The subalpine and alpine vegetation of the Georgian Caucasus - a first ethnobotanical and phytosociological synopsis

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Ethnobotany Research and Applications 23:12 (2022)

Research

Abstract

Background: The Republic of Georgia is part of the Caucasus biodiversity hotspot, and human agricultural plant use dates back at least 6000 years. Over the last years lots of ethnobotanical research on the area has been published. In this paper we analyze the use of food plants in the 80% of Georgia not occupied by Russian forces. We hypothesized that, (1) given the long tradition of plant use, and the isolation under Soviet rule, plant use both based on home gardens and wild harvesting would be more pronounced in Georgia than in the wider region, (2) food plant use knowledge would be widely and equally spread in most of Georgia, (3) there would still be incidence of knowledge loss despite wide plant use, especially in climatically favored agricultural regions in Western and Eastern Georgia. The alpine vegetation of the Caucasus hotspot has fascinated botanists for centuries. Given the very complicated biogeographic setting, a concise classification of vegetation communities has however eluded science so far.

Methods: The present work, based on 619 plots, is the first study to attempt a concise phytosociological classification. Even given this large number of samples a complete vegetation classification still proved difficult, and more releveés are needed for a detailed assessment, following Braun-Blanquet. It is also the first attempt to give an overview on plant uses in the alpine and subalpine areas of Georgia.

For plant uses we employed the very large dataset that we gathered all over Georgia interviewing over 300 participants from 2014-2019. For the vegetation analysis we employed traditional phytosociological table work combined with an analysis based on species composition, coverage and abiotic factors using "R", compared to a

Manuscript received: 21/01/2022 – Revised manuscript received: 05/02/2022 - Published: 06/02/2022
http://dx.doi.org/10.32859/era.23.12.1-60

classification using "Twinspan". From 2013 to 2019 we also interviewed over 380 participants in all regions of Georgia not occupied by Russian forces. All interviews were carried out in the participants' homes and gardens by native speakers of Georgian and its dialects (Imeretian, Rachian, Lechkhumian, Tush, Khevsurian, Psavian, Kakhetian), other Kartvelian languages (Megrelian, Svan) and minority languages (Ossetian, Ude, Azeri, Armenian, Greek).

Results: We found that 183 species of the subalpine and alpine flora, representing about 33% of all species encountered in the vegetation survey, had reported uses. The usage of alpine and subalpine species in Georgia is mostly focused on the use of the plants as fodder, which is unsurprising. Green crops such as *Lactuca sativa, Phaseolus vulgaris, Ocimum basilicum, Mentha x piperita, Allium cepa*, and *Artemisia dracunculus* are grown virtually everywhere. *Cucurbita pepo, Cucumis sativus, Solanum melongena*, and *Zea mays*, all introduced species, were discovered to be popular elements in local cuisine. In human and veterinary medicine, however, *Matricaria chamomilla, Berberis vulgaris,* and *Juniperus hemisphaerica* are still used. There are two vegetation classes: *Bromopsis variegatae - Festucaetea ovinea* (Class. nov.) (Subalpine pastures), which has seven orders and twelve alliances/eighteen associations, and *Sympoholoma graveolensis - Saxifragetea exaratae* (Class. nov.) (Alpine pastures), which has one order, two alliances, and four associations.

Conclusions: The alpine and subalpine vegetation of the Greater Caucasus and its uses were assessed in detail for the first time, highlighting the still existing gaps in both phytosociological and ethnobotanical work. Given the establishment of borders in post-soviet independence, it will be interesting to see how long this original cross-cultural knowledge will remain, given that the actual use of the traditional knowledge, as well as cross-border high altitude pastoralism are declining.

Keywords: Republic of Georgia, Caucasus, Traditional Knowledge, Knowledge loss, Food plants, Conservation, Vegetation analysis, vegetation communities, syntaxonomy

Background

Natural plant communities are being threatened by environmental changes such as global warming and increased human activity (Malhi et al., 2020). Alpine and subalpine ecosystems with cool climatic conditions are thought to be sensitive to environmental changes (Takahashi, 2018). Georgia's high altitudes are abundant in plant life, with a genetic diversity of medicinal plants, a wild relative of crop plants, and other economically important species. These fragile ecosystems are marked by rareness of topography, climate, soil, vegetation, and ethno-culture (Payal et al., 2020). As a result, a strategy for evaluating the relationship between vegetation and environmental conditions is to analyze plant species and classify them ecologically (Altaf et al., 2021). Traditional data regarding traditional use of natural resources and effective biodiversity protection can be found in ethnobotanical studies (Haq et al., 2021).

Georgia is situated between latitudes 41° and 44° N, and longitudes 40° and 47° E, with an area of 69700 km^2, with 20% of the country currently occupied by Russian troops. Georgia politically associates with the European Union and takes part in all major programs of European development and cooperation. Georgia can be defined as a transcontinental country on the divide between Asia and Europe, with its larger part located south to this divide (i.e., in Asia) and smaller but strategically important parts (e.g., Khevi, Piriketi Khevsureti,) located north of the continental divide (i.e., in Europe) (Bussmann *et al.* 2014).

The uplift of the Georgian Caucasus started in the late Oligocene and shares the same structural characteristics as the younger mountains of Europe. The Greater Caucasus mostly includes Cretaceous and Jurassic rocks, interspersed with Paleozoic and Precambrian formations in higher regions. Hard, crystalline, metamorphosed rocks like schist and gneisses, as well as pre-Jurassic granites are found in the western part, while softer, Early and Middle Jurassic clayey schist and sandstones in the eastern part. The foots of the Greater Caucasus are built of younger limestone, sandstones, and marls. The Lesser Caucasus in contrast is predominantly formed of Paleogene rocks interspersed with Jurassic and Cretaceous formations. The youngest geological structures of Georgia are represented by the vast volcanic plateaus in the southern part of the country. These divisions lead to an extremely complex terrain with pronounced climatic gradients: (1) the mountains of the greater Caucasus with peaks over 5000 m (Shkara, Babis Mta, Chanchakhi, etc.); (2) the inter-mountain plains between the Greater and Lesser Caucasus mountains; (3) the mountains of the Lesser Caucasus with peaks rarely exceeding 3000 m (Mepistskaro, Kheva, Shavi Klde, Kanis Mta, Arsiani); (4) the Volcanic plateau of the Southern Georgia with elevations from 1300-2200 m. (Nakhurtsrishvili 1999, 2021; Zazanashvili *et al.* 2000).

Georgia's climate is influenced by its location in the warm temperate zone stretching from the Black to the Caspian Seas, and the complexity of its terrain. Georgia has a coastline of 330 km with warm climate, the mean temperature reaching 4-7°C in January and 22-23°C in July, and high precipitation (1500-2000 mm annually). The warm oceanic-subtropical climate can be found only at lower elevations (less than 650 m); in more elevated terrains and to the north and east the climate becomes moderately warm. The Greater Caucasus bars cold air from the north, while warm and moist air from the Black Sea spreads easily into the coastal lowlands until reaching the Likhi range, which partly impedes further westward movement of the warm and moist air. In central Georgia precipitation in mountains can be twice that in the plains. In the mountains weather conditions change to cool and wet quite steeply with increasing elevation and above 2100 m the environment becomes sub-alpine and alpine, with permanent snow and ice above 3600 m (Nakhurtsrishvili 1999, 2021; Zazanashvili *et al.* 2000).

The alpine and subalpine vegetation of the Caucasus

High-mountain vegetation (from the viewpoint of botany) comprises the area situated above the climatic limit of trees. They are characterized by specific environmental conditions: high solar radiation, high ratio of ultraviolet radiation, low temperature, and low atmospheric pressure, (Larcher 1980, Körner 2003).The mean temperature of the growth period is generally 6-8 °C (Körner *et al.* 2003, Körner and Paulsen 2004, Pauli *et al.* 2011).One of the most pronounced peculiarities of life above the forest limit is the diversity of micro-habitats across even a very small area (Körner 2004, Nakhutsrishvili *et al.* 2011, 2012, 2017).

Georgia's climate is determined by its location within a warm temperate zone between the Black and Caspian Seas, and the complexity of its terrain in which mountain ranges and their orientation play an important part. The coastline of Georgia is 330 km long and the climate of the coastal zone is warm: the mean temperature is 4-7°C in January and 22-23°C in July. Precipitation is abundant (1500-2000 mm annually), especially in the southern part. At the same time, The Greater Caucasus mountains bars cold air from the north, while warm and moist air from the Black Sea spreads easily into the coastal lowlands from the west till the range of Likhi, which partly impedes further westward movement of the warm and moist air waves. In central Georgia, precipitation in mountains can be twice of that in the plains. Likewise, in the west the warm oceanic-subtropical climate can be found only at lower elevations (less than 650 m), in more elevated terrains and also to the north and east the climate becomes moderately warm. In the mountains weather conditions change to cool and wet quite steeply with increasing elevation and above 2100 m the environment becomes subalpine and alpine, permanent snow and ice are found above 3600 m (Nakhutsrishvili *et al.* 2017).

The debate on the origin of the alpine flora of the Caucasus has been going on for over a century. Kuznetsov (1915) hypothesized that the alpine flora of the Caucasus did not develop uniformly over time, and that many alpine plants existed as far back as the Miocene, but the bulk of the alpine flora arrived later from descendants of the forest vegetation. In his opinion, in the glacial periods, the alpine flora of the Caucasus became enriched due to the intensive exchange with the mountains of Europe and Asia. Kuznetsov (1915) dated the alpine flora to the Sarmatian, considering it essentially autochthonous. Medvedev (1915) suggests assemblages that were close to the modern tall herbaceous vegetation or to *Rhododendron* thickets with ancient Tertiary elements. The modern alpine vegetation, in his opinion, appeared only during the Pleistocene. Fedorov (1942, 1952) suggested that the alpine flora falls in three groups: arcto-alpine, alpine Caucasian and alpine Eurasian, of which only the first group is migratory. Maleev (1948) believed that the basis of modern subalpine and alpine meadows mostly established in glacial periods as a result of boreal invasions. Takhtajan (1946) recognized low stature grassland (alpine swards), pteridophytes and chionophile species. In his later work, Takhtajan (1957) suggested that moderate (alpine) and cryophilus (arctic) floras were of low-latitude mountain origin. Kharkevich (1954) advocated a migration hypothesis for the formation of the alpine flora of the Caucasus in the Quaternary Age. Popov (1949) believed that the alpine flora of the Caucasus was autochthonous. Elenevskyi (1964, 1965) dated subalpine and alpine meadows of the Lesser Caucasus to Quaternary formations, while subalpine tall herbaceous vegetation as well as *Rhododendron* thickets and rock vegetation should be dated back to Tertiary formations. Most Caucasian botanists regarded the high-mountain flora of the region to consist chiefly of the boreal and arctic-alpine elements, which radiated into this area during the Pleistocene. Later, the most typical representatives of the Caucasian alpine flora were believed to be of autochthonous origin (Fedorov 1952, Kharadze 1960), and that the alpine flora of today is of Tertiary origin, developed during the Quaternary. In his analysis of Caucasian endemism, Grossheim (1936) indicated that the area of the Greater Caucasus was a region for "processing" of migrating boreal and Asia Minor elements (Nakhutsrishvili *et al.* 2017).

The most conservative paleoendemic of the Caucasian high mountains have remained in the central parts and at the boundaries of the ice shield. In the Alps and Carpathians, as well as in the Caucasus, the highest mountain ranges served as refugia for the pre-glacial ancient endemic flora (Kharadze 1960). Both progressive and conservative paleoendemic can be found in the highest part of the Caucasian mountains. Conservative paleoendemic are exemplified by *Sredinskya grandis*, *Campanula mirabilis*, *C. ossetica*, *Edraianthus owerinianus*, *Symphyandra lezgina*. Progressive paleoendemic species include, *Charesia akinfiewii*, *Petrocoma hoefftiana* and *Symphyandra pendula* (Nakhutsrishvili *et al.* 2017).

The contribution of Zernov 2006) is the most recent publication that covers the history of the flora of the Caucasus, particularly of the North-West Caucasus. According to this author, most of the species of the alpine flora of the Caucasus were developed from pre-pleistocene migrants. Their penetration into the Caucasus took place partially from the north, partially from the south, from South-West Asia. Agakhanjanz and Breckle 2002) concluded that endemism is strongly influenced by the presence or absence of forest belts and thus the climatic conditions in the migratory belts. These belts are, however, often fragmented by riverbeds, erosion gullies, rock-cliffs, which altogether would permit by passing the forest belts (Nakhutsrishvili *et al.* 2017).

Kharadze (1960) outlined that the following species are originating from Daghestan, e.g., *Stipa daghestanica*, *Thymus daghestanicus*, *Heliotropium styligerum*. She also suggests that the limestone mountain massifs of the North Caucasus participated in the formation of the pre-Pleistocene xerophytic flora. The example of such mountains is the limestone Rocky Range of the Great Caucasus. Autochthonous hemi xerophytic elements are well represented in the areas of the Central Caucasus from the mid-montane to the subnival belts. Among the distant relations of the Caucasian oreo xerophytic flora, the connections with those of the Mediterranean and Asia Minor should be mentioned. Ancient connections with the Mediterranean flora have been found in the following genera: *Astragalus*, *Nepeta*, *Scabiosa*, *Symphyandra*, *Edraianthus*. The Late Pliocene is the period of the most ancient migrations from Asia Minor to the Caucasus. Radiation of these elements into the Caucasus was associated with the xeric periods of the Pleistocene and also of the Holocene (Grossheim 1936, Kharadze 1960.Autochthonous oreo xerophytic species of the Caucasus reveal ancient connections with those of the flora of Asia Minor. Examples are *Salvia canescens* var. *daghestanica*, *Betonica nivea*, species of *Silene*, *Astragalus*, *Scutellaria*, *Ziziphora*, etc. Members of the autochthonous subnival flora of the Caucasus are also regarded as xerophytic elements of the humid flora of the same region (Kharadze 1960).

The high elevations of the Caucasus display a great variety of life forms, which can be explained for by their evolution under different climatic conditions, strong relief, and habitat fragmentation, and also by the situation of the Caucasus at the crossway of contrasting physical and biogeographical regions (Nakhutsrishvili *et al.* 2017). The resultant postglacial vegetation has its roots in the Oligocene during which all high-elevation vegetation belts were represented. The first treeless formations, grass and shrubs appeared in the Upper Miocene. The vegetation has changed dramatically during glacial periods. Warm microhabitats in sheltered locations have contributed to the survival even during very cold periods. The postglacial xerophilization in the Caucasus resulted in a degradation of the meso thermophilous forest vegetation (Shatilova *et al.* 2011). The oroxerophilous vegetation of Irano-Turanian origin radiated into the Central Caucasus through narrow rocky gorges. This vegetation includes cushion-like tragacanths such as *Astragalus denudatus* and forbs like *Artemisia splendens*, *A. sosnovskyi*, *Silene linearifolia*, *Astragalus kazbekii*, etc. A similar type of vegetation formed under dry continental conditions in the Eastern Caucasus. A number of herbaceous species and communities arrived in the Central Caucasus in the post-glacial period. Of these, the *Astragalus bungeanus* aggregate, is a characteristic element of the mountain-steppe landscapes with phryganoid vegetation and *Scutellaria leptostegia* which is typical for the tragacanth vegetation of the subalpine belt of the Tergi gorge (Kharadze 1948a). Other examples of these postglacial elements are *Campanula alliariifolia* which inhabits talus, often at the edge of birch forests (Grossheim 1948) and particularly *Carex buschiorum* (a species closely related to *C. humilis*), which became a typical element of postglacial subalpine pine (*Pinus kochiana*) forests on glacial moraines. Today *P. kochiana* is only found on granite outcrops of the Daryali canyon (the Central Caucasus.As a result of the postglacial warming, birch (*Betula litwinowii*) forests became strongly reduced, and are now largely confined to park-type woodland and dwarf shrubs ('*Krummholz*') in the subalpine belt (Tumadjanov 1947, Gulisashvili 1964, Dolukhanov 2010, Nakhutsrishvili *et al.* 2017).

Thermophilous meadows with steppe species such as *Festuca ovina*, *F. valesiaca*, *Bromopsis riparia*, *Carex buschiorum*, *Pulsatilla violacea* and others became abundant. *Kobresia* species reached the highlands of the

Caucasus from the mountains of Central Asia and are found primarily on the wind-swept crests or ridges. The wide distribution of the *Festucetum variae* type of grassland in the highlands of the Caucasus is also associated with the postglacial xerothermic period (Kimeridze 1965a,b, Nakhutsrishvili 2013, Pysek, Srütek 1989).

Floristic Overview of Vegetation Belts

In the eastern part of the Central Caucasus, over 1300 species of vascular plants have been recorded (Sakhokia and Khutsishvili 1975, Ketskhoveli *et al.* 1971-2011.Among them 0.5% are gymnosperm species, 79.2% dicots, and 20.3% monocots (Grossheim 1936). These are: Asteraceae, Lamiaceae, Rosaceae, Caryophylaceae, Boraginaceae, Fabaceae, Liliaceae (in decreasing species richness. The region is especially rich in endemic species (Grossheim 1936, Schatz *et al.* 2014). The presence of 6 Caucasian endemic genera (out of 11) also underlines the richness of the flora of this region. e.g. *Agasyllis*, *Symphyoloma*, *Cladochaeta*, *Dolichorrhiza*, *Trigonocaryum*, and *Pseudovesicaria*. The highest number of endemic species appears in the genus *Campanula* (16 species), followed by *Alchemilla* and *Astragalus* with at least 10 species each. The genera *Thymus*, *Delphinium*, *Onobrychis*, and *Isatis* exhibit a 100% region-specific endemism (Gagnidze 2000, 2005, Nakhutsrishvili 2013, Nakhutsrishvili *et al.* 2017).

In the vegetation overview we adopt the classical biogeographic zonation of mountain belts by elevation as there are (from low to high): colline, lower montane, mid montane, upper montane, treeline ecotone, alpine (sometimes separated into a lower, mid and upper belt), subnival and nival. However, in addition, the term 'subalpine', often abandoned for its difficult definition (Löve 1970, Körner 2003), will play a prominent role here. For some authors, subalpine is a synonymous to the treeline ecotone, i.e. the belt of gradual opening of the upper montane forest towards the tree limit. For others, this is a synonymous to the upper montane zone. The difficulty in the central Caucasus is that the natural montane forest ecosystems are largely gone and became replaced by vast terrain with many types of different grassland, thus, extending the alpine grassland formation downhill, both by appearance as well, as in some cases, by taxonomy. Hence, traditionally, 'subalpine' has been applied to much of the open land between the potential natural position of the climatic treeline at ca. 2500 m and sloping down to 1900-2000 m elevation. From an ecological point of view there are good reasons for such a wider application of 'subalpine', given the short stature vegetation shares many of the common features of alpine vegetation, such as a warmer microclimate, strong influence of exposure and microtopography and many common taxa that are found both in the alpine and below alpine grassland. The term upper montane will thus, be restricted to patches of high elevation woodland. In addition, at each elevation, moisture conditions may vary from aquatic, to wet, moist, mesic, dry and very dry, addressed as xerophytic or, because of the mountain position, as oroxerophytic. Notably, that horizontal graduation of life conditions is more pronounced at low elevation, still significant in the subalpine belt, but vanishes at upper alpine and nival elevations, where moisture conditions become more similar across the Caucasus range (Nakhutsrishvili *et al.* 2017).

Materials and Methods

Ethnobotanical studies

From 2013 to 2019 we interviewed over 380 participants in all regions of Georgia not occupied by Russian forces on their general plant use, recording over 32000 individual uses. The analyses of all uses have been published in a variety of papers (Batsatsashvikli *et al.* 2020a,b; Bussmann 2017; Bussmann *et al.* 2016a,b,c, 2017a,b,c, 2018, 2020a,b,c,d,e,f,g,h,i,j,k; 2021a,b,c). However, of all uses over 19800 mentions were of food plants, which is why we regarded it as prudent to present a separate analysis of these. Interviews using semi-structured questionnaires were conducted after obtaining the oral prior informed consent of the participants (Mir *et al.,* 2021; Hassan *et al.,* 2021), which were selected by snowball sampling, trying to reach gender balance, and representing different age-groups. Most participants were however over 50 years old, as interviews targeted remote villages where only very few younger people remain. All interviews were carried out in the participants' homes and gardens by native speakers of Georgian and its dialects (Imeretian, Rachian, Lechkhumian, Tush, Khevsurian, Psavian, Kakhetian), other Kartvelian languages (Megrelian, Svan) and minority languages (Ossetian, Ude, Azeri, Armenian, Greek). Plants grown in home gardens were used as prompts, while wild-collected species were free listed. We classified species as "garden" when they were grown/collected in cultivated areas, and as "forest / wild-collected" when growing and harvested in the wild. We maintained the distinction of "forest" and "garden" because it was used in our previous publications from the region (Batsatsashvikli *et al.* 2020a,b; Bussmann 2017; Bussmann *et al.* 2016a,b,c, 2017a,b,c, 2018, 2020a,b,c,d,e,f,g,h,i,j,k; 2021a,b,c), to maintain consistency. In contrast to many other countries Georgia benefits from a complete flora (Flora of Georgia Committee 1941-1952, 1971-2011; Gagnidze 2005; Makashvili 1952-1953, 1991) and a broad inventory of vernacular names in all languages (Makashvili 1991). Species were

identified directly in the field, using this literature, and vouchers collected and deposited in the National Herbarium of Georgia (TBI). The nomenclature of all species follows www.tropicos.org, under APGIII (Angiosperm Phylogeny Group 2009). Collection permits were provided through the Institute of Botany, Ilia State University, Tbilisi.

Vegetation Sampling and plant identification

A total of 619 plots with sizes from $5m^2$ (rock vegetation) to $25m^2$ (alpine herb communities) and $100m^2$ (alpine pastures) were selected. For each sampling site, altitude, slope, and exposition were noted, and relative values of density, frequency, cover and Importance Value (IV) were calculated following the methodology of Curtis and McIntosh (1950), Son *et al.* 2019), Tian *et al.* 2018). Geographic coordinates were recorded for each sampling site. The expositions of the mountains i.e., east (E), west (W), south (S) and north (N) were determined with the help of clinometer, latitude, longitude, and altitude using geographical positioning system (GPS). Plant specimens were collected, and standard herbarium vouchers prepared (Ijaz et al., 2018). All the specimens were identified with the help of Flora of Georgia (Flora of Georgia Committee, 1941-52, 1972-2011, Gagnize 2005) and other available literature citations required. Scientific names of plant species were cross-checked and updated through www.theplantlist.org and www.tropicos.org. The plant specimens were deposited in the National Herbarium of Georgia.

Statistical analyses

All the collected data of plant species and other environmental variables data were used to find out the relationship among them (Mayor et al., 2017, Šmilauer and Jan, 2014). Matrixes of IV data of all the recorded plant species (563 species) from 619 plots were used in the analyzes. The analyses were carried using PCORD 5.0 and RStudio 4.0.0 (R Core Team, 2020) at 5% of probability.

Species area curves (SAC) and Two-way indicator species analysis (TWINSPAN)

Species area curves (SAC) were produced using PC-ORD to check the efficiency of the sampling effort, where plant abundance data with Sorensen distance values were used to create species area curves. For the classification of the recorded plant species (563 species) and 619 plots, Two-way indicator species analysis (TWINSPAN) were processed using PC-ORD version 5.0 to identify the major plant communities (Haq et al., 2017, Hill, 1979, Rahman et al., 2020). These analyses were based on patterns of similarity via Sorenson Distance Measurements using Wards Linkage Method (Greig-Smith, 1983) and IV (Rahman et al., 2020). Similarly, the plant communities were named on the basis of dominant species (Lou et al., 2016, Son et al., 2019, Song et al., 2015, Tian et al., 2018).

Community association and species composition

We visualized floristic relation among communities and environmental variables through a Principal Component Analysis (PCA) (Terzi et al., 2019) using the package "vegan" (Oksanen et al., 2019). To observe which environmental variable (altitude and different aspects) significantly influence communities' distribution in the ordination, we used the "envfit" function with 999 permutations using the package "vegan". The vectors projected on points had a maximum correlation with corresponding environmental variables.

To evaluate a potential variation in species composition between plant communities, we applied a Permutational Multivariate Analysis of Variance (PERMANOVA) with Euclidean distance and 999 permutations. Pairwise comparisons between communities with corrections for multiple testing were conducted using Euclidean distance and 999 permutations. False discovery rate (FDR) was used as p-value adjustment method. PERMANOVA and pairwise comparisons were conducted with the "RVAideMemoire" package (Hervé, 2020).

Partial CCA

To observe how explanatory variables drive the plant communities, we conducted a canonical correspondence analysis (CCA) and variation partitioning tests (partial CCA). We fit the best model using the variables that most explain the variance by conducting the *step* function in the "stats" package. We also checked multicollinearity between variables using the Variance Inflation Factor (VIF). Then, we carried out CCA and partial CCA using the package "vegan".

Regression models

To compare if there is variation in the average altitude among plant communities, we used a Generalized Linear Model (GLM) followed by Likelihood Ratio test using the "stats" package (R Core Team, 2020.The altitude was fit as

response variable and the communities as explanatory variables. Pairwise comparisons were conducted with estimated marginal means using the package "emmeans" (Lenth, 2020). To compare the species richness, Shannon diversity, Simpson diversity and Pielou's evenness between plant communities, we conducted a GLM with Gaussian error distribution (except for species richness, in which we used negative binomial distribution controlling for overdispersion) followed by Likelihood Ratio test using the 'stats' and 'car' (Fox and Weisberg, 2018) packages, respectively.

Diversity index

To evaluate the beta diversity patterns between the seven communities, the Sørensen dissimilarity index was decomposed in two additive components: the spatial turnover (Simpson pairwise dissimilarity) and nestedness-resultant components (nestedness-fraction of Sorensen pairwise dissimilarity) (Baselga, 2010, 2013, Baselga and Orme, 2012). These analyses were conducted using the "betapart" package (Baselga et al., 2018).

Results and Discussion

Use of the Alpine and Subalpine flora

We found that 183 species of the subalpine and alpine flora, representing about 33% of all species encountered in the vegetation survey, had reported uses. Eighty-four species were used as animal fodder, especially in summer pastures, 66 species were used medicinally, 65 species were used as food, especially to make phkhali (herb pie), khachapuri (herb and cheese filled bread), in sat'sebai (dipped in yogurt and milk), or lacto-fermented, 18 species as utensils, i.e., to make brooms, four for cultural purposes (e.g., as ornamentals and toys), two for construction purposes, and one species was used as fuelwood. A complete overview on all species and their uses is given in Table 1.

Plant use history

The Caucasus is regarded as global biodiversity hotspot (Akhalkatsi & Tarkhnishvili 2012; Otte *et al.* 2011; Schatz *et al.* 2009; Kimeridze & Akhalkatsi 2006), and Georgia has its fair share of the tremendous diversity of the region (Schatz *et al.* 2009.Botanical exploration of the Caucasus has a long history, yielding good recent treatments of the area's vegetation, in particular with regard to Georgia (Nakhutsrishvili 1999). As such Georgia has long been the center point of botanical Exploration in the Caucasus, with Bakuriani alpine Botanical Garden serving as a hub. The visitor's log of the garden reads like a "Who is who" of 20th century Botany.

The territory of modern-day Georgia has been continuously inhabited since the early Stone Age, and agriculture was developed during the early Neolithic era (Javakhishvili 1987). In Georgian the name of the country is "Sakartvelo", and "Georgia" is semantically linked to Greek (γεωργία) meaning "agriculture" (Javakhishvili 1987). Human occupation however started in the Early Pleistocene. The 1.7-Myr-old hominid fossils of Dmanisi in Southern Georgia are the earliest known hominid-site outside of Africa (Finlayson 2005, Gabunia, Vekua 1995, Gabunia *et al.* 2000). This specimen has been classified as In the Late Middle Paleolithic and Early Upper Neanderthal and modern human occupation are well documented (Adler, Bar-Oz 2009). Upper Paleolithic fossils of Dzudzuana Cave include remnants of wool (*Capra caucasica*) and dyed fibers of wild flax (*Linum usitatissimum* L.) dated to ~36-34 Ka BP (Adler, Bar-Oz 2009).

The archeological findings from Neolithic and Early Bronze periods are rich with plant fossils and seeds of both wild species and local landraces. Seven species of cultivated wheat - *Triticum aestivum* L.*, T. carthlicum* Nevski*, T. compactum* Host*, T. dicoccum* Schrank*, T. macha* Dekapr., Menabde*, T. monococcum* L.*, T. spelta* L.*,* one wild relative, *Aegilops cylindrica* Host.*,* as well as millet - *Panicum milliaceum* L., barley - *Hordeum vulgare* L., Italian millet - *Setaria italica* L.) P. Beauv., oats - *Avena sativa* L., wild lentil - *Lens ervoides* (Brignolidi, Brunhoff) Grande, and pea - *Pisum sativum* L. have been discovered in Arukhlo, dating back to the 6th - 2nd millennium BC (Melikishvili 1970). The earliest grapevine seeds indicating cultivation were excavated in southern Georgia and date to ~8.000 years BP (Ramishvili 1988). Due to its long tradition, agriculture in Georgia is characterized by a great diversity of landraces, and endemic species of crops. These show a high level of adaptation to local climatic conditions and often-high disease resistance. Early research documented this great variety (Dekaprelevich *et al.* 1929, Ketskhoveli 1928, 1957, Ketskovili *et al.* 1960, Menabde 1938, 1948), but a rapid loss of local cultivars of cereals, legumes and flax began in the 1950s with Stalinist agricultural reform (Akhaljatsi 2009, Akhalkatsi *et al.*, 2010). Despite the long cultural history, recent studies on cultivated plants are rather scarce (e.g., Pistrick *et al.* 2009, Zhizhizlashvili *et al.* 1980).

Table 1. Uses of Alpine plant species in Georgia

Family	**Species**	**Local Name** (Georgian, if not indicated otherwise in parenthesis: Arm. = Armenian; Imer. = Imeretian; Khev. = Khevsurian); Psha. = Pshaviab; Rach. = Rachian; Russ. = Russian; Svan. = Svanetian; Tush. = Tushetian)	**Use Category**
Amaryllidaceae	*Allium kunthianum* Vved.	კლდის ხახვი (k'ldis khakhvi); კლდისნიორა (k'ldisnora)	Food - bulbs eaten raw
Apiaceae	*Agasyllis latifolia* (M. Bieb.) Boiss.	დუცი (dutsi), გჰეჰ (gheh Svan.), ლაგი (lagi Khev.)	Food - leaves, petiole, stem for khachapuri, phkhali, pickled Medicinal - leaves, stem, petioles as anthelmintic, stem bark for asthma, root for the digstive system
	Anthriscus nemorosa (M. Bieb.) Spreng.	მათუთი (matuti), ლიმი (limi Svan.)	Food - fruits eaten as spice, leaves and stems pickled Plant is regarded as toxic
	Astrantia maxima Pall.	უკვდავა (uk'vdava)	Cultural - whole plant as decoration
	Astrantia trifida Hoffm.		Cultural - whole plant as decoration
	Astrodaucus orientalis Drude	ღორციფერა (ghortsipera)	
	Bupleurum polyphyllum Ledeb.		
	Carum carvi L.	კვლიავი (k'vilavi), ძირა (zira), წყალთქონდარა (ts'q'altkondara); წყლის ქონდარი (ts'q'lis kondari Tush.), გიცრულ (gitsrul Svan.)	Food - seeds in chave, eaten as spice, khinkali, pickled, in svan salt Medicinal - seeds for diarrhea and heartburn
	Carum caucasicum Boiss.		Animal food - leaves / whole plant grazed and as fodder
	Chaerophyllum aureum L.	ყვასგ (qhvasg Svan.), ჭიმი (ch'imi Tush.)	Food - root eaten raw, stems pickled Medicinal - root for nerves
	Chaerophyllum humile M. Bieb.		Animal food - leaves / whole plant grazed and as fodder
	Chaerophyllum roseum M. Bieb.		Animal food - leaves / whole plant grazed and as fodder
	Chaerophyllum rubellum Albov.		Animal food - leaves / whole plant grazed and as fodder

	Chamaesciadium acaule (M. Bieb.) C.A. Mey.	ცხვრის კელიავი (tskhvris k'eliavi)	
	Heracleum asperum M. Bieb.	შუპყაი (shupq'a)	Food - leaves and stems pickled, for sats'ebai and eaten raw Medicinal - root for toothache
	Heracleum sosnowskyi M. Bieb.	დიყი (diq'i); ქეხი (qekhi Arm.); ჩიჩვა (chichva Svan.)	Food - leaves and stems pickled, for sats'ebai, chave and eaten raw Medicinal - root to treat cancer and tumors
	Ligusticum alatum Spreng.	მარიამა (mariama)	Food - leaves eaten raw and in sats'ebai
	Pastinaca armena Fisch. & C.A. Mey.		Animal food - leaves / whole plant grazed and as fodder
	Pimpinella rhodantha Boiss.		Animal food - leaves / whole plant grazed and as fodder
	Pimpinella saxifraga L.	გვერდელა (gverdela)	Animal food - leaves / whole plant grazed and as fodder
	Seseli alpinum M. Bieb.		Animal food - leaves / whole plant grazed and as fodder
	Seseli transcaucasicum Pimenov & Sdobnina	სასუქა (sasuka); აპურსი (ap'ursi - Svan.); კაკბის-მკერდა (k'ak'bis-mk'erda - Khev.); ყარანდუცა (q'arandutsa - Mokh.); ძაბრა (dzabra - Kart.)	Animal food - leaves / whole plant grazed and as fodder
	Symphyoloma graveolens C.A. Mey.		
Aspleniaceae	*Asplenium septentrionale* (L.) Hoffm.		
Asteraceae	*Achillea millefolium* L.	ფარსმანდუკი (parsmanduk'i), მელაკუდა (melik'uda Tush.), წყლულის ბალახი (ts'q'lulis balakhi Tush.); Khazarateig Arm.	Food - leaves in khachapuri, whole plant as tea Medicinal - Leaves as anti-inflammatory, cholagogue, diuretic, inflammation, kidneys, liver, sore throat, ulcers, wounds, whole plant as panacea Utensils and Tools - leaves as dye
	Achillea ptarmicifolia (Willd.) Rupr. ex Heimerl	ველური ტარხუნა (Veluri tarkhuna)	Medicinal - leaves for wounds
	Aetheopappus caucasicus Sosn.	ოქროკუდა (okrok'uda)	
	Antennaria caucasica Boriss.		
	Anthemis iberica M. Bieb.		

Anthemis macroglossa Sommier & Levier		
Anthemis marschalliana Willd.		
Anthemis rudolphiana M. Bieb.		
Anthemis sosnovskyana Fed.		
Arctium lappa L.	ძირხვენა (dzirxvena); Graduk (Arm.)	Food - leaves and roots eaten raw, leaves in phkhali, stems pickled Medicinal - flowers and leaves as antibiotic
Artemisia absinthium L.	აბზინდა (abzinda), გიეში (gieshi Tush.)	Food - leaves eaten raw and as tea Medicinal - leaves to treat bedwetting in children, cold, sore throat, fever
Artemisia campestris L.		Utensils and tools - stem for brooms
Artemisia chamaemelifolia Vill.		Utensils and tools - stem for brooms
Artemisia marschalliana Spreng.	გიეში (gieshi)	Utensils and tools - stem for brooms
Artemisia splendens Willd.		
Artemisia vulgaris L.	ჯორთკუდა (jortk'uda); ველური ტარხუნა (veluri t'arkhuna Svan.)	Food - leaves eaten raw and in sats'ebai Medicinal - leaves as diuretic, for gallbladder and to kill lice
Aster alpinus L.		
Aster ibericus Steven ex M. Bieb.		
Carduus onopordioides Fisch. ex M. Bieb.	ნარშავი (narshavi)	
Centaurea cheiranthifolia Willd.		
Centaurea salicifolia M. Bieb.		
Cicerbita racemosa (Willd.) Beauverd		
Cirsium echinus Hand.-Mazz.	ნარი (nari)	Food - leaves for sats'ebai Medicinal - leaves for hemorrhoids
Cirsium obvallatum M. Bieb.	ნარი (nari)	Food - leaves for sats'ebai Medicinal - leaves for hemorrhoids
Cirsium osseticum Petr.	ნარი (nari)	Food - leaves for sats'ebai Medicinal - leaves for hemorrhoids
Cirsium pugnax Sommier & Levier	ნარი (nari)	Food - leaves for sats'ebai Medicinal - leaves for hemorrhoids

Cirsium rhizocephalum C.A. Mey.	ნარი (nari)	Food - leaves for sats'ebai Medicinal - leaves for hemorrhoids
Cirsium simplex C.A. Mey.	ნარი (nari)	Food - leaves for sats'ebai Medicinal - leaves for hemorrhoids
Crepis sonchifolia (M. Bieb.) C.A. Mey.	კიჭკიჭა (k'ich'k'ich'ia)	
Dolichorrhiza renifolia Galushko		
Doronicum macrophyllum Fisch. ex Hornem.		
Erigeron alpinus L.		
Erigeron caucasicus Steven		
Erigeron orientalis Boiss.		
Erigeron sp.		
Erigeron uniflorus L.		
Gnaphalium supinum L.	ბერული (dzeruli)	
Hieracium elisabethae M. Bieb.	ხარნუქა (kharnuka)	
Hieracium laevigatum Willd.	ხარნუქა (kharnuka)	
Hieracium panaeoliforme Üksip	ხარნუქა (kharnuka)	
Hieracium pilosella L.	ხარნუქა (kharnuka)	
Hieracium umbellatum L.	ხარნუქა (kharnuka)	
Inula orientalis Lam.		
Jurinea filicifolia Boiss.		
Jurinella subacaulis Iljin		
Lapsana grandiflora M. Bieb.	მწარე ხარნუყა (mts'are kharnuq'a)	Food - leaves eaten raw and in soup
Lapsana intermedia M. Bieb.		
Leontodon caucasicus Fisch.	ლომისკბილა (lomisk'bila)	
Leontodon danubialis Jacq.	ლომისკბილა (lomisk'bila)	
Leontodon hispidus L.	ლომისკბილა (lomisk'bila)	
Leucanthemum vulgare Lam.	მინდვრის გვირილა (mindvris gvirila)	

Ligularia sibirica (L.) Cass.		
Matricaria chamomilla L.	გვირილა (gvirila); Ромашка (Romaschka Russ.)	Food - leaves and whole plant for chave, tea Medicinal - whole plant for cough, diuretic, gastro-intestinal system, stomach, wounds; leaves for toothache
Petasites fominii Bordz.	ბუერა (buera)	
Podospermum armeniaca Boiss. & A. Huet		
Psephellus dealbatus (Willd.) K. Koch.		
Pyrethrum coccineum (Willd.) Vorosch.		
Pyrethrum demetrii Manden.		
Pyrethrum fruticulosum Biehl.		
Pyrethrum parthenifolium Willd.	გვირილა (gvirila)	Medicinal - leaves for inflammation, flu, oral inflammation, toothache
Pyrethrum roseum (Adams) M. Bieb.	სარწყილა (sarts'q'ila)	Medicinal - leaves for wounds
Scorzonera biebersteinii Lipsch.	ფამფარული (pamparul)	
Scorzonera filifolia Boiss.	ფამფარული (pamparul)	
Senecio aurantiacus (Hoppe ex Willd.) Less.	თავქვითელა (tavkvitela)	
Senecio karjaginii Sofieva	თავქვითელა (tavkvitela)	
Senecio rhombifolius (Willd.) Sch. Bip.	თავქვითელა (tavkvitela)	
Senecio taraxacifolius (M. Bieb.) DC.	თავქვითელა (tavkvitela)	
Solidago sosnovskyi M. Bieb.		
Solidago virgaurea L.	ოქროწვრილი (okrots'virili)	
Tanacetum vulgare L.	ასფურცელა (aspurtsela)	
Taraxacum campylodes G.E. Haglund	ბურბუშელა (burbushela)	Animal food - leaves / whole plant grazed and as fodder

	Taraxacum confusum Schichk.	საღვიძლა (saghvidzla), ბურბუშელა (burbushela Tush.), ფანდურპაპაი (pandurpapai Tush.), საჯარაი (sajarai Svan.), ნაგურელა (nagurela Svan.)	Food - leaves for chave, phkhali, tea, eaten raw Cultural - stems as whistles Medicinal - leaves for gallstones, diuretic, laxative, toothache, oral inflammation
	Taraxacum porphyranthum Boiss.	ბურბუშელა (burbushela)	Animal food - leaves / whole plant grazed and as fodder
	Taraxacum stevenii DC.	ბურბუშელა (burbushela)	Animal food - leaves / whole plant grazed and as fodder
	Tephroseris karjaginii Holub		
	Tragopogon filifolius Rehm. ex Boiss.	ფამფარა (pampara)	Food - leaves and root eaten raw, stems pickled
	Tragopogon graminifolius DC.	ფამფარა (pampara)	Food - leaves and root eaten raw, stems pickled
	Tragopogon reticulatus Boiss. & A. Huet	ფამფარა (pampara)	Food - leaves and root eaten raw, stems pickled
	Tripleurospermum caucasicum (Willd.) Hayek		
	Tripleurospermum subnivale Pobed.		
Athyriaceae	*Athyrium filix-femina* (L.) Roth		
Berberidaceae	*Berberis vulgaris* L.	კოწახური (k'otsakhuri), გოცხილ (goitskhil Svan.), ესკალძმარა (esholtsmana Khev.)	Food - fruit eaten raw, as condiment, in tqhemali, as tea, leaves as tea Medicinal - fruit for gallblader and liver, leaves for hyperytension Utensils and tools - leaves and roots as dye Construction - stems as posts
Betulaceae	*Betula litwinowii* Doluch.	არყი (arq'i), ბელყაც (belqhats Svan.), ჟახვარ (zhakhvar Svan.)	Construction - stems as timber Food - juice drunk raw Fuel - bark and stems as Firestarter and firewood Medicinal - Juice for arthritis and goiter, leaves for cold, dandruff, as panacea, bark for dandruff, hair loss, fruits applied to wounds, toothache Utensils and tools - branches as brooms, stems for beer ladles, bowls, candlesticks, carts, cups, dippers, furniture, plows, sleds, spinning wheels, spoons, tool handles, vessels for alcohol, yokes and walking sticks

Boraginaceae	*Aipyanthus echioides* Steven		
	Aipyanthus pulchra Kolak.		
	Cynoglossum officinale L.	ძაღლის ენა (dzaghlis ena)	
	Cynoglossum viride Eastw.		
	Echium maculatum L.	ძირწითელა (dzirtsitela), ავაჯუა (avajua)	
	Echium rubrum Forssk.	ძირწითელა (dzirtsitela), ავაჯუა (avajua)	
	Eritrichium caucasicum Grossh.		
	Lappula barbata (M. Bieb.) Gürke		
	Myosotis alpestris F.W. Schmidt	კესანე (k'esane)	
	Myosotis arvensis (L.) Hill.	კესანე (k'esane)	
	Myosotis sylvatica Ehrh. ex Hoffm.	კესანე (k'esane)	
	Nonea rosea (M. Bieb.) Link		
	Symphytum asperum Lepechin	ლაშქარა (lashkara)	
	Trigonocaryum involucratum Kusn.		
Brassicaceae	*Alyssum alyssoides* (L.) L.		
	Arabidopsis thaliana (L.) Heynh.		
	Bunias orientalis L.	ხატოტი (khat'ot'i), გომატი (gomat'i Tush.), ხოხნუტა (khokhnuta Khev.)	Food - leaves for chave and eaten raw, pickled, phkhali, stems pickled, flowers eaten raw Medicinal - leaves against poisoning, hangover, snakebite, seeds as anthelmintic and against parasites
	Capsella bursa-pastoris (L.) Medik.	ხავარტა (khavart'a), წიწმატურა (ts'ts'mat'ura), ხარკბილა (kharik'bila)	Food - leaves eaten raw and in phkhali
	Dentaria microphylla Willd.		
	Draba bryoides DC.	ჭუდუნა (ch'uduna)	
	Draba siliquosa M. Bieb.	ჭუდუნა (ch'uduna)	
	Draba supranivalis Rupr.	ჭუდუნა (ch'uduna)	

	Erysimum substrigosum N. Busch		
	Eunomia rotundifolia C.A. Mey.		
	Pseudo vesicaria digitata (C.A. Mey.) Rupr.		
	Sisymbrium erucastrifolium Trautv.	გონგოლა (gongola)	
	Sisymbrium loeselii L.	გონგოლა (gongola)	
	Thlaspi pumilum Ledeb.		
Campanulaceae	*Asyneuma campanuloides* (M. Bieb. ex Sims) Bornm.		
	Campanula annae Kolak.		
	Campanula bellidifolia Adams		Food - flowers eaten raw
	Campanula biebersteiniana C.A. Mey.	ქარცხვი (kartskhvi)	Food - flowers eaten raw
	Campanula ciliata Thunb.		
	Campanula collina M. Bieb.		
	Campanula hohenackeri Fisch. & C.A. Mey.		
	Campanula hypopolia Trautv.		
	Campanula latifolia L.	ალოშა (alosha)	
	Campanula oblongifolia (K. Koch) Kharadze		
	Campanula petrophila Rupr.		
	Campanula rapunculoides L.	მაჩიტა (machit'a), მიჩიგტარაი (michigt'arai)	Food - flower eaten raw, leaves for sats'ebai
	Campanula saxifraga M. Bieb.		
	Campanula sosnowskyi Kharadze		
	Campanula trautvetteri Grossh. ex Fed.		
	Campanula tridentata Schreb.		
Caprifoliacae	*Valeriana alpestris* Steven	კატაბალახა (k'at'abalakha)	
	Valeriana cardamines M. Bieb.	კატაბალახა (k'at'abalakha)	

Caryophyllaceae	*Arenaria lychnidea* M. Bieb.		
	Arenaria rotundifolia M. Bieb.		
	Arenaria serpyllifolia L.		
	Cerastium arvense L.		
	Cerastium cerastoides (L.) Britton		
	Cerastium holosteoides Fr.		
	Cerastium kasbek Parrot		
	Cerastium multiflorum C.A. Mey.		
	Cerastium polymorphum Rupr.		
	Cerastium purpurascens Adams		
	Dianthus caucasus Sm.		
	Dianthus cretaceous Adams		
	Gypsophila elegans M. Bieb.	წინწკალა (ts'ints'k'ala)	
	Melandrium album L.		
	Minuartia aizoides (Boiss.) Bornm.		
	Minuartia biebersteinii (Rupr.) Schischk.		
	Minuartia brotherana (Trautv.) Woronow ex Grossh.		
	Minuartia circassica (Albov) Woronow ex Grossh.		
	Minuartia imbricata (M. Bieb.) Mattf.		
	Minuartia inamoena (C.A. Mey.) Woronow ex Grossh.		
	Minuartia oreina Schichk.		
	Sagina saginoides (L.) H. Karst.		
	Silene commutata Guss.	ქოთანა (kot'ana)	
	Silene italica (L.) Pers.	ქოთანა (kot'ana)	
	Silene lacera Sims	ქართული ქოტანა (kartuli kot'ana)	
	Silene linearifolia Otth ex DC.	ქოთანა (kot'ana)	
	Silene marcowiczii Schichk.	ქოთანა (kot'ana)	

	Silene ruprechtii Schichk.	ქოთანა (kot'ana)	
	Silene wallichiana Klotzsch	მჭივანა (mch'ivana)	Food - leaves for phkhali and pickled
Chenopodiaceae	*Chenopodium botrys* L.		
Cistaceae	*Helianthemum grandiflorum* DC.	მზექვავილა (mzekvavila)	
	Helianthemum nitidum Clementi	მზექვავილა (mzekvavila)	
	Helianthemum nummularium Mill.	მზექვავილა (mzekvavila)	
	Helianthemum ovatum Dun.	მზექვავილა (mzekvavila)	
Colchicaceae	*Colchicum umbrosum* Steven	სატოვლია (tskhsat'ovlia)	
Crassulaceae	*Sedum acre* L.		
	Sedum gracile C.A. Mey.		
	Sedum oppositifolium Sims	კლდის დუმა (k'ldisduma Tush.)	Food - leaves eaten raw and in phkhali Medicinal - leaves for furuncles, toothache, wounds
	Sedum stoloniferum J.F. Gmel.	მსუქანა (musukana)	
	Sedum tenellum M. Bieb.		
	Sempervivum caucasicum Rupr. ex Boiss.	კლდიასვაშლა (k'ldiasvashla)	
	Sempervivum pumilum M. Bieb.	კლდიასვაშლა (k'ldiasvashla)	
Cupressaceae	*Juniperus depressa* Steven.	ჭილი (ch'ili)	
	Juniperus hemisphaerica J. Presl & C. Presl	გოცხილ (tzqhero Svan.)	Medicinal - branches for kidneys, urinary system, blood cleansing
Cuscutaceae	*Cuscuta europaea* L.		
Cyperaceae	*Baeothryon pumilum* (Vahl) Á. Löve & D. Löve		
	Blysmus compressus (L.) Panz. ex Link		
	Carex buschiorum V.I. Krecz.	ისლი (isli)	
	Carex caryophyllea Latourr.	ისლი (isli)	
	Carex dacica Heuff.	ისლი (isli)	

	Carex huetiana Boiss.	ისლი (isli)	
	Carex medwedewii Leskov	ისლი (isli)	
	Carex meinshauseniana V.I. Krecz.	ისლი (isli)	
	Carex microglochin Wahlenb.	ისლი (isli)	
	Carex pallens Z.P. Wang	ისლი (isli)	
	Carex pallescens L.	ისლი (isli)	
	Carex sylvatica Huds.	ისლი (isli)	
	Carex tristis M. Bieb.	ისლი (isli)	
	Kobresia capillifolia (Decne.) C.B. Clarke		
	Kobresia capilliformis Ivanina		
	Kobresia humilis (C.A. Mey. ex Trautv.) Serg.		
	Kobresia schoenoides (C.A. Mey.) Steud.		
Dipsacaceae	*Cephalaria gigantea* (Ledeb.) Bobrov	სკიპალო (sk'ip'alo)	Food - stems pickled Cultural - stems used by children as arrows Medicinal - leaves and stems for babies diseases
	Knautia montana DC.		
	Scabiosa bipinnata C. Koch		
	Scabiosa caucasica M. Bieb.	ცილფოლიო (tsilpolio)	
Dryopteridaceae	*Dryopteris filix-mas* (L.) Schott	ჩადუნა (chaduna); ჩადა (chada Tush.)	Food - leaves pickled, in phkhali and eaten raw Medicinal - leaves for bruises
Eleagnaceae	*Hippophaë rhamnoides* L.	ქაცვი (katsvi)	Medicinal - fruits for vitamins and diabetes
Ephedraceae	*Ephedra procera* C.A. Mey.	ეფედრა (epedra), ცხენისშუხლა tskhenisshukhla)	
Equisetaceae	*Equisetum arvense* L.	შვიტა (shvit'a)	Medicinal - leaves and stems for wounds, kidneys, urinary system

	Equisetum palustre L.	შვიტა (shvit'a)	
Ericaceae	*Empetrum caucasicum* Juz.	კეწერა (k'ets'era)	Food - fruit eaten Utensils and tools - branches as brush to wash tools
	Empetrum nigrum L.	კეწერა (k'ets'era)	Food - fruit eaten Utensils and tools - branches as brush to wash tools
	Pyrola rotundifolia L.		
	Rhododendron caucasicum Pall.	დეკა (dek'a), წითელი (ts'iteli), წითელა (ts'itela), შქერი (shgver Svan.)	Food - branches and leaves to darken beer, flowers eaten raw and in sats'ebai, leaves for phkhali, leaves, flowers, and fruits for tea Medicinal - flowers and leaves as anti-inflammatory and for digestive system, leaves for colds, diuretic, lower sexual potency, heart Utensils and tools - leaves as dye
	Vaccinium myrtillus L.	მოცვი (motsvi), ჟოლი (zholi Tush.), იღვი (ighvi Svan.), შელშავი (shelshavi Khev.), მეგმულდ (megmuld Svan.)	Food - fruits eaten raw, for marmalade, tea; leaves, branches, and flowers for tea Medicinal - leaves to decrease blood sugar and for kidney stones, fruits as tea and for dry throat Utensils and tools - branches for dye
	Vaccinium vitis-idaea L.	წითელი მოცვი (ts'iteli motsvi), სტომი (stomi Tush.), ვიღვი (vighv Svan.), მაიოლ / მაია (maiol / maia Svan.), წითელმოჩა (tsitelimocha Khev.)	Food - fruit eaten raw, branches and leaves for tea Medicinal - leaves against bedwetting in children, to decrease blood sugar, branches for liver Utensils and tools - fruit as dye
Euphorbiaceae	*Euphorbia glaberrima* K. Koch.	რძიანა (rdziana)	
	Euphorbia iberica Boiss.	რძიანა (rdziana)	
Fabaceae	*Anthyllis variegata* Boiss.	ბალაბუ (balabu)	Animal food - leaves / whole plant grazed and as fodder
	Astragalus alpinus L.		
	Astragalus capito Boiss. & Hohen.		
	Astragalus captiosus Boriss.		
	Astragalus denudatus Steven		
	Astragalus supinus C.A. Mey. ex Bunge		

Coronilla varia L.	ყვავისფრჩხილა (q'vavisprchkhila)	Food - leaves for khachapuri
Galega orientalis Lam.	ხბოშუბლა (Khboshubla)	
Lathyrus tuberosus L.	თერო (telo)	
Lotus caucasicus Kuprianova	კურდღლისფრჩხილა (k'urddglisprchkhila)	
Medicago falcata L.	კვითელი იოხჯა (k'viteli iokhja)	Animal food - leaves / whole plant grazed and as fodder
Medicago glutinosa M. Bieb.		Animal food - leaves / whole plant grazed and as fodder
Medicago lupulina L.	კვითელი იოხჯა (k'viteli iokhja)	Animal food - leaves / whole plant grazed and as fodder
Melilotus officinalis (L.) Lam.	კვითელი ძოძო (k'viteli dzodzo)	Animal food - leaves / whole plant grazed and as fodder
Onobrychis inermis Steven	ესპარცეყი (esp'artseq'i)	Animal food - leaves / whole plant grazed and as fodder
Onobrychis petraea Desv.	ესპარცეყი (esp'artseq'i)	
Orobus cyaneus Steven	ტყის ცერცველა (t'q'is tsertsvela)	
Oxytropis albana Steven		
Trifolium alpestre L.		
Trifolium ambiguum M. Bieb.	ცხრისსამყურა (tskhrissamq'uara)	Animal food - leaves / whole plant grazed and as fodder
Trifolium arvense L.	ბურტყლასამყურა (burt'q'lasamq'ara)	Animal food - leaves / whole plant grazed and as fodder
Trifolium campestre Schreb.		Animal food - leaves / whole plant grazed and as fodder
Trifolium canescens Willd.	ჭაღარა სამყურ (ch'aghara samq'ur)	Animal food - leaves / whole plant grazed and as fodder
Trifolium fontanum Bobrov		Animal food - leaves / whole plant grazed and as fodder
Trifolium pratense L.	წუთელი სამყყრა (ts'urteli samq'q'ara)	Animal food - leaves / whole plant grazed and as fodder
Trifolium repens L.	სამყურა (samq'ura)	Animal food - leaves as fodder
Trifolium rubrum Larrañaga		Animal food - leaves / whole plant grazed and as fodder
Trifolium spadiceum L.		Animal food - leaves / whole plant grazed and as fodder
Trifolium trichocephalum M. Bieb.	ბანჯგვლიანი სამყურა (banjgvliani samq'ura)	Animal food - leaves / whole plant grazed and as fodder

	Vicia alpestris Steven	ცერცველა (tsertsvela)	
	Vicia grossheimii Ekytim.	ცერცველა (tsertsvela)	
Gentianaceae	*Gentiana angulosa* M. Bieb.	ნაღველა (naghvela)	
	Gentiana aquatica L.	ნაღველა (naghvela)	
	Gentiana asclepiadea L.	ნაღველა (naghvela)	Medicinal - leaves cholagogue, gallbladder
	Gentiana pumila Jacq.	ნაღველა (naghvela)	
	Gentiana pyrenaica L.	ნაღველა (naghvela)	
	Gentiana schistocalyx K. Koch	ნაღველა (naghvela)	
	Gentiana septemfida Pall.	გაბლუარაი (gabluarai)	Food - leaves for Chave
	Gentianella caucasea Holub		
	Lomatogonium carinthiacum (Wulfen) Rchb.		
	Swertia iberica Fisch. & C.A. Mey.	გაბლუარაი (gabluarai)	Food - leaves for Chave
Geraniaceae	*Geranium gymnocaulon* DC.		
	Geranium ibericum Cav.	ქართული ნემსიწვერა (kartuli mensits'vera)	
	Geranium platypetalum Fisch. & C.A. Mey.		
	Geranium ruprechtii Grossh.		
	Geranium sanguineum L.		
	Geranium sylvaticum L.		
Hyacinthaceae	*Puschkinia scilloides* Adams		
Hypericaceae	*Hypericum caucasicum* Gorschk.		
	Hypericum nummularioides Trautv.		

	Hypericum perforatum L.	კრაზანა (k'razana)	Cultural - leaves for perfume Food - flowers and leaves for tea, and as ingredient in beer Utensils and tools - leaves and flowers for dye Medicinal - leaves for gum problems, enuresis, kidneys, nerves, liver, ulcers, whole plant for gallbladder problems, nerves, oral inflammation, flowers for nerves, as panacea, for gallbladder ailments
Iridaceae	*Crocus scharojanii* Rupr.		
	Gladiolus tenuis M. Bieb.		
	Iris pumila L.	ქონდარი ზამბახი	
Juncaceae	*Juncus articulatus* L.	ჭილი (ch'ili)	
	Luzula multiflora (Ehrh.) Lej.	ასლურა (aslura)	
	Luzula pseudosudetica V.I. Krecz.	ასლურა (aslura)	
	Luzula spicata (L.) DC.	ასლურა (aslura)	
Lamiaceae	*Ajuga orientalis* L.		
	Betonica macrantha K. Koch		
	Lamium album L.	ჭინჭრის-დედა (ch'inch'ris-deda)	Food - whole plant and leaves for phkhali Medicinal - leaves for hair loss and bath for small children
	Lamium tomentosum Willd.		
	Mentha longifolia (L.) L..	ტყის პიტნა (t'q'is p'it'na); შანტალი პიტნაი (shant'ali Pitn'a Tush.)	Food - leaves for chave, eaten raw, phkhali, tea Medicinal - leaves for nerves and tea, flowers as panacea
	Nepeta biebersteiniana Pojark.		
	Nepeta supina Steven		
	Prunella vulgaris L.		
	Salvia tesquicola Klokov & Pobed.		
	Salvia verticillata L.	დაჯირა (dajira)	Medicinal - anti-inflammatory, enuresis, wounds Utensils and tools - whole plant as filter
	Scutellaria leptostegia Juz.	მუზარადა (muzarada)	
	Scutellaria oreophila Grossh.	მუზარადა (muzarada)	

	Scutellaria raddeana Juz.	მუზარადა (muzarada)	
	Teucrium nuchense C. Koch		
	Teucrium orientale L.		
	Thymus collinus M. Bieb.	ბეგქონდარა (begkondara); ქონდარი (kondari)	Food - leaves as spice and tea Medicinal - leaves for cough and hypertension
	Thymus nummularius M. Bieb.		
	Ziziphora puschkinii Adams	ქონდარი (kondari); ურცი (urtsi); ბეგქონდარა (begkondara)	Food - leaves as tea Medicinal - leaves for hypertension, diuretic, antibiotic
Liliaceae	*Fritillaria collina* Adams		
	Fritillaria latifolia Willd.		
	Lloydia serotina (L.) Salisb. ex Rchb.		
Linaceae	*Linum hypericifolium* C. Presl.		
Lycopodiaceae	*Lycopodium selago* L.	ლიკოპოდიუმი	
Melanthiaceae	*Veratrum lobelianum* Bernh.	შხამა (shkhama)	Medicinal and veterinary - root and leaves against ektoparasits and for wounds
Onagraceae	*Chamerion angustifolium* (L.) Holub	თხაწართხალა (thkhatz'arthkhala)	Food - leaves in khachapuri Medicinal - leaves as tea
	Epilobium colchicum Albov	წქალნაწქენი (ts'kalnats'keni)	
Ophioglossaceae	*Botrychium lunaria* (L.) Sw.	მარგალიტა (margalit'a); წყლულის ბალახი (ts'q'lulis balakhi)	Medicinal - leaves and whole plant as panacea and for wounds
Orchidaceae	*Cephalanthera longifolia* (L.) Fritsch		
	Coeloglossum viride (L.) Hartm.		
	Dactylorhiza euxina (Nevski) H. Baumann & Künkele		
	Goodyera repens (L.) R. Br.	ტყის მრავალძარღვა (t'q'is mravaldzarghva)	
	Gymnadenia conopsea (L.) R. Br.		
	Herminium monorchis (L.) R. Br.		

	Platanthera chlorantha (Custer) Rchb. f.	ორფოთოლა (orpotola)	
	Traunsteinera sphaerica (Biebl) Schltr.		
Orobanchaceae	*Euphrasia hirtella* Jord. ex Reut.	კორდისკბილა (k'ordisk'bila)	
	Euphrasia minima Jacq. ex DC.	კორდისკბილა (k'ordisk'bila)	
	Euphrasia pectinata Ten.	კორდისკბილა (k'ordisk'bila)	
	Euphrasia petiolaris Wettst.	კორდისკბილა (k'ordisk'bila)	
	Euphrasia tatarica Fisch. ex Spreng.	კორდისკბილა (k'ordisk'bila)	
	Orobanche coerulescens Stephan	კელაპტარა (k'lep'tara)	
	Pedicularis armena M. Bieb.	სატილია (sat'ilia)	
	Pedicularis chroorrhyncha Vved.	სატილია (sat'ilia)	
	Pedicularis comosa L.	სატილია (sat'ilia)	
	Pedicularis condensata M. Bieb.	სატილია (sat'ilia)	
	Pedicularis crassirostris Bunge	სატილია (sat'ilia)	
	Pedicularis elisabethae T.N. Popova	სატილია (sat'ilia)	
	Pedicularis nordmannina Bunge	სატილია (sat'ilia)	
	Rhinanthus major L.	ხრიალა (khriala)	
	Rhinanthus minor L.	ხრიალა (khriala)	
	Rhinanthus vernalis (N.W. Zinger) Schischk. & Serg.	ხრიალა (khriala)	
Oxalidaceae	*Oxalis acetosella* L.	მჟაველა (mzhavela)	Food - leaves eaten raw
Papaveraceae	*Corydalis alpestris* C.A. Mey.		
	Fumaria schleicheri Soy.-Will.		
	Papaver oreophilum Rupr.	ქაქაჩო (kakacho)	

Parnassiaceae	*Parnassia palustris* L.	პარნასურა (p'arnasura)	
Plantaginaceae	*Linaria meyeri* Kuprian.	სელიჭა (selich'a)	
	Plantago atrata Hoppe		
	Plantago lanceolata L.	მრავალძარღვა (mravaldzarghva)	
	Plantago major L.	მრავალძარღვა (mravaldzarghva), ჯოოდიბალე (jo'odibale Svan.), კუთკვახ (kuthkvakh Svan.), ცხრაძარღვა (tskhradzargva Khev.)	Medicinal - leaves for bleeding, cough, digestive system, gastritis, intestines, wounds; root for stomach problems;; latex for wounds
	Plantago media L.		
	Veronica caucasica M. Bieb		
	Veronica chamaedrys L.		
	Veronica gentianoides Vahl		
	Veronica minuta C.A. Mey.		
	Veronica peduncularis M. Bieb.		
	Veronica petraea Steven		
	Veronica telephiifolia Vahl		
Poaceae	*Agrostis planifolia K. Koch*	ნამიკრეფია (namik'repia)	Animal food - leaves / whole plant grazed and as fodder
	Agrostis tenuis Sibth.	ნამიკრეფია (namik'repia)	Animal food - leaves / whole plant grazed and as fodder
	Alopecurus dasyanthus Trautv.	მელაკუდა (melak'uda)	Animal food - leaves / whole plant grazed and as fodder
	Alopecurus glacialis K. Koch.	მელაკუდა (melak'uda)	Animal food - leaves / whole plant grazed and as fodder
	Alopecurus tiflisiensis (G. Westb.) Grossh.	მელაკუდა (melak'uda)	Animal food - leaves / whole plant grazed and as fodder
	Alopecurus vaginatus (Willd.) Pall. ex Kunth	მელაკუდა (melak'uda)	Animal food - leaves / whole plant grazed and as fodder
	Anthoxanthum alpinum Á. Löve & D. Löve		Animal food - leaves / whole plant grazed and as fodder
	Anthoxanthum odoratum L.	ყვიტელტავთავა (q'vit'elt'avtava)	Animal food - leaves / whole plant grazed and as fodder

Arrhenatherum elatius (L.) P. Beauv. ex J. Presl & C. Presl	ფრანგული კოინდარი (pranguli k'ondari)	Animal food - leaves / whole plant grazed and as fodder
Avenella flexuosa (L.) Drejer		Animal food - leaves / whole plant grazed and as fodder
Briza marcowiczii Woronow	ცაბცაბი (tsabtasbi)	Animal food - leaves / whole plant grazed and as fodder
Briza media L.	ცაბცაბი (tsabtasbi)	Animal food - leaves / whole plant grazed and as fodder
Briza minor L.	ცაბცაბი (tsabtasbi)	Animal food - leaves / whole plant grazed and as fodder
Bromopsis biebersteinii (Roem. & Schult.) Holub		Animal food - leaves / whole plant grazed and as fodder
Bromopsis riparia (Rehmann) Holub		Animal food - leaves / whole plant grazed and as fodder
Bromopsis variegata (M. Bieb.) Holub		Animal food - leaves / whole plant grazed and as fodder
Bromus commutatus Schrad.		Animal food - leaves / whole plant grazed and as fodder
Calamagrostis arundinacea (L.) Roth	ბრძამი (brdzami)	Animal food - leaves / whole plant grazed and as fodder
Calamagrostis pseudophragmites (Haller f.) Koeler		Animal food - leaves / whole plant grazed and as fodder
Catabrosella variegata (Boiss.) Tzvelev		Animal food - leaves / whole plant grazed and as fodder
Colpodium versicolor (Steven) Schmalh.		Animal food - leaves / whole plant grazed and as fodder
Cynosurus cristatus L.	ტივაქერა	Animal food - leaves / whole plant grazed and as fodder
Dactylis glomerata L.	სათითური (satituri)	Animal food - leaves / whole plant grazed and as fodder
Deschampsia cespitosa (L.) P. Beauv.	მიხრჩობელა (mikhrchobela)	Animal food - leaves / whole plant grazed and as fodder
Elytrigia gracillima (Nevski) Nevski		
Elytrigia repens (L.) Desv. ex Nevski		
Festuca arundinacea Schreb.		Animal food - leaves / whole plant grazed and as fodder
Festuca buschiana (St.-Yves) Tzvelev		Animal food - leaves / whole plant grazed and as fodder
Festuca frigida Grossh.		Animal food - leaves / whole plant grazed and as fodder
Festuca ovina L.		Animal food - leaves / whole plant grazed and as fodder
Festuca pratensis Huds.	მდე (mde), ოს წივანა (os ts'ivana)	Animal food - leaves / whole plant grazed and as fodder
Festuca rubra L.	წიტელი წივანა (ts'it'eli ts'ivana)	Animal food - leaves / whole plant grazed and as fodder

Festuca ruprechtii (Boiss.) V.I. Krecz. & Bobrov		Animal food - leaves / whole plant grazed and as fodder
Festuca supina Schur		Animal food - leaves / whole plant grazed and as fodder
Festuca valesiana Schleich. ex Gaudin		Animal food - leaves / whole plant grazed and as fodder
Festuca varia Haenke		Animal food - leaves / whole plant grazed and as fodder
Festuca woronowii Hack.		Animal food - leaves / whole plant grazed and as fodder
Helictotrichon adzharicum (Albov) Grossh.		Animal food - leaves / whole plant grazed and as fodder
Helictotrichon asiaticum (Roshev.) Grossh.		Animal food - leaves / whole plant grazed and as fodder
Helictotrichon pubescens (Huds.) Pilg.		Animal food - leaves / whole plant grazed and as fodder
Hordeum violaceum Boiss. & Hohen.	ქერი (queri)	Medicinal - leaves to treat cancer
Kobresia capillifolia (Decne.) C.B. Clarke		
Koeleria caucasica (Trin. ex Domin) B. Fedtsch.	კეწეწურა (k'ets'ets'ura)	
Koeleria luerssenii Domin	კეწეწურა (k'ets'ets'ura)	
Koeleria macrantha (Ledeb.) Schult	კეწეწურა (k'ets'ets'ura)	
Melica transsilvanica Schur.		
Milium effusum L.		Animal food - leaves / whole plant grazed and as fodder
Nardus stricta L.	ძიგვა (dzigva)	
Phleum alpinum L.		Animal food - leaves / whole plant grazed and as fodder
Phleum montanum K. Koch		Animal food - leaves / whole plant grazed and as fodder
Phleum phleoides (L.) H. Karst.		Animal food - leaves / whole plant grazed and as fodder
Phleum pratense L.	ტიმოთელა (t'imotela)	Animal food - leaves / whole plant grazed and as fodder
Phragmites australis (Cav.) Trin. ex Steud.	ლელი (leli)	Animal food - leaves / whole plant grazed and as fodder
Poa alpina L.	თივაქასრა (tivakasra)	Animal food - leaves / whole plant grazed and as fodder
Poa badensis Haenke ex Willd.	თივაქასრა (tivakasra)	Animal food - leaves / whole plant grazed and as fodder
Poa caucasica Trin.	თივაქასრა (tivakasra)	Animal food - leaves / whole plant grazed and as fodder

	Poa compressa L.	თივაქასრა (tivakasra)	Animal food - leaves / whole plant grazed and as fodder
	Poa nemoralis L.	ტქის თივაქასრა (t'kes tivakasra)	Animal food - leaves / whole plant grazed and as fodder
	Poa pratensis L.	მდელოს თივაქასრა (mdelos tivakasra)	Animal food - leaves / whole plant grazed and as fodder
	Trisetum buschianum Seredin		Animal food - leaves / whole plant grazed and as fodder
	Trisetum flavescens (L.) P. Beauv.	ოქროშვრია (okroshvria)	Animal food - leaves / whole plant grazed and as fodder
	Trisetum rigidum (M. Bieb.) Roem. & Schult.		Animal food - leaves / whole plant grazed and as fodder
Polygalaceae	*Polygala alpicola* Rupr.	წუწსნაური (ts'uts'nauri)	
	Polygala caucasica Rupr.	წუწსნაური (ts'uts'nauri)	
	Polygala transcaucasica Tamamsch.	წუწსნაური (ts'uts'nauri)	
Polygonaceae	*Polygonum alpestre* C.A. Mey.		
	Polygonum alpinum All.	წართხალი (ts'artkhali); ლეცირ (letsir Svan.); ჭიჭიშვილი (tsets'ich'ala Khev.)	Food - leaves in khacahpuri, phkhali, sats'ebai and eaten raw, stems for phkhali and pickled Medicinal - leaves for gastrointestinal problems and joints Utensils and tools - root as dye
	Polygonum carneum K. Koch	დვალურა (dvalura), მატიტელა (matitela); ჭიჭიშვილი (tchitchishvili Khev.)	Medicinal - root for cirrhosis, diarrhea, liver, lungs, flower for lungs
	Polygonum viviparum L.		
	Rumex acetosa L.	მჟაუნა (mzhauna), , მწყემსთმჟავიაი (mts'q'emst mzhaviai), ყანის მჟავიაი (q'anis mzhaviai), ტელეფ (teleph Svan.), Teterdjik (Arm.), Dakht (Arm.)	Food - leaves for khachapuri, eaten raw, phkhali, sats'ebai, pickled, stems eaten raw, pickled
	Rumex acetosella L.	მჟაუნა (mzhauna)	Food - leaves in khachapuri, eaten raw, pickled, phkhali

	Rumex alpinus L.	ღოლო (gholo), ჭირტალი (ch'irt'ali Tush.), საგუგა (saguga Khev.), Kvalo Arm.	Food - leaves in chave, phkhali, pickled, stems pickled and in phkhali Medicinal - seeds for intestinal problems, hemorrhoids, colitis, leaves to treat tumors Utensils and tools - root for dye
	Rumex scutatus L.	ქვიშის მჟავია (kvishis mzhavia); ლახტარა (lakht'ara)	Food - leaves for phkhali and eaten raw, stems pickled
Primulaceae	*Androsace albana* Steven		
	Androsace barbulata Ovcz.		
	Androsace villosa L.		
	Lysimachia verticillaris Spreng.	ხახვთესლა (lik'op'odiumi)	
	Primula algida Adams		Food - leaves for phkhali
	Primula amoena M. Bieb.		Food - leaves for phkhali
	Primula auriculata Lam.		Food - leaves for phkhali
Ranunculaceae	*Aconitum anthora* L.	ტილჭიირი (t'ilch'iiri)	
	Aconitum nasutum Fisch. ex Rchb.	ეშმაკის ჭოში (eshmakis ch'oshi)	
	Anemonastrum fasciculatum (L.) Holub		
	Anemone speciosa Adam ex G. Pritz.		
	Delphinium caucasicum C.A. Mey.		
	Pulsatilla violacea Rupr.	მედგარი (medgari)	
	Ranunculus acutilobus Ledeb.	ბაია (baia)	
	Ranunculus astrantiifolius Boiss. ex Trautv.	ბაია (baia)	
	Ranunculus baidarae Rupr.	ბაია (baia)	
	Ranunculus buhsei Boiss.	ბაია (baia)	
	Ranunculus caucasicus M. Bieb.	ბაია (baia)	
	Ranunculus grandiflorus L.	ბაია (baia)	
	Ranunculus lojkae Sommier & Levier	ბაია (baia)	

	Ranunculus oreophilus M. Bieb.	ბაია (baia)	
	Ranunculus repens L.	ბაია (baia)	
	Thalictrum alpinum L.		
	Thalictrum bushianum Kem.-Nath.		
	Thalictrum flavum L.		
	Thalictrum foetidum L.	სამატლე (samat'le)	
	Trollius ranunculinus (Sm.) Stearn		
Resedaceae	*Reseda lutea* L.	ყანის რეზედა (q'anis rezeda)	
Rosaceae	*Alchemilla caucasica* Buser	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla chlorosericea Juz.	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla debilis Juz.	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla dura Buser	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla elisabethae Juz.	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla glabricaulis H. Lindb.	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla laeta Juz.	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla languida Buser	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla retinervis Buser	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla rigida Buser	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla sericata Reichenb. ex Bus.	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla sericea Willd.	მარმუჭი (marmuch'i)	Medicinal - leaves
	Alchemilla valdehirsuta Buser	მარმუჭი (marmuch'i)	Medicinal - leaves
	Cotoneaster integerrimus Medik.		
	Cotoneaster laxiflorus Jacq. ex Lindl.		
	Dryas caucasica Juz.	დრიადი (driadi)	

	Potentilla adscharica Sommier & Levier		
	Potentilla crantzii (Crantz) Beck ex Fritsch		
	Potentilla erecta (L.) Raeusch.		
	Potentilla gelida C.A. Mey.		
	Potentilla recta L.		
	Potentilla reptans L.	მარწყვაბალიხი (marts'q'vabalikhi)	
	Rosa oxyodon Boiss.	ასკილი (ask'ili)	Food - fruit and flower for alcohol, also eaten raw, fruit and leaves as tea Medicinal - fruit for colds, cough, gallbladder, kidneys and as tea
	Rosa pulverulenta M. Bieb.	ასკილი (ask'ili)	Food - fruit and flower for alcohol, also eaten raw, fruit and leaves as tea Medicinal - fruit for colds, cough, gallbladder, kidneys and as tea
	Rubus idaeus L.	ჟოლო (zholo); ჟოლის-დედა (zholis-deda); ინღა (Ingha Svan.); ხვაფა (khvapa Tush.); მწყერთიფქლა (mts'q'ertipkla Khev.); წერტიფხლა (t'sert'ipkhla Khev.); Малина (Malina Russ.)	Food - fruits and flowers eaten raw, fruits for chave, leaves for tea Medicinal - leaves for colds and tea, fruits for wounds
	Sanguisorba officinalis L.	თავსისხლა (tavuskhala)	
	Sibbaldia parviflora Willd.	ფესვმაგირა (pesvmagira)	
	Sibbaldia semiglabra C.A. Mey.	ფესვმაგირა (pesvmagira)	
	Sorbus caucasigena Kom. ex Gatsch.	ცირცელი (tsirtseli); გოგლანდ (gogland Svan.)	Food - fruits for alcohol, beer, eaten raw, marmalade Medicinal - fruits for blood pressure, heart, hypertension, wounds, leaves for cramps Utensils and tools - stem for household utensils, tool handles, brooms
	Spiraea hypericifolia L.	გრაკლა (grak'la), მაკაცი (makatzi Khev.)	Utensils and Tools - stems as brooms

Rubiaceae	*Asperula albovii* Manden.		
	Asperula cristata V.I. Krecz.		
	Cruciata glabra Ehrend.		Animal food - leaves / whole plant grazed and as fodder
	Cruciata laevipes Opiz		Animal food - leaves / whole plant grazed and as fodder
	Galium galioides Soó		
	Galium lucidum All.		
	Galium mollugo L.		
	Galium spurium L.		
	Galium valantioides M. Bieb.		
	Galium verum L.	მინდცრისნემსა (mindtsrisnemsa)	
Salicaceae	*Salix caprea* L.	მდგნალი (mdgnali), ფოხვი (pokhvi Tusch.), ჭიჭუნი (chitchuni Svan.), ბაგუნდი (bagund Svan.)	Animal Food - leaves as fodder Construction - stems and branches as timber, walls, fences Medicinal - leaves and bark for arthritis, gallstones, kidneys Utensils and tools - stem for tool handles, bopws, snowshovels, baskets, tough utensils
	Salix kazbekensis A.K. Skvortsov		
Santalaceae	*Thesium laxiflorum* Trautv.		
	Thesium procumbens C.A. Mey.		
Saxifragaceae	*Saxifraga cartilaginea* Willd.	ფხიჯა (pkhija), ქვატეხია (kavat'ekhia)	
	Saxifraga cymbalaria L.	ფხიჯა (pkhija), ქვატეხია (kavat'ekhia)	
	Saxifraga exarata Vill.	ფხიჯა (pkhija), ქვატეხია (kavat'ekhia)	
	Saxifraga flagellaris Willd.	ფხიჯა (pkhija), ქვატეხია (kavat'ekhia)	
	Saxifraga juniperifolia Adams	ფხიჯა (pkhija), ქვატეხია (kavat'ekhia)	
	Saxifraga kolenatiana Regel	ფხიჯა (pkhija), ქვატეხია (kavat'ekhia)	
	Saxifraga moschata Wulfen	ფხიჯა (pkhija), ქვატეხია (kavat'ekhia)	
	Saxifraga ruprechtiana Manden.	ფხიჯა (pkhija), ქვატეხია (kavat'ekhia)	
	Saxifraga sibirica L.	ფხიჯა (pkhija), ქვატეხია (kavat'ekhia)	
Scrophulariaceae	*Scrophularia minima* M. Bieb.		
	Scrophularia olympica Boiss.		

	Scrophularia sp.		
	Scrophularia variegata M. Bieb.		
	Verbascum gossypinum M. Bieb.	ქერიფქლა (keripkla)	
	Verbascum phoeniceum L.	ქერიფქლა (keripkla)	
	Verbascum pyramidatum M. Bieb.	ქერიფქლა (keripkla)	
	Verbascum sp.	ქერიფქლა (keripkla)	Medicinal - leaves for gallbladder, hemorrhoids, kidneys, skin problems
Selaginellaceae	*Selaginella helvetica* (L.) Link.		
Solanaceae	*Solanum persicum* Roem. & Schult.	ძაღლქურძენა (dzaghlkurdzena)	
	Solanum pseudopersicum Pojark.		
Thymelaeaceae	*Daphne glomerata* Lam.	წიბა (ts'iba); მოგოცხარა (magozhara Khev.)	Medicinal - leaves for toothache
Trilliaceae	*Paris quadrifolia* L.	ხარისთვალა (kharistvala)	
Urticaceae	*Parietaria judaica* L.	კედლისპირა (k'edlisp'ira)	
	Urtica dioica L.	ჭინჭარი (ch'inch'ari), მერხელ (merkhel Svan.); Santachi Arm.	Animal food - leaves fodder Food - leaves and stems as beverage, khachapuri, khinkali, phkhali, pickled Medicinal - leaves for burns, joint pain, nerves, increase of hemoglobin; stem for burns
Violaceae	*Viola odorata* L.	ია (ia); ია-ია (ia ia)	Food - root pickled
	Viola oreades M. Bieb.	ია (ia); ია-ია (ia ia)	Food - root pickled
	Viola somchetica C. Koch	ია (ia); ია-ია (ia ia)	Food - root pickled
	Viola sp.	ია (ia); ია-ია (ia ia)	Food - root pickled

Chave: made of dried herbs by boiling them, adding flour, fat (with or without meat) and salt; **Mkhlovana:** bread filled with beetroot leaves, spinach, herbs; **Khachapuri:** bread filled with cheese and herbs; **Khinkali:** dumplings with herbs and meat; **Phkhali:** minced herbs, sometimes mixed with walnuts, eaten as spread or cooked in pie; **Sats'ebai:** fresh herbs dipped in sour milk

Georgia counts as one of the oldest Christian regions, adopting Christianity around 320 CE. A great example for early church construction is Gergeti Trinity Church, built in the 14th century, located at 2170m at the base of Mount Kazbeghi (5047m), overlooking the narrow valley leading from Georgia to Ingushetia. However, ancestral shrines are still very common in many regions of Georgia.

Grapes - *Vitis vinifera* L. (Vitaceae) show genetic diversity in Georgia, with about 500 varieties known (Javakhishvili 1987, Ketskhoveli *et al.* 1960, Ramishvili 1988, This *et al.* 2006), and in most regions the population takes great pride to produce their own wine and share it with visitors. Hardly any house in the Georgian lowlands is without at least some grapes in its garden or backyard. Today, forty-one cultivars of grapevine are used as commercial varieties in Georgia (Bedoshvili 2010), and good wine is readily available, but the history of grape cultivation and winemaking goes back millennia. Like in other parts of Europe, Georgian grapes were devastated by the *Phylloxera vastatrix* (Planchon) Signoret and after the infestation in the 1860s most Georgian grape varieties are now grafted on rootstocks of American grapes resistant to *Phylloxera*.

Wheat - *Triticum* L. (Poaceae): In the 1940s sixteen species, 144 varieties, and 150 forms of wheat were registered in Georgia (Menabde 1948.This diversity has however greatly diminished, and most species had already disappeared by the 1960s, when introduced cultivars were favored in Soviet kolkhoz systems. At present, none of these species are sown in Georgian commercial agriculture. Pistrick *et al.* 2009) report some traditional varieties of bread wheat in Tusheti, Meskheti, Javakheti and Svaneti

Barley - *Hordeum vulgare* L. (Poaceae) is also an ancient agricultural crop in Georgia, and had particular importance in beer production, as well a function in religious rituals and traditional medicine (Badr *et al.* 2000, Javakhishvili 1987).

Caucasian Rye - *Secale cereale* L. (Poaceae) used to be cultivated in the high mountain regions of Georgia (1800-2200 m), and entered into bread and beer production, although barley was preferred for beer.

Legumes, especially peas (*Pisum sativum* L.), lentils (*Lens cornicularis* L.), chickpeas (*Cicer arietinum* L.), faba beans (*Vicia faba* L.) are still commonly grown in home gardens, and Green Pea (*Pisum sativum*) is thought to have originated in the Southern Caucasus. Traditional vegetables like garden lettuce (*Lactuca sativa* L.), beans (*Phaseolus vulgaris* L.), sweet basil (*Ocimum basilicum* L.), peppermint (*Mentha x piperita* L.), onions (*Allium cepa* L.), sugar beets (*Beta vulgaris* L.), spinach (*Spinaca oleracea* L.), carrots (*Daucus carota* L.), radishes (*Raphanus sativus* L.), turnips (*Brassica rapa* var. *rapa* L.), Welsh onion (*Allium fistulosum* L.), Amaranth (*Amaranthus viridis* L.), Goosefoot (*Chenopodium album* L.), leeks (*Allium apeloprasum* L.) and garlic (*Allium sativum* L.) are still very common throughout the region, and herbs like parsley (*Petroselinum crispum* (Mill.) Fuss.), coriander (*Coriandrum sativum* L.), tarragon (*Artemisia dracunculus* L.), savory (*Satureja hortensis* L.), gardencress (*Lepidium sativum* L.), dill (*Anethum graveolens* L.), fennel (*Foeniculum vulgare* Mill.), celery (*Apium dulce* Mill.), *Allium fistulosum* L., *Brassica rapa* L. subsp. *rapifera* Metzger, *Lathyrus sativus* L., *Linum usitatissimum* L., *Medicago sativa* L., *Onobrychis transcaucasica* Grossh., *Pisum arvense* L., *Trigonella caerulea* (L.) Ser. are cultivated almost everywhere. In addition, introduced species like zucchini (*Cucurbita pepo* L.), cucumber (*Cucumis sativus* L.), eggplant (*Solanum melongena* L.), marigold (*Tagetes patula* L.), watermelon (*Citrullus lanatus* (Thunb.) Matsum., Nakai), sunflower (*Helianthus annuus* L.), tomato (*Solanum lycopersicum* (Mill.) Wettst.), pepper (*Capsicum annuum* L.), potato (*Solanum tuberosum* L.), and maize (*Zea mays* L.), and were found to be popular ingredients of local cuisine. A large number of additional species is traditionally also grown in home gardens, e.g., Sour plum (*Prunus cerasifera* var. *divaricata*) is commonly used as sauce with meat, Rose hips (*Rosa canina* L.) are often used for tea and to make jam, and *Staphyllea pinnata* L. (Bladdernut) inflorescences are a favorite pickle.

Pkhali and Pickles - emblematic foods of the Caucasus

Of all food preparations the use of plants as ingredient of boiled herb preparations (mostly as გაზაფხულის ფხალი - gazapkhuli pkhali = Spring Pkhkali, as the first vitamin source after winter), and as lacto-fermented or vinegar-based pickles are probably the most emblematic ones in the Caucasus. Only 60% of participants reported making pickles / lacto fermented preparations. Of these, over 16% each came from Zemo Imereti and Khevsureti, and 12% each from Zvemo Svaneti, the Javakheti-Plateau, representing all high altitude - short growing season areas, where the population does need to preserve food for winter. In the case of Pkhali, over 93% of all participants

reported to use such boiled herbs, normally in Spring. Zemo Imereti (19% of all Phkhali preparations), Tori and Kvemo Racha (16% each), Tusheti (15%) and Khevsureti (14%) - all mountain regions with long winters, stood out as the real "herb eater" areas. In contrast to the pickled species, essentially only young leaves were used for pkhali, with great emphasis on the same families indicated in pickles. (all pickled plant species were also used for phkhali). The elaboration of phkhali often involves many steps to reduce the toxicity of species used, and in most cases a wide variety of herbs are included in each preparation.

Subalpine and Alpine Vegetation communities

Species Area Curve analysis

A total of 563 plant species were recorded from 619 plots in alpine pastures of Caucasus. The species area curve analysis revealed that the maximum number of plant species appeared up to 600 plots after which the species curve became parallel, as no new species were recorded further. We also found that the curve reached the asymptote, showing adequate sampling in the targeted region (Figure 1).

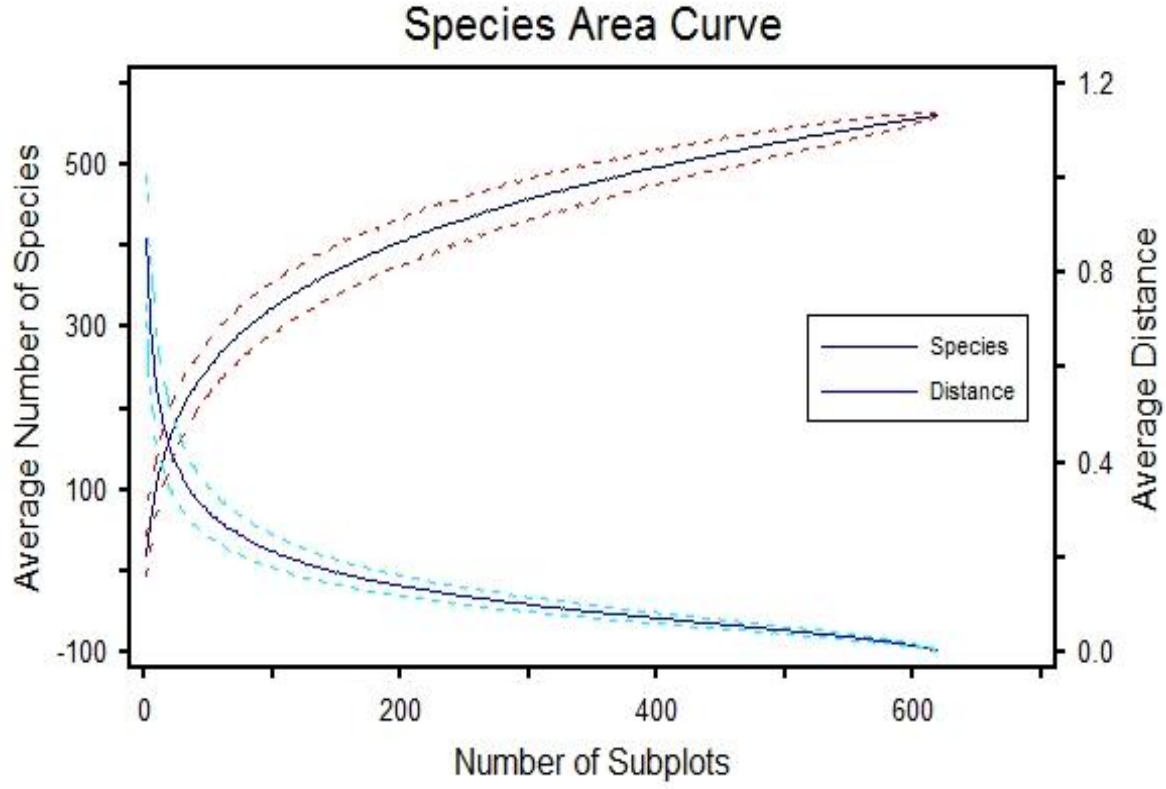

Figure 1. Species Area Curve illustrating the adequacy level of sampling sites (619) for the vegetation (563 plant species) of the study area.

Classification of the alpine vegetation TWINSPAN

According to TWINSPAN, a total of seven major plant communities were recognized by clustering all the plant species (563 plant species) recorded in 619 plots under the strong influence of altitude and exposition variables (TWINSPAN, Figure 2). They ranged from alpine ranges of 1735m to the cold desert (3600m.We can observe by the TWINSPAN method, two large different clusters, which show a high cluster heterogeneity value (Lambda = 0.5568.) One of these clusters had four major plant communities and was formed by 591 plots, while the other cluster presented three major plant communities structured in 28 plots. Furthermore, we observed different subdivisions within these two large groups. Each community was composed of different indicator species and was recorded at different altitudinal range (Figure 2).

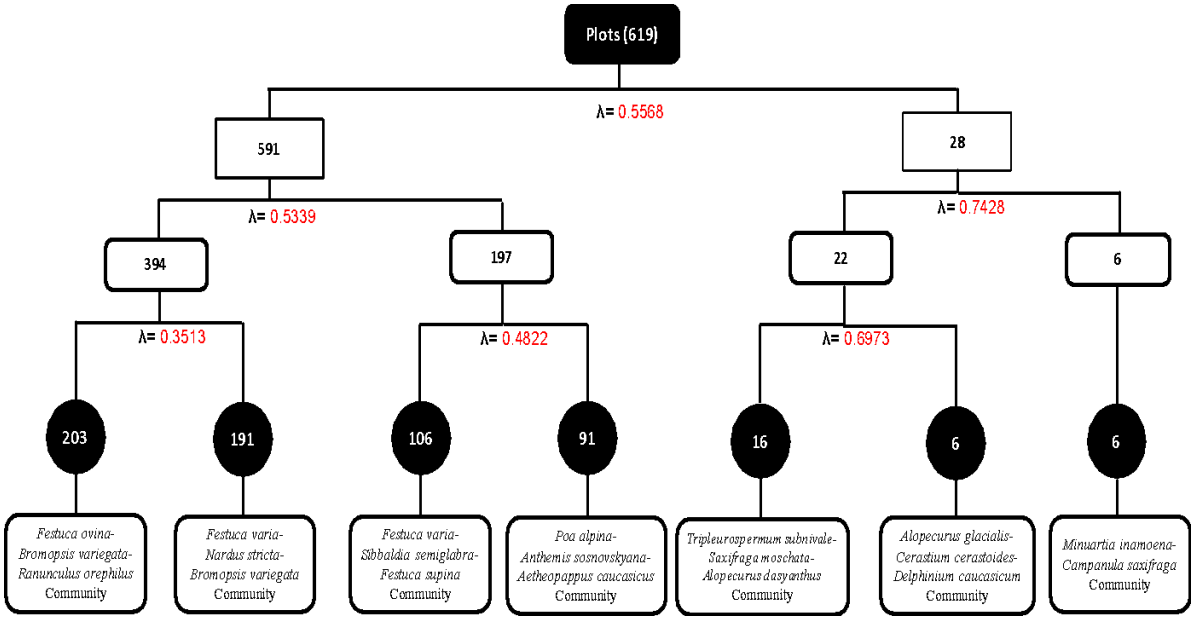

Figure 2: TWINSPAN classification of the alpine vegetation of the Georgian Caucasus. For the classification of 563 plant species and 619 plots simultaneously.

Altitude

We observed a significant variation in the average altitude between plant communities (χ^2=3905.4, df=6, p<0.001, Figures 3a,b,c). FBR (**FBR:** *Festuca ovina, Bromopsis variegata, Ranunculus oreophilus*) and FNB (**FNB:** *Festuca varia, Nardus stricta, Bromopsis variegata*) had the lowest values of average altitude, 1954±9.9 and 2255±17 (mean±SE) respectively, significantly different from each other and from all other communities. ACD (**ACD:** *Alopecurus glacialis Cerastium cerastioides, Delphinium caucasicum)*, FSF (**FSF:** *Festuca varia, Sibbaldia, semiglabra Festuca* supina), MC (**MC:** *Minuartia inamoena, Campanula saxifraga)* and PAA (**PAA:** *Poa alpina, Anthemis sosnovskyana, Aetheopappus* caucasicus (**TSA:** *Tripleurospermum subnivale, Saxifraga moschata, Alopecurus dasyanthus*) showed intermediate values of average altitude (3125±25, 2952±15, 2903±21, 2897±2, respectively), and TSA (3213±49) had the highest average altitude.

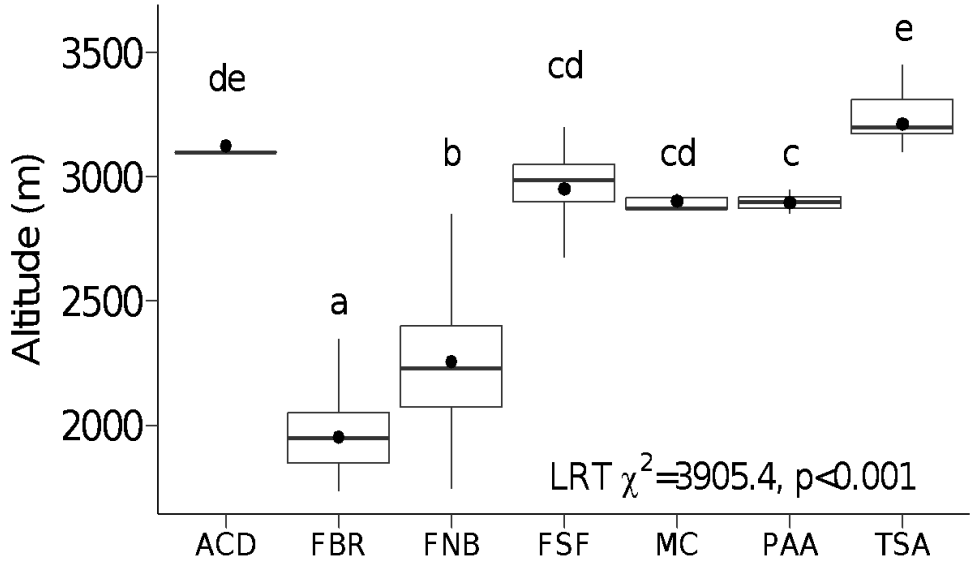

Figure 3a. Variation in the average altitude between plant communities. Letters differ from each other by the estimated marginal means. Box plots are represented by raw data, median and mean (black dot).

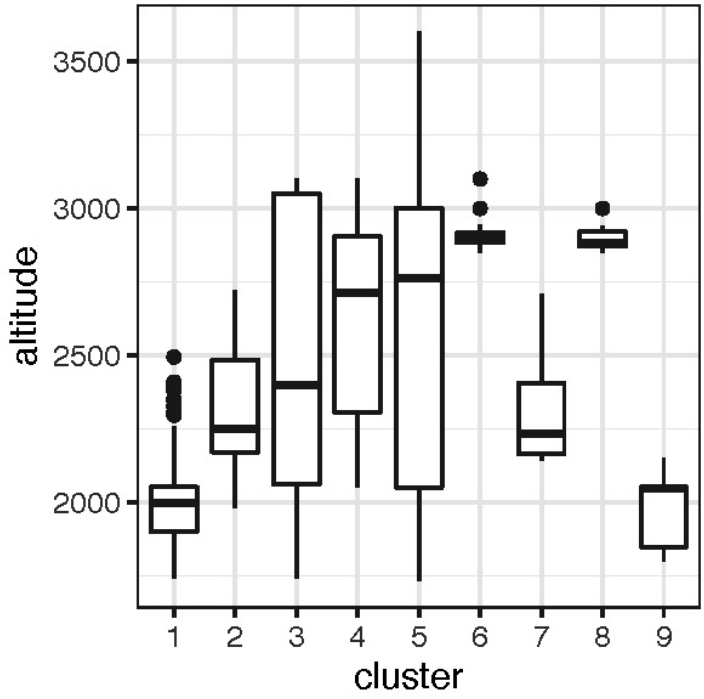

Figure 3b. Altitudinal distribution of the main phytosociological units.
(1: *Bromopsio variegatae - Festucetea ovinea*, 2: *Nardo strictae - Caricetea pallescentis*, 3: *Festuco variae - Carietalia meinshausianae*, 4: *Carico tristis - Festueetalia supinae*, 5: *Sympoholomo graveolensis - Saxifragetea exaratae*, 6: *Sibbaldio semiglabratae - Gnaphalietea supinae*, 7: *Kobresio humilis - Kobresietalia capilliformis*, 8: *Alchemillo sericeae - Anthemetea sosnovskayae*, 9: *Rhinantho minoris - Trifolietalia pratensis*)

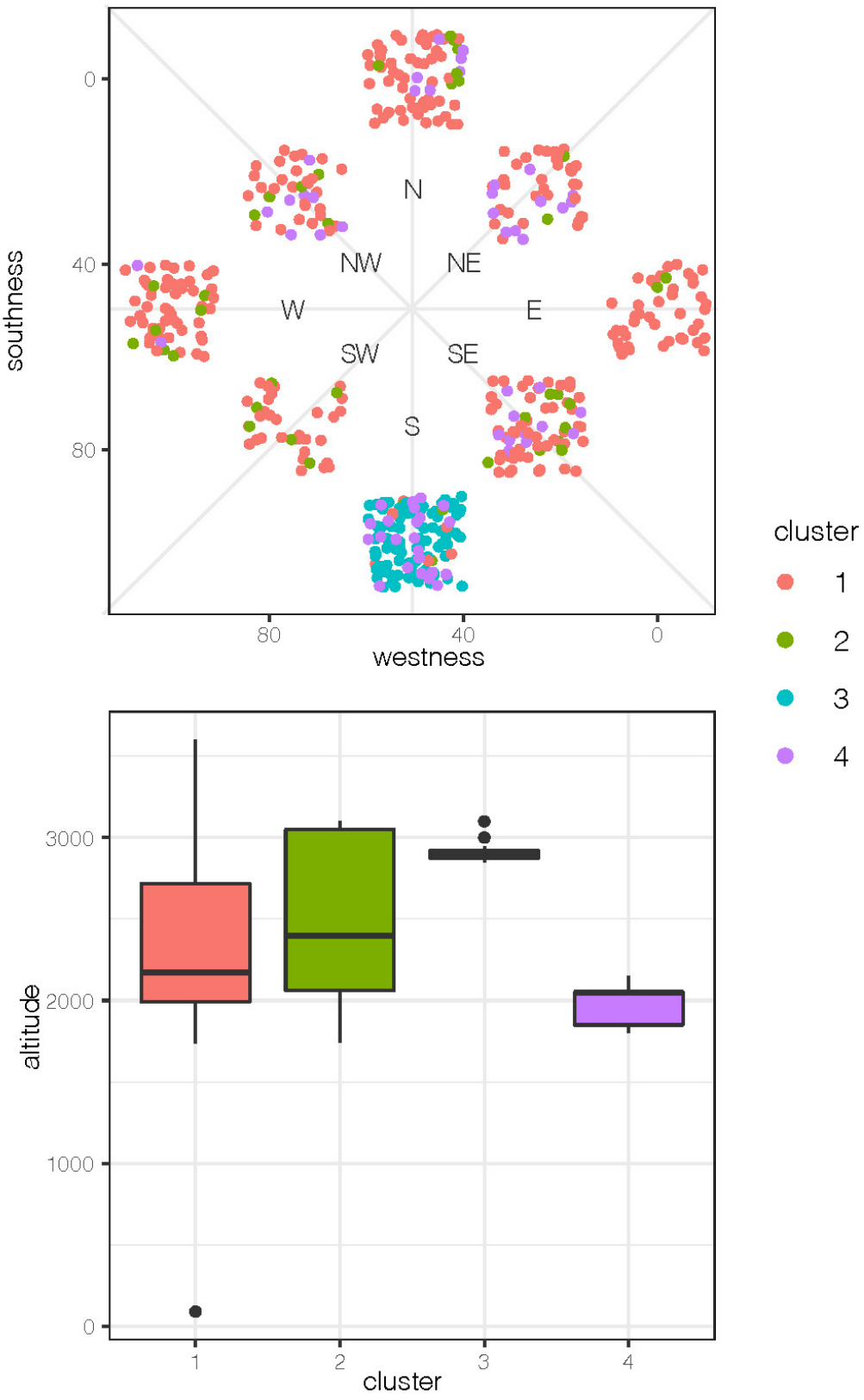

Figure 3c. Altitudinal distribution and exposition of main phytosociological units.
(1: Subalpine pastures *Bromopsio variegatae - Festucetea ovinae*, 2: Nutrient-rich alpine pastures: *Festuco variae - Carietalia meinshausianae*, 3: Alpine pastures: *Sympoholomo graveolensis - Saxifragetea exaratae*, 4: *Rhinantho minoris - Trifolietalia pratensis*).

Community Assemblages

The correlation between alpine pastures vegetation and environmental variables was indicated in the analysis obtained through PCA (Figures 4a,b). In constrained PCA ordination, the maximum explanatory variation was accounted on PC1 axis (15.9%) and lower variation on PC2 axis (11.3%). Maximum strength was recorded for the most important environmental gradient that is altitude and southern aspect among exposition variables. We observed from PCA ordination that environmental variables grouped the seven communities in three major groups (Figure 4): MC and PAA, ACD, FSF and TSA, and FBR and FNB. FBR and FNB showed a positive relationship with SW, NE, N, E aspect, but a negative with S and altitude, once these two communities showed the lowest values of altitude (Figure 4). All other communities were positively related to altitude and S aspect. Altitude (R^2=0.5, p<0.001), SW (R^2=0.02, p<0.007), NW (R^2=0.03, p<0.001), W (R^2=0.04, p<0.001), N (R^2=0.03, p<0.003) and S (R^2=0.18, p<0.001) aspect were the variables that significantly influenced communities' distribution in the ordination. The other aspects did not significantly influence (NE: R^2=0.01, p=0.053, SE: R^2=0.01, p=0.100, WN: R^2=0.01, p=0.444, E: R^2=0.01, p=0.088). The FBR and FNB communities were found scattered due to the presence of associated species having vast ecological amplitude. In contrast with this, all the rest of five communities were found separately in clumps with clear differences based on their particular set of environmental variables (see Figure 2).

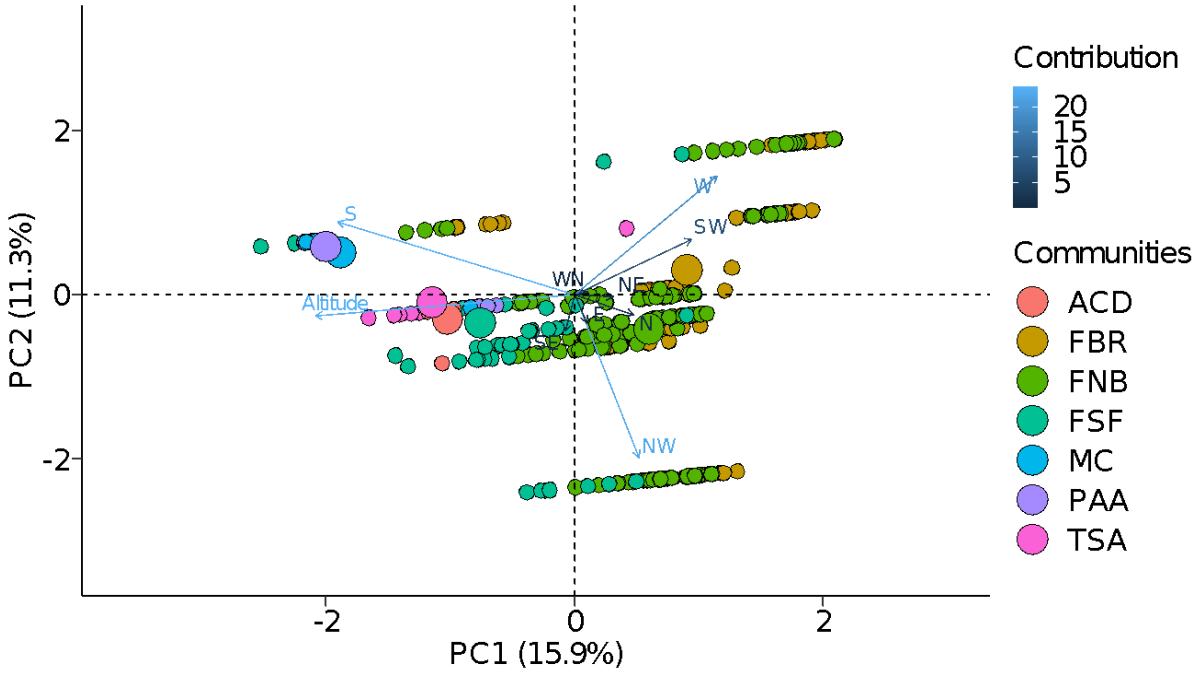

Figure 4a. Principal Component Analysis (PCA) illustrating the relationship of environmental variables with the seven different communities indicated in colored circles. Each circle with different colors indicates a separate community based on a 95% confidence level. Direction of the arrow illustrates the correlation of each environmental gradient, whereas length indicates the influence and strength of those gradients. Gradients on the same axis showed positive correlation while those on the opposite axes indicate negative correlation. Big circle demonstrates the centroid of each plant community. **FBR:** *Festuca ovina, Bromopsis variegata, Ranunculus oreophilus*, **FNB:** *Festuca varia, Nardus stricta, Bromopsis variegata*, **FSF:** *Festuca varia, Sibbaldia semiglabra, Festuca supina*, **PAA:** *Poa alpina, Anthemis sosnovskyana, Aetheopappus* caucasicus, **TSA:** *Tripleurospermum subnivale, Saxifraga moschata, Alopecurus dasyanthus,* **MC:** *Minuartia inamoena, Campanula saxifraga,* **ACD:** *Alopecurus glacialis, Cerastium cerastioides, Delphinium caucasicum*

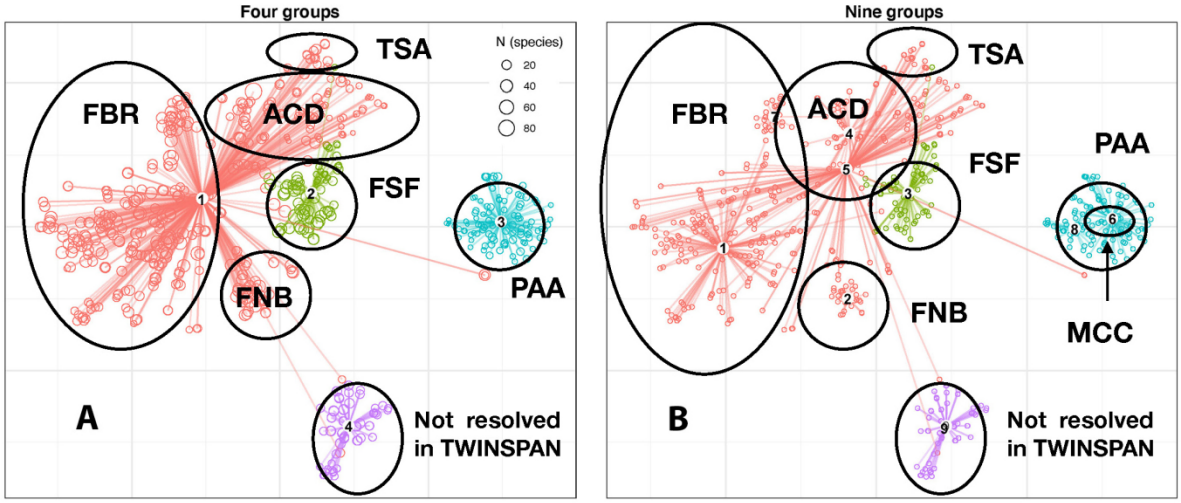

Figure 4b. Main Phytosociological units compared to TWINSPAM categorization

A: (1: Subalpine pastures *Bromopsio variegatae - Festucetea ovinae*, 2: Nutrient-rich alpine pastures: *Festuco variae - Carietalia meinshausianae*, 3: Alpine pastures: *Sympoholomo graveolensis - Saxifragetea exaratæ*, 4: *Rhinanthuo minoris - Trifolietalia pratensis*.**FBR:** *Festuc ovina, Bromopsis variegata, Ranunculus oreophilus*, **FNB:** *Festuca varia, Nardus stricta, Bromopsis variegata*, **FSF:** *Festuca varia, Sibbaldia semiglabra, Festuca supina*, **PAA:** *Poa alpina, - Anthemis sosnovskyana, Aetheopappus caucasicus*, **TSA:** *Tripleurospermum subnivale, Saxifraga moschata, Alopecurus dasyanthus,* **MC:** *Minuartia inamoena, Campanula saxifraga,* **ACD:** *Alopecurus glacialis, Cerastium cerastioides, Delphinium caucasicum*

B: (1: *Bromopsio variegatae - Festucetea ovinea*, 2: *Nardo strictae - Caricetea pallescentis*, 3: *Festuco variae - Carietalia meinshausianae*, 4: *Carico tristis - Festucetalia supinae* , 5: *Sympoholomo graveolensis - Saxifragetea exaratæ*, 6: *Sibbaldio semiglabratae - Gnaphalietea supinae*, 7: *Kobresio humilis - Kobresietalia capilliformis*, 8: *Alchemillo sericeae - Anthemetea sosnovskyae*, 9: *Rhinantos minoris - Trifolietalia pratensis*), **FBR:** *Festuca ovina, Bromopsis variegata, Ranunculus oreophilus*, **FNB:** *Festuca varia, Nardus stricta, Bromopsis variegata,* **FSF:** *Festuca varia, Sibbaldia semiglabra, Festuca supina*, **PAA:** *Poa alpina, Anthemis sosnovskyana, Aetheopappus* caucasicus, **TSA:** *Tripleurospermum subnivale, Saxifraga moschata, Alopecurus dasyanthus,* **MC:** *Minuartia inamoena, Campanula saxifraga,* **ACD:** *Alopecurus glaciali,s Cerastium cerastioides, Delphinium caucasicum*

Species Composition

Plant species composition significantly varied among communities (Table 2). All communities showed a significant difference in species composition between each other (Table 3.) Based on the overall Bray-Curtis dissimilarity of species between communities (Table 4), we identified eighteen plant species that most contributed to the overall dissimilarity, namely *Achillea millefolium, Alopecurus dasyanthus, Alopecurus glacialis, Bromopsis variegata, Campanula saxifraga, Carex tristes, Cerastium cerastoides, Delphinium caucasicum, Festuca ovina, Festuca supina, Festuca varia, Kobresia capillifolia, Kobresia capillifolia, Kobresia capilliformis, Minuartia inamoena, Nardus stricta, Poa alpina, Ranunculus oreophilus, Saxifraga moschata, Sibbaldia semiglabra,* and *Tripleurospermum subnivale.*

Table 2. PERMANOVA results comparing species composition between the four communities found in Moist temperate forest. This analysis was made with Euclidean distance and 999 permutations. Pairwise comparisons between communities are depicted in Table 2.

	Df	Sums of Sqs	Mean Sqs	F	R^2	Pr(>F)
Communities	6	104000	17333.3	8.77	0.079	0.0001
Residuals	612	1209567	1976.4		0.920	
Total	618	1313567			1	

Table 3. Pairwise comparisons with FDR p-value adjustment method of species composition between communities after PERMANOVA analysis (Table 1). Analyses were based on Euclidean distance and 999 permutations.

	ACD	FBR	FNB	FSF	MC	PAA
FBR	0.0016	-	-	-	-	-
FNB	0.0098	0.0016	-	-	-	-
FSF	0.0105	0.0016	0.0016	-	-	-
MC	0.0045	0.5020	0.4998	0.3990	-	-
PAA	0.0016	0.0016	0.0016	0.0016	0.1190	-
TSA	0.0016	0.0016	0.0016	0.0016	0.1001	0.0016

Table 4. Contrast table of the three species that most contributed to the overall Bray-Curtis dissimilarity of species composition between the seven communities identified in our study. Av. dis. Average dissimilarity, SD Standard deviation, Av Com1 Average Community 1, Av Com2 Average community 2, Cum. Cumulative, Cont. Contribution.

Communities	Plant species	Av dis	SD	Ratio	Av Com1	Av Com2	Cum	Cum %	Cont %
ACD-FBR	Alo.gla	0.3	0.2	1.3	0	28	0.3	27	27
	Cer.cer	0.1	0.2	0.4	0	10.8	0.4	35.3	8.3
	Fes.ovi	0.1	0.1	0.6	8.6	0	0.4	40.7	5.4
ACD-FNB	Alo.gla	0.2	0.1	1.4	0	28	0.2	16.2	16.2
	Fes.var	0.1	0.1	0.5	10.3	0	0.2	22	5.7
	Cer.cer	0.1	0.1	0.4	0	10.8	0.3	27.6	5.6
ACD-FSF	Alo.gla	0.3	0.2	1.3	0.8	28	0.3	26	26
	Cer.cer	0.1	0.2	0.4	0.1	10.8	0.3	34.2	8.3
	Fes.var	0.1	0.1	0.6	9.8	0	0.4	42.2	8
ACD-MC	Alo.gla	0.6	0.3	2	28	0	0.6	59.4	59.4
	Cer.cer	0.1	0.3	0.4	10.8	0	0.7	74.3	15
	Del.cau	0.1	0.2	0.5	3.5	0	0.8	81.6	7.2
ACD-PAA	Alo.gla	0.5	0.3	2	0	28	0.5	54.8	54.8
	Cer.cer	0.1	0.3	0.4	0	10.8	0.7	69.1	14.3
	Del.cau	0.1	0.1	0.5	0	3.5	0.8	75.9	6.8
ACD-TSA	Alo.gla	0.3	0.2	1.5	0.3	28	0.3	29.3	29.3
	Tri.sub	0.1	0.2	0.8	14.1	0	0.4	43.4	14.1
	Cer.cer	0.1	0.2	0.4	0.3	10.8	0.5	52.8	9.4
FBR-FNB	Fes.var	0.1	0.1	0.5	1.1	10.3	0.1	5.9	5.9
	Bro.var	0	0.1	0.8	8.2	7.6	0.1	11.1	5.2
	Fes.ovi	0	0.1	0.7	8.6	4.6	0.2	16	4.9
FBR-FSF	Fes.var	0.1	0.1	0.6	1.1	9.8	0.1	7.5	7.5
	Sib.sem	0	0.1	0.5	0	8.7	0.1	12.3	4.8
	Fes.ovi	0	0.1	0.6	8.6	0	0.2	17.1	4.8
FBR-MC	Fes.ovi	0.1	0.1	0.7	8.6	0	0.1	8.4	8.4
	Bro.var	0.1	0.1	0.8	8.2	0	0.2	16.1	7.8
	Ran.ore	0	0.1	0.6	5.1	0	0.2	20.6	4.4
FBR-PAA	Fes.ovi	0.1	0.1	0.7	8.6	0	0.1	8	8
	Bro.var	0.1	0.1	0.8	8.2	0	0.2	15.4	7.4
	Ran.ore	0	0.1	0.6	5.1	0	0.2	19.6	4.2
FBR-TSA	Tri.sub	0.1	0.2	0.7	0	14.1	0.1	12.5	12.5
	Sax.mos	0.1	0.1	0.6	0	8.1	0.2	19.1	6.5
	Alo.das	0.1	0.1	0.5	0	7.7	0.3	25.2	6.1
FNB-FSF	Fes.var	0.1	0.1	0.7	10.3	9.8	0.1	8.2	8.2
	Nar.str	0	0.1	0.4	8	0.5	0.1	12.6	4.3
	Car.tri	0	0.1	0.6	5.8	3.9	0.2	16.7	4.1
FNB-MC	Fes.var	0.1	0.2	0.5	10.3	0	0.1	7.9	7.9
	Nar.str	0.1	0.1	0.4	8	0	0.1	14	6.1
	Kob.cap	0	0.1	0.4	6.8	0	0.2	19	5
FNB-PAA	Fes.var	0.1	0.1	0.5	10.3	0.1	0.1	59.4	59.4
	Nar.str	0.1	0.1	0.4	8	0	0.1	74.3	15
	Kob.cap	0	0.1	0.4	6.8	0	0.2	81.6	7.2
FNB-TSA	Tri.sub	0.1	0.1	0.8	0	14.1	0.1	7.8	7.8
	Fes.var	0.1	0.1	0.5	10.3	0.1	0.1	13.4	5.6

	Nar.str	0	0.1	0.4	8	0	0.2	17.8	4.4
FSF-MC	Fes.var	0.1	0.2	0.6	9.8	0	0.1	13.4	13.4
	Sib.sem	0.1	0.2	0.5	8.7	0	0.2	21.7	8.3
	Fes.sup	0.1	0.1	0.5	5.9	0.2	0.3	28.4	6.8
FSF-PAA	Fes.var	0.1	0.2	0.6	9.8	0.1	0.1	13.2	13.2
	Sib.sem	0.1	0.2	0.5	8.7	0.1	0.2	21.4	8.2
	Fes.sup	0.1	0.1	0.5	5.9	0.2	0.3	28.1	6.7
FSF-TSA	Tri.sub	0.1	0.2	0.8	0.9	14.1	0.1	12.2	12.2
	Fes.var	0.1	0.1	0.6	9.8	0.1	0.2	20.1	7.8
	Sax.mos	0.1	0.1	0.6	0.3	8.1	0.3	26.5	6.4
MC-PAA	Min.ina	0.1	0.1	1.2	0.4	1	0.1	11.3	11.3
	Poa.alp	0.1	0.1	1.2	0.7	0.2	0.2	22.4	11.1
	Cam.sax	0.1	0.1	1.2	0.1	0.7	0.3	33.4	11
MC-TSA	Tri.sub	0.3	0.3	0.8	14.1	0	0.3	26.3	26.3
	Sax.mos	0.1	0.2	0.7	8.1	0	0.4	39.4	13
	Alo.das	0.1	0.2	0.6	7.7	0	0.5	50.9	11.5
PAA-TSA	Tri.sub	0.2	0.3	0.8	0	14.1	0.2	24.7	24.7
	Sax.mos	0.1	0.2	0.7	0	8.1	0.4	37	12.3
	Alo.das	0.1	0.2	0.6	0	7.7	0.5	48	11

Ordination of sampling plots

Detrended Correspondence Analysis (DCA) ordination of all 619 plots of the study area were analyzed based on the plant species association. The floristic relationships among the major plant communities were visualized by means of DCA. The DCA resulted in correlation of 619 stands into the recognition of seven plant communities (Figure 5). Distribution of these recognized plant communities is dependent upon the presence of positively associated species within them, similar vegetation, and its linkage with the particular set of environmental variables and slope exposition. For instance, PAA community has been strongly influenced by the Southern aspect.

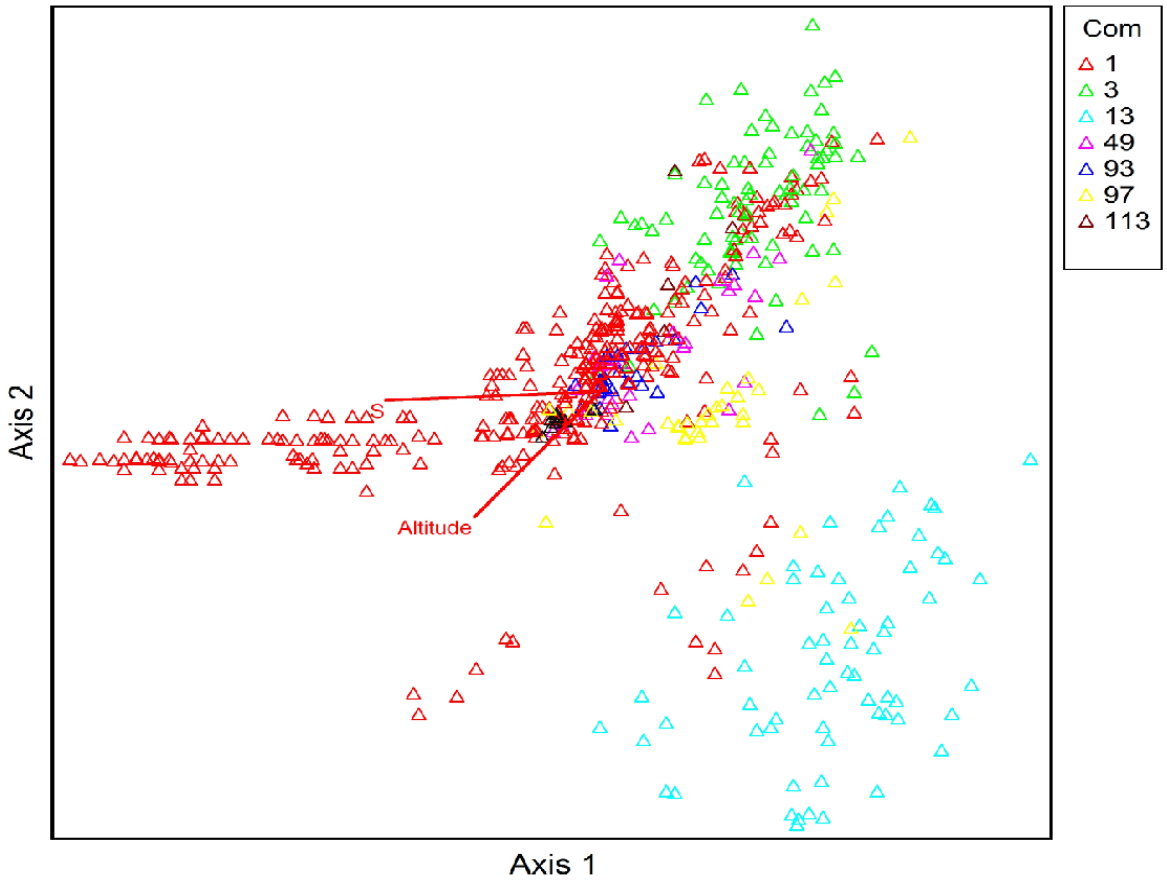

Figure 5. DCA ordination of 619 plots further grouped into seven major plant communities.

Partial CCA

Total inertia results of CCA were 40.825, in which all variables were present in the final model and explained 4.2% of variation (sum of canonical eigenvalues was 1.753). The first two canonical axes explained 51.7% of variation. CCA model was significant (χ^2=1.753, pseudo-F value=2.727, p<0.001, df=10, permutations=999). Testing simple term effects for the 10 explanatory variables, we found that only six variables were significant (p<0.05, Table 5). Performing the partial CCA for all the three possible classes (Table 6), the sum of the three classes explained 1% of the total variation (Figure 6.). Similar ordination techniques were used by other researchers including Haq et al. (2021a) from Pir Panchal mountain range of Himalayas and Rahman et al. (2022) from Pakistan Himalayas.

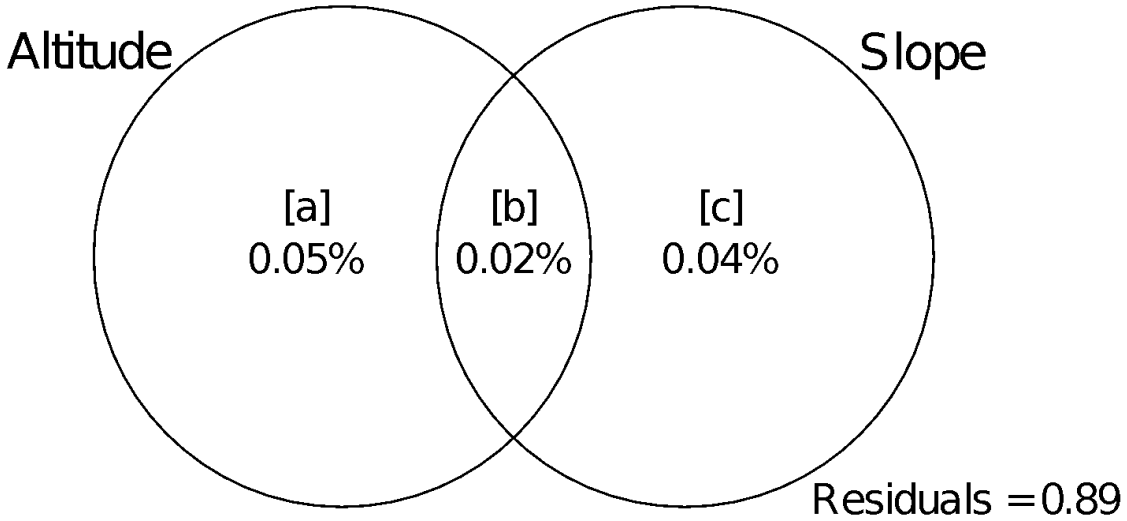

Figure 6. Venn diagram showing results of partial CCA and contribution (%) of the two variable groups studied.

Table 5 The contribution and ranking of the studied variables in our partial CCA model. Significant variables are displayed in bold.

	Df	ChiSquare	F	p-value
Altitude	1	0.632	98.396	**0.001**
SW	1	0.084	13.095	0.127
NE	1	0.079	12.311	0.163
NW	1	0.124	19.336	**0.001**
SE	1	0.082	12.816	0.167
WN	1	0.138	21.515	0.112
W	1	0.138	21.399	**0.001**
N	1	0.158	24.630	**0.001**
E	1	0.192	29.839	**0.001**
S	1	0.125	19.392	**0.005**

Table 6. Results of variation partitioning (partial CCA) of four variable groups studied (see Figure VENN for individual fraction letter code).

Individual Fraction	**Adjusted R^2**	**Variation explained (%)**	**% of all**	**Df**
[a]	0.050	0.438	0.122	1
[b]	0.024	0.214	0.060	0
[c]	0.040	0.348	0.097	9
Total explained	11.396	1	0.279	10
All variation	40.825	/	100	

Species richness and Diversity indices

Species richness values differed significantly (χ^2=957.02, df=6, p<0.001, Figure 7a) among seven plant communities, ranging from 06 to 350 plant species (Figure 7a). The highest number of plant species were recorded in the FNB community (350 species) at the lowest altitudinal range (1744m up to the middle range 2914m) followed by FBR (321 species) at the altitudinal range of 1735-2352m. Moreover, 173 plant species were recorded in the FSF community between 2075-3526m. TSA was the highest elevational range plant community recognized at 2800-3600m altitude with 36 associated species. Further, the lowest number of species was marked for MC community (six species) at the altitudinal range of alpine pastures 2870-3000m) in lowest number of plots (6 plots). FNB showed the highest average number of species per plot 28.2±0.8, mean±SE) followed by FBR 21.5±0.6) and FSF (11.5±0.7), which were significantly different from each other (Figure 7a). The other four communities showed an average of species per plot of 2.3-5.43±0.2-0.9.

We found significant difference of the four diversity indices, Species Richness Shannon (χ^2=476.22, df=6, p<0.001, Figure 7b), Simpson (χ^2=283.43, df=6, p<0.001, Figure 7c), and Pielou's evenness (χ^2=440.03, df=6, p<0.001, Figure 7d) between the seven plant communities. Again, the highest values of Shannon index were present in FBR 2.4±0.03, mean±SE) and FNB 2.2±0.03) (Figure 7b). Intermediate values were observed in FSF (1.6±0.06) and PAA (1.5±0.04) (Figure 7c.And the lowest values were observed in TSA (1.0±0.14), MC (0.8±0.08) and ACD (0.6±0.14.FBR (0.84±0.01, mean±SE), FNB (0.79±0.01), and PAA (0.75±0.01) showed the highest values of Simpson index (Figure 8c), followed respectively by FSF (0.69±0.01), MC (0.55±0.03), TSA (0.52±0.05), and ACD (0.31±0.08.Finally, MC (1±0.0, mean±SE) and PAA (0.98±0.01) showed the highest values of Pielou's evenness, followed respectively by FBR (0.81±0.01), FSF (0.71±0.01), TSA (0.70±0.04), FNB (0.68±0.1), and ACD (0.48±0.08) (Figure 7d.).

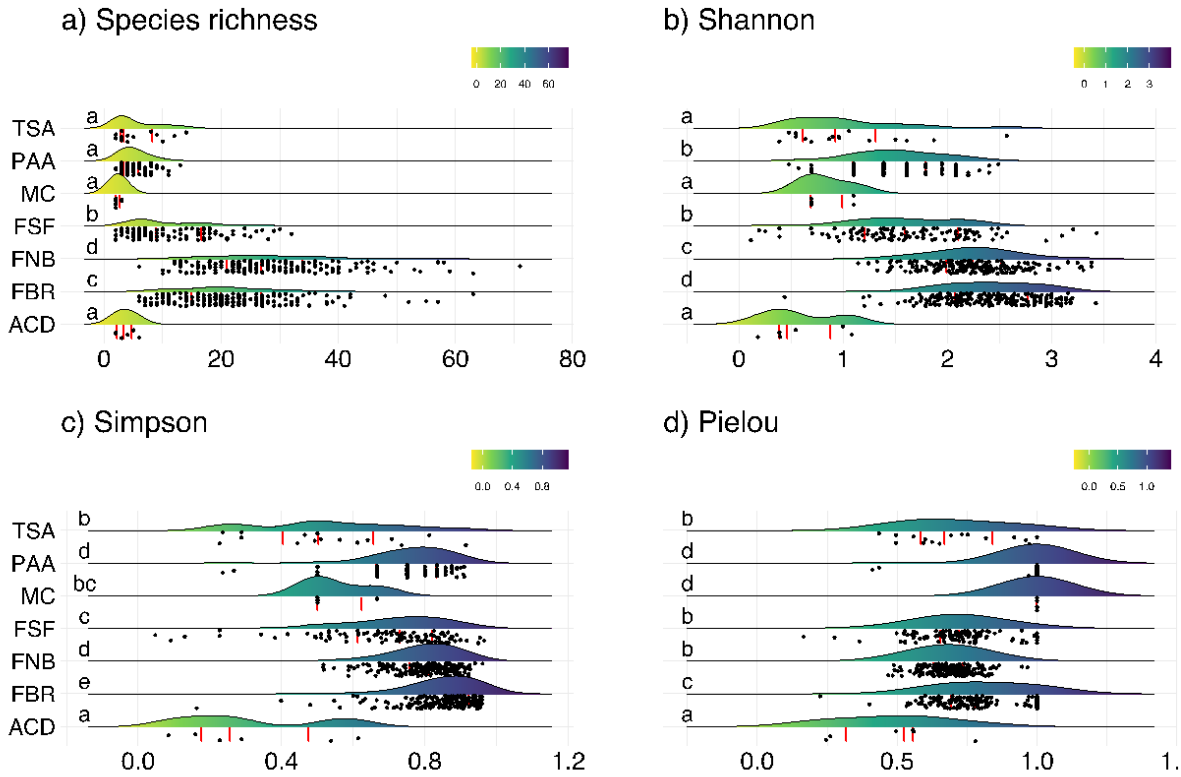

Figure 7. Variation of a) species richness, b) Shannon diversity, c) Simpson's diversity, and d) Pielou's evenness between the seven plant communities. Figures represent ridgeline plots with raw data (black dots below each density distribution) and first, second and third quartile (vertical red lines). Lowercase letters on the left differ from each other by estimated marginal means.

Beta diversity (βsim and βsne)

The total beta diversity (βsor) showed a value of 84.3% dissimilarity, of which spatial turnover (βsim) made up 48.8% and nestedness-resultant components (βsne) made up 35.4%. In the βsim cluster, we observed two major groups

with 80% dissimilarity, one formed by TSA, FNB and ACD, and another formed by the other four communities (Figure 8). FBR was 66% dissimilar from PAA, MC and FSF cluster. MC and FSF were 100% similar to each other. TSA showed a dissimilarity of 38.8% with FNB and ACD. In the βsne component, we found 93.3% dissimilarity between FSF, FNB and FBR cluster and TSA, PAA, MC and ACD cluster (Figure 8). FSF showed 24.4% dissimilarity with FNB and FBR. TSA and PAA showed 1% dissimilarity between each other, and 61% with the MC and ACD cluster (Figure 8). Similar classification was carried in High altitude vegetation in other parts of the world (Haq et al. 2021b; Yang et al., 2021).

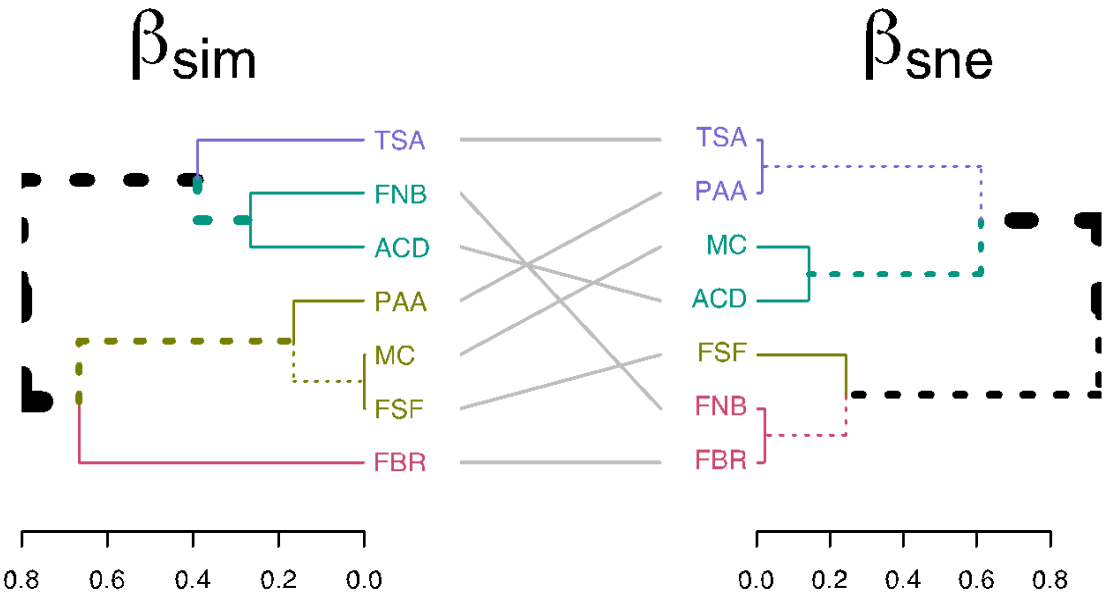

Figure 8. Dissimilarity cluster based on spatial turnover (βsim) and nestedness-resultant components (βsne) of beta diversity components of species dissimilarity between seven plant communities.

Phytosociological classification

A complete overview on phytosociological units, as well as all relevé data is given in Appendices 1 2-1 to 2-7 and 3) in the separate galleys.

Subalpine pastures *Bromopsio variegatae - Festucetea ovinea* (Class. nov.) (=FBR TWINSPAN) Type relevé: N120
Main altitude: (1750)1994-2720(3600) m
Character species: *Bromopsis variegata, Festuca ovina, Veronica gentianoides, Trifolium ambiguum, Leontodon hispidus, Plantago atrata, Carum caucasicum, Ranunculus oreophilus, Poa alpina, Festuca supina, Alchemilla sericata, Carex buschiorum*
Subalpine meadows comprise all more or less mesic herbaceous communities which are either mown or grazed. The Caucasian subalpine grassland is very diverse floristically, phytocoenotically and in terms of the spectrum of life forms. Below we describe the main types of subalpine grassland, which are commonly used as hayfields and some of them also as pastures. These communities occupy both dry and moist localities, they occur on skeletal cobble soils. Main components of the above-mentioned coenoses are *Trifolium ambiguum, Lotus caucasicus, Alchemilla sericata,* etc. The above communities are widespread in the Caucasian high-mountains and reach the altitude of 2700 m. Tussocks are used as hay-meadows.
Bromopsis variegatae Festucetea ovinea communities occupy both dry and moist habitats. They occur on skeletal eroded soils. The driest eroded slopes of the subalpine belt are covered by *Bromopsietum ripariae* communities. They grow on thin, scree and skeletal soils. Among the most widespread communities in the relatively dry semi-continental highlands of the Central Great Caucasus are *Bromopsis variegata* and *Agrostis tenuis* meadows. They are distributed from the upper mountain to the alpine belt (up to 2700 m). In this belt, these communities occupy flat and moderately sloping hillsides of almost all exposures. These meadows (sparse meadows corresponding to 'Magerwiesen') are distinguished by a large number of species. They are used both as hayfields and pastures.

Astragalo capitosae - Thymetalia collinae **(Ord. nov.) (=FBR TWINSPAN) Type relevé: N120**
Main altitude: 1900-2053 m
Character species: *Astragalus captiosus, Thymus collinus, Plantago atrata, Rhinanthus vernalis, Koeleria caucasica, Koeleria luerssenii, Galium verum, Agrostis tenuis, Pulsatilla violacea, Dianthus cretaceus, Pedicularis comosa, Trifolium alpestre, Bupleurum polyphyllum*
In mostly stony places. Communities dominated by *Astragalus captiosus* are characteristic to the subalpine belt of the eastern part of the Central Great Caucasus. These communities are dominated by the endemic *Astragalus captiosus* and occupy steep rocks and screes. Companion species are: *Carex buschiorum*, *Campanula bellidifolia*, and *Koeleria luerssenii*. There is a variant on strongly eroded slopes, with species such as *Festuca valesiaca*, *Bromopsis variegata*, *Lotus caucasicus*, *Alchemilla sericata*, *Pulsatilla violacea*, *Bupleurum polyphyllum*, *Trifolium alpestre*, *Koeleria luerssenii*, *Carex buschiorum*. Festucetum valesiacae as well as Festucetum ovinae can also be frequently found in the alpine belt up to 2560 m. For example, Kolteshi, steppes ascend often quite high, almost up to the alpine belt, though with elevation, these communities are depleted of xerophytes. Throughout the transect from 1800 2600 m, xerophilic vegetation is very sharply interrupted by mesophilic meadow communities.

Scabioso caucasicae - Agrostion planifoliae / Scabioso caucasicae - Agrostetum planifoliae typicum (All. / Ass. nov.)
Type relevé: N120
Character species: *Scabiosa caucasica, Agrostis planifolia, Phleum phleoides, Anemonastrum fasciculatum, Helictotrichon adzharicum, Hieracium umbellatum, Ranunculus acutilobus, Trifolium alpestre, Gentianella caucasea, Pedicularis comosa, Anthyllis variegata, Lotus caucasicus, Alchemilla debilis, Centaurea cheiranthifolia, Gentiana septemfida, Trifolium trichocephalum*
Distributed almost throughout the Caucasus on moderately humid northern and north-western slopes, forest edges and openings. Characteristic companion species are: *Trollius ranunculinus*, *Geranium ibericum, Betonica macrantha*, *Veratrum album*, *Polygonum carneum*. Subalpine meadows with *Veratrum album* are abundant in the western and partly Central Great Caucasus. *Veratrum album* is a tall and poisonous pasture weed, usually rejected by animals, it is commonly associated with *Trollius ranunculinus* and *Ranunculus caucasicus*.

Agrostio planifoliae - Phleetum phleoideum (Ass. nov.) **Type relevé: N308**
Character species: *Agrostis planifolia***,** *Phleum phleoides***,** *Ranunculus acutilobus*

Sileno linearifoliae - Alchemillion sericeae / Sileno linearifoliae - Alchemilletum sericeae typicum (All. / Ass. nov.)
Type relevé: F4
Character species: *Silene linearifolia, Alchemilla sericata, Poa badensis, Scabiosa bipinnata, Asperula albovii, Pulsatilla violacea, Draba nemorosa, Campanula hohenackeri, Sedum acre, Sempervivum pumilum. Campanula bellidifolia*
Typical for disturbed areas and are confined to slopes of southern exposure. *Pulsatilla violacea* is frequently associated with hemixerophitic grasses such as *Festuca ovina*, *Koeleria luerssenii* and with *Carex buschiorum*.

Campanulo hohenackeris - Pulsatilletum violaceae (Ass. nov.) **Type relevé: F16**
Character species: *Campanula hohenackeri***,** *Pulsatilla violacea***,** *Trifolium alpestre***,** *Campanula bellidifolia*
Differential species: *Saxifraga juniperifolia, Sempervivum caucasicum, Festuca valesiaca, Thalictrum foetidum, Artemisia campestris, Sedum oppositifolium, Vicia grossheimii*

Silieno linearifoliae - Scutellarietum oreophilae (Ass. nov.) **Type relevé: N7003**
Character species: *Trifolium alpestre*
Differential species: *Silene linearifolia, Scutellaria oreophila, Rumex acetosella, Crepis sonchifolia*

Rhinantho vernalis - Agrostion tenuis / Rhinantho vernalis - Agrostetum tenuis typicum (All. / Ass. nov.) **Type relevé: N4**
Character species: *Rhinanthus vernalis, Agrostis tenuis, Alchemilla sericata, Cerastium arvense, Lotus caucasicus, Ranunculus caucasicus, Trifolium fontanum, Centaurea cheiranthifolia, Euphrasia hirtella, Pedicularis comosa, Myosotis arvensis, Bromopsis variegata, Alchemilla rigida*

Alchemilo rigidae - Polygonetum alpinae (Ass. nov.) **Type relevé: N37**
Character species: *Alchemilla rigida, Polygonum alpinum, Ranunculus acutilobus*
Differential species: *Pedicularis comosa, Silene wallichiana, Pastinaca armena, Campanula oblongifolia, Tragopogon reticulatus*

Potentillo erectea - Campanuletum bellififoliae (Ass. nov.) **Type relevé: N39**
Character species: *Pulsatilla violacea*, *Campanula bellidifolia*

Nardo strictae - Caricetea pallescentis **(Ord. nov.) (=FNB TWINSPAN) Type relevé: N52**
Main altitude: 2172-2484 m
Character species: *Nardus stricta*, *Carex pallescens*, *Prunella vulgaris*, *Trifolium trichocephalum*, *Anthoxanthum alpinum*, *Potentilla erecta*, *Leontodon danubialis*, *Cerastium purpurascens*, *Cruciata laevipes*, *Daphne glomerata*, *Chaerophyllum roseum*
Nardus-Caricetea communities are widespread throughout the Caucasus, mainly on gentle slopes of almost all exposures. Due to overgrazing, the secondary forms of Nardeta communities are predominant. The primary Nardeta communities are confined to the slopes around glaciers, and in the upperpart of steep gullies. Mixed communities of Nardeto-Festucetum variae can be found in the central and eastern parts of the Great Caucasus. Under the influence of pasturing hygrophytic *Nardus* communities have developed on wetlands in depressions of alpine belt. Nardetum strictae companion species are: *Avenella flexuosa*, *Alchemilla caucasica*, *Sibbaldia semiglabra*, *Taraxacum stevenii*, *Cerastium purpurascens*, *Geranium gymnocaulon*, *Pedicularis crassirostris*, *Phleum alpinum*

Potentillo erectae - Leontodontion danubialis / Potentillo erectae - Leontodonetum danubialis typicum (All. / Ass. nov.) **Type relevé: N52**
Character species: *Plantago lanceolata, Cynosurus cristatus, Vaccinium myrtillus, Polygala alpicola, Ajuga orientalis, Phleum alpinum.*
Differential species: *Campanula trautvetteri, Luzula pseudosudetica, Viola somchetica*

Carico tristis - Festucetalia supinae **(Ord. nov.) Type relevé:**
Main altitude: 2300-2900 m
Character species: *Carex tristis*, *Festuca supina*, *Alchemilla caucasica*, *Polygonum viviparum*, *Dryas caucasica*, *Thalictrum alpinum*, *Potentilla gelida*, *Astragalus supinus*
The areas occupied by these communities are not large. *Habitat:* Stony, calcareous soils on steep 20-50º) slopes with North and North-West aspects. Relatively wide in the Truso gorge and on the Mt. Kuro slopes, between 2000 and 2600 m. Among the sedge dominated grasslands the *Carex tristis Festucetalia supinae* occupies the upper levels of the closed alpine vegetation and is widespread in the Caucasus. Usually, they inhibit prominent slopes exposed to winter winds. *Carex tristis* participates in the formation of the sedge-fescue association (*Festuca supina Carex tristis).* The most typical communities are: Cariceto-Alchemilleta (*Alchemilla caucasica*) and Cariceto-Kobresieta (*Kobresia macrolepis*.). Companion species are: *Carex tristis*, *Festuca supina*, *Thalictrum alpinum*, *Eritrichium caucasicum*, *Polygonum viviparum*, *Antennaria caucasica*, *Anemone speciosa*.

Minuartion imbricatae / Minuartietum imbricatae typicum (All. / Ass. nov.) **Type relevé: F12**
Character species: *Minuartia imbricata, Potentilla gelida, Erigeron alpinus, Anemone speciosa, Astragalus alpinus, Empetrum nigrum, Antennaria caucasica, Luzula spicata, Androsace villosa*
Festucetum supinae communities chiefly occupy the highest elevations of the belt 2700-2900 m), steep or slightly inclined slopes. Companion species are: *Kobresia macrolepis*, *K. persica*, *Astragalus supinus*, *Polygonum viviparum*, *Thalictrum alpinum*, *Alchemilla caucasica*, *Anemone speciosa*, *Carex tristis*, *Lomatogonium carinthiacum*. Relatively dry variant of the meadows also occurs with participation of steppe vegetation: *Pulsatilla violacea*, *Koeleria luerssenii*.

Euphrasio petiolaris- Campanulaetum ciliatae (Ass. nov.) **Type relevé: F12**
Character species: *Antennaria caucasica, Campanula biebersteiniana*
Differential species: *Euphrasia petiolaris, Campanula ciliata, Kobresia capillifolia, Lomatogonium carinthiacum*

Primulo amoenea - Desachampsietum caespitosae (Ass. nov.) **Type relevé: N162**
Character species: *Anemone speciosa, Festuca supina, Veronica gentianoides*
Differential species: *Primula amoena, Deschampsia cespitosa, Matricaria caucasica, Leontodon caucasicus, Eritrichium caucasicum, Festuca varia* subsp. *woronowii* communities in the alpine belt occupy rather steep slopes of southern exposure and occur within the entire mountainous part of the Caucasus. Most frequently they occur in the eastern part of the Great Caucasus. Companion species are: *Festuca supina*, *Carex tristis*, *Kobresia schoenoides*, *Astragalus supinus*, *Luzula spicata*, *Polygonum viviparum*, *Alchemilla sericea*, *Fritillaria lutea*.

Sibbaldio semiglabratae - Gnaphalietea supinae **(Ord. nov.) Type relevé: N178**
Main altitide: 2050-3000 m
Character species: *Sibbaldia semiglabra*, *Gnaphalium supinum*, *Geranium gymnocaulon, Saxifraga moschata*, *Taraxacum stevenii*, *Colpodium versicolor*, *Hordeum violaceum*, *Campanula biebersteiniana*
Sibbaldia semiglabratae Gnaphalietea supinae communities occupy gentle slopes and alluvial cones in the lower part of the subalpine belt (1800-2200 m). *Colpodietum versicolor* communities occupy small areas between the skeletal substrates and moraines. They are widespread in the upper alpine and subnival belts. Companion species are: *Alopecurus glacialis*, *Veronica telephiifolia*, *Potentilla crantzii*, *Taraxacum stevenii*, *Lamium tomentosum*, *Nepeta supina*. These species are both typical alpine and subalpine belts.

Seselio transcaucasicae - Trifolion arureum / Seselio transcaucasicuae - Trifolietum arureum typicum (All. / Ass. nov.) **Type relevé: N268**
Character species: *Seseli transcaucasicum, Trifolium aureum, Sibbaldia parviflora, Alchemilla retinervis, Saxifraga moschata, Avenella flexuosa, Ranunculus grandiflorus, Trifolium fontanum, Cerastium polymorphum, Carex medwedewii*

Saxifrago sibiricae - Cerastietum cerastioidis (Ass. nov.) (=ACD TWINSPAN) **Type relevé:**
Character species: *Saxifraga moschata Geranium sylvaticum, Lamium tomentosum Blysmus compressus, Cerastium polymorphum, Colpodium versicolor*
Differential species: *Saxifraga sibirica, Cerastium cerastoides, Delphinium caucasicum, Gladiolus tenuis*
Snowbed communities are composed of plant species that require or tolerate longterm snow cover (7-9 months, and sometimes throughout the year.Snowbed vegetation of the central European Alps belongs to the Saliceta herbacea Arctic Alpine community on siliceous substrate (Englisch 1993.Some of these snowbed species are found in the Caucasus as well as in the Alps: *Cerastium cerastoides*, *Plantago atrata* subsp. *saxatilis*, *Sagina saginoides*, *Gnaphalium supinum*, and *Sibbaldia procumbens*, which is a relative of *S. parviflora*. The floristic richness of these communities is low. Soil is permanently moist and supports the development of bryophytes. Humus content is low and nutrient availability is believed to be low. However, the snow supplies these communities with organic dust, which is partly mineralized by bacteria and fungi. In contrast to the Alps and the Scandinavian mountains, species such as *Salix herbacea* do not occur in alpine areas of the Caucasus (Ellenberg 1996.Similarly, another typical snowbed species of the Alps, *Soldanella pusilla*, is not present. Two phanerogam species in the alpine zone of the Central Great Caucasus that are dependent on reliable snow cover in winter, are *Daphne glomerata* and *Rhododendron caucasicum*, but these species clearly do not belong to snowbed communities. In Europe, typical snowbed communities cover large areas (hundreds of square meters each). By floristic composition snowbed communities of the Central Great Caucasus are apparently distinct from snowbed communities of the Anatoliam mountains, actually none of the species are identical (Kürschner *et al.* 1998).

In the Caucasus, these snowbed communities are composed of low stature geophytes and caespitose forb species, such as *Galanthus platyphylllus*, *G. caucasicus*, *Gagea sulphurea*, *G. glacialis*, *G. anisanthos*, *Merendera raddeana*, *Ornithogalum schmalhausenii*, *Puschkinia scilloides*, *Primula algida*, *P. ruprechtii*, *Campanula biebersteiniana*, *Minuartia aizoides*, *Taraxacum stevenii*, *Cerastim cerastoides*, *Gnaphalium supinum*, and *Sibbaldia parviflora*, and they include small grasses, such as *Poa alpina* and *Phleum alpinum*, as well as *Carex medwedewii*, *Alchemilla rigida*.

(a) Isolated plants are present in all biotopes of the subnival belt with the exception of snowbeds. For example, on unstable screes: *Cerastium kasbek*, *Delphinium caucasicum*, on slightly more stable substrate: *Veronica minuta*, *V. telephiifolia*, *Scrophularia minima*, *Lamium tomentosum*, on stable substrate: *Aetheopappus caucasicus*, *Symphyoloma graveolens*, *Jurinella subacaulis*, *Minuartia inamoena*, on rock *Primula bayernii*, *Draba bryoides*, *Saxifraga exarata* subsp. *moschata*. All these plants are chionophobes or hemichionophobes and have different

habit: Prostrate plants such as *Veronica minuta* and *V. telephiifolia*, Acaulescent rosette plants such as *Scrophularia minima*, *Symphyoloma graveolens*, *Aetheopappus caucasicus*, Cushion plants such as *Minuartia inamoena*, *M. trautvetteriana*, *Saxifraga exarata*s subsp. *moschata* and *Draba bryoides*. Almost all above-mentioned species are typical representatives of the subnival belt and are well adapted to these harsh environmental conditions.

Pastinaco armenae - Agrostietum planifoliae (Ass. nov.) **Type relevé: N1023**
Character species: *Pastinaca armena, Agrostis planifolia*
Differential species: *Poa nemoralis, Anthriscus nemorosa, Phleum montanum, Bromopsis riparia*

Sibbaldio parviflorae - Alchemilletum retinervis (Ass. nov.) **Type relevé: N167**
Character species: *Sibbaldia parviflora, Alchemilla retinervis, Carex medwedewii, Phleum alpinum, Anthoxanthum alpinum, Leontodon caucasicus, Avenella flexuosa, Daphne glomerata, Taraxacum stevenii*
Differential species: *Carex caryophyllea, Hieracium laevigatum*

Sibbaldio semigrabrae - Geranion gymnocaulae / Sibbaldio semigrabrae - Geranietum gymnocaulae typicum (All. / Ass. nov.) (=TSA TWINSPAN) **Type relevé: N1035**
Character species: *Sibbaldia semiglabra, Geranium gymnocaulon, Gnaphalium supinum, Colpodium versicolor, Taraxacum stevenii, Phleum alpinum, Potentilla gelida, Festuca supina, Corydalis alpestris*
Differential species: *Pedicularis crassirostris, Minuartia aizoides, Alopecurus glacialis, Tripleurospermum subnivale, Luzula multiflora*
Alchemilla glabricaulis

Sibbaldio semigrabrae - Geranion gymnocaulae communities are distributed in the Western and Central Great Caucasus. According to Dolukhanov (1946) as well as Onipchenko 2004), *Geranium* communities extend from the lower part of the alpine belt to the upper limits of dense vegetation, these meadows merge into the subnival belt. They occur on mountain-meadow skeletal soils. *Sibbaldia parviflora* and *S. semiglabra* are important taxa in both alpine and nival herbfields, yet their taxonomic status is unclear. The majority of Caucasian botanists recognize these two species as independent, while others only rank *Sibbaldia parviflora* as a recognised species, with *Sibbaldia semiglabra* considered to be a synonym (Kolakovsky 1985, Zernov 2006, Güner 2012.Some botanists (e.g., Onipchenko 2004) deny both Caucasian species and consider them resembling the European species *Sibbaldia procumbens*. Kamelin 2001) recognized only *S. parviflora* but considers it to be very close to *S. procumbens*. Carpet-forming alpine herbfields, addressed as 'Dicotylen-Teppiche' by Ellenberg (1996), are a very diverse group of communities spread over the upper part of the alpine belt. Caucasian botanists call it 'the upper alpine sub-belt' (Dolukhanov *et al.* 1946.Along with snowbeds the carpet-like herbfields are distributed on volcanic scree, rocks and between moraines and large stones. These small herb-fields occupy sheltered gaps among large boulders and gullies, often characterized by long-term snow cover. A short growing season is typical for all these herbfields. The plant canopy commonly does not exceed a height of 3-4 cm and 85% of aboveground phytomass is accumulated in the 0-1 cm layer, thus, forming dense swards. Roots in the upper 5-6 cm layer form a thick felt. A second, lower layer consists of sparse roots down to 20-25 cm. Some species have large and brightly coloured inflorescences while others are inconspicuous. The term 'Nanoherbeta' has been attributed to such herbfields. Besides these primary carpet-like alpine herbfields, vast alpine areas are occupied by secondary herbfield carpets with a dominance of *Alchemilla* spp. as a result of high manure input and cattle resting. Another species-poor variant of secondary and alpine herbfields follows from overgrazing and trampling on dry soils with a dominance of *Sibbaldia semiglabra* and *S. parviflora*. On moist sites, carpet-like herbfields with *Carum caucasicum* develop with companion species such as *Taraxacum stevenii*, *Campanula biebersteiniana*, *Plantago atrata* subsp. *saxatilis* and *Minuartia aizoides*. Carpet-like communities are also developed around late laying patches of snow and at the edges of the glaciers and they include *Ranunculus oreophilus var. pumilus*, *R. baidarae*, *Primula algida*, *Gentiana pyrenaica*, *G. angulosa*, *G. nivalis*, *Minuartia aizoides*, and *Cerastium cerastoides*. In wet conditions, on the banks of meltwater streams *Pedicularis crassirostris*, *P. nordmanniana*, *Primula auriculata*, and *Poa alpina* become prominent. Alpine carpet-like communities are characterized by the same species in the entire Euxine province (Anatolia, the Great and Lesser Caucasus mountains) and are forming plant communities made up of *Sibbaldia parviflora-Campanula biebersteiniana* or *Alchemilla retinervisSibbaldia parviflora* (Fedorov 1942, Mikeladze 1960, Narinyan 1959, Kolakovsky 1961, Onipchenko 2004, Zernov 2006, Nakhutsrishvili 2013).

Colpodium versicolor Corydalis alpestris variety **Type relevé: N3007**
Character species: *Colpodium versicolor*, *Corydalis alpestris*

*Kobresio schoenoideea - Minuartion oreinae / Kobresio schoenoideae - Minuartietum oreinae typicum (*All. / Ass. nov.) **Type relevé: N3017**
Character species: *Kobresia schoenoides, Minuartia oreina, Alchemilla sericata, Salix caprea, Anthemis marschalliana, Minuartia aizoides, Briza marcowiczii, Campanula tridentata, Campanula petrophila, Saxifraga kolenatiana, Trollius ranunculinus, Myosotis alpestris, Androsace villosa, Saxifraga flagellaris, Helictotrichon asiaticum*
Humid broad-leaved meadows with dominant *Trollius ranunculinus* are distributed in periodically wet places, they are found in forest openings as well as on slightly sloping hillsides and small depressions of both subalpine and alpine belts. The areas occupied by these meadows are not large. They occur as patches scattered over the other vegetation belts. *Ranunculus caucasicus* frequently occurs in these communities as a subdominant. Almost pure *Ranunculus* herb-fields were formed under the influence of overgrazing. Characteristic companion species are: *Veratrum album*, *Dactylorhiza euxina*, *D. urvilleana*, *Poa alpina*, *Swertia iberica*, *Avenella flexuosa*, *Pedicularis crassirostris*.

Alchemillo sericeae - Minuartio aizoides variety **Type relevé: N1049**
Character species: *Alchemilla sericea*, *Minuartia aizoides*, *Minuartia oreina*, *Anthemis marschalliana*
Kobresia schoenoides communities occur mostly on stony localities and within variegated fescue grassland. Companion species are: *Kobresia macrolepis*, *K. persica*, *Festuca supina*, *Astragalus alpinus*, *Anthemis marschalliana*, *Taraxacum stevenii*, *Anemone speciosa*, *Thalictrum alpinum*, *Alchemilla elisabethae*, *Polygonum viviparum*. The Kobresietum is mainly spread along the wind direction on mountain ridges in both subalpine and alpine belts. Companion species are: *Kobresia macrolepis*, *Alchemilla elisabethae*, *Carex tristis*, *Thalictrum alpinum*, *Polygonum viviparum*, *Alchemilla caucasica*.

Kobresio humilis - Kobresietalia capilliformis **(Ord. nov.) Type relevé: N195**
Main altitude: 2165-2400 m
Character species: *Kobresia humilis*, *Kobresia capilliformis*, *Chamaesciadium acaule*, *Alchemilla elisabethae*, *Veronica gentianoides*, *Polygonum viviparum*, *Carex buschiorum*, *Trifolium ambiguum*, *Gentiana aquatica*, *Cirsium rhizocephalum*, *Primula algida*, *Minuartia circassica*
Marginal ridges of the valley harbor specific vegetation reflecting extreme effects of wind, water erosion, frost action (soil polygons), and intensive grazing. The species composition of particular ridges is influenced by the steepness and size of the ridge as well as by contact communities.

*Cirsio rhizocephalae - Primulion algidae / Cirsio rhizocephalae - Primuletum algidae typicum (*All. / Ass. nov.) **Type relevé: N195**
Character species: *Cirsium rhizocephalum, Primula algida, Trifolium ambiguum, Draba siliquosa, Taraxacum confusum, Carum caucasicum, Festuca supina, Scabiosa caucasica, Campanula collina, Anthyllis variegata*

Gentiana aquatica variety **Type relevé: N315**
Character species: *Gentiana aquatica*
Typical spring ephemerals in uncut meadows are *Primula amoena*, *P. cordifolia*, *Fritillaria lutea*, *F. latifolia F. caucasica*, *Gentiana aquatica*, *Iris reticulata*.

Nutrient-rich alpine pastures: *Festuco variae - Caricetalia meinshausianae* (Ord. nov.) (=FSF TWINSPAN) Type relevé: N28
Main altitude: (1750)2060-3050(3150m)
Exposition: Never South, very rarely East or Northest
Character species: *Festuca varia*, *Carex meinshauseniana*, *Betonica macrantha*, *Campanula collina*, *Polygonum carneum*, *Minuartia circassica*, *Helictotrichon adzharicum*, *Primula amoena*, *Inula orientalis*, *Gentiana septemfida*
Festuco variae - Caricetalia meinshausianae occupies vast slopes of the subalpine belt, forming the first stage of succession. Under the influence of intensive grazing, *Calamagrostis arundinacea* communities become replaced by those of variegated fescue, but after grazing was discontinued, these tussock grasslands became transformed. On wet slopes, *Festuca* communities are richer than on dry ones. Jaroshenko (1942) and Geideman (1932) attributed

variegated fescue meadows to steppe communities, while Busch (1935) and Magakian (1941) regarded them as typical meadows. Later Jaroshenko (1942) suggested that Festucetum variae is a relict steppe, formed during the xerothermal period, and that since then, due to the further increase of climate humidity, the above-mentioned communities have been subject to the process of steppization. This opinion is shared by Grossheim (1948.Kimeridze (1965a, b) considers them as meadows. Variegated fescue meadows are well-spread throughout the Caucasus. Though, in South Georgian Uplands, unlike the Great Caucasus, these communities occur on grazed areas on northern slopes.

Festuco variae - Caricetion meinshausianae / *Festuco variae - Caricetum meinshausianae* typicum (All. / Ass. nov.)
Type relevé: N28
Main altitude: 2060-3050 m
Character species: *Primula amoena*, *Inula orientalis*, *Pyrethrum coccineum (Tanacetum coccineum)*, *Gentiana septemfida*, *Oxytropis albana*, *Polygonum carneum*, *Minuartia circassica*, *Helictotrichon adzharicum*, *Seseli alpinum*, *Vicia alpestris*
Very common in the Great Caucasus. Communities dominated by *Polygonum carneum* are of particular importance as natural grasslands. Under the influence of overgrazing, these meadows become replaced by more grazing resistant communities with robust tussock grasses.
Astrantia trifida variety **Type relevé: N15**
Character species: *Astrantia trifida*

Anthemio sosnovsyanae - Jurinellion subacaulis / *Anthemio sosnovsyanae - Jurinellietum subacaulis typicum (*All. / Ass. nov.) **Type relevé: N1059**
Character species: *Anthemis sosnovskyana, Jurinella subacaulis, Aetheopappus caucasicus, Alchemilla sericea, Potentilla crantzii, Anemone speciosa, Campanula collina, Silene commutata, Geranium ruprechtii, Veronica telephiifolia, Alchemilla chlorosericea, Salix kazbekensis, Senecio taraxacifolius, Saxifraga flagellaris, Arenaria lychnidea, Saxifraga cartilaginea*
Veronica telephiifoliae Alchemilletum chlorosericeae (Ass. nov.) **Type relevé: N1069**
Differential species: *Veronica telephiifolia, Alchemilla chlorosericea*

Rhinantho minoris- Trifolietalia pratensis **(Ord. nov.) Type relevé: N401**
Altitude: (1800)1850-2050-2200) m
Exposition: Never in East or Southwest exposition
Character species: *Rhinanthus minor*, *Trifolium pratense*, *Festuca pratensis*, *Sisymbrium sp.*, *Thlaspi sp.*

Polygono alpestris - Taraxacion campylodes / *Polygono alpestris - Taraxacetum campylodes* typicum (All. / Ass. nov.) **Type relevé: N4012**
Main altitude: 1850-2050 m
Character species: *Polygonum alpestre*, *Taraxacum campylodes*, *Hieracium sp., Scutellaria leptostegia*, *Fumaria schleicheri*, *Phleum phleoides*, *Scrophularia sp.*, *Scutellaria raddeana*, *Scutellaria raddeanus*, *Scutellaria sp., Silene lacera*, *Silene sp.*, *Silene wallichiana*, *Bunias orientalis*

Polygonum alpestre - Taraxacum campylodes variety **Type relevé: N4013**
Character species: *Phleum phleoides, Scrophularia sp., Scutellaria raddeana, Scutellaria sp., Silene lacera, Silene sp., Silene wallichiana, Bunias orientalis*
Differential species: *Polygonum alpestre, Taraxacum campylodes, Hieracium sp., Scutellaria leptostegia, Fumaria schleicheri*
Polygonum alpestre Taraxacum campylodes communities are found on wet gentle slopes, mostly within the range of the birch woodlands. Floristically, they are also connected with *Rhododendron* thickets.

Pedicularis chroorrhyncha - Tanacetum vulgare variety **Type relevé: N4004**
Character species: *Pedicularis chroorrhyncha, Cerastium arvense, Bupleurum polyphyllum, Euphrasia hirtella, Anthyllis variegata, Phleum phleoides*
Differential species: *Tanacetum vulgare*

Alpine pastures: *Sympoholomo graveolensis - Saxifragetea exarata*e (Class. nov.) (=PAA TWINSPAN) Type relevé: N2071
Altitude: 2800)2874-2920(3150) m Exposition: Mostly South
Character species: *Symphyoloma graveolens, Saxifraga exarata, Taraxacum porphyranthum*, *Minuartia aizoides*, *Silene marcowiczii*, *Minuartia inamoena, Poa alpina, Potentilla crantzii*

***Alchemillo sericeae - Anthemetea sosnovskayae / Alchemilla sericeea Anthemietumn sosnovskayae* typicum (Ord. / All. / Ass. nov.) (=MCC TWINSPAN) Type relevé: N2071**
Main altitude: 2880-2920m
Character species: *Alchemilla sericea*, *Anthemis sosnovskyana*, *Pedicularis chroorrhyncha*, *Myosotis alpestris*, *Campanula saxifraga*, *Minuartia inamoena*, *Crocus scharojanii*, *Taraxacum stevenii*, *Arenaria lychnidea*, *Minuartia oreina*, *Draba siliquosa*, *Veronica gentianoides*
Arenaria lychnidea Minuartia aizoides variety **Type relevé: N2050**
Character species: *Arenaria lychnidea*, *Minuartia aizoides*, *Pedicularis chroorrhyncha*, *Taraxacum stevenii*

Arenaria serpyllifolia Minuartietum inamoenae variety **Type relevé: N2066**
Character species: *Arenaria serpyllifolia*, *Minuartia inamoena*, *Taraxacum stevenii*, *Campanula collina*, *Minuartia oreina*

Campanula saxifraga - Minuartieta aizoides variety **Type relevé: N2073**
Main altitude: 2870-2920m
Character species: *Campanula saxifraga, Minuartia aizoides*

Conclusions

Ethnobotany

This study reported on 529 identified plant taxa from the subalpine and alpine regions of the Georgian Caucasus. Of these, based on our own data interviews as well as literature surveys, 183 were used in Georgia, mostly as fodder, food, and medicine. As many mountain regions all over the world, the rural areas of the Georgian Caucasus have suffered a constant population decline for decades, due to harsh economic conditions and lack of modern infrastructure. While this has especially accelerated the loss of traditional agricultural practices, it also has affected the use of wild gathered plants. It remains to be seen to what extent the border closures, and with them largely the cessation of cross border pasture use, will affect the use of traditional knowledge in the Georgian Caucasus in the future.

The process of genetic erosion of ancient crop varieties was originally of little concern for the mountain areas of Georgia, which until the 1990s acted as a depository of ancient crops. Nowadays the main reason for genetic erosion of ancient crop varieties is the demographic decline in mountain regions due to harsh economic conditions and lack of modern infrastructure (Nakhutsrishvili *et al.* 2009.The shift from ancient cultivars to modern high-yielding crops such as maize and potato, which took place in the lowland areas much earlier, began in mountain villages after the end of Soviet occupation, when local inhabitants who had been forced to the lowlands, returned to their original villages. However, many villages in high altitude Georgia were abandoned under pressure during Soviet occupation, and while some families have returned at least for the summer, many villages were completely abandoned in the 1980s and remain in ruins. In occupied villages old household utensils like butter barrels are often to be found in storage, but not used anymore. Small bridges are still made from wood, but many other wooden household items like beautiful bed-headboards are simply discarded. Some implements, e.g., snowshoes or brooms are still maintained. Agricultural tools such as hay rakes are a common sight in abandoned barns, but more sought afar items like ox-drawn threshing sledges could only be found in museums. While sheep were produced on a large scale during Soviet times, leading to widespread overgrazing, nowadays only a few scattered herds remain, and traditional wool items are getting more difficult to find, while tourist products abound along roadsides especially in the outskirts of Tbilisi and resort areas like Borjomi and Barisako. Sadly, we could not find any grain cultivation anywhere at higher altitudes, although old landraces of wheat and barley were formerly preferred to prepare bread and beer for religious rituals. Many abandoned terrasses indicate where grain was formerly grown but now these fallow fields were long overgrown. No grain has been grown in the region for decades and residents indicated that last time barley was cropped 30 years ago

Vegetation

The alpine vegetation of the Caucasus hotspot has fascinated botanists for centuries. Given the very complicated biogeographic setting, a concise classification of vegetation communities has however eluded science so far. All attempts to classify the alpine vegetation have suffered from the lack of sufficient releveés, given that many communities have been often described on very few, often only one, vegetation sample.

The present work, based on 619 plots, is the first study to attempt a concise phytosociological classification. However, even given this large number of samples a complete vegetation classification still proved difficult, and more releveés are needed for a detailed assessment. In the present study we employed traditional phytosociological table work combined with an analysis based on species composition, coverage and abiotic factors using "R", compared to a classification using "Twinspan". The results indicated that while Twinspan has been used for decades in phytosociology, the program failed to elucidate a detailed vegetation classification in the extremely diverse Caucasus ecosystem, albeit being useful for a coarse classification of higher vegetation units. This indicates that especially in very species rich communities a traditional classification is still preferable.

Declarations

Ethics statement: Prior to the survey, we obtained oral informed consent from each participant.
Consent to publish: This manuscript does not contain any personal data and does not require publishing permission.
Funding: The study was funded by the Saving Knowledge Foundation. The sponsor himself has no direct role in planning the research, collecting, and analyzing the data, or using the results.
Competition of interests: The authors state that they have no competing interests
Author contribution: GN and KB collected data and revised the first draft of the manuscript. RWB, IUR and REH analyzed and interpreted the data and results. RWB and IUR wrote the manuscript. RWB and MH revised the manuscript. All authors read and approved the final manuscript.

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