Pak. J. Bot., 45(4): 1123-1134, 2013.

CHARACTERISITS OF VEGETATION AND THE VERTICAL DISTRIBUTION PATTERNS ON THE NORTHERN SLOPE OF THE USUN MOUNTAINS, XINJIANG

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Abstract

Representative plant communities on the northern slope of the Usun Mountains, Xinjiang were selected for sampling and investigation. A total of 48 plots were established along the slope, ranging from 1,400 to 3,000m asl. The investigated vegetation communities covered all community types along the altitude gradient. Using TWINSPAN classification, GAM model diversity index fitting and comprehensive DCCA sorting analysis, the results showed that: (1) Plant genera and species were relatively diverse. *Rosaceae*, *Cruciferae*, *Leguminosae*, *Compositae*, *Poaceae* and *Labiatae* were relatively abundant, seed propagation was dominant. (2) Four vegetation vertical bands were classified from high to low elevation as sub-alpine meadow, coniferous forest, mountain steppe and desert steppe, respectively. (3) Total species richness, Simpson index, Shannon-Wiener diversity index and Pielou evenness index exhibited multiple peaks with the increase in elevation gradient, although only the last Pielou evenness index peak was very obvious. (4) The specific species diversity index pattern observed along the northern slope of the Usun Mountains was likely related to climate and soil nutrient status, and was specific for the Tianshan Mountains. (5) Under complex mountainous terrain, the differences in biotope conditions were very significant. The combination of elevation, slope, soil moisture, available phosphorus, available potassium and pH influenced and controlled the formation of community distribution patterns on the northern slope. This study revealed vegetation distribution patterns and their relationship with the environment on the northern slope of the Usun Mountains and provided important information for biodiversity conservation and the development.

Introduction

The distribution pattern of plant species diversity is the synthetic reflection of all kinds of ecological gradients and patterns of biodiversity along environmental gradients is one of the basic issues in biodiversity research (Kratochwil, 1999; Ghulam, 2012). Studies on the relationship between vegetation and the environment are important for the field of vegetation ecology (Noss, 1990; Atta, 2012). Different environmental factors on the earth surface significantly influence plant diversity and vegetation distribution (Zhou & Wang, 1999; Muhammad, 2012). Variation in elevation is accompanied by variation in temperature, humidity, light and other environmental factors, thus, it becomes an important aspect in species diversity gradient patterns (Whittaker *et al*., 2001; Tang *et al*., 2004; Qian *et al*., 2011). Changes in environmental factors along an altitudinal gradient occur a thousand times faster than along latitude (Walter, 1979) and therefore it has attracted greater research attention (Lomolino, 2001).The distribution of natural plant communities is the product of complex interactions between plants and the environment (Jiang, 1994). Therefore, it is important to quantify the inter-relationship between elevation, soil texture, nutrients and other environmental factors with community distribution.

Exploration of the relationship between mountain vegetation and the environment is a core issue of vegetation ecology and mountain ecology (Fang *et al*., 2004). Mountain vegetation studies often focus on the potential impact of climate warming on the distribution of alpine plants. A significant amount of work has also been done on the quantification of ecological factors closely related to vegetation distribution, such as radiation, temperature, moisture, topography, and has been applied to the landscape-mountain vegetation-environment relationships, vegetation mapping and key species distribution simulation (Pfeffer *et al*., 2003). It would be more meaningful, however, to explore the relationship between environmental factors (such as soil and terrain) and vegetation and its composition. With a concentrated environment gradient and highly heterogeneous habitats, mountains have always been a refuge for a large number of species and a historic geological cradle for the differentiation and reproduction of emerging flora. Mountains develop and conserve high biological diversity, functioning as a germplasm bank for species survival, reproduction and preservation. Mountains also maintain more complete vegetation vertical bands than do plains (He, 2006). Therefore, studies on the relationships between vertical patterns of mountain vegetation and the environment have important implications for understanding the formation and evolution of natural mountain vegetation and biological diversity.

The vertical structure of the mountain vegetation is complete. Western Tianshan Mountains is the only key biodiversity conservation area of global significance in Xinjiang (Fan *et al*., 2008). Usun Mountain is part of Western Tianshan Mountains. Special geographical location, topographical features and the resulting diverse vegetation makes Usun Mountains an ideal place to study the relationship between vegetation and the environment. In the present paper, attempt is made to elucidate the characteristics of plant species diversity, as well as the relationship between it and environmental factors by analyzing (1) the variation in diversity indices of the different community types, (2) the main factors affecting the spatial patterns of species diversity, (3) the variation in species diversity along an elevational gradient, and (4) the relationship of plant communities and environment.

This study not only provides important scientific evidence for the protection and utilization of vegetation and plant resources, but also deepens scientific theory about mountainous vegetation and environmental correlations on both sides of the valley, and provides a reference case and basic data for the restoration of degenerated mountain vegetation.

Materials and Methods

Natural overview of study area: The north slope of the Usun Mountains was selected as the study site. It has an elevation of 2,000 – 3,500 m and forms the boundary between Qapqal and Turks counties. Geographical coordinates are latitude N43°23' ~ 44°31' and longitude E81°01' ~ 82°09'. The west side of the mountain has complex terrain changing from low mountains and hills with an elevation of 1,100 m to high mountains with an elevation of 3,000 m. The study area belongs to a semi-arid region. The terrain is high in the east and low in the west. With the high mountain barrier north of the valley and the warm and humid air driving in from the west, extreme cold conditions are rare. Monthly precipitation is highest from April to July, decreases from October to December and is lowest from August to September and January to February. Precipitation on the west side of Tianshan Mountain is higher than on the east side. The monthly average temperature is highest in summer; temperatures on the east and west are roughly the same. Annual average rainfall is 248 mm and annual average temperature of 8.16°C (Zhang *et al*., 2009).

Sampling plot set: In July 2009, representative plant communities (600,000m^2) located on the northern slope of the Usun Mountains were selected for surveying and sampling (Fig. 1). Survey scope was from the top of the mountain to the front, and a total of 48 plots (100 × 100 m) were established on the northern slope of the Usun mountains, between 1,400–3,000 m. One tree quadrat (20 × 20 m), one shrub quadrat (10 × 10 m) and three herb quadrats (1 × 1 m) were randomly set in each plot(Ma *et al*., 1995; Xu *et al.*, 2011).

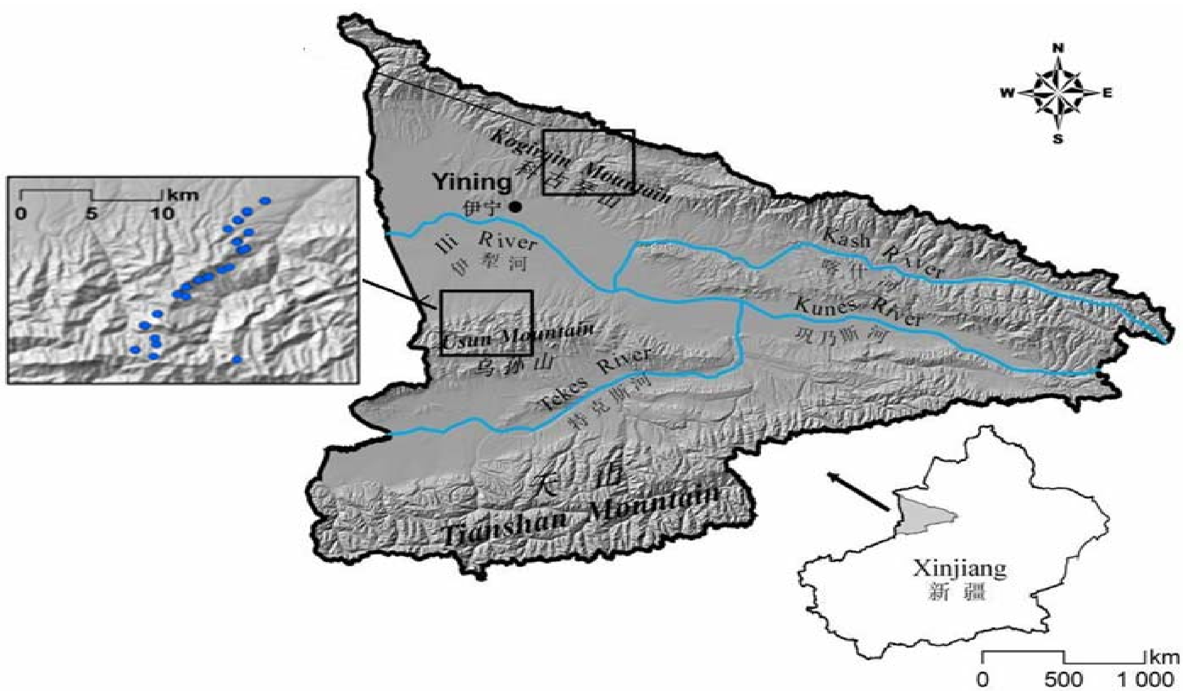

Fig. 1. Set samples of plant community on the northern slope of the Usun Mountains.

Data collection: Trees, shrubs and herbs were investigated in each quadrat, and included abundance, height, crown and cover of trees and shrubs, and height and cover of herbs. Fourteen non-biological inorganic environmental factors were recorded and measured in each sampling plots, which included (1) topographic factors, such as elevation (ELEV), slope (SLOP), and aspect (ASP); (2) geographical factors, such as longitude (LONG) and latitude (LAT); and (3) soil factors, such as soil moisture (SM), organic matter (SOM), available nitrogen (AN), available phosphorus (AP), available potassium (AK), pH value (PH), electricity conductivity (EC), total salt (TS) and general salt (GS).

Soil sampling method: The geographic location and the elevation of each sample plot were recorded using GPS, and the slope gradient and slope aspect were measured using a compass. Three points were randomly selected in each sampling plot and soil samples were collected (0 – 20 cm) and taken back to the laboratory, evenly mixed and air-dried for analysis. Soil moisture was determined by way of drying, soil organic matter was determined by $K_2Cr_2O_7$-H_2SO_4 oxidation method of Walkley-Black, available N was determined by diffuse, available P was determined by Bray-P, available K was determined by NH_4-acetate, and pH was determined by a potentiometer. Electricity conductivity was measured using a DDS-307 conductivity meter. Total salt content was determined by dry residue method and general salt content was calculated by the standard curve method (Anon., 1983).

Species identification and naming were based on the Flora of China, China's higher plant, Flora of Xinjiang and other literature (Wu *et al*., 2007). As the effects of latitude and longitude on vegetation distribution in plots were not obvious, they were excluded of analysis.

Data processing and analysis

Quantification of environmental factors: Slope values were measured between 0–90°; the slope direction was represented as transformation of aspect(TRASP) index, the value of which ranges from 0 to 1 and was converted from azimuth (TRASP index 1 represents 30° south by west, 0 represents 30° north by east.). The greater the TRASP index, the more sunny the slope, otherwise, the more shady. TRASP index were calculated as follow(Liu *et al*., 2005):

$$TRASP = \frac{1-\cos[\pi(aspect-30)/180]}{2} \quad (1)$$

TRASP represents slope index, aspect represents slope direction angle.

Calculation of species importance value: Density (D), frequency (F), cover (C), relative abundance (RA), relative frequency (RF), relative coverage (RC) and other basic information for each species were calculated, used them to calculate importance value. Importance values were calculated hierarchically for the tree layer, shrub layer and herb layer; digitals were accurate to at least the forth decimal place. Tree quadrats had an area of 400 m^2 and shrub quadrats 100 m^2. Three small herb quadrats were sampled in each large quadrat. Importance values of plants within each herb quadrat were calculated and averaged. The importance values of the same species within the three small quadrats were then combined and deemed the herb importance value of the large quadrats (Ma *et al*., 1995).

To accurately reflect the growth and distribution of the trees, shrubs and herbs, the importance values (IV) of the species were calculated as follows (Zhang *et al*., 2006):

Trees, shrubs importance value (%) = (relative abundance + relative height + relative coverage) / 3

Herbal importance value (%) = (relative height + relative coverage) / 2

Calculation of species diversity: (1) Species richness S: refers to the number of species included in survey place.

(2) Simpson index: $\lambda = 1-\Sigma P_i^2$
(3) Shannon-Wiener index: $H' = -\Sigma P_i \quad P_i$
(4) Pielou evenness index: $E_p = (-\Sigma P_i \quad P_i)/ \quad S$

Pi is the relative importance value of species i, and S is the total number of species i in the quadrat. These indicators are widely applied for studies of species diversity. Because body size of individuals in communities differed greatly, diversity calculated by the number of certain plant species does not well reflect community diversity. Therefore, importance values were used instead of plant number to calculate plant species diversity (Ma *et al*., 1995).

Quantitative analysis

Community classification: The plots and species were first divided into two categories (0 and 1) and each category was then further divided into another two categories, and so on, until it reached the required classification level (Hill & Šmilauer, 2005). Analysis was done by WinTWINS Version 2.3 software. The default cut levels (0, 2, 5, 10 and 20) was used in TWINSPAN, and default options were also used in the division procedure, the species of the degree of clustering more than 1.1 as indicator species (Hill & Šmilauer, 2005; Zhang & Dong, 2010).

Mountain vertical pattern: The distribution pattern of species diversity index with elevation was obtained by GAM model fit using the MGCV package program of R software (Anon., 2011). The GAM model is a semi-parametric expansion of a generalized linear model, assuming that the function can be added and the composition of the function is smooth and establishes the relationship between the mathematical expectation of the response and predictor variables through connecting the functions. When the response variable follows binomial distribution, the general formula of the generalized additive model is:

$$G\{E(Y)\} = b_0+f_1(X_1)+\ldots\ldots+f_m(X_m) \quad (2)$$

where, E(Y) is the expected value; G{} is the contact function; b_0 is the intercept; and $f_1 \ldots f_m$ are smooth functions of environment variable X [smooth function is generally estimated by the cubic spline function (Cawsey *et al*., 2002)]. In this GAM model, species diversity index was the dependent variable and elevation was the independent variable. Terrain factors such as aspect and slope generally affects species diversity on the landscape scale, and less obviously on the regional scale (Whittaker *et al.*, 2001). Consequently, elevation is the main factor to be considered, which affects species diversity index, nutrients and salt content.

Order of relationship of species distribution and environment: In the present study, detrended canonical correspondence analysis (DCCA) was performed by CANOCO Version 4.5 analysis software and CANODRAW Version 4.0 mapping software (ter Braak, 1997). The data of environmental variables were square-root transformed in the analysis. The significance of the resulting ordination was evaluated by 499 Monte Carlo permutations. 47 of the 214 species unable to participate detrended canonical correspondence, because of its importance value was <5% (Petr, 2009).

Results

Mountain vegetation composition and TWINSPAN classification on the northern slope of the Usun Mountains

Mountain vegetation composition: This research recorded a total of 214 plants species belonging to 36 families and 121 genera in 48 sampling plots (Table 1). *Rosaceae*, *Cruciferae*, *Leguminosae*, *Compositae*, *Poaceae* and *Labiatae* were relatively abundant, as were single numbers of genera and species, with simple family and genus structure. Species distribution with elevation was obvious, with only one relatively tall tree, *Picea schrenkiana*, appearing in the sample plots within 2,600–2,800 m elevation, while small trees, shrubs, half-shrubs and herbs were found from 1,800–3000 m, and herbaceous plants were dominant from 1,400–1,800 m. According to *Flora of China*, *China's higher plant* and *Flora of Xinjiang*, only 14 woody plants existed among the 214 species. Conversely, herbs accounted the other species. Plant reproduction was mainly from seeds, accounting for 94.86% of total species found.

TWINSPAN classification of mountain vegetation: According to the vegetation importance value of each of the 48 sampling plots, communities were divided into eight groups using TWINSPAN classification (Fig. 2 and Table 2). The main features are as follows:

Group I: *Carex stenocarpa* + *Thalictrum alpinum*+ *Primula nivalis*, including plots P1–P3, between 2,900–3,000 m, shady plots, slope 4–22°, relatively high soil moisture. *C. stenocarpa* was the constructive species, while *P. nivalis* and *T. alpinum* were the dominant species, mainly associated with *A. tianschanica*, *V. rupestris*, *T. goloskokovii* and *P. argentea*.

Group II: *Picea schrenkiana*– *C. stenocarpa* + *Kobresia capillifolia*, including plots P4 – P9, between 2,600 – 2,900 m, sunny aspect, but P8 was especially shady, slope 28–40°. The soil moisture was relatively high in P4 plot, soil moisture of other plots was in the average level. There were more woody plants, associated with herbs. *Picea schrenkiana*, was the constructive species, while *C. stenocarpa* and *K. capillifolia* were dominant species, mainly associated with *S. hypericifolia*, *P. parvifolia*, *Festuca* spp., *C. melanantha* and *P. alpina*.

Group III: *Rosa albertii* + *S. hypericifolia* - *Phleum alpinum* + *Poa nemoralis*, including plots P10–P15, between 2,400–2,600 m, sunny aspect, but P13–P14 were especially shady, with slope of 25–46°, and relatively high soil moisture. Shrubs were the constructive species in six plots, mainly associated with herbs; *R. albertii* was a constructive species, while *S. hypericifolia*, *P. alpinum* and *P. nemoralis* were dominant species, mainly associated *C. roborowskii*, *M. suaveolens*, *A. alpestre*, *P. hydropiper*, *A. adsurgens* and *G.. boreale*.

Group IV: *Spiraea hypericifolia* + *Rosa platyacantha* - *Galium verum* + *Phlomis pratensis*, including plots P16–P18, between 2,300–2,400 m, and P40 appeared at 1,632 m. Aspect was relatively sunny, but P40 was relatively shady, slope was between 14–45°, with relatively high soil moisture. Shrubs were constructive species of vegetation at four plots, mainly associated with herbs. *Spiraea hypericifolia* was the constructive species, while *R. platyacantha*, *G. verum* and *P. pratensis* were the dominant species mainly associated with *Lonicera hispida*, *Geranium pratense*, *P. nemoralis* and *Bothriochloa ischaemum*.

Group V: *Spiraea hypericifolia* + *R. albertii* - + *G. boreale* + *Phleum phleoides*, including plots P19–P21, between 2,200–2,300 m, and plots P31–P34, between 1,800–1,900 m. Aspects were relatively shady, slopes were between 26–34°, P21 had relatively high soil moisture, while soil moisture in other plots was lower. *Spiraea hypericifolia* was the constructive species in seven plots, while *R. albertii*, *G. boreale* and *P. phleoides* were dominant species mainly associated with *L. hispida*, *Eremostachys fulgens*, *Dactylis glomerata*, *Potentilla chrysantha*, *Aegopodium podagraria* and *Lamium album*.

Group VI: *R. platyacantha* + *S. hypericifolia* - *Dracocephalum nutans* + *P. chrysantha*, including plots P22–P25 and P28–P30, was between 1,800–2,200 m. Plots P22–P25 were relatively sunny, and plots P28–P30 were relatively shady, slope was between 10–36°, soil moisture was relatively low. *R. platyacantha* was the constructive species in seven plots, while *S. hypericifolia*, *D. nutans* and *P. chrysantha* were the dominant species, mainly associated with *R. albertii*, *C. roborowskii*, *G. verum*, *Potentilla bifurca* and *Artemisia rutifolia*.

Group VII: *Rosa platyacantha* + *S. hypericifolia*– *Festuca* spp. + *Carex liparocarpos*, including plots P26 and P27 between 2,000–2,100 m, and plots P35–P38 between 1,800–1,700 m. Plot P26 was relatively sunny, the other plots were neither shady nor sunny, slope was between 14–31°, and the soil moisture of this group was the lowest. *Rosa platyacantha* was the constructive species in six plots, while *S. hypericifolia*, *Festuca* spp. and *C. liparocarpos* were the dominant species, mainly associated with *Cerasus tianshanica*, *Polygonum acetosum*, *G. verum*, *P. bifurca* and *A. rutifolia*.

Group VIII: *Carex turkestanica* + *Festuca* spp. + *Alyssum desertorum*, including plots P39 and P41 – P48 between 1,400 – 1,700 m. Plot P42 was relatively sunny, with a slope of 21°, while the other plots were relatively shady, with lower slopes between 1 – 14° and lower soil moisture. The communities in the nine plots were shrub communities below sea level. The constructive species was *C. turkestanica*, while *Festuca* spp. and *A. desertorum* were the dominant species, mainly associated with *Elymus dahuricus*, *Thymus altaicus*, *A. rutifolia* and *Polygonum aviculare*.

Table 1. Codes and Latin name of 214 species present in 48 plots in the northern slopes of the Usun mountains.

Nº	Latin name	Family	Nº	Latin name	Family
1	*Picea schrenkiana* Fisch. et Mey	Pinaceae	108	*Rumex crispus* L.	Polygonaceae
2	*Subgen sabina* L.	Cupressaceae	109	*Lathyrus pratensis* L.	Leguminosae
3	*Spiraea hypericifolia* L.	Roseaceae	110	*Vicia villosa* Roth.	Leguminosae
4	*Potentilla parvifolia* Fisch.	Roseaceae	111	*Fragaria vesca* L.	Roseaceae
5	*Caragana jubata* (Pall.) Poir.	Leguminosae	112	*Bothriochloa ischaemum* (L.) Keng	Gramineae
6	*Rosa albertii* Rgl.	Roseaceae	113	*Hypericum subalatum* Hayata	Clusiaceae
7	*Cotoneaster multiflorus* Bge.	Roseaceae	114	*Artemisia sacrorum* Ledeb.	Compositae
8	*Rosa platyacantha* Schrenk	Roseaceae	115	*Thalictrum minus* L.	Ranunculaceae
9	*Lonicera hispida* Pall. Ex Roem. Et Schult.	Caprifoliaceae	116	*Poa relaxa* Ovcz.	Gramineae
10	*Euonymus semenovii* Regel. et Herd.	Celastraceae	117	*Astragalus alpinus* L.	Leguminosae
11	*Cerasus tianschanica* Pojark.	Roseaceae	118	*Eremurus altaicus* (Pall.) Stev.	Liliaceae
12	*Berberis nummularia* Bge.	Berberidaceae	119	*Krasnovia longiloba* (Kar. et Kir.) M. Pop.	Umbelliferae
13	*Salix taraikensis* Kimura	Salicaceae	120	*Mentha asiatica* Boriss.	Lamiaceae
14	*Primula nivalis* Pall.	Primulaceae	121	*Linaria bungei* Kuprian.	Scrophulariceae
15	*Pedicularis cheilanthifolia* Schrenk	Scrophulariceae	122	*Corydalis adiantifolia* Hook. f. et Thoms.	Papaveraceae
16	*Androsace delavayi* Franch.	Roseaceae	123	*Ziziphora clinopodioides* Lam.	Lamiaceae
17	*Potentilla gelida* C.A. Mey. Ind. Plant.	Cruciferae	124	*Bromus inermis* Leyss.	Gramineae
18	*Carex stenocarpa* Turcz. Ex V. Krecz.	Cyperaceae	125	*Berula erecta* (Huds.) Cov.	Umbelliferae
19	*Vida biflora* L.	Violaceae	126	*Aquilegia atrovinosa* M. Pop. ex Gamajun	Ranunculaceae
20	*Thalictrum alpinum* L.	Ranunculaceae	127	*Aegopodium podagraria* L.	Umbelliferae
21	*Geranium strigellum* R. Knuth	Geraniaceae	128	*Geranium transversale* (Kar. et Kir.) Vved.	Geraniaceae
22	*Schultzia albiflora* (Kar. et Kir.) M. Pop. Fl. Almaat. Gos. Zapovedn.	Umbelliferae	129	*Dactylis glomerata* L.	Gramineae
23	*Poa alpina* L.	Gramineae	130	*Lathyrus humilis* (Ser. ex DC.) Spreng.	Leguminosae
24	*Alchemilla tianschanica* Juz.	Gramineae	131	*Phleum phleoides* (L.) Karst.	Gramineae
25	*Viola rupestris* F. W. Schmidt	Violaceae	132	*Pedicularis oederi* Vahl.	Scrophulariceae
26	*Tulipa heterophylla* (Regel) Baker	Liliaceae	133	*Polygonum viviparum* L.	Polygonaceae
27	*Viola altaica* Ker-Gawl.	Violaceae	134	*Trollius dschungaricus* Regel	Ranunculaceae
28	*Kobresia capillifolia* (Decne.) C.B. Clarke	Compositae	135	*Euphorbia buchtormensis* Meyer ex Ledeb.	Euphorbiaceaec
29	*Taraxacum goloskokovii* Schischk.	Compositae	136	*Melilotus suaveclens* Ledeb	Leguminosae
30	*Potentilla argentea* L.	Cruciferae	137	*Potentilla recta* L.	Roseaceae
31	*Oxytropis saposhnikovii* Kryl.	Leguminosae	138	*Potentilla chrysantha* Trev	Roseaceae
32	*Carex melanantha* C.A. Mey.	Cyperaceae	139	*Rhodiola rosea* L.	Crassulaceae
33	*Allium atrosanguineum* Schrenk	Liliaceae	140	*Artemisia gmelinii* Web. ex Stechm. Artem.	Compositae
34	*Stellaria decumbens* Edgew.	Caryophyliaceae	141	*Turritis glabra* L.	Cruciferae
35	*Polygonum bistorta* L.	Polygonaceae	142	*Rumex acetosa* L.	Polygonaceae
36	*Cortusa matthioli* L.	Primulaceae	143	*Festuca ovina* L.	Gramineae
37	*Plantago minuta* Pall.	Plantaginaceae	144	*Artemisia rutifolia* Steph. ex Spreng	Compositae
38	*Phlomis alpina* Pall.	Lamiaceae	145	*Carex liparocarpos* Gaudin	Cyperaceae
39	*Sanguisorba alpina* Bge.	Roseaceae	146	*Dracocephalum bipinnatum* Rupr.	Lamiaceae
40	*Cardamine trifoliolata* Hook. f. et Thoms.	Cruciferae	147	*Oxytropis floribunda* (Pall.) DC.	Leguminosae
41	*Papaver nudicaule* L.	Papaveraceae	148	*Deyeuxia langsdorffii* (Link) Kunth	Gramineae
42	*Tulipa dasystemon* (Regel.) Regel.	Liliaceae	149	*Alyssum desertorum* Stapf.	Cruciferae
43	*Myosotis Suaveolens* W.et K.	Boraginaceae	150	*Alyssum dasycarpum* Steph. ex Willd.	Cruciferae
44	*Silence wallichiana* Klotzsch	Caryophyliaceae	151	*Euphorbia lingiana* Shih	Euphorbiaceaec
45	*Veronica tenuissima* Boiss.	Scrophulariceae	152	*Medicago falcata* L.	Leguminosae
46	*Euphorbia pachyrrhiza* Kar. et Kir.	Euphorbiaceaec	153	*Rosularia platyphylla* (Schrenk) Berger	Crassulaceae
47	*Cirsium alberti* Rgl.	Compositae	154	*Orostachys spinosus* (L.) C.A. Mey.	Crassulaceae
48	*Gypsophila cephalotes* (Schrenk) Williams	Caryophyliaceae	155	*Leontopodium leontopodioides* (Willd.) Beauv.	Compositae
49	*Cerastium tianschanicum* Schischk.	Caryophyliaceae	156	*Allium petraeum* Kar.et Kir.	Liliaceae
50	*Lloydia serotina* (L.) Rchb.	Liliaceae	157	*Polygonum acetosum* M.B.	Polygonaceae
51	*Lagotis integra* W. W. Smith	Scrophulariceae	158	*Scutellaria przewalskii* Juz.	Lamiaceae
52	*Aegopodium alpestre* Ledeb.	Umbelliferae	159	*Elymus dahuricus* tarcz.ex Griseb	Gramineae
53	*Thymus altaicus* Klok. Et Shost.	Lamiaceae	160	*Artemisia dracunculus* L.	Compositae

Table 1. (Cont'd.).

Nº	Latin name	Family	Nº	Latin name	Family
54	*Astragalus lepsensis* Bge.	Leguminosae	161	*Cicuta virosa* L.	Umbelliferae
55	*Iris ruthenica* Ker-Gawl.	Iridaceae	162	*Paeonia anomala* L.	Ranunculaceae
56	*Leonto pusillum* (Beauv.) Hand. -Mazz.	Compositae	163	*Poa pratensis* L.	Gramineae
57	*Codonopsis clematidea* (Schrenk) C. B. Cl.	Campanulaceae	164	*Ferula songorica* Pall. Ex Spreng.	Umbelliferae
58	*Cirsium tenuifolium* Shih	Compositae	165	*Lappula echinata* Gilib	Boraginaceae
59	*Galium verum* L.	Rubiaceae	166	*Artemisia leucophylla* (Turcz.ex Bess.) C.B. Clarke	Compositae
60	*Draba nemorosa* L.	Cruciferae	167	*Calystegia hederacea* Wall.	Convolvulaceae
61	*Achillea millefolium* L.	Compositae	168	*Hypericum perforatum* L.	Clusiaceae
62	*Dracocephalum nutans* L.	Lamiaceae	169	*Lonicera heterophylla* Decne.	Caprifoliaceae
63	*Trachydium tianschanicum* Korov	Umbelliferae	170	*Poa florida* N. R. Cui	Gramineae
64	*Paraquilegia anemonoides* (Willd.)	Ranunculaceae	171	*Leonurus artemisia* (Laur.) S. Y. Hu	Lamiaceae
65	*Dracocephalum grandiflorum* L.	Lamiaceae	172	*Erysimum cheiranthoides* L.	Cruciferae
66	*Geranium pratense* L.	Geraniaceae	173	*Seriphidium transiliense* (Poljak.) Poljak.	Compositae
67	*Iris loczyi* Kanitz	Iridaceae	174	*Cardaria draba* (L.) Desv.	Cruciferae
68	*Myosotis sparsiflora* Mikan	Boraginaceae	175	*Silene wolgensis* (Hornemann) Otth	Caryophyliaceae
69	*Phleum alpinum* L.	Gramineae	176	*Geum aleppicum* Jac.	Roseaceae
70	*Festuca rubra* L.	Gramineae	177	*Ranunculus japonicus* Thunb.	Ranunculaceae
71	*Polygonum hydropiper* L.	Polygonaceae	178	*Viola acutifolia* (Kar. et Kir.) W. Beck.	Violaceae
72	*Campanula albertii* Trautv.	Campanulaceae	179	*Iris songarica* Schrenk	Iridaceae
73	*Poa nemoralis* L.	Gramineae	180	*Fragaria vesca* L.	Roseaceae
74	*Taraxacum kok-saghyz* Rodin	Compositae	181	*Thalictrum isopyroides* C. A. Mey.	Ranunculaceae
75	*Astragalus adsurgens* Pall.	Leguminosae	182	*Tragopogon orientalis* L.	Compositae
76	*Sedum hybridum* L.	Crassulaceae	183	*Poa angustifolia* L.	Gramineae
77	*Stellaria media* (L.)Vill.	Caryophyliaceae	184	*Campanula medium* L.	Campanulaceae
78	*Galium boreale* L.	Rubiaceae	185	*Phlomis oreophila* Kar. et Kir.	Lamiaceae
79	*Lathynls tuberosus* L.	Leguminosae	186	*Polygala hybrida* DC	Polygalaceae
80	*Draba stylaris* Gay ex E.Thoms.	Cruciferae	187	*Trifolium lupinaster* L.	Leguminosae
81	*Thymus disjunctus* Klokov	Lamiaceae	188	*Viola selkirkii* Pursh ex Gold	Violaceae
82	*Origanum vulgare* L.	Lamiaceae	189	*Lathyrus odoratus* L.	Leguminosae
83	*Rheum wittrockii* Lundstr.	Polygonaceae	190	*Viola collina* Bcss	Violaceae
84	*Thalictrum minus* L.	Ranunculaceae	191	*Pachypleurum alpinum* Ledeb.	Umbelliferae
85	*Potentilla multifida* L.	Roseaceae	192	*Phlomis umbrosa* Turcz.	Lamiaceae
86	*Potentilla evestita* Wolf	Roseaceae	193	*Hieracium krameri* Fr. Et Sav.	Compositae
87	*Potentilla bifurca* L.	Cruciferae	194	*Astragalus lithophilus* Kar. et Kir.	Leguminosae
88	*Valeriana dubia* Bge.	Valerianaceae	195	*Festuca arioides* Lam.	Gramineae
89	*Cerastium falcatum* Bge.	Caryophyliaceae	196	*Acorus calamus* L.	Acoraceae
90	*Nonea caspica (*Willd.) G.	Boraginaceae	197	*Neopallasia pectinata* (Pall.) Poljak.	Compositae
91	*Pedicularis anas* Maxim.	Scrophulariceae	198	*Iris scariosa* Willd. ex Link.	Iridaceae
92	*Eremostachys fulgens* Bunge.	Lamiaceae	199	*Carex turkestanica* Regel	Cyperaceae
93	*Lamium album* L.	Lamiaceae	200	*Achnatherum splendens* (Trin.) Nevski	Gramineae
94	*Thlaspi arvense* L.	Cruciferae	201	*Astragalus membranaceus* (Fisch.)	Leguminosae
95	*Geranium albiflorum* Ledeb.	Geraniaceae	202	*Stipa capillata* L.	Gramineae
96	*Poa altaica* Trin	Gramineae	203	*Galium odoratum* (L.) Scop.	Leguminosae
97	*Thalictrum aquilegifolium* L. var. sibiricum Regel	Ranunculaceae	204	*Erigeron anuranticus* Rgl.	Compositae
98	*Taraxacum bicorne* Dahlst.	Compositae	205	*Chenopodium glaucum* L.	Chenopodiaceae
99	*Phlomis pratensis* Kar.et Kir.	Lamiaceae	206	*Taraxacum lipskyi* Schischk.	Compositae
100	*Polygonum aviculare* L.	Polygonaceae	207	*Trifolium pratense* L.	Leguminosae
101	*Plantago depressa* Willd.	Plantaginaceae	208	*Suaeda linifolia* Pall.	Chenopodiaceae
102	*Cirsium esculentum* (Sievers) C. A. Mey.	Compositae	209	*Seriphidium kaschgaricum* (Krasch.) Poljak.	Compositae
103	*Rhinanthus glaber* Lam.	Scrophulariceae	210	*Myosotis suaveolens* W.et K.	Boraginaceae
104	*Verbascum phoeniceum* L.	Scrophulariceae	211	*Convolvulus arvensis* L.	Convolvulaceae
105	*Corydalis edulis* Maxim.	Papaveraceae	212	*Medicago sativa* L.	Leguminosae
106	*Allium chrysanthum* Regel	Liliaceae	213	*Bromus japonicus* Thunb.	Gramineae
107	*Delphinium iliense* Huth	Ranunculaceae	214	*Seriphidium rhodanthum* (Rupr.) Poijak.	Compositae

Table 2. Environmental variables of 8 groups by TWINSPAN in the study area.

Group	Plot	ELEV (m)	SLOP (°)	ASP	SM (%)	OM g/kg	AN (mg/kg)	AP (mg/kg)	AK (mg/kg)	pH	COND (ms/cm)	TS (g/kg)	GS (g/kg)
I	P1-3	3000-2900	15.67 ± 7.33	0.19 ± 0.11	77.03 ± 9.44	148.74 ± 28.28	60.98 ± 2.98	5.00 ± 0.81	214.67 ± 121.67	7.63 ± 0.39	0.13 ± 0.01	0.85 ± 0.01	0.84 ± 0.01
II	P4-9	2900-2600	32.5 ± 4.50	0.61 ± 0.07	47.48 ± 18.04	95.93 ± 6.06	75.28 ± 56.12	10.11 ± 5.71	143.50 ± 57.50	7.57 ± 0.38	0.22 ± 0.13	1.27 ± 0.58	1.25 ± 0.60
III	P10-15	2600-2400	33.00 ± 13.00	0.38 ± 0.02	33.13 ± 25.04	104.44 ± 54.79	62.67 ± 30.47	19.56 ± 14.66	129.17 ± 57.17	7.44 ± 0.10	0.18 ± 0.08	1.11 ± 0.41	1.08 ± 0.38
IV	P16-18	2400-2300	36.00 ± 9.00	0.81 ± 0.13	44.42 ± 6.93	102.45 ± 97.11	114.99 ± 25.00	33.73 ± 0.48	229.33 ± 64.33	7.82 ± 0.25	0.31 ± 0.01	1.72 ± 0.10	1.66 ± 0.07
V	P19-21 P31-34	2300-1800	30.57 ± 3.43	0.04 ± 0.01	38.21 ± 5.66	129.71 ± 33.05	56.80 ± 15.79	11.58 ± 6.16	142.14 ± 61.14	7.43 ± 0.47	0.17 ± 0.06	1.06 ± 0.25	1.03 ± 0.27
VI	P22-25 P28-30	2200-1800	25.29 ± 10.71	0.54 ± 0.41	15.58 ± 0.93	109.62 ± 19.75	53.03 ± 9.44	29.41 ± 22.79	346.57 ± 146.57	7.67 ± 0.58	0.21 ± 0.05	1.21 ± 0.21	1.18 ± 0.23
VII	P26-27 P35-38	2100-1700	21.67 ± 9.33	0.46 ± 0.40	8.16 ± 0.34	73.45 ± 16.41	41.76 ± 6.77	23.55 ± 9.94	333.67 ± 208.67	7.75 ± 0.19	0.15 ± 10.05	0.97 ± 0.22	0.96 ± 0.21
VIII	P39-48	1700-1400	7.50 ± 6.50	0.28 ± 0.19	13.57 ± 5.86	77.38±20.36	34.77 ± 17.19	18.75 ± 4.86	470.40 ± 29.60	7.67 ± 0.40	0.14 ± 0.02	0.89 ± 0.12	0.87 ± 0.11

S: General salt

The mountain pattern of diversity indexes: As shown in Fig. 3, total species richness, the Simpson index, the Shannon-Wiener diversity index and the Pielou evenness index demonstrated multiple peaks with elevation, although the first two Pielou evenness index peaks were not obvious and the last peak was.

The desert steppe zone was located at an elevation below 1,700 m and included only herbaceous plants, such as *C. turkestanica*. The plots were relatively shady, with gentle slopes between 1 – 14°, and soil moisture was relatively low. All community diversity indexes were low. The mountain steppe zone was located between 1,700 – 2,600 m, where shrubs such as *R. albertii*, *S. hypericifolia*, were widely distributed. Herbs were dominant and included *G. boreale*, and so on. The plots were both sunny and shady. Slopes were relatively steep, between 10 – 45°, and soil moisture was relatively low. Total species richness, the Simpson index and the Shannon-Wiener diversity index reached a peak value at 1,800 m, which was the transition line from desert to mountain steppe. When elevation increased, these indexes started to decrease. All indexes decreased to a lowest point at 2,100 m, increased to form a small peak at 2,500 m, and finally decreased again to another low point at 2,600 m. The coniferous forest zone was between 2,600 – 2,900 m and consisted of relatively more woody plants associated with herbs. *Picea schrenkiana* was the constructive species, while *C. stenocarpa* was dominant species, mainly associated with *S. hypericifolia*, and so on. The aspect was sunny, the slope was 28 – 40° and water moisture was in the average level. Woody plants were dominant. Within the scope, every diversity index reached to a peak value. Above 2,900 m was sub-alpine meadow zone. *C.. stenocarpa* was the constructive species, while *Thalictrum alpinum* was dominant species. The total species richness, the Simpson index, the Shannon-Wiener diversity index and Pielou's evenness index showed a downward trend.

Relationship of vegetation and environmental factors: As shown in Table 3, the eigenvalue sum of axis 1 and axis 2 accounted for 10.5% of the sum of total eigenvalues (9.403), which explains 10.5% of the information about species and their distribution. From the cumulative percentage variance of the species–environment relationship, axis 1 and axis 2 explain 27.8% and 36.4% , respectively, and the correlation between axis 1 and axis 2 is minor, only -0.061.

From the eigenvalues (Table 4, Fig. 4), elevation was negatively correlated with the first axis ($p<0.01$), while soil water moisture, available K and slope exhibited very significant positive correlation with the first axis ($p<0.05$). Along with the data increase of the first axis, elevation, slope, aspect, soil moisture, electrical conductivity, organic matter, available N, total salt and general salt decreased significantly (showing negative correlation), while available P, K and pH increased significantly (showing positive correlation). The second axis showed very significant negative correlation with available P ($p<0.01$) and significant positive correlation with available K and pH ($p<0.05$). The correlations of available N and P with the first axis and organic matter, total salt, and general salt with the second axis were not significant, the correlation coefficients were relatively lower.

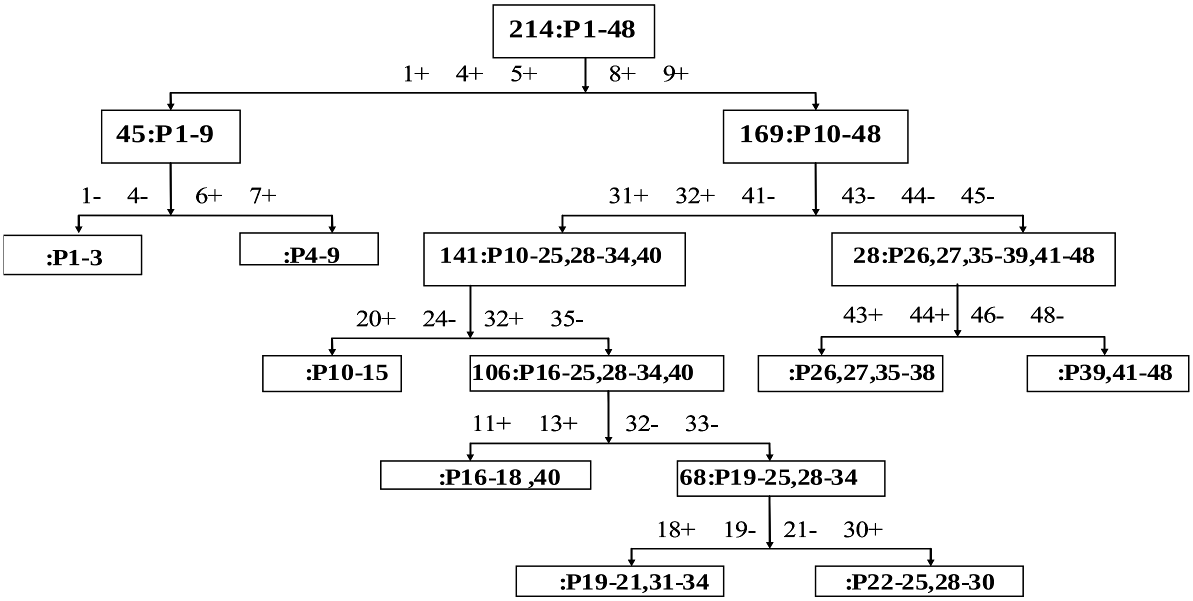

Fig. 2. Schematic diagram of plant community classification on the northern slopes of the UsunMountains. 1 - 214: nº species; P: plot (1 - 48); I - VII: groups formed. "+" represented plus indicator species; "-" represented negative indicator species.

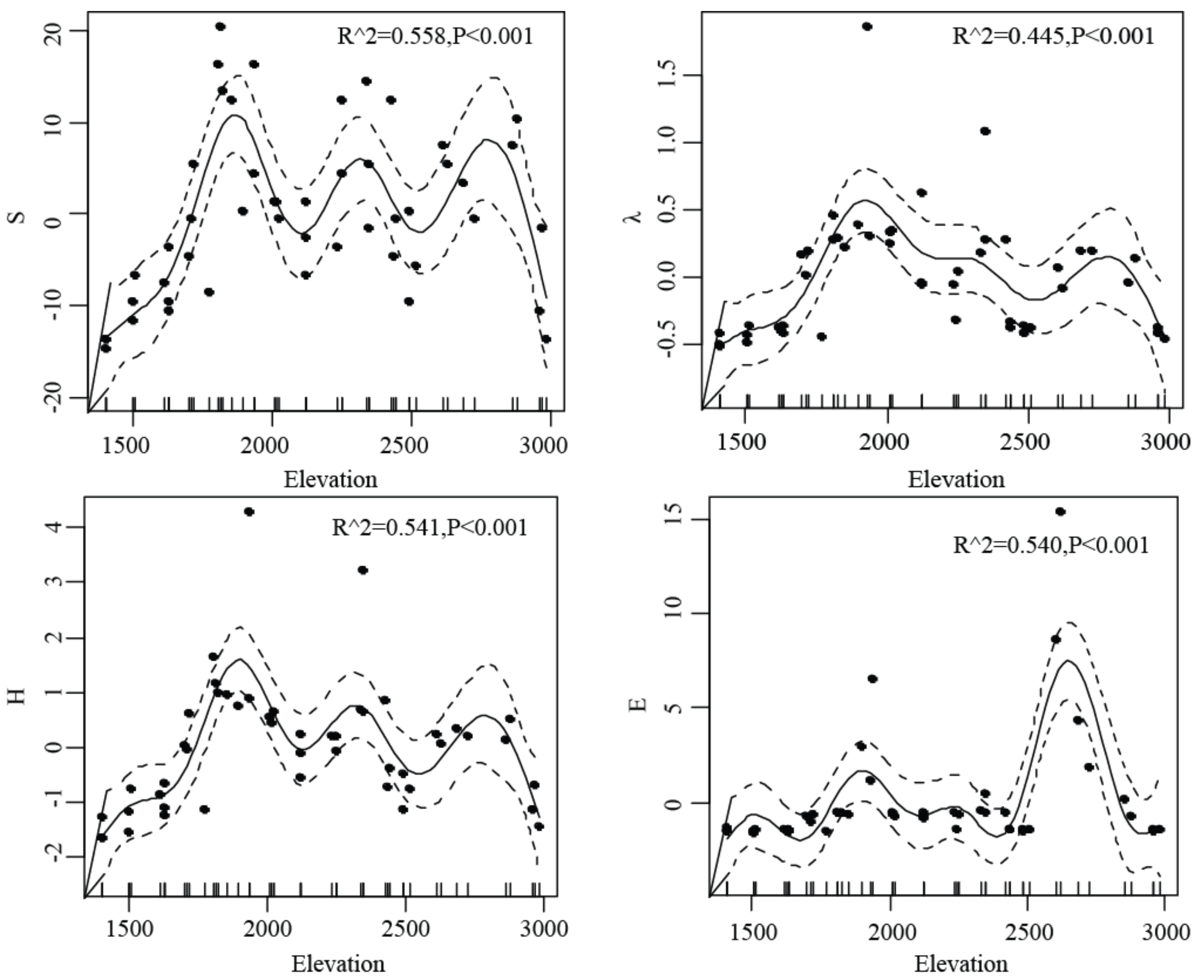

Fig. 3. Altitudinal pattern of species diversity on the northern slope of the Usun mountains. S: species richness; λ: Simpson index; H: Shannon-Wiener index; E: Pielou evenness index.

Table 3. Eigenvalue gradient lengths and cumulative variances of DCCA ordination.

Axis	Eigenvalue	Gradient length	Cumulative percentage variance of species (*P*/%)	Cumulative percentage variance of species–environment relation (*P*/%)
Axis 1	0.761	6.208	8.1	27.8
Axis 2	0.222	1.833	10.5	36.4
Axis 3	0.141	1.998	12.0	41.6
Axis 4	0.100	1.429	13.0	45.1

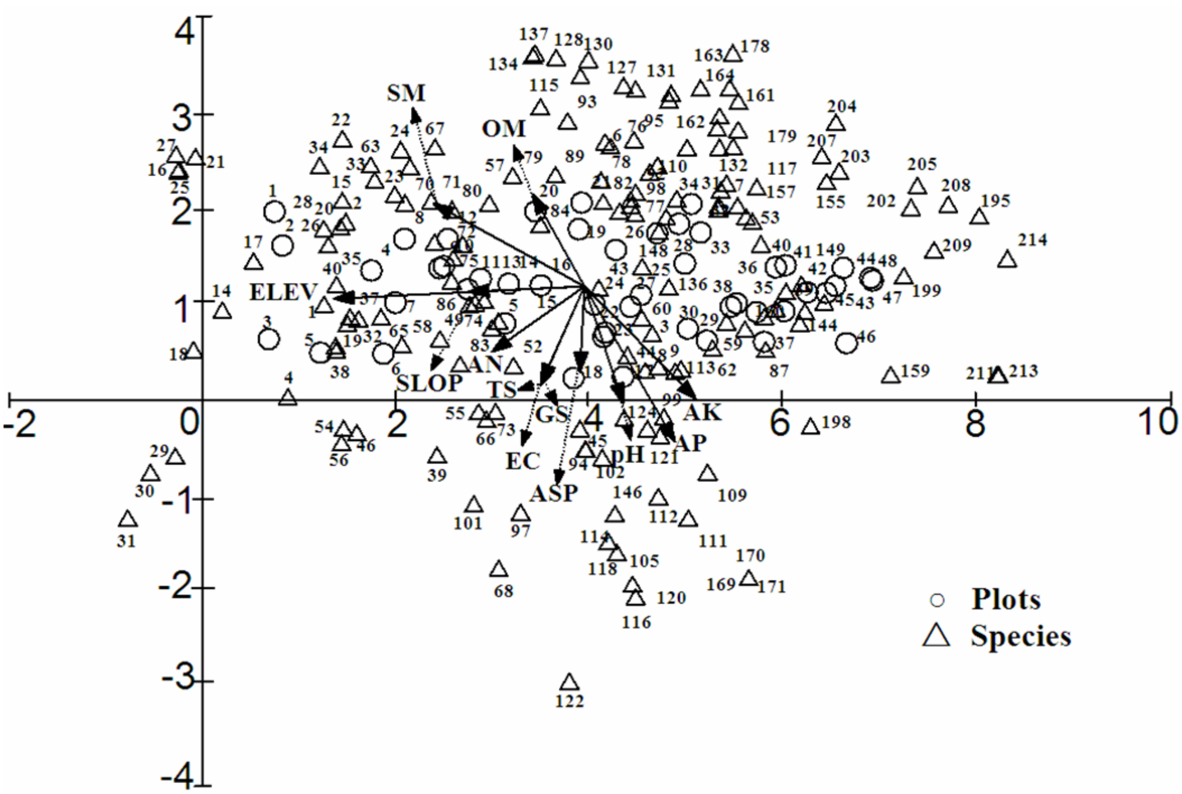

Fig. 4. DCCA ordination of the 167 plant community species on the northern slopes of the Usun Mountains and environmental variables. ELEV: Elevation; SLOP: Slope; ASP: Aspect of slope; SM: Soil moisture; OM: Organic matter; AN: Available nitrogen; AP: Available phosphorus; AK: Available potassium; EC: Electrical conductivity; TS: Total salt; GS: General salt.

Table 4. Correlation coefficient between environmental factors and the first two axes of DCCA.

	Axis 1	Axis 2
Axis 1	1.0000	-0.0610
Elevation	-0.9880**	-0.0104
Slope	-0.4567*	-0.0028
Aspect	-0.0143	-0.3401
Soil moisture	-0.5993*	0.3508
Organic matter	-0.2088	0.3738
Available N	-0.3624	-0.2464
Available P	0.3639	-0.6316**
Available K	0.4453*	-0.4649*
pH	0.1579	-0.4702*
Electricity conductivity	-0.1688	-0.3895
Total salt	-0.1680	-0.3787
General salt	-0.1688	-0.3895

*p<0.05; **p<0.01

Influenced by environmental factors, the tree and shrub layer communities were clearly divided into two species distributions (Fig. 4), there was a relatively long elevation gradient range at all sampling plot. Elevation 2,900 – 2,600 m section (P4 – P9), with only one area containing tree species (*P. schrenkiana*) (1) (The number in the parentheses refers to the serial number of the species, and so does in the following texts). The high density part at DCCA ordination were mainly mountain steppe zone [elevation 1,700–2,600 m section (P10–P38)]. Areas in this elevation had an abundant and concentrated distribution shrub and herb species. As seen in Fig. 4, some environmental factors had close correlation with the first axis, of which elevation had an important effect on the survival distribution of trees. Thus, the first axis in the DCCA ordination was the changing axis of elevation. Along the direction of the first axis, the main community constructive species moved from *P. schrenkiana* (1) [elevation 2,600–2,900 m section (P4–P9)] to *S. hypericifolia* (3) [elevation 2,400–2,600 m (P10–P15)], then to *R. albertii* (9) [elevation 2,200–2,400 m (P16–P21)] and, finally, to *R. platyacantha* (11) [elevation 1,700–2.200 m (P22–P38)]. There exhibited a trend that, with the gradual decrease in elevation from high elevation (P4 – P9) to relatively high elevation (P10–P15) to middle-lower elevation (P16–P21) to low elevation (P22–P38), slope, aspect, soil moisture, conductivity, soil organic matter, soil available nitrogen, total salt and general salt decreased gradually, while pH value, available phosphorus, and available potassium increased gradually.

Along the direction of the second order axis, the arrow of available P was relatively long and was closely correlated with the environmental axis (Table 4, Fig. 4), reflecting that available P had a relatively greater effect on the distribution of tree survival communities and species composition than other factors. Hence, the second order axis was a changing axis of available P. Along the direction of the second axis from the bottom to the top, the main tree and shrub community species changed from *P. schrenkiana* to *S. hypericifolia* (3), then to *R. albertii* (9) and finally to *R. platyacantha* (11), indicating that along with changes in different community type, pH and available phosphorus decreased, while soil moisture , available K and organic matter gradually increased.

The herbaceous layer was also affected by environmental factors. The arrow length of the elevation, soil moisture, available N, pH and aspect is relatively long reflecting that elevation, soil moisture, available N, pH and aspect had strong influences on the survival distribution and species composition of the herbaceous community (Table 4). With decreasing elevation, different elevation sections were composed of different representative species. As seen in Fig. 4, this was mainly affected by the gradual decrease in elevation, soil moisture and slope. In addition, with the gradual decrease in soil organic matter, available N, electrical conductivity, total salt, and general salt along the direction of the first axis, the community changed from *C. stenocarpa* (18) as the constructive species [elevation 2,600–3,000 m section (P1–P 9)] to *P. alpinum* (69) as the dominant species [elevation 2,300–2,600 m (P10–P 18)], to yellow *P. chrysantha* (138) as the dominant species [elevation 1,700–2,300 m (P19–P38)], and to *C. turkestanica* short column (199) as the constructive species [elevation 1,400–1,700 m (P39–P 48)].

As seen along the direction of the second axis, species are mainly concentrated in the upper half, available phosphorus, available potassium and pH value in the environment of plant communities in the lower part of the second axis are relatively high, and representative plants are *A. chrysanthum* (106) and *C. adiantifolia* (122). The plant species were mainly affected by available phosphorus, available potassium and pH effects, and weakly affected by elevation, slope Species communities in plots with higher levels of organic matter and soil moisture are present above the second axis, and representative plants are *R.. acetosa* (142). The species communities were mainly affected by organic matter, soil moisture and less affected by the conductivity.

By TWINSPAN classification and sorting DCCA, all tree and shrub layer species on the northern slope of Usun Mountains were divided into four categories. The first category was the sub-alpine meadow community (P1–P3) with *C. stenocarpa* (18) as the constructive species. The second category was the coniferous forest community (P4–P9) with *P. schrenkiana* (1) as the constructive species. The third was the mountain grassland community (P10–P38) with *P. alpinum* (69) and *P. chrysantha* (138) as dominant species, which grew mainly under shrubs. The forth category was the typical desert steppe community (P39–P48) with short column *C. turkestanica* (199) as constructive species. Among the main environmental characteristic values, elevation had the strongest influence, slope, soil moisture, available P, K and pH had relatively high influence, while~~,~~ organic matter, available N, electrical conductivity, total salt and general salt had less influence. Therefore, TWINSPAN classification and sorting DCCA generally showed that elevation had influence on species distribution and composition.

Discussion

Plant community diversity patterns: Because of its complex and diverse ecological conditions, mountains are a germplasm resource for the survival, reproduction and preservation of a variety of species. (Whittaker *et al.*, 2001). Different mountains having different vertical distribution patterns. Studies have shown that there are generally five pattern forms for species diversity distribution along an elevation gradient. These five patterns are first decrease then increase along elevation gradient, first increase then decrease (single peak curve), monotonic increase, monotonic decrease, and no obvious pattern(Gaston, 1996; Klimes, 2003; Paivi, 2006; Amit *et al.*, 2008). Overall species richness, Simpson index, Shannon-Wiener diversity index and Pielou evenness index on the northern slope of Usun Mountains showed multiple peaks with increasing elevation, although the first two peaks of Pielou evenness index were not very obvious. Actually, the spatial patterns of species diversity are determined by many ecological factors and altitudinal patterns of species diversity largely depend on the covariation and interaction of these factors (Kratochwil, 1999). The hydrothermal condition of different locations varies greatly with the variations in topography, slope gradient, and aspect even at the same contour line. After all, the ecological environment of plant communities in the mountains is rather complicated (Wang *et al.*, 2002).

Relationship between vertical distribution of communities and the environment

Topographic factors and community distribution: The territory and community distribution patterns of plant communities on the northern slope of Usun Mountains showed very significant correlations with elevation. Along the elevation gradient, trees and shrubs in areas with high temperature and abundant sunlight were the main constructive species, showing thermophilic, drought-tolerant characteristics, eg , the sample of trees and shrubs existence of soil moisture is low, but the branches and leaves exuberant. Topography (elevation, slope, and aspect) affects soil and climate, in addition to affecting temperature and evapo-transpiration (as elements of climate), makes deeper soil and higher content of organic matter (Liu, 1993).However, herbs at high elevation and low elevation were located in low temperature and shady sites, in contrast to shrubs growing on sunny slope habitats, which demonstrated that plant types were closely related to environmental factors at different elevations. And, altitude itself represents a complex combination of related climatic variables closely correlated with numerous other environmental properties (soil texture, nutrients, substrate stability, etc.) (Petr, 2009; Xu, 2011). In addition, these results suggested that elevation and slope were the most important factors restricting community distribution at the study area.

Water conditions and community distribution: In the former study, moisture conditions, especially soil moisture, are considered the most important ecological factor for vegetation growth (Körner, 1999). In this study, moisture condition preferences for different communities differed significantly. Previous research has shown that precipitation increases significantly with the increase of elevation in the Usun Mountains of Tianshan (Hou & Xu, 2005). This result agrees with our DCCA analysis, reflecting that the elevation gradient was positively correlated with soil moisture. Soil moisture in the coniferous forest zone on the northern slope of Usun Mountains was higher than that in the low elevation desert steppe zone. The decrease in soil moisture occurred with the transition from mountain desert coniferous forest communities with *P. schrenkiana* as the dominant species to typical steppe communities with *Festuca* spp. as the dominant species. Beacause of changes in soil moisture were affected by vegetation (e.g.; cover, plant species) (Liu, 2005). In this study, some samples of cover higher, soil moisture also high, especially Coniferous forest sample. Coniferous forest grew densely on the northern slope of Usun Mountains due to the high soil moisture content associated with the wet and shady conditions and abundant precipitation at higher elevations.

Nutrition status and community distribution: Nutrition differences in the study area strongly influenced community distribution patterns on the northern slope of Usun Mountains. This may be soil chemical properties characteristics affect the speed of vegetation germination, development and succession (An *et al*., 1997). In this study, soil available phosphorus and available potassium were well correlated with the second order axis. Soil available phosphorus, available potassium and second order axis correlation coefficient is -0.61, -0.46. Indicate, soil available phosphorus and available potassium don't change with the elevations gradient, but the impact of community distribution. Impact value of Soil available phosphorus is higher than available potassium. The *S. hypericifolia* community lay at the high end of the nutrition gradient, while mountain grassland communities were at the low end. This demonstrated that mountain grassland vegetation grew in areas with barren soil, organic matter and available N had little effect on community distribution. In foemer study, Nitrogen-fixing bacteria can also occur in mutualisms with certain vascular plants. Some species of grasses occur in a relatively loose, non-obligate mutualism with nitrogen-fixing microorganisms(Freedman, 1995). So, some grass species could be fixing N biologically in association with *diazotrophic bacteria.*

Other habitat conditions and communities distribution: Soil pH had a significant effect on community distribution patterns, with *C. adiantifolia* the main community in areas with high pH. The soil electrical conductivity, total salt and general salt for each quadrat did not showed significant differences, which may relate to the limitations of study area scope.

Thus, under complex mountainous terrain, community biotope conditions differed significantly. Combinations of elevation, slope, soil moisture, available phosphorus, available potassium and pH influenced and controlled the formation of each community distribution pattern on the northern slope of Usun Mountains.

Conclusions

From studyed to now, the territory and community distribution patterns of plant communities on the northern slope of Usun Mountains showed very also significant correlations with elevation. Along the elevation gradient, trees and shrubs in areas with high temperature and abundant sunlight were also the main constructive species, herbs at high elevation and low elevation were located in low temperature and shady sites, in contrast to shrubs growing on sunny slope habitats, which demonstrated that plant types were closely related to environmental factors at different elevations.The survey again found that tourism and grazing activity have spread from the foot to the top of the slope due to the convenience of the Yizhao Road on the northern slop of Usun Mountain, community has been more and more human interference. Therefore, extended research is needed to study the effects of anthropogenic disturbances on the plant species diversity, and attention should be paid to conserve the plant species diversity.

Acknowledgements

The research was funded by National Technology Support Program (Nº 2007BAC17B08), National Basic Research Program of China (973 Program, Nº2009CB825101), National Natural Science Foundation of China (Nº 30900176 and Nº 2010JC02), Western Light Talent Culture Project (Nº RCPY200801).

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(Received for publication 13 February 2012)