GRASSLAND COMMUNITIES AND SOILS ON A HIGH ELEVATION GRASSLAND OF CENTRAL PERU

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ABSTRACT

There is little information published on the vegetation and soils of the high elevation (4100-4700 m) grasslands of the Central Andes known as the puna. The objective of this study was to describe major plant community types and their associated soils on a 17,000 ha study area in one zone of the puna (moist puna belt).

Ten community types were recognized on the basis of dominant species and topographic position. Major topographic positions were floodplain, glaciated mountain valleys, mountain slopes, and high elevation (> 4600 m) exposed ridges. The vegetation was dominated by grasses (Calamagrostis, Festuca, Poa, and Stipa species) and forbs. Trees were rare and shrubs uncommon. Soils were generally high in organic matter at the surface and had dark surface horizons (mollic or umbric epipedons). Depending on the moisture regime, most soils were classified either as Histosols, Mollisols, or Alfisols. Argillic horizons were prevalent in the soils. Common soil parent materials were glacial till, andesite, limestone, siltstone, and river alluvium. Vegetation was arranged on a moisture gradient controlled by topographic position.

INTRODUCTION

The Andes are part of a major mountain network which extends from Alaska to Tiera del Fuego. High elevation grasslands of the Andes are unique ecosystems which constitute important grazing lands for the Andean countries. In Peru and Bolivia these grasslands are known as the puna. The puna extends over several hundred thousand square kilometers from latitudes of 8°S to 27°S and is associated with a series of high plateaus and intermontane basins beginning with the Pampa de Junin in central Peru. The altiplano, a vast tableland above 3600 m in southern Peru and Bolivia is the most familiar of these plateaus. Elevation of the puna varies from about 3900 to 4800 m. Troll (1968) divided the puna into three provinces: the moist puna, the dry puna, and the desert puna. The moist puna begins in northern Peru at a latitude of about 8°S where it blends in with another high elevation grassland typical of the northern Andes, the paramo, and lies adjacent to the eastern cordillera of the Andes as far south as Bolivia. The dry puna begins in southern Peru and extends into the altiplano of Bolivia, while the desert puna occurs in southern Bolivia and Chile adjacent to the Atacoma Desert.

A single wet season of variable duration occurs sometime between October and April, and supplies an average of 150 mm of precipitation to the desert puna and 1200 mm to the moist puna belt annually (Molina and Little, 1981). Annual rainfall decreases to the south and west. There is also a steady increase in concentration of rainfall into November to April towards the south (Johnson, 1976). Mean annual temperatures are less than 10°C and nocturnal frosts are common, especially during the dry season (Troll, 1968). Frost occurs nightly at 4100 m. Diurnal fluctuations can be as much as 20°C in the moist puna and even greater in the desert puna. Seasonal temperature differences become greater to the south. Paramo grasslands are distinguished from the puna by the lack of seasonal differences in precipitation and temperature in the paramo, and also by a higher relative humidity.

Puna vegetation has evolved under harsh environmental conditions, including a lengthy dry season, frequent frosts, low temperatures, pronounced diurnal temperature variation, high solar radiation, and low oxygen (Thomas and Winterholder, 1976). Plants have adapted to these environmental stresses in various ways (Cabrera, 1968). Perennial forbs typically have well-developed root systems many times larger than the above ground portions of plants. Leaves are often reduced, felty and lightly pubescent, or have a thick cuticle layer. Succulents such as Opuntia are also common. Many grasses have rolled leaves. Stems are often reduced or are below ground with only the leaves protruding above the surface.

The moist and dry puna are closely related florestically. Evergreen shrubs such as Lepidophyllum quadrangulare, and Fabina densa are more common in the dry puna (Molina and Little, 1981). In the desert puna shrubs predominate and vegetation cover is lower. Vegetation changes as a result of human impact are the elimination of Polylepis forests in much of the puna and proliferation of Opuntia flocosa.

Little information is available about soils of the puna. Early investigators grouped the high Andean soils into broad associations. Drosdoff et al. (1960) described three major soil groups as: (1) dark brown stoney loams to silt loams, (2) deep well-drained, dark brown to black loams and silt loams, and (3) hydromorphic medium to fine textured soils. Beek and Bramao (1968) included the soils of the central Andes as Paramo soils, and described them as being derived from heavy clays of glacial origin.

Information on vegetation and soils in the Central Andes is fragmentary (Glaser and Celecia, 1981). The objective of this study was to describe vegetation and associated soils in one area of the moist puna belt.

STUDY AREA

The 17,700 ha study area was located on an agricultural cooperative, Sociadad Agricola de Interes Social (S.A.I.S.) Pachacutec, headquartered at Corpacancha in the Department of Junin, Peru (11°25'S, 76°15'W). Corpacancha is about 42 km ENE of La Oroya, Peru. Rangeland of the cooperative has historically received better management than most of the puna, much of which is severely overgrazed. Elevation ranged from 4,150 m to 4,700 m. Topography included both gently rolling glaciated terrain and rugged mountainous terrain.

Corpacancha is in the moist puna belt as classified by Troll (1968). Climatic data from Corpacancha is limited. Vallejos and Quillatupa (1975) reported that in Corpacancha, the average yearly precipitation from 1965 to 1972 was 865 mm, and varied from 1,033 mm to 672 mm. Snow makes up a small percentage of this precipitation and does not accumulate below the permanent snow line (Troll 1968) which begins at about 5,150 m (Thomas and Winterhalder 1976).

METHODS

Our objective was to describe major plant community types in a 17,000 ha study area. The concept of dominance-types (e.g., Whittaker 1962, 1975; Beard 1975) provided the basis for distinguishing community-types through a combination of environment (indicated by topographic position) and dominant vegetation physiognomy and composition. Similar concepts have been widely applied in the study of tropical vegetation (Shimwell 1971; Beard 1975). Field methods were based on this concept. Potential community-types were tentatively delineated using aerial photographs and verified by extensive ground reconnaissance. Although this approach lacks complete objectivity, it is suitable for large-scale reconnaissance surveys (Mueller-Dombois and Ellenberg 1974) when a vegetation description and workable classification of a given area are required (Whittaker 1975).

Within each community-type 5 to 10 stands were selected on the basis of uniformity of habitat and lack of disturbance (inaccessibility limited sampling of the high elevation ridges to only one stand). Each stand was sampled with 5 to 10 randomly located 25-m line transects placed perpendicular to the slope. A total of 188 transects were established. Species composition and basal cover were estimated with point samples (Goddall 1952) taken at 0.5 m intervals along each transect. Cover categories were specific plant species, bare ground, litter, moss or rock. If a plant species was not encountered at a point, the nearest plant to this point was recorded. Therefore, species identity was recorded at 50 locations on each transect. Species composition was estimated from these data. Basal cover was estimated from point samples on each transect. Although this method overestimates cover, relative differences within a given study are useful in distinguishing species importance in different community types.

Twenty-eight soil pedons were described from hand-dug pits. Samples were collected from selected pedons. In some cases, sampling below 70 cm was by soil auger due to a high water table. Sites for soil description were selected to be representative of surrounding topographic position and parent material. Soils were classified according to the U.S. system (USDA 1975).

RESULTS AND DISCUSSION

Ten community types were recognized, and named on the basis of topographic position (Table 1). A brief description of the soils and vegetation of each community type follows.

Flood Plain

The Rio Corpacancha dissected the study site. Its flood plain was entrenched and varied in width from 100 m to 500 m. Elevation was around 4150 m. On the flood plain the water table was at or near the surface throughout the year. Soils developed on alluvial parent material. Organic horizons up to 36 cm thick were observed. The mineral soil was silty and gleyed reflecting poor drainage. Several buried organic horizons were also noted. These soils were classified as Typic Cryaquents.

Vegetation of the flood plain was dominated by grasses and sedges; forbs were uncommon (Table 2). Poa gilgiana, Festuca dolichophylla, and Calamagrostis brevifolia, were all important components of the flood plain flora. P. gilgiana grew evenly interspersed throughout most of the site. Distribution of Calamagrostis ligulata was quite variable, ranging from 2 to 32% of the species composition.

Glaciated Valley Community Types

All of the mountain valleys in the study area have been reworked by glaciers (Clapperton 1972). In these glaciated valleys four distinct community types were recognized. Soil moisture differences due to changes in topographic position have created a vegetation mosaic in these glaciated valleys.

Glaciated Bottomland

Glaciated bottomlands occurred in depressed basins in the valleys. Slope seepage creates saturated soils on these sites; soils remain saturated throughout the rainy season and for several months thereafter. Soils on these sites had thick organic horizons

Table 1. Site characteristics for 9 plant communities on the Corpacancha study area, Peru.

Character	Flood Plain	Xeric Glaciated Upland	Mesic Glaciated Upland	Bottom-land	Mountain Gravelly Loam	Mountain Andesite	Mountain Siltstone	Mountain Deep Loam	High Elevation Ridgetop
Slope (%)	0	8.8	6.3	6.7	41.0	36.7	59.0	43.0	7.4
Litter	45.7	58.5	54.8	45.0	41.4	46.6	32.0	51.0	62.0
Bareground	11.0	7.6	10.4	4.3	30.9	21.4	44.8	28.0	13.8
Rock	0.0	0.3	0.0	0.0	3.6	7.0	0.8	2.2	0.0
Moss	0.0	3.2	3.4	0.6	3.9	2.6	0.8	1.5	0.0
Basal cover	43.7	30.4	30.4	50.0	20.2	22.4	20.8	17.4	23.5
% Grass 1/	95.8	91.5	98.0	98.4	71.6	68.0	70.4	81.0	47.2
% Forb 1/	4.2	9.5	2.0	1.6	28.4	32.0	29.6	19.0	52.8
Species richness 1/	9.3	10.9	9.1	7.9	13.1	14.9	14.6	12.0	13.9

[1]Values were based on percent of the relative species composition.

[2]Values were calculated using the average number of plant species encountered along each transect (Whittaker 1970).

Table 2. Plant composition (> 1%) of the Flood Plain community on the Corpacancha study area.[1/]

Species	Relative Species Composition (%)		Basal Cover (1)	
	Avg	Range	Avg	Range
Poa gilgiana	19.3	12-34	7.5	4-12
Festuca dolichophylla	16.0	2-34	11.3	2-18
Calamagrostis brevifolia	13.8	4-20	5.8	2-14
Calamagrostis ligularis	12.8	2-32	9.0	2-22
Cyperaceae sp	12.3	2-22	6.0	0-10
Poa spicigera	9.8	4-22	2.3	0-8
Calamagrostis rigescens	4.5	0-10	1.8	0-6
Plantago tubulosa	4.0	0-8	0.5	0-4
Carex sp	3.5	0-10	1.0	0-4
Poa horridula	1.3	0-4	0.3	0-2

[1/] Data compiled from 8 transects; 17 species were encountered.

(> 40 cm). Mineral horizons were loams and gravelly clay loams. Parent material was glacial till. Soils were classified as Typic Cryohemists.

Vegetation in this community type was similar to the flood plain vegetation (Table 3). Grasses dominated and forbs were uncommon. On this site however, Calmagrostis brevifolia was clearly dominant, Festuca dolichophylla was also important; and Calamagrostis ligularis was absent. Basal cover was also very high on this site (Table 1). Also, species richness was lower than on the flood plain.

Mesic Glaciated Upland

The mesic glaciated upland community type usually occurred on lower slopes of the glaciated valleys. Soils of this community type had mollic epipedons with a relatively high amount of organic carbon. Argillic horizons were observed in all the pedons examined. Often a thin surface organic horizon (< 5 cm) was also present. Soil textures were loam and clay loam and became more gravelly with depth. Soils were classified as Argic Pachic Cryoborolls.

Vegetation was dominated by grasses (Table 4). Sedges were also common. Forbs were not abundant. Festuca dolichophylla was a characteristic spp., followed by Poa gilgiana. Both of these species were present on the flood plain and glaciated bottomland as was Poa spicigera. Calamagrostis brevifolia was less important on this site than on the flood plains and glaciated bottomlands.

Xeric Glaciated Upland

This extensive community type occurred on the drier valley slopes. Soils on the xeric glaciated uplands were very similar to those on mesic glaciated uplands. A dark surface horizon was prevalent; however, the epipedon was umbric rather than mollic because of low base saturation percentage. The bases have probably been leached out on the xeric sites and resupplied to the mesic sites by slope seepage. Argillic horizons were also present. Textures were similar to those of mesic glaciated uplands. Soils were classified as Mollic Cryoboralfs.

Vegetation in this community type was similar to the mesic upland type (Table 5), and the two community types blended into one another. Festuca dolichophylla was the most common species in this type, but it provided less basal cover than the more mesic sites. Carex ecuadorica, Festuca rigescens, and Calamagrostis vicunarum were more common, and Poa gilgiana and P. spicigera were less common in the xeric uplands. Forbs are more abundant in this community type than in other communities in the glaciated valleys (Table 1).

Table 3. Plant composition (> 1%) of the Glaciated Bottomland community on the Corpacancha study area.[1/]

Species	Relative Species Composition (%)		Basal Cover (%)	
	Avg	Range	Avg	Range
Calamagrostis brevifolia	50.0	26-62	29.3	10-44
Festuca dolichophylla	23.0	10-36	13.0	0-24
Poa gilgiana	7.0	0-22	1.4	0-8
Carex ecuadorica	6.7	0-18	1.3	0-4
Cyperaceae sp	3.3	0-20	1.6	0-10
Carex sp	3.2	0-14	0.3	0-2
Poa spicigera	3.0	0-12	0.4	0-10
Plantago tubulosa	1.0	0-8	0.6	0-8

1/ Data compiled from 14 transects; 22 species were encountered.

Table 4. Plant composition (> 1%) of the Mesic Glaciated Upland community on the Corpacancha study area.[1/]

Species	Relative Species Composition (%)		Basal Cover (%)	
	Avg	Range	Avg	Range
Festuca dolichophylla	33.8	18-62	16.3	8-34
Poa gilgiana	19.2	2-46	3.4	0-14
Calamagrostis vicunarum	9.6	0-20	4.3	0-12
Poa spicigera	8.1	0-36	1.4	0-6
Carex ecuadorica	5.3	0-18	0.7	0-4
Calamagrostis brevifolia	4.2	0-18	1.3	0-8
Bromus lanatus	3.4	0-12	0.7	0-4
Carex sp	3.2	0-24	0.4	0-4
Cyperaceae sp	2.1	0-16	0.2	0-2
Luzula peruviana	1.9	0-14	0.5	0-4
Festuca rigescens	1.4	0-12	0.2	0-4

[1/] Data compiled from 20 transects; 34 species were encountered.

Table 5. Plant composition (> 1%) of the Xeric Glaciated Upland community on the Corpacancha study area.[1/]

Species	Relative Species Composition (%)		Basal Cover (%)	
	Avg	Range	Avg	Range
Festuca dolichophylla	33.0	2-68	13.7	0-32
Carex ecuadorica	16.1	2-36	2.2	0-8
Calamagrostis vicunarum	13.1	2-30	4.4	0-16
Festuca rigescens	10.4	0-16	2.8	0-10
Bromus lanatus	3.6	0-10	0.9	0-4
Alchemilla pinnata	2.4	0-22	0.3	0-4
Scirpus rigidus	2.3	0-16	1.0	0-6
Agrostis breviculmis	2.0	0-14	0.7	0-6
Aciachne pulvinata	1.9	0-14	1.3	0-10
Poa gilgiana	1.4	0-14	0.2	0-4
Carex sp	1.1	0-10	0	0-4
Muhlenbergia ligularis	1.0	0-22	0.2	0-2

[1/]Data compiled from 43 transects; 50 species were encountered.

Bofedales

The discussion of the vegetation in glaciated mountain valleys would not be complete without mention of the "bofedal" community type. "Bofedal" is a local word describing small (5-25 m diameter) carpet like plant communities which abruptly appear in glaciated bottomlands and mesic glaciated upland community types. Soils under these dense evergreen mats of forbs were Histosols on either glacial till or alluvial parent material. The organic horizon (Histic epipedon) was quite thick (> 40 cm) and soils were gleyed reflecting poor drainage. Dominant species were Plantago tubulosa, Hypochoeris taraxacoides and some Carex sp. Other common forbs were Gentiana carneorubra and Gentiana prostrata. Calamagrostis brevifolia also appeared in small clumps.

Mountain Slope Community Types

Vegetation changed notably on slopes greater than 25%. Tall (80 cm) grass replaced mid (< 60 cm) grass of the glaciated valleys, and forbs were much more common. Four community types are described on the mountain slopes.

Mountain Gravelly Loam

This community type was found on both glacial till on steep slopes of glacial moraines and limestone colluvium on steep slopes. Soils (Mollic Cryoboralfs) on the glacial till were very similar to the Xeric Glaciated Upland soils. Soils which developed in limestone colluvium had mollic epipedons and argillic horizons (10 cm thick) that were thinner than those in glacial till soils. Textures were silt loams and silty clay loams on the surface, and became gravelly with depth. These soils were classified as Argic Cryoborolls.

The occurrence of the same plant community on two seemingly different soils is noteworthy. The glacial soil was deeper, more strongly developed, and more leached than the limestone soil. Both soils, however, had gravelly clay loam texture in the lower solum, perhaps contributing to similar soil water relationships.

Vegetation was dominated by Calamagrostis macrophylla and Festuca dolichophylla (Table 6). Stipa brachyphylla was also common. The only species present on this community type which also commonly occurred on the flatter glaciated sites were Festuca dolichophylla, Calamagrostis vicunarum, Bromus lanatus, and Alchemilla pinnata. Forbs made up almost 29% of the species composition. Azorella crenata and Baccharis alpina, a spreading prostrate semi-shrub whose woody stems grew underground with numerous small leaves protruding above the surface, were common. Basal cover was lower and species richness was higher on this site than on the valley sites (Table 1).

Table 6. Plant composition (> 1%) of the Mountain Gravelly Loam community on the Corpacancha study area.[1/]

Species	Relative Species Composition (%) Avg	Relative Species Composition (%) Range	Basal Cover (%) Avg	Basal Cover (%) Range
Calamagrostis macrophylla	31.1	14-54	11.5	4-18
Festsuca dolichophylla	17.9	2-44	4.7	0-18
Stipa brachyphylla	11.4	2-22	1.4	0-6
Azorella crenata	4.3	0-22	0.6	0-4
Bromus lanatus	2.9	0-6	0.6	0-2
Alchemilla pinnata	2.8	0-12	0.2	0-2
Baccharis alpina	2.3	0-8	0.6	0-4
Poa candomoana	2.3	0-8	0.1	0-2
Agrostis breviculmis	1.9	0-8	0.3	0-2
Luzula racemosa	1.8	0-10	0.5	0-4
Calamagrostis vicunarum	1.5	0-10	0.5	0-4
Werneria cespitosa	1.3	0-6	0.3	0-6
Werneria villosa	1.3	0-6	0.0	---
Oreithales integrifolia	1.1	0-4	0.0	---

[1/]Data compiled from 19 transects; 53 species were encountered.

Mountain Andesite

Portions of the study area were covered by andesite peaks. Only one soil profile was described on this site and it was classified as a Mollic Cryoboralf. Parent material was andesite colluvium and textures were loams and silt loams on the surface and gravelly loams from 50 cm - 100 cm. The mollic epipedon was very thick (75 cm) but the argillic horizon was only weakly developed, indicating the relative youth of the soils and/or the instability of the slope surface.

These slopes were uniformly dominated by Calamagrostis recta. The next most important grass was Stipa brachyphylla. Other grasses such as Festuca dolichophylla, F. rigescens, Poa gymnantha, and Agrostis breviculmis were common but not abundant on this site (Table 7). Forbs made up 32% of the community composition (Table 1). Baccharis alpina and Azorella crenata were most abundant, but many others were present. The forb component of this community type was very similar to the mountain gravelly loam type.Basal cover was about 22%.

Mountain Siltstone

This community type, found exclusively on red siltstone residuum parent material, made up a small portion of the study area. Soils on this site were classified as Mollic Cryoboralfs. The argillic horizon was well developed. Textures were silty clay loam in the A horizon and silty clay in the B and C horizons. Unlike the other Mollic Cryoboralfs on the study area, this soil had an ochric rather than an umbric epipedon.

Stipa brachyphylla and Calamagrostis recta were co-dominants (Table 8). Basal cover estimates of these two species in this community type were very close to their estimates in the mountain andesite community type. Festuca distichovaginata and C. macrophylla, each dominants on other sloping sites, were present in this community. Other common grasses were Bromus lanatus, Calamagrostis heterophylla, Agrostis tolensis, and Poa gymnatha.

Forbs made up 30% of the species composition (Table 1). Baccharis alpina was the most abundant forb. Plantago lamprophylla, Hypochoeris setosa and Alchemilla pinnata also were common. Bare ground estimates were highest in this community (45%) and basal cover was about 17%.

Mountain Deep Loam

This community type was found on glacial till and siltstone residuum and was the most common of all mountain slope community types. Soils were well drained and had deeper B horizons than other mountain soils. Glacial till soils were classified as Mollic Cryoboralfs with umbric epipedons. Thin organic horizons also were

Table 7. Plant composition (> 1%) of the Mountain Andesite community on the Corpacancha study area.[1/]

Species	Relative Species Composition (%) Avg	Relative Species Composition (%) Range	Basal Cover (%) Avg	Basal Cover (%) Range
Calamagrostis recta	41.5	28-52	9.7	6-16
Stipa brachyphylla	7.3	0-10	1.5	0-4
Baccharis alpina	7.2	2-16	1.8	0-4
Azorella crenata	5.4	0-14	1.0	0-4
Werneria nubignea	3.7	0-10	1.0	0-6
Festuca dolichophylla	2.9	0-8	0.8	0-2
Alchemilla pinnata	2.7	0-18	0.0	---
Poa gymnantha	2.5	0-6	0.3	0-2
Festuca rigescens	2.3	0-6	0.0	---
Agrostis breviculmis	2.0	0-4	0.8	0-4
Luzula racemosa	1.8	0-4	0.2	0-2
Geranium sessiliflorum	1.7	0-6	0.2	0-2
Pycnophyllum molle	1.5	0-8	0.7	0-6
Bromus lanatus	1.5	0-4	0.3	0-2
Werneria villosa	1.3	0-4	0.0	---
Agrostis tolensis	1.2	0-8	0.2	0-2

1/ Data compiled from 12 transects; 44 species were encountered.

Table 8. Plant composition (> 1%) of the Mountain Siltstone community on the Corpacancha study area.[1/]

Species	Relative Species Composition (%)		Basal Cover (%)	
	Avg	Range	Avg	Range
Stipa brachyphylla	22.7	18-30	2.2	0-4
Calamagrostis recta	20.4	8-28	6.2	0-10
Festuca districhovaginata	6.2	2-10	2.2	0-4
Plantago lamprophylla	5.1	0-16	0.9	0-4
Bromus lanatus	4.7	0-10	1.1	0-4
Baccharis alpina	4.4	0-12	1.8	0-4
Hypochoeris setosa	4.4	0-10	0.7	0-2
Alchemilla pinnata	3.8	0-12	0.4	0-2
Calamagrostis macrophylla	3.8	0-10	0.7	0-4
Bidens andicola	3.8	0-6	0.4	0-2
Calamagrostis vicunarum	2.4	0-10	0.2	0-2
Carex ecuadorica	2.2	0-12	0.2	0-2
Calamagrostis heterophylla	2.0	0-6	0.0	---
Stipa hans-meyeri	1.6	0-10	0.2	0-2

[1/]Data compiled from 9 transects; 46 species were encountered.

common. Textures were loam and sandy loam throughout. The B horizon extended to 80 cm. The brown siltstone soil also was deep (B horizon to 90 cm) and well drained. The mollic epipedon was 75 cm thick and the argillic horizon was 70 cm thick. Textures were silt loam and clay loam.

Festuca distichovaginata was the dominant species (Table 9). Stipa brachyphylla was an important subdominant, and Poa candamoana, Calamagrostis vicunarum, Bromus catharticus, and Calamagrostis heterophylla were common. Forbs comprised 19% of the species composition. Trifolium amabile and Alchemilla pinnata were the most common, and Baccharis alpina was absent.

High Elevation Ridge

On wind blown exposed knolls greater than 4600 m the vegetation changed from that of the tall grasses on mountain slopes to decumbant grasses and forbs. One community type was observed at these elevations.

Sampling was limited on this site because of its inaccessibility and limited extent. Only one soil pedon was described and vegetation sampling was limited to one site. The soil in this community type differed from the other soils described because it lacked a mollic epipedon and an argillic horizon. Parent material was an unidentified sedimentary rock. Textures were loam and clay loam and the B horizon extended to 70 cm. It was classified as a Typic Cryumbrept and was the only Inceptisol described on the study area.

The vegetation was made up of decumbent grasses, forbs and cushion plants. Grasses, dominated by Festuca rigescens, made up 47% of the composition. Calamagrostis vicunarum, Agrostis breviculmis, F. dolichophylla, Dissanthelium calycinum, Festuca humilor, and Aciachne pulvinata were common (Table 10). Forbs and cushion plants made up 54% of the species composition with Azorella crenata the most abundant. Cotula mexicana, Baccharis alpina, Werneria caespitosa, and Gentianella vaginalis also were common. Many of the plants found were unique to this community type.

CONCLUSION

Ten plant community types were identified and characterized by floral composition. Soils, parent material, and topographic position of each type were also described. Major topographic positions on the study area were the flood plain (alluvial), glaciated valleys (glacial till), mountain slopes (glacial till, limestone, andesite, siltstone) and the high elevation ridge. The vegetation was dominated by grasses. Dominant vegetation changed from mid grasses to tall grasses as slopes became greater than 25%. In the glaciated valleys community types blended into one another, providing few clear or abrupt ecotones, with the exception of the

Table 9. Plant composition (> 1%) of the Mountain Deep Loam community on the Corpacancha study area.[1/]

Species	Relative Species Composition (%)		Basal Cover (%)	
	Avg	Range	Avg	Range
Festuca distichovaginata	35.1	18-52	9.5	4-22
Stipa brachyphylla	17.6	14-40	2.6	0-6
Trifolium amabile	5.3	0-20	0.5	0-4
Alchemilla pinnata	4.6	0-12	0.2	0-2
Poa candomoana	4.6	0-32	0.5	0-8
Calamagrostis vicunarum	3.0	0-14	0.6	0-4
Bromus catharticus	2.7	0-8	0.2	0-2
Calamacrostis heterophylla	2.6	0-14	0.2	0-2
Carex ecuadorica	2.4	0-8	0.3	0-4
Bromus lanatus	2.3	0-10	0.2	0-2
Oenotheris multicaulis	1.5	0-6	0.1	0-2
Bidens andicola	1.2	0-12	0.3	0-2

1/ Data compiled from 22 transects; 52 species were encountered.

Table 10. Plant composition (> 1%) of the High Elevation Ridge community on the Corpacancha study area.[1/]

Species	Relative Species Composition (%)		Basal Cover (%)	
	Avg	Range	Avg	Range
Festuca rigescens	23.3	14-34	4.5	0-12
Azorella crenata	12.25	2-20	1.0	0-2
Calamagrostis vicunarum	9.5	2-18	2.0	0-6
Agrostis brevifolia	7.5	2-12	3.0	0-6
Cotula mexicana	7.3	0-10	1.8	0-8
Baccharis alpina	6.3	2-14	2.8	0-4
Festuca dolichophylla	4.3	0-10	1.8	0-6
Werneria cespitosa	3.5	0-10	0.5	0-2
Dissanthelium calycinum	3.0	0-10	1.0	0-4
Gentianella vaginalis	3.0	0-2	0.0	---
Festuca humilor	2.8	0-14	0.5	0-2
Alchemilla pinnata	2.3	0-6	0.5	0-2
Aciachne pulvinata	1.8	0-6	0.0	---
Pycnophyllum molle	1.8	0-6	1.3	0-4
Oreithales integrifolia	1.3	0-4	0.0	---

[1/] Data compiled from 8 transects; 30 species were encountered.

bofedal community. Basal cover was greater in the glaciated valley community types, and highest in glaciated bottomlands. The ratio of forbs to grasses also changed with moisture conditions. Forbs assumed more importance on the mountain slopes and high elevation ridgetops. Species richness was also greater in these community types. Mountain slope vegetation was most influenced by parent material. Tall grass dominants on these slopes were Calamagrostis machrophylla, Calamagrostis recta, and Festuca distichovaginata. Stipa brachyphylla was also common on these slopes. Festuca dolichophylla, Calamagrostis brevifolica, and several Poa species dominated the lesser sloping uplands, while Calamagrostis macrophylla, Calamagrostis recta, and Festuca distichovaginata dominated the mountain slopes. Festuca dolichophylla occurred on most sites.

Soils also differed with topographic position. Soils on the most hydric sites (flood plain, glaciated bottomland) had thick organic horizons (> 30 cm) and exhibited gleyed mineral horizons. Soils were similar on the mesic and xeric glaciated uplands. Usually they had a thin organic horizon (< 5 cm) and dark mollic or umbric epipedons. Argillic horizons were also prevalent. indicating moderate soil stability and maturity. On the mountain slopes soils varied with parent material, and mollic epipedons and argillic horizons were common. Common soil orders in the study area were Histosols (hydric sites), Alfisols and Mollisols.

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