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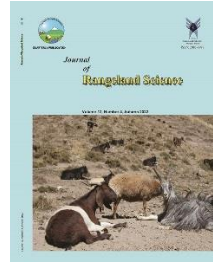

Research and Full Length Article:

Investigating Environmental Factors Affecting Plant Distribution in QezelOzan - Kosar Rangelands (Ardabil Province), Iran

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Abstract. The purpose of this study was to investigate the effect of environmental factors on the plant composition and diversity in QezelOzan - Kosar rangelands of Ardabil province, Iran in 2016. Eight sites with elevation ranging from 900 to 2100 meters above sea level were selected, and three 100-m transects with 10 plots of 1 m^2 were established along each one. Species were collected from the plots and their vegetative forms were determined and the factors related to the frequency of species were recorded. Forbs frequency were determined as 2.1% to 33.3%, shrubs 0.4% to 29.2% and grasses 0.4% to 46.7%. Along each transect, a soil sample was collected from depths of 0 to 30 cm. Then, some soil properties such as pH, Electrical Conductivity, Calcium, Sodium, Potassium, Phosphorus, Nitrogen, Magnesium, Calcium Carbonate equivalent, Organic carbon and Soil texture were determined. Vegetation ordination analysis including Principal Component Analysis (PCA), Detrended Correspondence Analysis (DCA), redundancy analysis (RDA) and Canonical Correspondence Analysis (CCA) were performed in Canoco$_{4.5}$ and PC-ORD$_5$ software. Results of PCA showed organic carbon with eigenvector values of (0.42), nitrogen (0.41) and elevation (0.37) were important factors influencing the distribution of plants. CCA showed that elevation with eigenvector values of (0.37), potassium (0.35) and clay (0.44) were the most effective ones in forbs and grass distribution, potassium with eigenvector values of (0.35), pH (0.58) and organic carbon (0.42) were the most important factors. RDA in shrubs distribution also showed slope with eigenvector values of (0.44), elevation (0.37) and sand percent (0.46) were the most important factors. By doing this research, the basic knowledge of the ecological requirements in the rangelands of these areas was obtained. Thus, by the increase of technical knowledge, some activities can be done to protect, systematically exploit and restore the degraded areas.

Key words: Vegetative forms, PCA, Kosar County, Soil properties, Plant diversity

Introduction

Vegetation is one of the most important elements in the structure and function of ecosystems and is affected by various environmental factors, appearing in different vegetation communities (Asadian *et al*., 2017; Aghajanlou *et al*., 2018; Ghorbani *et al*., 2020a). Investigating the relationships between vegetation communities and environmental factors has a particular complexity, which means that a) environmental variables vary greatly, b) there are complex interactions between environmental variables and plants; and c) the observed correlations are often associated with unpredictability (Mesdaghi, 2007; Abdolalizadeh *et al*., 2020; Ghorbani *et al*., 2020b). Species distribution is a worth source of data for biogeography, sites requirement models, protection of threatened species, areas of provenance for plant genetic resources and species selection for environmental recovery (González and Martín, 2006; Ahmadauli *et al*., 2015; Teimoorzadeh *et al*., 2015; Bagheri *et al*., 2017). Therefore, comprehending the dispersion of plant species is essential for the management and conservation of rangeland ecosystems (Bano *et al*., 2017; Ghorbani *et al*., 2017b). Hence, plant ecologists have long been interested in researching the effects of natural factors on the distribution of plant species against environmental changes (Ghorbani *et al*., 2015). On the other hand, conceiving the model of composition variations between different areas is one of the main purposes of ecology (Dias dos Santos *et al*., 2014; Teimoorzadeh *et al*., 2015).

By studying vegetation and various environmental factors such as topographical conditions, soil and climate, some information can be obtained regarding the stability of plant communities and the relationship of these factors with vegetation (Mesdaghi, 2007; Aghajanlou *et al*., 2018; Abdolalizadeh *et al*., 2020). In this regard, different studies have investigated biodiversity by considering topographical conditions or perusing each factor in isolation such as elevation, slope and aspect (Mesdaghi, 2007; Aghajanlou *et al*., 2018; Ghorbani *et al*., 2020a). Elevation is one of the most significant agents to specify micro-site situation that affect the plant's distribution, morphology, physiology, and growth (Ghorbani *et al*., 2013; Arila and Gupta, 2016). According to McCain and Grytnes (2010), elevation causes to reduce atmospheric pressure, to decrease temperature, and increase solar radiation, influencing the observed changes in the plant species.

Any management plan to reform, rehabilitate and exploit natural resources in the first step requires the identification of vegetation in the respective area (Asadian *et al*., 2017). Quantitative analysis of the relationship between environmental factors and vegetation is one of the important issues in the ecology of plant communities (Zare Chahouki *et al*., 2010; Abdolalizadeh *et al*., 2020). Moreover, in each region, depending on the scale that is used, one or more environmental factors are the most relevant to vegetation (Mesdaghi, 2007; Zare Chahouki *et al*., 2010; Ghorbani *et al*., 2020b). The vegetation structure and its ecological assessment change according to different factors. Therefore, scientific management of the ecosystem should be conducted based on the understanding of the relationship between ecological factors (Zhang *et al*., 2006; Jafari *et al*., 2016; Esfanjani *et al*., 2018). Distribution of plant species is a reflection of several different factors in different scales along with the factors of soil that affect the distribution of plants in areas and landscapes (Cantero *et al*., 2003).

Several studies have been carried out in this regard. For example, in the study of vegetation relations with environmental factors in Changsha, China, Jin Tun (2010) concluded that the distribution of vegetation has a direct relationship with climatic and soil variables. Chawla *et al*. (2016) in studying the biodiversity of plant species along the elevations of Bahabaha valley in the west of Himalayan mountain range concluded that the values of biodiversity indicators have changed over A gradients. As the elevation increases, biodiversity indicators first have a rising and then falling trend. In other words, the highest and lowest diversities were in the middle and high elevations, respectively.

Jafari *et al*. (2006) examined the relationship between soil characteristics and distribution of plant species in rangelands of Qom province, Iran and reported that the soil properties including soil texture, electrical conductivity (EC) and level of limestone were the most important factors affecting the distribution of species. Kia *et al*. (2010) used analytic methods to analyze the relationship between environmental factors and vegetation changes in Chahar-Bagh area of Golestan province, Iran. Their results indicated that there was a direct relationship between the distribution of plants and some soil characteristics so that the soil texture, potassium, lime, organic carbon and nitrogen as compared to other soil characteristics and topographical factors had more effect on the distribution of plants in their studied area. Ghorbani and Bahrami (2017) by studying the effects of environmental factors on distribution of plant species in southeast ranges of Sabalan, Iran reported that except pH of beneath depth, potassium, sand and clay in two depths and in soil surface depth, the remaining factors of elevation that were selected in three classes have been significantly different.

The aim of this study was to investigate the distribution of plant species and their relationship with environmental variables in elevation gradients of QezelOzan-Kosar rangelands of Ardabil province in the North West of Iran. Results of this study can be useful in the selected rangelands and similar areas as a basic information for proper rangelands management, their conservation and restoration.

Materials and Methods

Study area

Kosar County with a total area of 124,883 ha is located in Ardabil province, Iran and 69.4% of that is covered by natural ecosystems, mostly rangelands (Kakeh Mami *et al*., 2017). Minimum and maximum elevation profiles of sites are 937 and 2162 m above sea level, respectively (Fig. 1). The annual rainfall (mean of 15 years) of the region is about 203 to 401 mm (Taheri Niari *et al*., 2018). Depending on the topographical conditions and semi-arid climate of the region, the depth and type of soil are different. These areas mostly include irregular slopes that are mainly devoted to agriculture and less productive drylands (Ghorbani *et al*., 2017a; Taheri Niari, 2018; Taheri Niari *et al*., 2018). Vegetation types of the designated profile, elevation classes and their associated species for eight selected sites are presented in Table 1 (Taheri Niari *et al*., 2018).

Table 1. Vegetation types and dependent plants in each of the sites of the study area

Sites	Elevation (m)	Vegetation type	Dependent plants
Site 1	937-965	*Cirsium arvense* L. -*Gundelia tournefortii* L.	*Chardinia orientalis* L., *Aegilops crassa* Boiss, *Crepis multicaulis* Lede, *Helianthemum salicifolium* L.
Site 2	1470-1516	*Amygdalus lycioides* Spach- *Juniperus excelsa* M.	*Aegilops crassa* Boiss, *Acinos graveolens* Link, *Prangos uloptera* DC, *Astragalus microcephalus* Willd
Site 3	1568-1609	*Astragalus microcephalus* Willd- *Cotoneaster nummularioides* Pojark	*Elymus libanoticus* Hack, *Bromus tectorum* L., *Onobrychis sativa* Lam, *Festuca ovina* L.
Site 4	1388-1435	*Stipa barbata* Desf- *Galium humifusum* M.	*Elymus libanoticus* Hack, *Centaurea depressa* M., *Anthemis coelopoda* Boiss, *Alyssum minus* L.
Site 5	1583-1683	*Astragalus microcephalus* Willd- *Poa bulbosa* L.	*Taeniatherum crinitum* Schreb, *Acinos graveolens* Li, *Bromus tectorum* L., *Aegilops crassa* Boiss
Site 6	1493-1555	*Poa bulbosa* L.- *Serratula latifolia* Boiss	*Xeranthemum annuum* L., *Amygdalus lycioides* Spac, *Crupina crupinastrum* Moris, *Euphorbia amygdaloides* L.
Site 7	1635-1677	*Astragalus microcephalus* Willd- *Poa bulbosa* L.	*Elymus libanoticus* Hack, *Stipa barbata* Desf, *Dendrostellera lessertii* Tiegh, *Thymus kotschyanus* Boiss.
Site 8	2139-2162	*Astragalus microcephalus* Willd- *Acantholimon bodeanum* Bunge	*Elymus libanoticus* Melderis, *Poa bulbosa* L., *Tanacetum polycephalum* Sch., *Phlomis olivieri* Benth

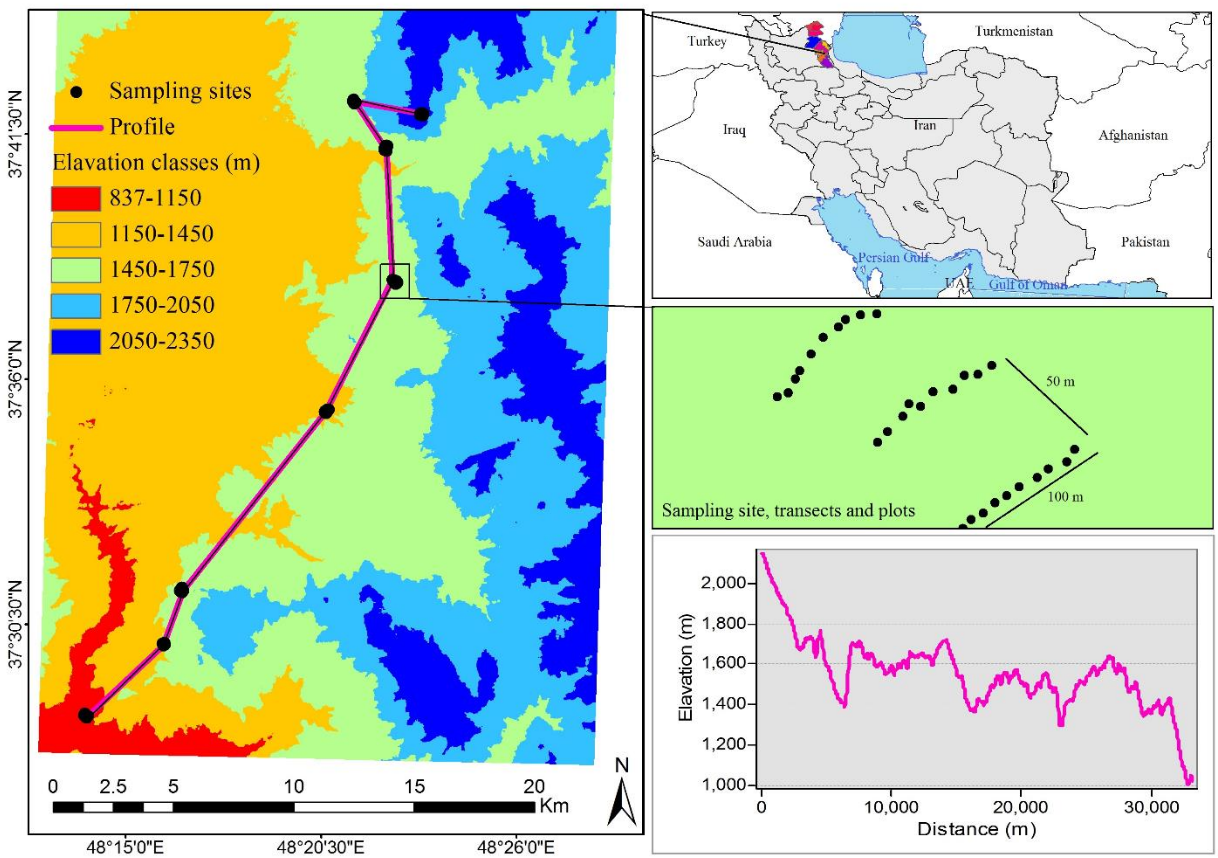

Fig. 1. Location of the study area in Ardabil province, Iran, elevation profile and sampling sites

Data collection

Eight sites were selected along the elevation gradient of QezelOzan – Kosar rangelands. In each site, three 100 m transects were established at a distance of 50 m, the first transect was randomly assigned, and others were selected systematically in the aspect of perpendicular to the slope. Along each transect, 10 plots of 1 m^2 were established with a distance of 10 m (totally, 240 plots) (Fig. 1). The sizes of the plots were determined according to the vegetation structure and the previous studies (Arzani, 1997; Ghorbani *et al*., 2017a; Taheri Niari, 2018; Taheri Niari *et al*., 2018, Ghorbani *et al*., 2020a). Field sampling was conducted in May and June 2016 when the dominant plants were in full growing and flowering stage. In each plot, the factors of frequency of species were recorded. The frequency of species based on vegetative forms is shown in Table 2.

For soil sampling, three samples from beginning, middle and end of each transect were taken from 0 to 30 cm depth and mixed together and a mixture of soil samples were prepared from these three samples (3 soil samples per site) and totally, 24 soil samples were collected for eight sites. At first, samples were transferred to the lab and then, dried in the open air and passed the sieve. Soil attributes such as pH (using pH meter in saturated extracts), EC (using EC meter in saturated extracts), calcium (Ca) and magnesium (Mg) (using the titrimetric method), sodium (Na) and potassium (K) (using flame photometer), phosphorus (P) (using Olsen method with a spectrophotometer), nitrogen (N) and organic carbon (OC) (by calculating organic carbon using the modified Walkley–Black wet oxidation procedure), calcium carbonate equivalent (Lime) (using the titrimetric method) and soil texture (including clay, silt and sand) (using two hydrometer readings method) were measured in the laboratory (Lentz, 1987; Jafari Haghighi, 2003).

Table 2. The frequency of some species based on vegetative forms

Vegetative forms	Species name	abbreviation	Frequency (%)	Species name	abbreviation	Frequency (%)
Forbs	*Acinos graveolens*	Ac-gr	33.3	*Xeranthemum annuum*	Xe-an	12.1
	Cirsium arvense	Ci-ar	30.4	*Chardinia orientalis*	Ch-or	11.3
	Crupina crupinastrum	Cr-cr	27.1	*Phlomis olivieri*	Ph-ol	10.0
	Minuartia hamata	Mi-ha	21.3	*Tanacetum polycephalum*	Ta-po	8.3
	Crepis multicaulis	Cr-mu	19.6	*Gundelia tournefortii*	Gu-to	6.7
	Helianthemum salicifolium	He-sa	17.1	*Onobrychis sativa*	On-sa	5.8
	Serratula latifolia	Se-la	13.8	*Prangos uloptera*	Pr-ul	2.1
	Euphorbia amygdaloides	Eu-am	13.3	*Verbascum songaricum*	Ve-so	2.1
Shrubs	*Astragalus microcephalus*	As-mi	29.2	*Astragalus curvirostris*	As-cu	2.1
	Thymus kotschyanus	Th-ko	12.5	*Acantholimon bodeanum*	Ac-bo	2.1
	Scariola orientalis	Sc-or	7.9	*Alhagi pseudalhagi*	Al-ps	1.7
	Amygdalus lycioides	Am-ly	6.3	*Scutellaria pinnatifida*	Sc-pi	1.3
	Astragalus vegetus	As-ve	5.0	*Stachys trinervis*	St-tr	0.8
	Astragalus filicaulis	As-fi	3.3	*Astragalus chrysanthus*	As-ch	0.8
	Artemisia absinthium	Ar-ab	2.9	*Asperula glomerata*	As-gl	0.4
	Rubia florida	Ru-fl	2.9	*Astragalus aureus*	As-au	0.4
Grasses	*Poa bulbosa*	Po-bu	46.7	*Avena sterilis*	Av-st	4.6
	Aegilops crassa	Ae-cr	44.6	*Boissiera squarrosa*	Bo-sq	2.5
	Bromus tectorum	Br-te	36.7	*Festuca ovina*	Fe-ov	2.1
	Elymus libanoticus	El-li	30.0	*Briza media*	Br-me	1.7
	Hordeum murinum	Ho-mu	16.3	*Dactylis glomerata*	Da-gl	0.8
	Bromus danthoniae	Br-da	12.5	*Nardurus maritimus*	Na-ma	0.4
	Stipa barbata	St-ba	10.8	*Melica persica*	Me-pe	0.4
	Taeniatherum crinitum	Ta-cr	10.0	*Pennisetum orientale*	Pe-or	0.4
	Bromus tomentellus	Br-to	7.1	*Stipa hohenackeriana*	St-ho	0.4

Data analysis

In order to investigate the effect of environmental factors on the distribution of plants, Principal component analysis (PCA) was done. Redundancy analysis (RDA), Canonical correspondence analysis (CCA) and Detrended Correspondence Analysis (DCA) were also done for plants ordination.

a) PCA

According to the purpose of the study, the effect of environmental factors (elevation, slope and aspect) on the composition and diversity of species, PCA was used to identify the most important variables affecting species composition and diversity. Generally, the major application of PCA is the reduction of the number of variables and finding the structural relationship of variables which means classification of them. In this analysis, the distribution chart of communities is also shown on the coordinate axis, and this method simplifies the complex relationships between plant and environment (Jafari *et al*., 2002). For the selection of components, the Eigenvalues of each component were considered and the components were selected when Eigenvalue were greater than the Broken-Stick Eigenvalue (BSE) (Zare Chahouki *et al*., 2007).

b) RDA and CCA

In RDA method, species are directly associated with measured environmental factors. Because community data have many multiple species and gradients, RDA is a better way to reduce dimensions. RDA and CCA are the most commonly used gradient analysis methods (Ter Braak and Smilauer, 1998). To determine the type of regression method, the first detrended correspondence analysis (DCA) was used for regression analysis. Where the gradient length was less than 3, RDA was used and when gradient length was greater than 3, CCA was used to examine the relationship between environmental factors and plant species (Leps and Smilauer, 2003). Vegetation classification analysis including PCA, DCA, RDA and CCA was performed in $Canoco_{4.5}$ and $PC\text{-}ORD_5$ software.

In this research and analysis, lengths of vectors show the degree of influence and importance of the factors. Thus, the longer vector has a greater effect (positive or negative), and a shorter vector has a smaller effect (positive or negative). Two parallel vectors refer to a positive effect and two opposite vectors with a maximum angle of 180 degrees indicate the negative and mutually exclusive effect of the two factors (Figs. 3, 4 and 5).

Results

a) PCA of the environmental factors

The PCA in investigating the common effects of environmental factors on the distribution of total plants showed that the Eigenvalues for components of 1 to 6 were higher than BSE index. Thus, these 6 components were selected to justify the variation among variables. The first component has devoted 23.24 percent of the variation to itself and the last component showed 7.79 percent of the variation. Overall, these components justify 75.01% of total variation (Table 3).

Table 3. Eigenvalues and variance related to each component in PCA method

Components	Eigenvalues	Variances (%)	Cumulative variance (%)	BSE index
PC1	4.41	23.24	23.24	3.54
PC2	2.63	13.84	37.09	2.54
PC3	2.28	12.04	49.14	2.04
PC4	1.85	9.76	58.90	1.71
PC5	1.57	8.30	67.20	1.46
PC6	1.48	7.79	75.01	1.26
PC7	1.05	5.57	80.57	1.09
PC8	0.76	4.02	84.60	0.95
PC9	0.67	3.55	88.15	0.83
PC10	0.48	2.56	90.72	0.71

According to the result of the correlation of variables with main components, the first component was positively correlated with the variables of organic carbon, nitrogen and elevation, the second component was positively correlated with sand and slope and negatively correlated with silt and potassium, the third component was positively correlated with sodium, calcium and EC, the fourth component was negatively correlated with pH, calcium carbonate and phosphorus, the fifth component was positively correlated with stone, gravel, and clay and the sixth component was negatively correlated with bare soil (Table 4). The PCA diagram based on environmental factors is shown in Fig. 2. Organic carbon and nitrogen have the highest positive correlation with each other (Fig. 2).

Table 4. Eigenvalues for each effective variable in each PCA

Variables	PC1	PC2	PC3	PC4	PC5	PC6
Organic carbon (%)	**0.42**	0.10	0.16	0.04	-0.05	-0.08
Nitrogen (%)	**0.41**	0.11	0.18	0.03	-0.07	-0.09
Elevation (m)	**0.37**	-0.12	-0.14	0.13	-0.29	-0.00
Sand (%)	0.17	**0.46**	-0.11	-0.12	-0.26	-0.08
Slope (%)	-0.04	**0.44**	-0.17	0.23	0.09	-0.11
Silt (%)	0.08	**-0.40**	-0.12	-0.08	-0.22	0.34
Potassium (ppm)	0.28	**-0.35**	-0.03	0.06	0.176	-0.12
Sodium (ppm)	-0.12	-0.13	**0.51**	0.09	0.02	-0.04
Calcium (mg/lit)	0.11	0.20	**0.49**	-0.00	0.09	0.16
EC (ds/m)	0.30	-0.00	**0.38**	-0.11	-0.02	0.02
pH	0.02	-0.18	0.15	**-0.58**	-0.13	-0.14
Calcium carbonate (%)	-0.25	-0.05	-0.04	**-0.46**	-0.12	-0.22
Phosphorus (ppm)	-0.14	0.31	0.11	**-0.36**	0.03	-0.01
Stone and gravel	0.15	0.09	-0.15	-0.27	**0.52**	0.24
Clay (%)	-0.24	-0.14	0.21	0.20	**0.44**	-0.19
Bare soil	-0.04	-0.11	0.02	0.22	-0.43	**-0.44**
Aspect	-0.02	0.04	-0.01	0.04	0.05	-0.32
Magnesium (mg/lit)	0.23	-0.04	-0.18	0.09	-0.17	0.32
Litter (%)	-0.19	0.07	0.24	0.16	-0.27	0.37

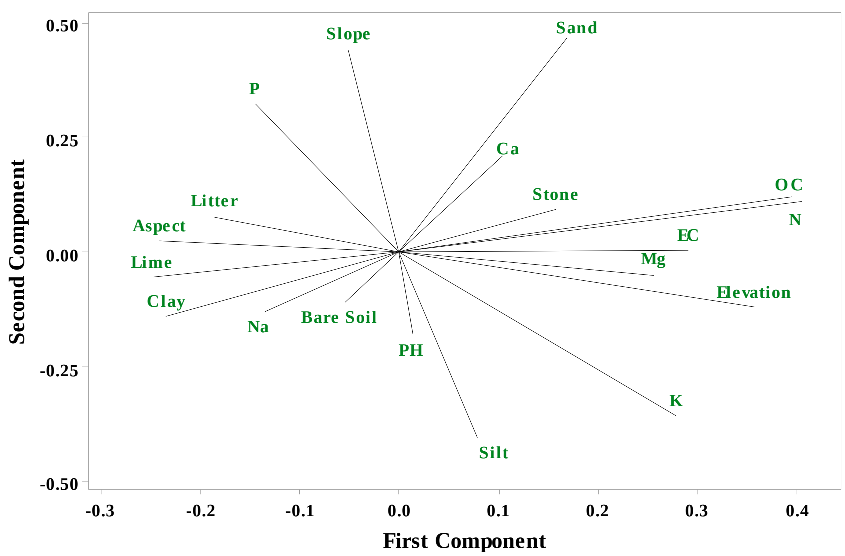

Fig. 2. PCA graph based on effective environmental factors

b) RDA and CCA based on different vegetative forms

Regarding different impressionability of each vegetative form as compared to environmental variables, in order to determine effects of each factor of topographical conditions and soil specifications in each vegetative form and on the other hand, given that each vegetative form has ecological needs different from the others, RDA and CCA were separately explored.

Forbs

The results of DCA on forbs showed that the gradient length was greater than 3 (gradient length equaled 3.29), thus CCA was used to examine the correlation between environmental factors and plants (Table 5). The results of CCA showed that the first axis with an Eigenvalues of 0.81 and correlation of 96% has devoted 2.9% of variation, and the second axis with an Eigenvalues of 0.56 and correlation of 84% has justified 4.8% of variation in forbs. Finally, the third axis with an Eigenvalues of 0.45 and correlation of 77% has devoted 6.4% of variation, and the fourth one with an Eigenvalues of 0.31 and correlation of 71% has justified 7.5% of variation in forbs.

Table 5. CCA ordination results for environmental factors related to plants in forbs types

Parameters / Axes	1	2	3	4
Eigenvalues (CCA)	0.81	0.56	0.45	0.31
Species-environment correlations	0.96	0.84	0.77	0.71
Cumulative percentage variance of species data	2.90	4.80	6.40	7.50
Cumulative variance of species-environment relation	22.01	37.20	49.50	58.11

Figure 3 shows the most important environmental factors affecting the distribution of forb species in the study rangeland. Among the environmental factors, topographical conditions, elevation, EC, nitrogen, organic carbon, stone, gravel and slope in the first quadrant, calcium and clay variables in the second quarter, the sodium variable in the third quarter, and the variables of potassium, silt, sand, bare soil, calcium carbonate equivalent and soil pH are distributed in the fourth quarter. The two vectors of nitrogen and organic carbon as well as calcium carbonate equivalent and bare soil have a positive correlation with each other (Fig. 3). *Chardinia orientalis* with calcium, *Crepis multicaulis* with sodium, *Serratula latifolia* with calcium carbonate equivalent and *Acinos graveolens* with EC have a direct correlation (Fig. 3).

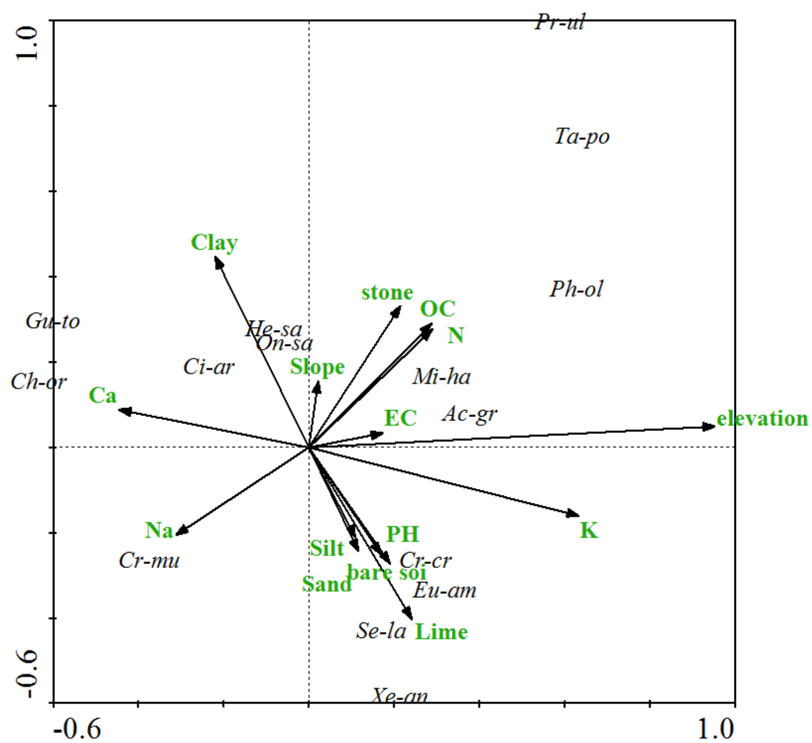

Fig. 3. Distribution of forbs species in relation to environmental factors in the studied area using the CCA method (See Table 2 for the full name of the species)

Shrubs

The results of DCA on shrubs showed that gradient length was less than 3 (gradient length equal to zero), so RDA was used to examine the correlation between environmental factors and plants (Table 6). The results of RDA showed that the first axis with an Eigenvalues of 0.11 and correlation of 50% has devoted 11.2% of variation, and the second axis with an Eigenvalues of 0.07 and correlation of 40% has justified 18.2% of variation in shrubs. Finally, the third axis with an Eigenvalues of 0.01 and correlation of 41% has devoted 19.4% of variation in shrubs.

Table 6. RDA Ordination Results for environmental factors associated with plants in shrub types

Parameters / Axes	1	2	3
Eigenvalues (RDA)	0.11	0.07	0.01
Species-environment correlations	0.50	0.40	0.41
Cumulative percentage variance of species data	11.20	18.20	19.40
Cumulative variance of species-environment relation	56.60	92.40	98.40

Fig. 4 shows the most important environmental factors affecting the distribution of shrub species in the study area. Among the environmental and topographical factors, calcium carbonate equivalent in the first quarter, sand, slope and calcium variables in the second quarter, stone, gravel, clay, sodium and bare soil in the third quarter, and organic carbon, nitrogen, EC, Potassium, pH, silt and elevation variables were distributed in the fourth quarter. The two vectors of slope and sand as well as elevation and silt have a positive correlation with each other. (Fig. 4). *Scutellaria pinnatifida* with calcium, *Scariola orientalis* with stones and gravels, *Astragalus filicaulis* with nitrogen and *Acantholimon bodeanum* have a direct correlation with calcium carbonate (Fig. 4).

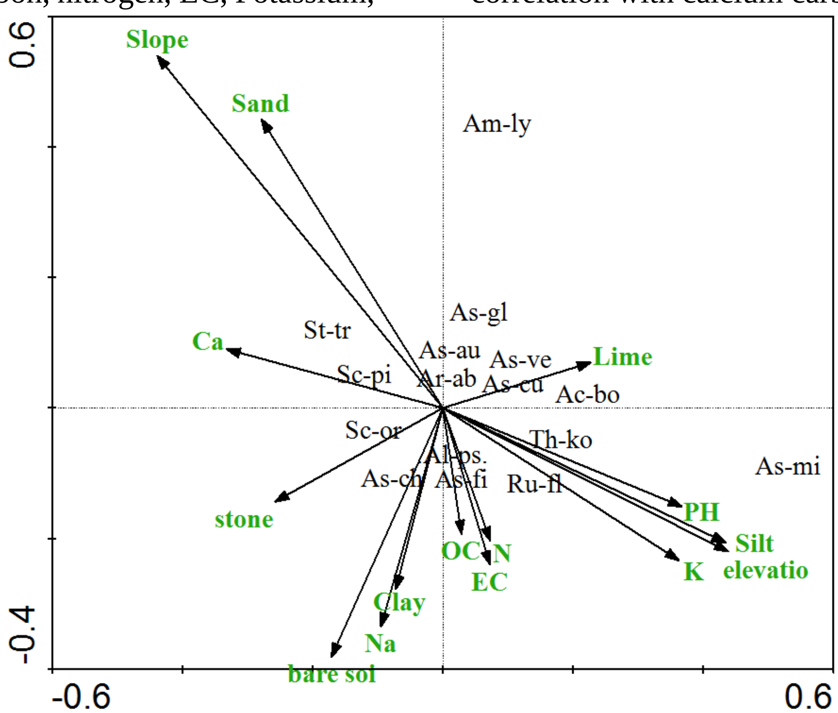

Fig. 4. Distribution of shrub species in relation to environmental factors in the studied area using the RDA method. (See Table 2 for the full name of the species).

Grasses

The results of DCA on Grasses showed that gradient length was greater than 3 (gradient length equal to 4.95), so CCA was used to examine the correlation between environmental factors and plants (Table 7). The results of CCA showed that the first axis with an Eigenvalues of 0.50 and correlation of 82% has devoted 6% of variation, and the second axis with an Eigenvalues of 0.40 and correlation of 77% has justified 10.8% of variation in Grasses. Finally, the third axis with a Eigenvalues of 0.28 and correlation of 75% has devoted 14.2% of variation, and the fourth one with a Eigenvalues of 0.16 and correlation of 48% has justified 16.1% of variation in Grasses.

Table 7. CCA ordination results for environmental factors in relation to plants in Grasses type

Parameters / Axes	1	2	3	4
Eigenvalues (CCA)	0.50	0.40	0.28	0.16
Species-environment correlations	0.81	0.77	0.75	0.48
Cumulative percentage variance of species data	6.00	10.80	14.20	16.10
Cumulative variance of species-environment relation	30.20	54.10	71.30	81.20

Fig. 5 shows the most important environmental factors affecting the distribution of Grass species in the study rangeland. Among the environmental and topographical factors, slope and clay variables in the first quadrant, sodium, bare soil and elevation in the second quarter, the variables of calcium, potassium, sand, nitrogen, organic carbon, stone and gravel, EC, silt and pH in the third quarter and calcium carbonate equivalent are distributed in the fourth quarter. The two vectors of potassium and nitrogen as well as organic carbon and nitrogen have a positive correlation with each other. (Fig. 5). *Bromus tectorum* with sodium, *Dactylis glomerata* with organic carbon, *Briza media* with equivalent calcium carbonate and *Boissiera squarrosa* with clay have a direct correlation (Fig. 5).

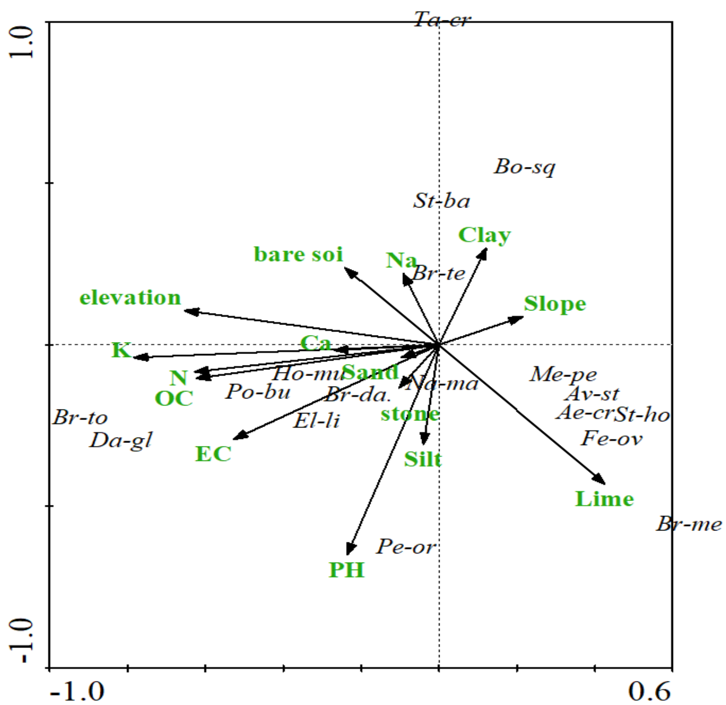

Fig. 5. Distribution of grasses in relation to environmental factors in the studied area using CCA method. (See Table 2 for the full name of the species).

Discussion

According to the results of PCA, organic carbon, nitrogen and elevation were positively correlated in the environmental factors affecting the distribution of plants and were included in the first component. Sand and slope were positively correlated and silt and potassium were negatively correlated in the environmental factors which were also contained in the second component, but factors such as geographical aspect, magnesium and litter were not included in any of the six components. Hersak (2014) stated that soil organic carbon and nitrogen should be considered as the most important effective factors to plant succession over the sand dunes of the northern parts of Croatia. Ghorbani *et al*. (2015) and Ghafari *et al*. (2018) stated that litter and elevation were among the factors influencing the distribution of *Artemisia fragrans* and *Artemisia austriaca* species. Hassanzadeh Kuhsareh *et al*. (2018) in the study of net primary production variations under the effect of topographic factors in mountain rangelands of Namin county in Ardabil province, Iran reported that primary production in different classes showed a significant difference, so the highest rate of primary production was observed in the slope of 20 to 34%. Yibing (2008) used PCA in China, and considered soil chemical and physical specifications like nutrients, humidity, salinity and pH as determinants of ecosystem's homogeneity and spatial distribution of plant communities. Mirzaei Mossivand *et al*. (2017) also reported that firstly, the slope, elevation and aspect, and secondly, soil characteristics are important in the distribution of species like *Prangos uloptera*. Wang *et al.* (2012) reported that the most important factor for the distribution of plant communities was the soil depth in Qinghai-Tibet Plateau, China. In supporting our results, the results of study by Ravanbakhsh *et al*. (2016) also showed that elevation is one of the environmental factors affecting the distribution and deployment of plants in mountainous regions. In another study, Asadian *et al*. (2017) reported that DCA results showed that in the first axis of variables, percentage of stone, sand and gravel, soil EC, clay and organic carbon were important, and in the second axis, variables such as grasses canopy cover and pH were in the top priority. Our results showed that among soil chemical and physical characteristics, only organic carbon and nitrogen have the most direct relationship with the species distributions. According to the fact that in the selected sites, geological and physiographic variables showed slight differences; it may be a change in organic carbon as a result of the overall interaction between soil and vegetation, which itself is affected by the level of use.

CCA showed that in forbs, species such as *Chardinia orientalis*, *Gundelia tournefortii*, *Cirsium arvense* and *Crepis multicaulis* had a direct and positive relationship with calcium, sodium and clay (an increase of these environmental factors increases the presence of these species). Conversely, with elevation, potassium, EC, nitrogen, organic carbon and other environmental factors, they had indirect and negative relationships (an increase of these environmental factors reduces the presence of these species). Tavili and Jafari (2009) also reported that EC with other factors were the most important factor correlated strongly with the distribution of plant ecological groups in the north of Iran, which confirms the results of our study. *Acinos graveolens*, *Minuartia hamata* species had direct and positive correlation with elevation and soil EC and they had an indirect and negative relationship with calcium. Species such as *Crupina crupinastrum*, *Euphorbia amygdaloides*, *Serratula latifolia* and X*eranthemum annuum* had a direct correlation with silt, sand, bare soil, pH and calcium carbonate, and they had an indirect and negative relation with slope, clay and calcium. In addition, *Helianthemum salicifolium* and *Onobrychis sativa* had a direct and positive relationship with clay and they had a negative and indirect relationship with silt, sand, bare soil, and calcium carbonate equivalent and pH. Among all environmental and soil factors affecting the distribution of forb species, elevation was the most affecting factor. These results had also been reported in other studies such as Khademolhosseini *et al*.

(2007); Ghorbani *et al*. (2015) and Dadjou *et al*. (2018). They also highlighted that elevation was one of the important and influential factors in the distribution of plant species in the respective areas. Vittoz *et al*. (2010) showed that elevation is the main factor because the elevation changes are associated with temperature, soil type, and other factors which effect on plant communities.

RDA showed that at the level of shrubs, species such as *Stachys trinervis* and *Scutellaria pinnatifida* had direct and positive correlation with calcium, slope and gravel, and they were indirectly and negatively related to elevation, silt, pH and potassium. The species such as *Scariola orientalis* and *Astragalus chrysanthus* were directly and positively correlated with stone, gravel, bare soil, sodium and clay, and they were indirectly and negatively correlated with calcium carbonate. *Astragalus microcephalus*, *Thymus kotschyanus* and *Rubia florida* species had a direct and positive correlation with elevation, silt, pH and potassium and they had indirect and negative relationships with slope, sand and calcium. Moreover, *Asperula glomerat* and *Acantholimon bodeanum* species had a direct and positive correlation with calcium carbonate and they were negatively correlated with stones and gravels. In this group of plants, slope was the most effective factor and after that, elevation, silt, pH, potassium and sand were in the next ranks. Soil texture has significant influence on moisture and food control for plants (Jafari *et al*., 2006). Mirzaei Mossivand *et al*. (2017) in examining the environmental factors affecting the distribution of plant species stated that by the increase of slope, organic carbon, soil and gravel more than 50%, the density of *Prangos* species were increased. They had also introduced slope and gravel as environmental factors affecting the distribution *Prangos* species. Wang *et al*. (2019) in the study of the relationship between plant communities and environmental factors in a very arid region in China had also introduced slope, potassium, and sand as environmental factors affecting the distribution of species, which confirms the results of our study.

CCA showed that at the level of Grasses, species such as *Bromus tomentellus*, *Dactylis glomerata*, *Poa bulbosa*, *Elymus libanoticus*, *and Hordeum murinum* had a positive and direct relationship with elevation, potassium, nitrogen, organic carbon, EC and calcium and they were indirectly and negatively correlated with slope. The species of *Pennisetum orientale* showed a direct and positive relationship with pH, silt, stone and gravel, and they showed an indirect and negative relationship with clay. Moreover, *Boissiera squarrosa* has a direct and positive relationship with clay and it has indirect and negative relationships with silt, stone, gravel and pH. In addition, species such as *Briza media*, *Festuca ovina* and *Stipa hohenackeriana* were directly and positively correlated with calcium carbonate and indirectly and negatively correlated with bare soil and sodium. In this group of plants and at the level of Grasses, potassium was the most effective one and elevation, calcium carbonate equivalent, nitrogen, organic carbon, EC and pH, and other factors were in the next ranks. The results of our study were consistent by the results of studies by Shafagh Kolvanagh and Abbasvand (2014) and they reported that potassium and soil nitrogen were the most effective factors. Moreover, Azarnivand *et al*. (2007) also reported that elevation, organic carbon and slope are among the most important factors affecting vegetation changes in their study area. Griffiths *et al*. (2009) in the study of the effects of topography on soil characteristics in the Oregon Casade Mountains in the USA had introduced potassium, nitrogen, organic carbon as environmental factors affecting plant communities, which confirms the results of our study.

To sum up, it can be concluded that among topographical conditions (elevation, slope and aspects), elevation had the highest effect on plant community distribution, and then, the slope was in the second priority. However, aspect did not have a significant effect on the distribution of plant communities. Among soil factors, organic carbon and nitrogen had the most effect on the distribution of plant species, after that, gravel, silt, and potassium were in the next priorities. In our study, soil factors of magnesium, phosphorus, and litter were not effective in the distribution of plants. By doing this study, the basic knowledge of the plant communities condition and its changes in relation to topographical and soil conditions were obtained in the rangelands of this area, which would be useful for proper management and restoration of these communities.

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بررسی عوامل محیطی مؤثر بر توزیع گونه‌های گیاهی در قزل اوزن - مراتع کوثر (استان اردبیل)، ایران

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چکیده. این تحقیق با هدف بررسی تأثیر عوامل محیطی بر ترکیب و تنوع گونه‌ها در مراتع قزل اوزن - شهرستان کوثر استان اردبیل در سال ۱۳۹۶ انجام شده است. هشت سایت با دامنه ارتفاعی ۹۰۰ تا ۲۱۰۰ متر از سطح دریا انتخاب شدند و در هر یک، سه ترانسکت ۱۰۰ متری با ۱۰ پلات یک مترمربعی در امتداد آن‌ها مستقر شد. گونه‌ها از سطح پلات‌ها جمع‌آوری، فرم رویشی آن‌ها مشخص شد و عوامل مربوط به فراوانی گونه‌ها ثبت شد. فراوانی گونه‌های مربوط به پهن‌برگان علفی بین ۲/۱ درصد تا ۳۳/۳ درصد، بوته‌ای ها بین ۰/۴ درصد تا ۲۹/۲ درصد و گندمیان بین ۰/۴ درصد تا ۴۶/۷ درصد بدست آمد. در طی هر ترانسکت، یک نمونه خاک از عمق صفر تا ۳۰ سانتی‌متر جمع آوری شد. سپس برخی از خصوصیات خاک مانند pH، هدایت الکتریکی ، کلسیم، سدیم، پتاسیم، فسفر، نیتروژن، منیزیم، کربنات کلسیم معادل، کربن آلی و بافت خاک تعیین شد. آنالیزهای رسته‌بندی پوشش گیاهی شامل PCA، DCA، RDA و CCA در نرم‌افزارهای $CANOCO_{4.5}$ و $PC\ ORD_5$ انجام شدند. نتایج حاصل از PCA نشان داد که کربن آلی با مقادیر ویژه (۰/۴۲)، نیتروژن (۰/۴۱) و ارتفاع (۰/۳۷) از عوامل مؤثر در پراکنش گیاهان بوده است. آنالیز CCA نشان داد در پراکنش پهن‌برگان علفی، ارتفاع با مقادیر ویژه (۰/۳۷)، پتاسیم (۰/۳۵) و رس (۰/۴۴) بیش‌ترین تأثیرگذاری را داشتند و در پراکنش گندمیان، پتاسیم با مقادیر ویژه (۰/۳۵)، pH (۰/۵۸) و کربن آلی (۰/۴۲) از مهم‌ترین عوامل بودند. آنالیز RDA در پراکنش بوته‌ای‌ها نیز نشان داد که شیب با مقادیر ویژه (۰/۴۴)، ارتفاع (۰/۳۷) و درصد شن (۰/۴۶) از مهم‌ترین عوامل بودند. با انجام این تحقیق شناخت پایه از وضعیت پوشش گیاهی در مراتع این مناطق به‌دست آمد. بنابراین، با افزایش دانش فنی، می‌توان برخی اقدامات را برای حفاظت و بهره برداری سیستماتیک و همچنین بازسازی مناطق تخریب شده انجام داد.

کلمات کلیدی: فرم‌های رویشی گیاهان، تجزیه به مؤلفه‌های اصلی، شهرستان کوثر، خصوصیات خاک، تنوع گیاهان