# Vegetation Community Characteristics of Alpine Grasslands in River Valleys of the Eastern Qilian Mountains and Their Relationships with Soil Properties: Postprint

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## Abstract

To investigate the relationship between vegetation community characteristics and soil properties of alpine grasslands in the river valleys of the Eastern Qilian Mountains, five different vegetation types of alpine grasslands distributed on the upper and lower parts of sunny slopes, upper and lower parts of shady slopes of valley mountains, and horizontal terraces of river valleys were selected as research objects based on the valley topography and geomorphology and distribution characteristics of alpine grasslands in the study area. The characteristics of grassland vegetation communities and soil properties and their correlations were studied. The results showed that: the dominant species of alpine grassland vegetation communities differed among different slope aspects and positions in the river valley; alpine grasslands on sunny slopes of the river valley were dominated by Kobresia species, while those on shady slopes were dominated by Polygonum species; the total vegetation coverage was higher on shady slopes and lower on sunny slopes; the grass layer height was highest on the lower part of shady slopes and lowest on horizontal terraces; the total number of families, genera, and species of vegetation communities all showed higher values on lower slope positions than upper positions, and higher on shady slopes than sunny slopes; the aboveground biomass followed the order: lower shady slope > upper sunny slope > upper shady slope > lower sunny slope > horizontal terrace; the belowground biomass in the 0–60 cm soil layer followed the order: lower shady slope > lower sunny slope > upper shady slope > horizontal terrace > upper sunny slope. There were significant differences in soil properties among different alpine grasslands ($P<0.05$). Correlation analysis indicated that indicators such as soil water content, bulk density, porosity, and total nitrogen had significant correlations with total vegetation coverage, aboveground biomass, total number of families, and average grassland height. It is evident that the influence be-

tween vegetation and soil in the river valley alpine grasslands of the study area was mainly manifested as the interactions between soil water content, bulk density, porosity, and total nitrogen with total vegetation coverage, aboveground biomass, total number of families, and average grassland height.

## Full Text

# Relationship Between Grassland Characteristics and Soil Conditions in the Eastern Qilian Mountains


## Abstract

This study explored the relationship between grassland characteristics and soil conditions in the Eastern Qilian Mountains. We selected grass and soil samples from five areas of the mountain valley: the upper shady slope, lower shady slope, upper sunny slope, lower sunny slope, and level terraces. Results showed that each site harbored different dominating species; the sunny slope was dominated by *Kobresia* sedges and the shady slope was dominated by Polygonaceae flowering plants. Total vegetation coverage was greatest on the sunny slope and weakest on the shady slope; grassland height was tallest on the lower shady slope and shortest on the horizontal terrace; the number of genera and species on the lower shady slopes were higher than those on the upper sunny slopes. The aboveground biomass, from greatest to least, was as follows: bottom shady slope > upper sunny slope > upper shady slope > bottom sunny slope > horizontal terraces. Through an examination of 60 cm deep soil, the underground biomass was found to be: bottom shady slope > bottom sunny slope > upper shady slope > horizontal terraces > upper sunny slope. Both the biomass and soil conditions at each site significantly differed ($P < 0.05$). There were significant correlations and interactions between characteristics of the soil (i.e., moisture content, bulk density, porosity, and total nitrogen content) and the grassland (i.e., total vegetation coverage, aboveground biomass, grassland heights, and number of genera and species present). Therefore, these results indicated that aboveground soil characteristics were key factors that affected the quality of the grassland.


**Keywords:** alpine grassland; vegetation community; soil characteristics; correlation relationship; Qilian Mountains

## 1. Study Area

The study area is located in the Eastern Qilian Mountains (102°29 -102°33 E, 37°11 -37°13 N) at an elevation of 2900–4300 m. The region has a mean annual temperature of -0.1°C, with extreme minimum temperatures reaching -18.3°C (January) and extreme maximum temperatures of 12.7°C (July). The accumu-

lated temperature above 0°C is 1380°C. Annual precipitation averages 416 mm, while annual evaporation reaches 1592 mm, yielding an aridity index of 3.8. The area experiences concentrated rainfall during July, August, and September. Soils are classified as alpine meadow soil. The vegetation consists primarily of alpine meadow communities dominated by *Kobresia capillifolia*, *Kobresia humilis*, and other cold-resistant perennial herbaceous plants.

## 2. Methods

### 2.1 Sample Collection

Sampling was conducted in July 2017. Five representative slope positions were selected: upper shady slope, lower shady slope, upper sunny slope, lower sunny slope, and level terrace. At each slope position, three 10 m × 10 m sample plots were established, with three replicates per plot. Soil samples were collected from six depth layers: 0–10 cm, 10–20 cm, 20–30 cm, 30–40 cm, 40–50 cm, and 50–60 cm.

### 2.2 Vegetation Survey

Vegetation surveys were conducted in 10 m × 10 m quadrats, with 15 quadrats established per slope position. For each quadrat, we recorded species composition, plant height, coverage, density, frequency, and aboveground biomass.

### 2.3 Soil Sampling

Soil samples were collected using a 100 $cm^3$ soil corer from three depth layers (0–10 cm, 10–20 cm, and 20–30 cm), with three replicates per layer.

### 2.4 Biomass Measurement

Aboveground biomass was harvested by clipping all vegetation within each quadrat, then oven-dried at 65°C for 12 hours. Belowground biomass was obtained from soil cores, washed clean, and oven-dried at 65°C for 12 hours.

### 2.5 Diversity Indices

We calculated the following diversity indices: - **Shannon-Wiener diversity index:** $H = -\sum P_i(\ln P_i)$ - **Pielou evenness index:** $E = H/\ln S$ - **Simpson dominance index:** $D = 1 - \sum P^2$ - **Margalef richness index:** $Ma = (S-1)/\ln N$

Where $S$ is the number of species, $N_i$ is the number of individuals of species $i$, $N$ is the total number of individuals, and $P_i = N_i/N$.

### 2.6 Data Analysis

Data were analyzed using Excel and SPSS 13.0 software. One-way ANOVA was performed, followed by LSD tests for multiple comparisons. Significance was set at $P < 0.05$.

## 3. Results

**Table 2.** Characteristics of vegetation distribution in alpine grassland

**Table 3.** Main plant species of alpine grassland

**Table 5.** Characteristics of soil properties of alpine grassland

**Table 6.** Correlation coefficient between vegetation community characteristics and soil properties

The results demonstrated significant differences in vegetation and soil characteristics among the five slope positions ($P < 0.05$). The lower shady slope exhibited the highest aboveground biomass, while the upper sunny slope showed the lowest. Underground biomass distribution followed a similar pattern, with the lower shady slope having the greatest biomass and the upper sunny slope the least. Soil moisture content, bulk density, porosity, and total nitrogen content varied significantly across slope positions and soil depths.

Correlation analysis revealed significant positive relationships between vegetation coverage and soil moisture content ($r = 0.953$, $P < 0.05$), and between aboveground biomass and soil total nitrogen content ($r = 0.902$, $P < 0.01$). Significant negative correlations were observed between soil bulk density and vegetation height ($r = -0.758$, $P < 0.01$) and between bulk density and species richness ($r = -0.746$, $P < 0.05$).

## 4. Discussion

The distribution patterns of alpine grassland vegetation are closely coupled with soil characteristics. Slope aspect significantly influences species composition, with *Kobresia* species dominating sunny slopes and Polygonaceae species thriving on shady slopes. This differentiation reflects adaptations to microclimatic conditions and soil moisture regimes.

Soil moisture emerges as a primary factor controlling vegetation distribution, with coverage and biomass showing strong positive correlations with water availability. The lower shady slope, with its favorable moisture retention, supports the highest plant diversity and productivity. Conversely, the upper sunny slope experiences greater evapotranspiration stress, limiting plant growth.

Soil nutrient status, particularly total nitrogen content, significantly affects community structure and biomass accumulation. The positive correlation between aboveground biomass and soil nitrogen ($r = 0.902$, $P < 0.01$) underscores the importance of nutrient availability in these alpine ecosystems.

Bulk density shows strong negative correlations with vegetation parameters, indicating that soil compaction limits root penetration and water infiltration, thereby constraining plant establishment and growth. The interplay between soil physical and chemical properties creates distinct habitat templates that filter species composition and determine ecosystem productivity.

These findings highlight that aboveground vegetation characteristics serve as reliable indicators of belowground soil conditions in alpine grasslands. Conservation and restoration efforts should prioritize maintaining soil moisture and nutrient status to preserve grassland quality and biodiversity in the Qilian Mountains.

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*Note: Figure translations are in progress. See original paper for figures.*