# 3

# Pasture Productivity and Utilisation

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## Introduction

This chapter describes the results of the pasture studies conducted within the Agri-Karakoram Project, with the broad aim of gaining information about the ecology of mountain pastures in the Northern Areas of Pakistan. The study had two main objectives. The first was to classify and characterise the vegetation communities present in the study area and their distribution. The second was to measure the biomass production, and utilisation of the vegetation, and identify the key differences in pasture use between the two geographical transects, determining where possible the causes of any differences found. This objective was approached using data from this and other components of the project. Full details of the study area are given in Chapter 1.

## Pasture ownership and management

The pastures of northern Pakistan fall under communal, state, and private ownership (Buzdar 1988). The most common type of pasture ownership is communal, in which the pasture resources are owned by a defined group of users (a single village or cluster of hamlets). In the case of communal pastures, institutional arrangements (village committee, village pasture committee, pasture interest group, or herders group) exist to manage the use of the resource. For state pastures, the ownership of the pasture lies with the Northern Areas government, but a village or villages have grazing rights in the area. Khunjerab National Park is an example of such a state-owned pasture area. In the case of private pastures, individuals develop certain pasture areas (through personal inputs) for grazing or cutting, and hence establish secure claims to the future benefits from that pasture area.

Each village or cluster of villages has an institutional body for managing pastures, primarily consisting of experienced herders of the village. Such an institutional body makes various decisions based on consensus. Decisions made by the institutional body usually relate to: (a) grazing schedules (movement of livestock to and from the village); (b) distribution of pastures to different households, tribes, or clans; (c) grazing fees to be charged to other villages that wish to use the pasture resources of the village; and (d) penalties to be imposed on those who do not follow the mutual agreement.

## Rangeland types and distribution in the Northern Areas

The only comprehensive information available on the land use of the Northern Areas (Table 3.1) is based on the interpretation of 54 Landsat Satellite Thematic Mapper images at a scale of 1:250,000 carried out in 1990/1991 by the Forest Sector Master Plan (ADB and UNDP 1992). There is, however, some doubt as to the accuracy of this information, since many of the images are impossible to interpret due to cloud cover and the rugged nature of the terrain. For this reason more than 65% of the total land area remained unclassified in this survey. Rangelands are described as predominant compared to other land types, but unfortunately much of the relevant land area for this land type is within the unclassified category.

In current literature for the Himalayan regions of Pakistan and India, three different range types are described for the Northern Areas of Pakistan (Khan 1985; Mohammed 1998). These are the foothill, dry temperate, and alpine range types, and they differ in altitudinal range and the type of vegetation supported. The foothill range type occupies the lowermost part of the mountains up to about 1,500m elevation. These ranges tend to be near to villages and are normally used

Table 3.1: Forest cover and land use classes in the Northern Areas of Pakistan, from ADB and UNDP (1992) Landsat image classification

| Forest cover and land use class | Area ('000 ha) | Percentage |
|---|---|---|
| Forest/Trees/Scrub | | |
| Conifer\scrub (natural) | 660 | |
| Farmland trees (planted) | 6 | |
| Total | 666 | 9 |
| Agricultural | | |
| Irrigated | 44 | |
| Rainfed | 4 | |
| Total | 48 | 0.6 |
| Rangelands | | |
| Degraded | 896 | |
| Alpine | 705 | |
| Total | 1601 | 23 |
| Barren Land | | |
| Snow \ glacier | 27 | |
| Total | 24 | 0.39 |
| Water Bodies | | |
| Lake | 1 | |
| Total | 1 | 0.01 |
| Unclassified | | |
| Above 3,650 m | 3161 | |
| Below 3,650 m | 1536 | |
| Total | 4697 | 67 |
| All Land Classes | 7040 | 100 |

by livestock during the winter season. The dry temperate range type lies between 1,500m and 3,000m elevation. Livestock graze this range type during the spring season while moving towards the alpine range type, and the autumn while returning to the villages. The alpine range type is above an elevation of approximately 3,000m and below the zone of perpetual snow cover. These pastures are grazed only during the summer season when free of snow.

An approximate estimation of the pasture area associated with each village was made at the start of the study. The total number of pastures available to each village and the approximate area per pasture available to livestock for grazing were used to estimate the total pasture area for each village (Table 3.2, Fig. 3.1).

Table 3.2: Number of pastures, mean area of each pasture (±SE) and total pasture area available to each of the study villages

| Transect | Agro-ecological Zone | Village | Total number of pastures | Mean pasture area (ha) | Total pasture area (ha) |
|---|---|---|---|---|---|
| GGR | DCZ | Bargo-Bala | 6 | 7.66 ± 1.00 | 45.96 |
| | TCZ | Gahkuch-Bala | 4 | 6.11 ± 1.05 | 24.44 |
| | SCZ | Darkut | 15 | 3.41 ± 0.41 | 51.15 |
| KKH | DCZ | Bunji | 10 | 7.65 ± 1.23 | 76.50 |
| | TCZ | Minapin | 9 | 5.20 ± 0.62 | 46.80 |
| | SCZ | Morkhun | 8 | 4.76 ± 1.04 | 38.08 |

GGR = Gilgit Ghizer transect, KKH = Karakoram Highway transect, DCZ = double cropping zone, TCZ = transitional cropping zone, SCZ = single cropping zone

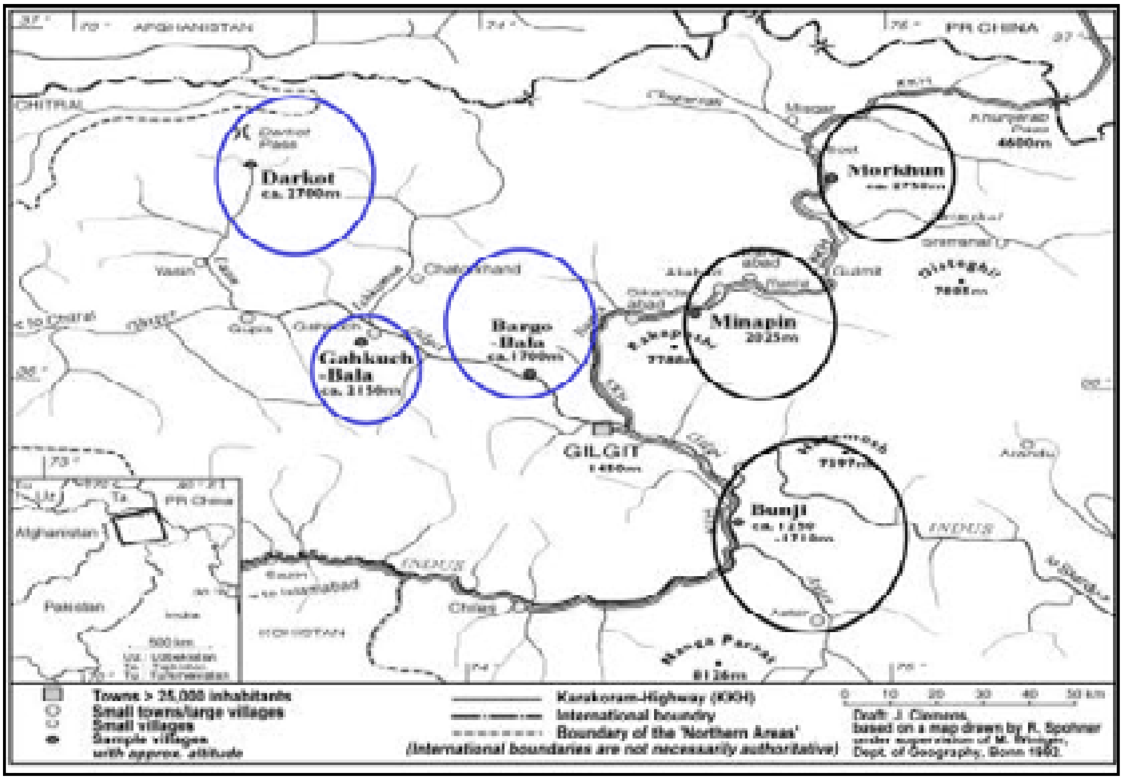


Figure 3.1: **Pasture area associated with the different study villages, area of circle indicates relative area of total available pasture**

Along the Gilgit-Ghizer (GGR) transect, Gahkuch-Bala village had a relatively small total pasture area, Bargo-Bala had a medium-sized area, and Darkot had a large total pasture area. On the Karakorum Highway (KKH) transect, Bunji had an extremely large total pasture area (the largest of the six villages), whereas Minapin and Morkhun had medium-sized pasture areas. Although total pasture areas varied among individual villages, the total area available in each transect was similar.

## Preliminary pasture survey

At the start of the study, a preliminary survey was conducted to devise criteria for selecting study pastures. Information was gathered from herd owners and shepherds in the six study villages. In each village, all the pastures of the foothill and dry temperate range types were selected for study, as there were relatively few of these. However, some villages had large numbers of widely dispersed alpine pastures and in these villages a sub-sample of three alpine pastures per village was selected for study. This was done on the basis of any one or a combination of the 'main features', with the aim being to sample as wide a range of variation in key features and uses as possible. The main features considered were vegetation composition, stocking density, livestock species using the pasture, and altitude and/or aspect.

In Bargo-Bala, Gahkuch-Bala, and Morkhun, all pastures were selected for study, since these villages only had three or fewer pastures in the alpine range type. Sub-pastures were selected within the main pastures to cover the full range of vegetation types, uses, altitudes, and aspects present within each pasture area. These were used for the vegetation transects (see below). The main factors influencing the type and condition of the vegetation appeared to be aspect, altitude, extent of use of pastures by livestock (estimate from livestock trails), soil depth, degree of exposure to regular snow-melt each year, geological features, and degree of competition for grazing with wild herbivores (predicted from the faeces of wild goats, rabbits, and marmots).

## Characterisation of vegetation communities

During summer 1999, transects of 30m were laid at random locations within the selected pastures and sub-pastures in each pasture area. They were laid across the contour, and quadrats were placed at 10m intervals starting from zero metres. Quadrats of 50 x 50 cm and 100 x 100 cm were used in the different alpine range types, and quadrats of 2m x 2m in the dry temperate and foothill range types, according to the scale of variation in the vegetation. Quadrats were divided into 100 equal segments (Figure 3.2), and these segments were used to estimate visually the percentage ground area covered by each species. Measurement of cover also included bare ground, rock, cryptogams, dung, and litter. Presence of any above-ground plant part in the quadrat – rather than the presence of roots – was used as the criterion for inclusion in the assessment of plant cover.

Figure 3.2: **Quadrat method for estimating surface material and vegetation cover**

Data were analysed using multi-variate techniques. Initially, the complete set of 70 species found was classified into three main plant groups – grasses, forbs, and shrubs – and their cover was described for each range type. A plant community classification was then carried out using Two Way Indicator Species Analysis (TWINSPAN; computer based, PC ORD program, version 3.19). Mean plant percentage cover data per transect was used to classify the samples (Castle 1976) into groups constituting the plant communities described later in this chapter.

## Composition

Vegetation structure and composition varied among the different range types. The foothill range type was present only in Bunji village and constituted a flat area adjoining the village. The dominant plant species was *Ephedra gerardiana*. This shrub was sparsely distributed, and the area without vegetation, covered by bare ground and rock, was over 80% (Figure 3.3a).

In dry temperate pastures, shrubs were dominant (on a percentage cover basis), followed by grasses and forbs (Figure 3.3b). The main species were *Artemisia* spp. and *Aerva persica*. The vegetation was also quite sparse, with approximately 60% of the area being bare ground or rock.

In alpine pastures, forbs and grasses constituted over half of the total plant cover (Figure 3.3c), while shrubs had a small representation. The main plant species were *Antennaria nana, Potentilla* spp., and *Ranunculus* spp., and there was a sizable amount of litter. These pastures also had significant, although lesser, areas without vegetation cover (bare ground and rocks).

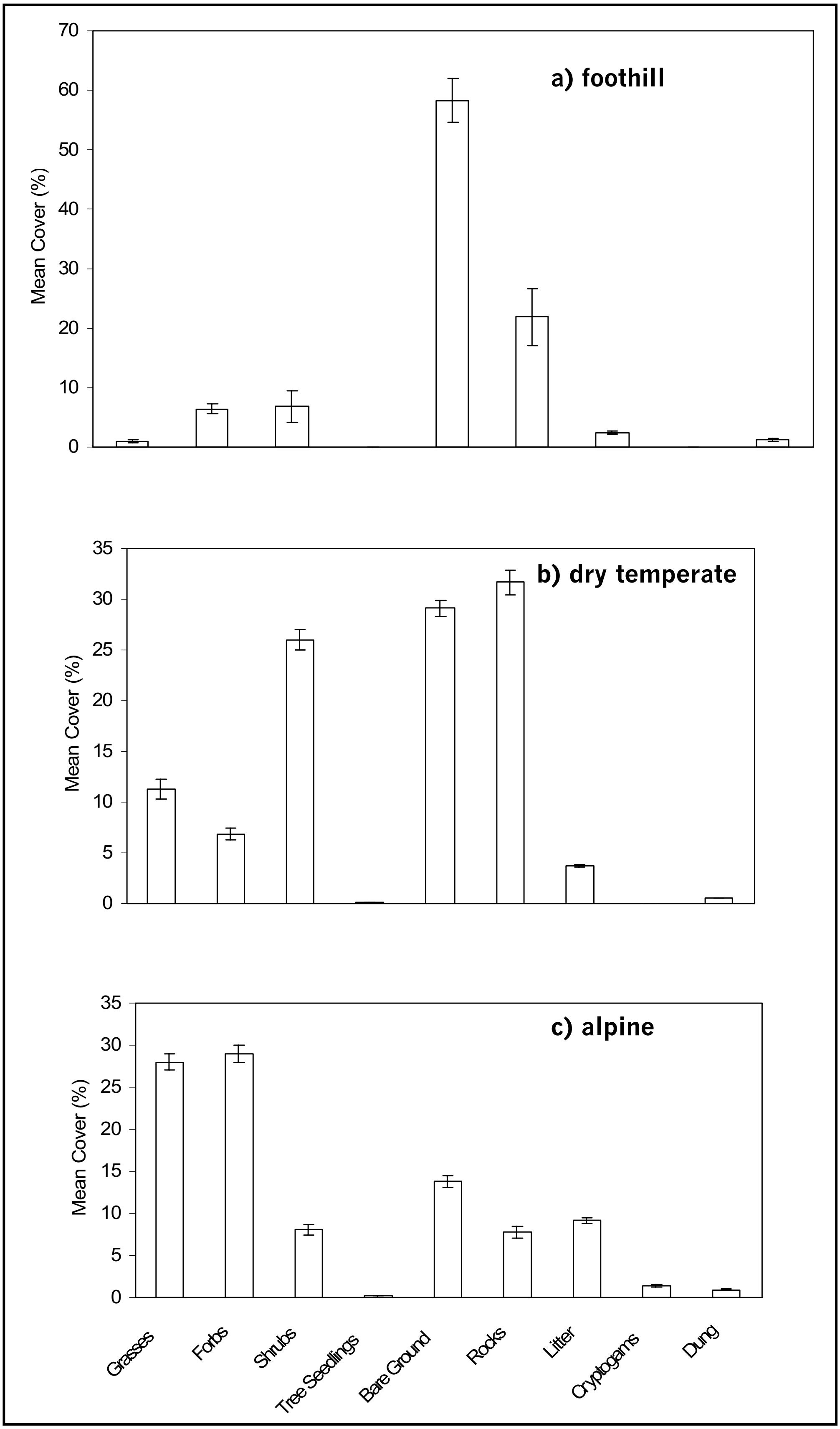


Figure 3.3: **Mean cover a) foothill range type, b) dry temperate range type, c) alpine range type**

In summary, plant cover increased from the foothill to the alpine range type. Vegetation consisted of very sparse shrubs in the foothill range type, less sparse shrubs in the temperate range type, and dominant grass and forbs in the alpine range type.

In the alpine pastures, the TWINSPAN analysis of plant cover data indicated that the *Antennaria nana-Potentilla* spp. community was the most extensive of all the alpine communities. It was generally found in areas that had been ponds, but were now empty due to changes in geographical features such as landslides. These areas were well drained at the time of the study. The *Polygonum affine-Ranunculus leatus* and *Potentilla sibbaldai-Polygonum affine* communities were of almost equal extent. The former was present either near wooded areas or in areas with sparse trees, whereas the latter was usually found on flat meadows close to ponds and at high altitudes. All of these plant communities were widely distributed in all of the alpine pastures available to the study villages.

In the temperate plant communities the *Artemisia* spp. community existed on gentle slopes and was mostly far from any water source. The *Aerva persica* community was present near rivers, streams, or irrigation channels but was never inundated by water. Both of these communities were widely distributed in all of the study villages. The *Festuca* spp.-*Carex* spp. community was relatively scarce and was found in areas within and surrounding pasture settlements. The *Peganum harmala* community existed only in the pastures of Morkhun village. It occupied an abandoned shepherd settlement.

In the foothill plant community, the *Pennesitum lacutum-Ephedra gerardiana* community was only found in the foothill pastures of Bunji village. *Ephedra gerardiana* bushes provided favourable conditions for the grass, *Pennesitum lacutum*, which grew in the shade of the former. The vegetation was sparse, with a mean plant density of 19 *Ephedra* plants per $25m^2$.

## Production and utilisation of forage resources

Production, utilisation, and available biomass were measured during summer 2000 and winter 2000-01, using the paired cage plot method (Figure 3.4). In each sub-pasture area described above, cages were set up at six points. These were paired with uncaged plots of the same dimensions to allow combined quantification of herbage production and utilisation. Cages and their paired plots encompassed sample areas of 50 x 50 cm in the alpine range type and 2 x 2m in the dry temperate and foothill range types.

Grazing was allowed on the uncaged plots, whereas the caged plots remained ungrazed during each sampling period (Figure 3.4). Vegetation was clipped to ground level from both caged and uncaged plots simultaneously on each clipping date. Clipping dates were designed to encompass the main periods of livestock use, as well as the growing season. In foothill pastures, clipping was carried out in March, May, and October 2000 and again in January and March 2001. Dry

Figure 3.4: **Caged plot method for measuring forage production, utilisation, and available biomass**

temperate pastures were clipped during March, May/June, October/November and December 2000 and again in March/April 2001. Alpine pastures were clipped in late May, July/August, and October 2000. Caged and uncaged plots were moved to new locations after each clipping.

Plant material was sorted by species to obtain species composition and proportion of live and dead material as indications of both forage availability (by plant species) and changes in vegetation biomass and species composition due to grazing. Fresh plant material was oven-dried at 65°C for 48 hours and weighed to obtain the dry matter amount of each plant species. The dry matter obtained from each uncaged plot gave the total biomass at that date. The dry matter obtained from the corresponding caged plot, minus the dry matter clipped from the uncaged plot at the previous clipping/caging date, gave the seasonal production of forage during the period between those two clipping dates. The difference in dry matter obtained from the paired ungrazed and grazed plots on the same clipping date gave the utilisation during that time period.

Production, utilisation, and biomass data were examined for the different range types through the year. Relationships with environmental variables and geographical transects (GGR versus KKH) were examined using residual maximum likelihood (REML) analysis (GenStat version 4.2; Lawes Agricultural Trust 1998), a statistical method for analysing categorised data that is subject to variation at different levels or strata (Patterson and Thompson 1971).

The production and utilisation data presented here relate to the periods between clippings whereas the biomass data reflect the amount of herbage standing at the time of clipping. Mean production, utilisation, and biomass all increased with altitude, from foothill through dry temperate to alpine range types (Table 3.3). The overall trend in livestock use was that alpine pastures were more heavily used than were pastures in the dry temperate and foothill range types. We hypothesise that increased water from snowmelt led to the greater levels of production and biomass in the alpine pastures, which in turn enabled heavier levels of utilisation.

Production and utilisation were only measured during periods when livestock were using the pastures, but biomass was recorded periodically throughout the year. Table 3.3 shows seasonal summaries for the three range types. Available biomass in the foothill pasture area was greatest in October after a growing season and a period of rest from animal use (Table 3.3). March (spring) biomass was also relatively high, when new growth was accumulating, but biomass declined as animals consumed vegetation between March and May. The main reason for heavy use was the movement of livestock from the village towards the dry temperate and alpine range types. Utilisation was very light, however, when animals again used this area from December 2000 to March 2001, and relatively more biomass remained.

Table 3.3: Seasonal production, utilisation (g DM $m^{-2}$ $day^{-1}$) and biomass (g DM $m^{-2}$) in different range types.

| | Production | Utilisation | Biomass |
|---|---|---|---|
| Foothills | | | |
| March | | | 5.09[ab] |
| March - May | 0.09[ab] | 0.07[a] | 0.55[ab*] |
| May - October | 0.20[ab] | - | 7.81[ab*] |
| October - January | 0.01[ab] | - | 2.25[ab*] |
| January - March | 0.12[ab] | 0.01[a] | 3.23[ab*] |
| | | | |
| Dry temperate | | | |
| March | | | 5.02[a] |
| March - May/June | 0.64[b] | 0.27[a] | 32.48[ab*] |
| May/June - October/November | -0.12[a] | - | 38.01[b*] |
| October/November - December | 0.05[a] | 0.11[a] | 28.06[ab*] |
| December - March/April | -0.08[a] | 0.02[a] | 13.57[ab*] |
| | | | |
| Alpine | | | |
| May | | | 121.86c |
| May - July/August | 0.82[b] | 1.04[b] | 111.95c* |
| July/August - October | 0.50[ab] | 0.15[a] | 109.25c* |

* Biomass at the end of the period.
Within columns, means with the same superscript are not significantly different ($P<0.05$).

In the dry temperate range type, production exceeded utilisation from March to June 2000 (Table 3.3). Biomass then accumulated further when livestock moved to the alpine range type between June and September, but it declined when animals returned to the dry temperate pastures in September. Sporadic use until March continued to reduce the remaining biomass. Negative values for production in the December-March period indicate winter die-back. Overall, there are indications of possible under-use of these pastures in the spring season, although because this study represents only one year of data, conclusions must remain tentative.

In the alpine range type, biomass remained relatively high during the whole growing season (Table 3.3). Production and utilisation were heaviest between May and August, the main period of both growth and animal use. Late in the season, both production and utilisation were lower when growth started to slow down and livestock started moving down towards the temperate range type.

As expected, mean levels of vegetation production did not vary significantly between the two transects, because most vegetation types were distributed across the whole study area and both transects contained similar ranges of altitude, aspect, and other important abiotic factors (Table 3.4). Mean utilisation, however, was significantly higher on the GGR compared to the KKH transect. The main difference in utilisation was in the alpine range type, where mean utilisation was three times higher in the GGR than in the KKH transect.

Table 3.4: Variation in production and utilisation along the GGR and KKH transects*

| | Pasture type | Transect | | Transect ***p***-value |
|---|---|---|---|---|
| | | Gilgit Ghizar (GGR) | Karakoram Highway (KKH) | |
| Production ($g\ m^{-2}\ day^{-1}$) | Foothill | – | 0.01 ± 0.23 | |
| | Dry temperate | 0.23 ± 0.18 | 0.19 ± 0.19 | |
| | Alpine | 0.32 ± 0.23 | 0.47 ± 0.22 | |
| | Mean | 0.26 ± 0.14 | 0.23 ± 0.12 | n.s. |
| Utilisation ($g\ m^{-2}\ day^{-1}$) | Foothill | – | 0.05 ± 0.19 | |
| | Dry temperate | 0.14 ± 0.15 | 0.11 ± 0.16 | |
| | Alpine | 0.83 ± 0.19 | 0.29 ± 0.18 | |
| | Mean | 0.40 ± 0.13 | 0.15 ± 0.11 | 0.002 |

* Values relate to the period of grazing only.

## Conclusions

Vegetation changed from very sparse shrubs in foothill pastures to less sparse shrubs in dry temperate pastures to forb/grass dominance in the alpine range type. Production, utilisation, and biomass increased with increasing altitude, probably due to increased water through snowmelt. Water availability also governs the movement pattern of livestock in the transhumance grazing system under semi-arid conditions.

The two main conclusions from this study relate to patterns of use of two different range types. The data indicate two potential areas for modifying patterns of use to maximise benefit from the available forage resource. First, mean forage production of dry temperate pastures overall appeared to be higher than utilisation during the spring season. This indicates a potential for increased use of temperate range pastures in spring, which in turn would reduce pressure on the foothill and alpine range types, as well as allowing earlier movement of livestock from villages, sparing scarce stored food resources (Chapter 2). However, longer-term data are needed to establish whether this result was representative of typical patterns of use.

Second, the much heavier use of alpine pastures (three times higher than mean utilisation) in the GGR transect compared to the KKH transect raises two questions requiring investigation: (a) why is the use so much heavier? and (b) despite this heavier use, why does animal condition improve faster in the GGR transect? (see Chapter 2). These linked questions are explored further in Chapter 5.

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