with downweighing the rare species. Abundance data having density values was more effective in displaying the distinct separation of clusters for the sites. The DCA result shows three distinct characteristics of the study area. One, the separation of sites along the moisture gradient. Two, identification of the three community types viz. sedge dominated sites in the moist depressions, grass dominated sites on the steep dry slopes and the shrub dominated-legume dominated sites on the dry slopes. Third, the separation of clusters of the sites frequented by the different types of animals was also reflected.

Majority of the sites in the dry area was dominated by the shrub cover. The most conspicuous and the dominant species in the most of the sites was the leguminous shrub, *Caragana versicolor*. *Caragana versicolor* is a deep-rooted and nitrogen fixing leguminous shrub while the grasses and the forb, which co-exist with
it, are perennial and comparatively shallow rooted. Therefore, there is a less chance of inter-specific competition with the dominant species and any association in such a situation is likely to benefit grasses and other forbs. In the moist depressions, sedges dominate in the wake of low competition and high soil nutrients (N and available P). However, unpalatable forbs were able to increase their abundance in highly grazed sites.

Total 50 were studied for their phenophases during the summer season and later grouped according to their growth-forms. Most of the species (78%) were in their vegetative growth in the month of June. August was the month maximum species (86%) were in their fruiting stage. Seed dispersal for most of species (80%) began in September. Majority of species (64%) started senescence earlier in September and only some sedges in the moist depressions, showed delayed senescence: The early growing species also have longer growth cycle, larger biomass and cover as compared to others in the communities where they grow and therefore are the dominant species. Late growing species were some of the perennial grasses on the dry slopes and some annual forbs. Although many of the species (42%) had shorter growth cycle of 2-4 months, most species (58%) showed longer growth cycle of more than 4 months.

Of the 67 species recorded across the nine sites during the peak growing month, only 50 species had cover value of >1% and among them 22 species could be accounted for >5% of cover. The Shanon diversity index across the sites ranges from 0.10 to 0.95, suggest low species diversity. Nevertheless, this is relatively higher plant diversity when compared to short growing season length and the stress conditions present in the high altitude and cold desert environment. Species diversity in the different ecosystems has been explained in the light of intermediate disturbance hypothesis. In the present study when species diversity for all the sites was correlated with the grazing intensity, the correlation coefficients were not significant at $p = 0.05$. Here, diversity seems to be controlled by moisture stress and relatively low disturbance in the form of grazing in some sites. However, for the wet sites it may be affected by competitive exclusion along with relatively higher level of grazing disturbances. Moreover, when all the sites are considered together, species richness/diversity at the landscape level is higher reported for elsewhere.

The values for the total live biomass ranged from 117.2 gm$^{-2}$ in the months of April/May to 1403.6 gm$^{-2}$ in the months of August/September. Aboveground net
primary production (ANPP) for the wet sites ranged from 141.7 to 433.2 g m⁻² and for the dry sites from 25.2 to 166.2 g m⁻². The highest contribution to ANNP was from sedges in the wet sites and from legumes in the dry sites. The annual aboveground primary productivity for the wet sites 147.3 to 280.72 g m⁻² year⁻¹ and for the dry sites from 18.6 to 169.7 g m⁻² year⁻¹. The contribution of different life forms to the aboveground productivity was observed similar to that of ANNP. There was strong positive correlation (r = 0.93) between ANNP and above ground annual primary productivity. The ratio for aboveground to aboveground biomass varies between 2:1 – 5.7:1 for the vegetation on the dry sites and 3.8:1 – 8:1 for the vegetation on the wet sites.

Wet sites were most productive and here only three species viz. Carex curta, Carex alpina and Carex maritima contributes most to both aboveground and belowground productivity. The general pattern for the variation of both aboveground and belowground production in the present study shows similar trends as observed in both arctic and alpine tundra environments and also to some cold desert regions of central asia. However, they were lower were as compared to the ANNP for the Central Himalayan alpine meadows, except only moist/wet sites in the present study. When biomass was correlated with grazing intensity across all the sites the correlation coefficients obtained for both belowground biomass and total biomass were not significant at p = 0.05. The high below ground biomass in intensively grazed sites could be either due to plant tolerance and increase in dead root mass or both.

Maintenance of relatively high plant diversity and productivity despite being regularly grazed suggest that traditional grazing practices in the region are sustainable at the present stocking rate/grazing intensity. In the hay removal site, high plant diversity and productivity was recorded despite of high disturbance in the form of both grazing and biomass removal. No significant correlations could be made between grazing intensity and species diversity or productivity. Moisture seems to have major role in determining ecosystem structure and function in the region and grazing have comparatively minor role.

6.5. Traditional Livestock Husbandry Practices

Although by legalizing the protected areas, a significant contribution has been made to save species from extinction, such steps have also adversely affected
the livelihood of local communities, especially in the developing countries. Enforcement agencies tend to disregard traditional agriculture, natural resource uses and socio-cultural values of the local communities leading to between the traditional societies and conservation practitioners over the resources especially around the legalized protected areas. In the present study, an attempt has been made to contribute to the people-policy compatibility debate by looking at the dynamics of traditional grazing management practices in this ecologically fragile cold desert environment.

Pastureland in Spiti falls under three categories: (1) the village-grazing land surrounding the villages, (2) areas kept for collecting hay for winter stall-feeding and usually protected from summer grazing and (3) the pastures situated away from the villages where organized grazing take place by local small-scale migratory graziers (locally called as “Doksa”). Most of villages in the valley/river-side generally lack in the second and third category of the pastures. The villages situated on the hill-side and in the interiors posses all three kinds of pastures. The animals are grazed from June to October in the Doksa area. In Spiti, 6 such major areas where identified out of which only 4 were currently found to be functional. Based on the data collected over three year period for the Doksa area belonging to Demul village, it was observed that 121-140 cattle, 50-62 horses and 48-56 yaks graze in this pasture land. It was found that over the last decade, some Dokpas have abandoned their occupation for better livelihood options available from employment in development activities implemented by government agencies and tourism sector.

Of the two villages studied here, the river-side village had lower livestock population in comparison to the hillside village. The hillside village showed a larger livestock holding and higher relative abundance of yaks and horses compared to the river-side village. The livestock census was available from the 1982 to 1997 period. Livestock population doubled in last 25 years. The maximum increase (52.7 %) occurred during 1992 – 1997 period. Data collected for Demul during the household survey shows that average biomass harvested for hay/mulch in the year 1999, was 2016 ± 76 Kg/year/household. Mean dried dung collected per household in village Demul was estimated as 268 ± 16 Kg/year/household and fuelwood 187 ± 13 Kg/year/household. The local communities utilize most of pastures in the Spiti catchment. However, there are some areas, which are grazed by the migratory
shepherds from outside the region. There was no conflict over utilization of pastures and the local people did not feel any threat in terms of degradation of pastures at the current stocking rate.

Strict regulations pertaining to grazing practices and utilization of other resources from the pastures together with non-commercial type animal husbandry have helped to check the over exploitation. Grazing pressure is dispersed for optimizing production of livestock. Diversification of the resource utilization in terms agriculture, utilization of the pastures in different seasons and the mix of livestock has helped the local community in the region to take advantage of different type vegetation in the pastures and their heterogeneity. The customary practices of Dokpas are designed to effectively reduce the risk of overgrazing of village pastures by taking the lactating cattle to the remote pastures. Extensification rather than intensification of pastoral land use has led to conservation of resources. In the recent years, the increase in livestock population is accompanied by increase in number of goats. Goats are browsers and could graze on the spiny shrubs frequently excluded by other livestock. Introduction of exotic species of plants and livestock or expansion of village agriculture land was not observed in this region of cold desert due to limited availability of irrigation facility.

Wolf is the main predator in the hillside village Demul and Snow leopard in the riverside village Lidang. The differences could be attributed to the location of the pastures where the livestock graze. Assessment of livestock killings by wolf in the area has received less attention than snow leopards. The total livestock population for the two villages was 1010. Total 223 deaths due to depredation were reported in Demul over the period of 4 years. In Lidang, these deaths were comparatively lower (87). Both the predator allegedly killed 7.7 % of the total livestock holding of Demul and 10.4 % of Lidang. This amounts to huge economic loss to the villagers. During four-year assessment, 4.7 % of the actual reported loss was compensated. In the present study, not a single incidence of crop damage was observed or reported by the villagers. This could be due limited agriculture or abundance of forage for wild herbivore in the area. The herding practices of the local communities in the region seem to be responsible for high predation rates by the wild carnivores. Depredation of livestock in the region is not a recent development. Villagers agree that livestock depredation in the region is an age-old phenomenon with occasional increase in the frequency of attack in some years. The increase of
attack cannot be correlated with the formation of protected area network in the region or increase in the population of wild carnivores.

6.6. Future perspective

Moisture seems to be a major factor in determining the ecosystem structure and function in comparison to grazing. To meet the future challenges necessary changes had to made in the traditional grazing management practices to maintain its sustainability. In future, the likely increase in the livestock population would have adverse impact on the pasture and may ultimately lead to decline in traditional grazing practices. Free ranging livestock is more susceptible to the wild predators and also in absence of any concrete measures to protect them from depredation. Only appropriate protection measures and increase in wild herbivore population will ensure to check the livestock killings. Providing proper irrigation facilities, extensification of irrigated agriculture land, incentives in the terms of cash crops and irrigation of pastures will not only help to check the grazing pressures on pastures, but will also reduce the people-conflict and hence conserving the wildlife in the region.