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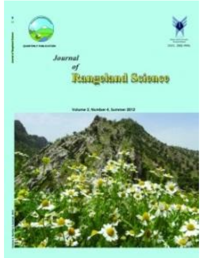

Full Length Article:

Floristic Structure and Vegetation Composition of Boralan Mountainous Rangelands in North-Western Azerbaijan, Iran

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Manuscript Received: 04/11/2012
Manuscript Accepted: 06/04/2013

Abstract. Recognition of habitats and conditions of species presences in different situations can be effective in proper utilization of vegetation. Little is known about the vegetation composition of Boralan Mountain region located in North West of Iran in the border of Turkey and Azerbaijan with the altitude range of 800-2000m. The aim of this study therefore was to investigate the floristic composition quantitatively and analyze the vegetation response to altitudinal gradient conditions of mountain. Firstly, plants were collected by floristic field survey and identified using the floras. To investigate the relationship between the gradients of elevation and vegetation, two transects of 100m were established at every 100m of elevation belts and the percentages of canopy cover and density of species were totally recorded in 20 plot samples using a random plot design. Plant community zones were characterized on the basis of species' cover dominances using cluster analyses. According to this study, the area includes 108 species that were classified into 26 families. Totally, Poeaseae and Asteraceae with 40 percent cover dominance were more frequent than other families. Based on species similarity of elevation classes, the cluster analysis led to four vegetation type groups. The grass group and the shrub group occurred on high altitudes at 1900 m and lowland sites at 800-1300 m, respectively. The results also showed that elevation variations had considerable effects on diversity and richness indices of vegetation groups with the highest number of species at high altitudinal belt. It seems that precipitation improvement and low grazing intensities has mainly caused these changes.

Key words: Vegetation, Plant groups, Shrub, Grass, Biodiversity, Boralan region.

Introduction

Mountains act as refuges for biodiversity in many terrestrial ecosystems (Kluge and Kessler, 2006; Myers *et al*., 2000). Approximately 25% of land surfaces of the Earth and 60% of Iran area are covered by arid and semi-arid mountains which contain at least one third of terrestrial plant species diversities (Barthlott *et al*., 1996; Azarnivand, and Zare Chahoki, 2008). In these regions, vegetation is considered as one of the main components of these natural ecosystems and studies should be conducted on the conservation of endangered species, especially forage endangered species which supply the required forage for domestic livestock. Moreover, the plant diversity pattern at the species level is very important for biodiversity conservation in these regions (Zechmeister and Moser, 2001). With regard to the development of restoration ecology and understanding of biodiversity principles, it is realized that species composition and diversity are fundamental characteristics of ecosystems (Burke, 2001). A set of various factors determines the botanical composition, the related species richness and functional trait variations among the species of the rangeland vegetation (Petchey and Gaston, 2006). Vegetation patterns are affected by the environmental factors more intensively as compared to humid areas (Fossati *et al*., 1999). In addition, vegetation distribution in mountain landscapes is characterized by spatially heterogeneous environmental conditions concerning climate, soil and geology as well as frequency and intensity of disturbance. The physical environment is often regarded as one of the most important factors controlling the spatial heterogeneity of the landscape in mountain areas (Bolstad *et al*., 1998; Tappeiner *et al*., 1998). Because major environmental changes can occur over short distances, mountainous regions are ideal for describing and studying the environmental responses of plant communities (Naqinezhad *et al*., 2009). Various efforts have been made to reveal the vegetation-environment relationships in the arid zone quantitatively (Liu *et al*., 2002). Moreover, studies related to the altitude, pH, slope inclination and vegetation have been carried out in many mountainous habitats (Miserere *et al*., 2003; Rolon and Maltchik, 2006). One important factor is altitude which has a strong influence on the vegetation structure. Changes in species richness along the altitudinal gradients have been considered as the subject of numerous studies (Lomolino, 2001). As such altitudinal gradients are regarded as the most powerful ecological element which affects the natural vegetation structure. Equally, there are not sufficient quantitative data on the distribution and ecology of different plant species, and also the vegetation response to environmental conditions. To understand and manage the rangeland ecosystems effectively, it is important to study the relationships between environmental factors and vegetation. Boralan region is located in northwest of Iran in the border of Turkey and Azerbaijan. Mountainous conditions and wind erosion in lowlands have made it a particular and important area from the viewpoint of controlling the wind erosion. Nevertheless, the recognition of such ecosystems is necessary for achieving the integrated management and detailed information on the vegetation which may lead to conduct the desertification operations for stopping the sand dune extending.

Thus, this study aims to analyze the species composition, floristic diversity and stand structure of vegetation along altitudinal gradient and provide the needed scientific support urgently for the programs of biodiversity conservation. The findings should provide insights into: (1) the conservation value of these mountain habitats, and (2) the effects of altitudinal variations on floristic characteristics and plant diversity and richness in the Boralan Mountains.

Methods and Materials

Study area

Boralan region is located in the northwest of Iran in West Azerbaijan province in the border of two counties, Turkey and Azerbaijan. It is approximately situated at 39°46' to 39°33' N and 44°30' to 44°43' E (Fig. 1). This region climate is cold and semi-arid (Assareh and Akhlaghi, 2009). According to the nearest climatologic station (Makou station), the long-term mean annual rainfall is 294 mm and generally has cool and snowy winters. Maximum and minimum monthly mean temperatures occur in July and January with the degrees of 29.4 and -7.4^{o}C, respectively (Iranian Weather Organization, 2010). The altitudinal range of the study area in the Boralan Mountains is 800-2000 m a.s.l. with the mean annual temperature decrease and the total annual precipitation increase regarding the altitude and dominant aspect of the region in northern slope. The area has been mainly grazed by Makou sheep breed and native goat breed during summers for several years.

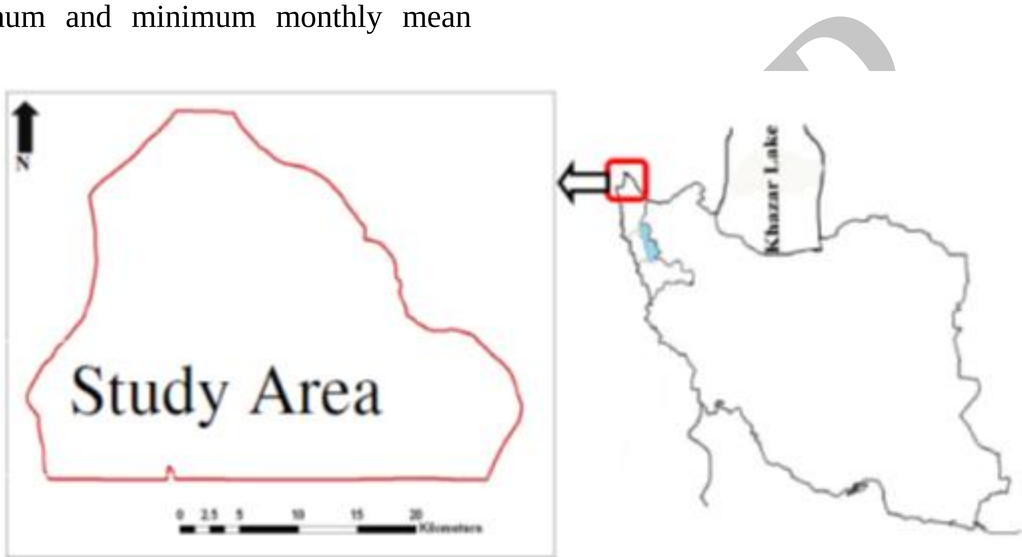

Fig. 1. Study area (Boralan region) in Iran

Floristic surveys

In this study, floristic composition surveys were carried out during the summer of 2009. All plant species were collected during the field surveys and then, they were moved to herbarium of natural resources faculty of Uremia University, Iran. Scientific names of species were specified on the basis of the Flora Iranica and flora of Turkey (Davis, 1972-1984; Rechinger, 1963-2005). So, the species were classified according to the life forms (i.e. phanerophytes, chaemophytes, hemicryptophytes, geophytes and therophytes) of Raunkiaer and Pabot system (Raunkiaer, 1934). It should be mentioned that from the viewpoint of ecological researches, this method is suitable for the classification based upon the tolerance of unfavorable seasons (Raunkiaer, 1934). The growth form (i.e. grass, forbs, shrub and brush) and life longevity (annual, perennial and biennial) of species were noted upon morphological characteristics.

Moreover, the distribution and abundance of the vascular plant groups were evaluated along the altitudinal gradient as completely as possible. In order to determine the effects of elevation gradients on the changes of vegetation structure and its relationship with diversity, we divided the mountain into altitudinal belts spanning 100 vertical meters from the foot hill zone at an elevation of 800m up to the summit at 2000m. At every 100m of elevation classes (belt), two transects of 100 m long were established systematically and the percentages of canopy cover and density of each species were randomly recorded in 10 plots of 1-4 m square on each transects (n=20). Plot sizes varied in each belt and have been determined by the means of minimal area method in each elevation class (Kent & Coker, 1996). Also according to the manual of rangeland assessment plan in the rangelands of Iran (Arzani, 1997), the number of selected plots was 20. It seems that the data gathered from these plots are statistically confident representative of the vegetation communities upon which the numbers to semi-arid regions of Iran are proposed (Mesdaghi, 2002; Basiri *et al*., 1989).

Effects of elevation on vegetation structure

To explore the trends in species richness and diversity along the altitudinal gradient, all the recorded species data in each elevation belt were first allocated to different groups based on their vertical distribution. Then, cluster analysis was performed with the squared Euclidean distance and Single's Method. Each group was named after the highest species value (dominant species) of the belts within the respective group and then, plant communities and their zones were characterized upon their ranges. In each delimited vegetation group, the alpha diversity index of Shannon-Wiener and richness index of Margalef were calculated according to Magurran equation (2003) in PAST ecological software, version 2.17 (Hammer *et al*., 2001).

Statistical Analyses

Based on these indices, the variations of alpha-diversity and richness level were statistically analyzed as the functions of latitude and elevation directions. The data were tested for normality before conducting the statistical analysis using the Anderson Darling test (Steel & Torrie, 1980). One-way ANOVA and Duncan tests were used to examine whether there was a significant difference between species richness and diversity within the identified distinct samples. All statistical analyses were conducted in statistical software SPSS, version 19.

Results

We recorded 108 species from 26 families in the study area. The most abundant families were Poaceae (24%), Asteraceae (16%) and Fabaceae (16%). Other families have less abundant species such as Berberidaceae, Boraginaceae, Caryophyllaceae, Salsolaceae, Convolvulaceae, Brassicaceae, Cupressaceae, Ephedraceae, Euphorbiaceae, Labiatae, Liliaceae, Malvaceae, Papaveraceae, Tamaricaceae and Ulmaceae. Some important species are shown in (Table 1). Perennial species with 70% coverage had the highest plant composition. The biological spectrum of the study area indicates the prevailing of hemicryptophytes (50%) and therophytes (22%). The herbaceous layer of selected study area is consisted of cool-season grasses and forbs including *Agropyron trichophorum, Festuca ovina, Cousinia Commutate*, *Euphorbia* sp., *Cirsium arvense*, *Artemisia aucheri*, *Bromus tomentellus*, with *scattered Artemisia* sp. and *Astragalus* sp. *shrubs*. The results showed that the forbs have the highest percentage of growth forms (Table 2).

The grass community is also viewed as a vegetation type with high adaptability that exists broadly in the study area. Floristic analysis shows that the majority of plants in the study area are perennial. *Calligonum comosum* was the most abundant woody bush species in the low elevations and grasses had more occurrences in the high elevations. The presence of the highest number of *Calligonum comosum* contributes to the soil stabilization.

Table 1. Names of important species in the region

Species Name	Species Name	Species Name
Alhagi camelorum	*Teucrium polium*	*Andropogon schemum*
Kochia prostrata	*Hordeum gluacum*	*Festuca ovina*
Agropyron trichophorum	*Artemisia vugaris*	*Neoa mucronata*
Amygdalus lysiodes	*Peteropyrum aucheri*	*Poa bulosa*
Agropyron cristatum	*Astragalus siliqusus*	*Senecio vulgaris*
Chenopodium album	*Calligonum crinitum*	*Stachys inflata*
Carex stenophylla	*Bromus tectorum*	*Stipa barbata*

Table 2. Grouping of plants into various functional types

Percentage of Life Forms		Percentage of Life Longevity		Percentage of Growth Forms	
Therophytes	23.15	Annual	22.22	Forbs	50.00
Geophytes	1.85	Biennial	5.56	Grasses	22.22
Hemcryphtophyte	50.93	Perennial	70.37	Bushes	12.96
Phanerophytes	13.00			Shrubs	12.04
Chamophyte	12.04				

Classification

Applying data classification techniques produced four vegetation groups. Based on vegetation hierarchical agglomerative clustering of all elevation classes, four different vegetation types with high and significant similarity levels of species composition were determined along an altitudinal gradient. To identify the most representative species at each level, we analyzed the data with regard to the fact that vegetation groups are named after the major species with local dominance or distinctly importance in a certain group of sites. The groups were as follows: A) *Calligonum comosum*, B) *Astragalus siliqusus* and *Salsola kali*, C) *Acanthophyllum spinosum* and *Stipa barbata* and D) *Festuca ovina*, *Agropryon cristatum* and *Bromous tomentellus* (Fig. 2).

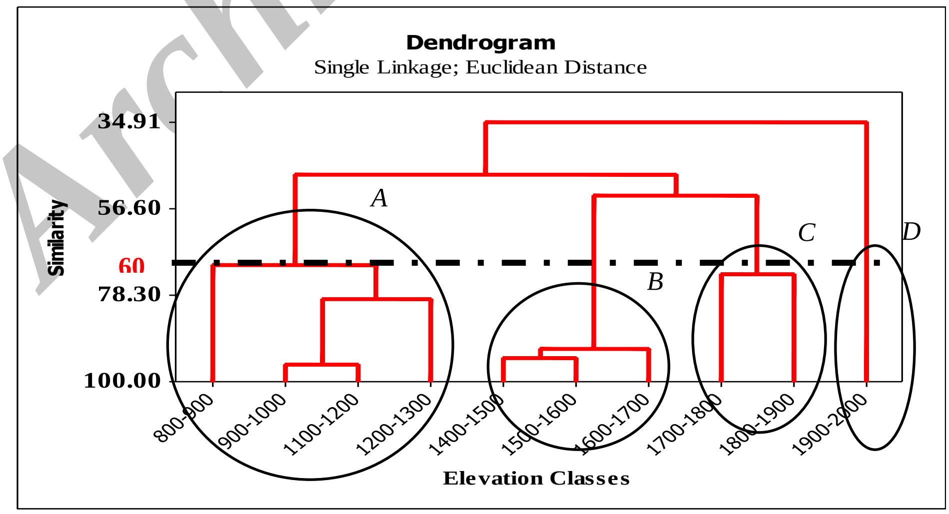

Fig. 2. Dendogram and cluster classification analyses of the species composition similarity of elevation belts; A) *Calligonum comosum*, B) *Astragalus siliquosus* and *Salsola kali*, C) *Acanthophyllum spinosum* and *Stipa barbata* and D) *Festuca ovina*, *Agropryon cristatum* and *Bromous tomentellus*

Diversity and Richness

Species diversity and richness indices were calculated as the mean value for each separated clustering vegetation group (Table 3). The results implied that the elevation in the study area remarkably affects the vegetation distribution and there are significant differences among these four main groups. Duncan test shows that the diversity and richness values are increasing with the increase of altitudinal increments.

Table 3. Variance analyses (ANOVA) of diversity and richness indices of four vegetation structures

Type Name (Based on Dominant Species)	Range asl.(m)	Shannon-Winner	Richness (Margalef)
Caligonum comosum	800-1400	1.21 ± 0.030 c	0.65 ±0.037 d
Astragalus siliquosus, Salsola kali	1400-1700	1.50 ± 0.012 b	0.84 ± 0.021 c
Acanthophyllum spinosum, Stipa barbata	1700-1900	1.60 ± 0.070 b	1.10 ±0.032 b
Festuca ovina, Agropryon cristatum, Bromous tomentellus	1900-2000	2.01 ± 0.061 a	1.30±0.054 a

* not significant at α=0.05

Relationships of Vegetation Characteristics and Elevation

Spatial distribution of vegetation communities in the region can be imagined in an ecogram (Fig. 3). This figure shows that as the elevation and consequently precipitation increase, the diversity and richness indices are increased. Also, we observed the shift of bush land in lowlands to grassland in highland.

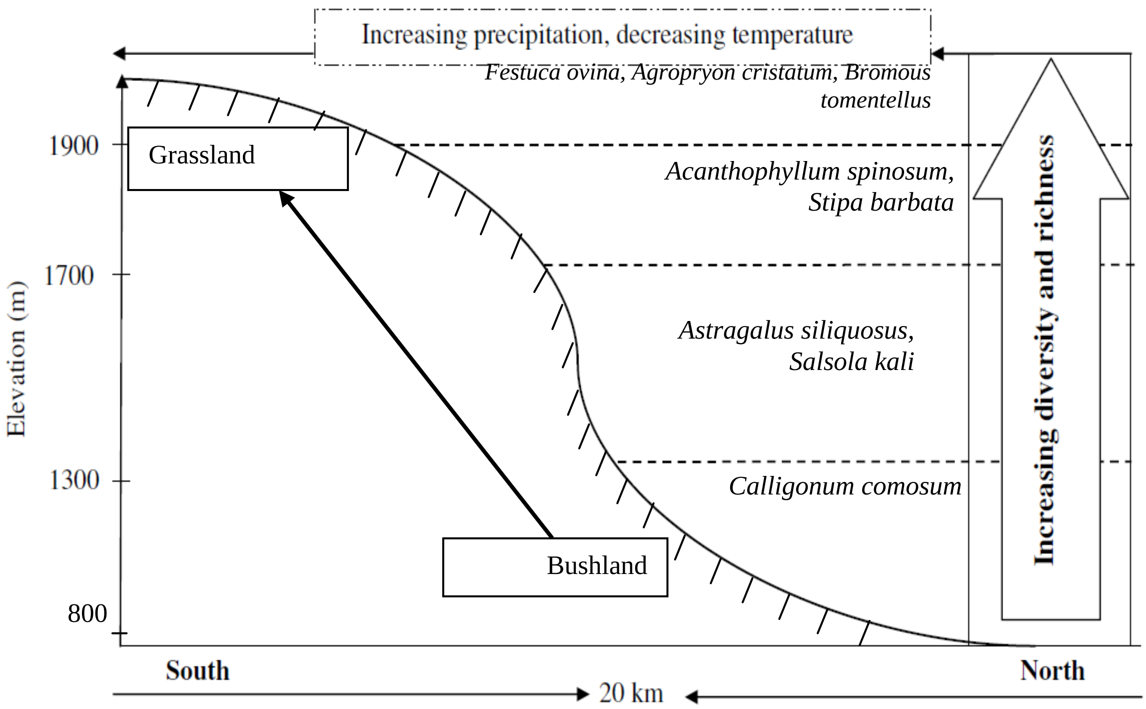

Fig. 3. Ecogram of vegetation communities in Boralan region

Discussion

Floristic composition of vascular plants was studied in the northwest of semi-arid Boralan Mountains. The occurrence of 108 vascular plant species clearly demonstrates that the Boralan Mountains have high floristic richness and considerable conservation importance. Therefore, it is noted that a detailed management plan can be developed for the region to ensure the sustainable utilization and conservation of the area vegetation and soil. Species richness and diversity are high due to the area soil, erratic rainfall and climate as well as variations in altitude and habitat for Boralan region.

The floristic composition analysis showed that Poaceae which is the largest family is represented by the highest number of species in the study area. Another large family is Asteraceae represented by 18 species. As illustrated before, high presences of Poaceae (24%) and Asteraceae (16 %) correspond with the most floras of the region regarded as the largest family in the floras of arid to semi-arid regions (Goldblatt & Manning, 2000). In similar research done by Rasouli (2007) to identify medicinal plants in Kiamaki Mountain of North Eastern Azerbaijan province, it was found that Lamiaceae and Asteraceae were the most important medicinal families in the study region. Also, Mosavi (2004) showed that Asteraceae, Lamiaceae and Rosaceae were the most important medicinal families in Zanjan province in vicinity of the area with almost same climate conditions. Moreover, floristic analysis shows that the frequency of perennial plants were higher in the study area followed by annual species while the lower group was biennial species.

It is clear that vegetation is much more than a list of plant species. This floristic account along with the studies done on plant communities (Brown & Bezuidenhout, 2000) serves as a basis to develop a habitat management plan for the Boralan region. Thus, we investigated the floristic composition, vegetation structure and its relationships with the elevation in Boralan region. Analyses of transect vegetation data by the means of classification techniques highlighted four primary vegetation groups along with the elevation gradient zones in Boralan region and the result showed that the elevation was one of the main factors affecting the diversity and distribution of vegetation groups. A comparison of mean value of Shannon-Weiner index for each vegetation type suggests that the lowest value (1.20) and the highest value (2.01) were found in the lowland dominated by *Calligonum comosum* shrubs and high land with grass group dominated by *Festuca ovina* and *Agropyron cristatum*, respectively. Similar results were obtained by Aronson and Shmida (1992). Positive shifts of elevation on a regional scale are directly correlated with rainfall amounts and temperature (Korner, 2003) and they represent one of the most obvious influences of mountains on plant diversity (Grytnes and Beaman, 2006). Plant species may also use mountainous areas to protect themselves (refuges) from human-induced disturbances (Burke, 2003). Hoffman and Cowling (1987) noted that an overall increase in grass cover from low to high elevations is correlated with an overall increase in rainfall. Also, the highest species number in the high elevation may be associated with the heterogeneity of disturbance. Heterogeneity of microsites can influence the distribution and coexistence of plant species; therefore, it can affect the floristic composition. It should be pointed out that predicting the response of plant communities to variations of resources and disturbance is still a challenge because the findings depend on how ecological gradients are characterized.

However, a complete species list with the information on the distribution of each species always is not available and a detailed survey of flora is limited or even impossible in many cases due to the lack of time, research funds and/or unavailability of researchers with enough professional knowledge.

In overall, this research information will be used to develop conservation policies for the mountains of the Boralan which is an important and vulnerable habitat. This paper also points out the need for managerial practices to conserve plant diversity in the mountains. Also, the results of the present study demonstrate the need for further studies on the diversity and changing vegetation of the Boralan region. It indicates that the mountainous Boralan region forms an important conservation area and is a noteworthy region of biological diversity, species richness, ecosystem complexity and genetic variation.

Overall results showed that Boralan region comprises diverse ecosystems and presents very interesting aspects for vegetation studies and also, it is needed to investigate the effects of other environmental factors such as geology, soil, species distribution and vegetation communities in future researches.

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