Journal of Biological Studies **JBS**
https://onlinejbs.com/ Vol.1(2): 49-58, 2018
ISSN 2209-2560

Research Article

Vegetation Classification in Relation to Environmental Factors, in Fars Province, Iran

Leila Moradipour[a,*], Hassan Pour Babaei[b], Ahmad Hatami[c]

[a] Department forestry, Faculty of Natural resources, University of Guilan, Iran
[b] Department forestry, Faculty of Natural resources, University of Guilan, Iran
[c] Research Center of Agricultural and Natural Resources of Shiraz, Iran
* Corresponding author: moradiporleila@gmail.com

Received 17 May 2018; Accepted 27 May 2018; Published online 4 June 2018

Abstract

The study was carried out in the oak forests that is located in the Southwest part of Iran. The objective of this research was to determine the plant ecological groups and site classification in this region. Data were collected from 96 sample plot using the systematic-random method. The size of sampling plot was 20 m× 50 m for the tree and shrub layers, and 8 m × 8 m for the herbaceous layer. In each plot, topographical factors (elevation, slope, aspect) and percent cover of herbaceous and the crown cover of tree species were recorded. Multivariate analysis methods were used to classify and determine the relationship between species composition and environmental factors. The results of TWINSPAN and MRPP analysis showed that eight groups were recognized. The most important environmental factors associated with plant composition in oak communities were the slope, elevation, aspect, respectively. The ordination results (HRDA) indicated that the topography factors influenced on the establishment of indicator species. Furthermore, they were one of the limiting factors of the growth, presence, and absence of woody and herbaceous species.

Keywords: Oak, Vegetation cover, Topographical factors, Multivariate analysis, Zagros

Introduction

The vegetation cover in mountain areas is very important Vegetation cover affects local and regional climate and reduces erosion.The economy of local communities and millions' people in mountain areas depends on forests and plants. They also effectively protect people against natural hazards such as landslides, debris flows, and floods (Brang et al., 2001). Zagros forests are one of the most important biological resources of Iran, particularly in terms of breadth, plant and animal species, sub-products, and genetic reserves of meadows (Pour babaei *et al*,. 2014). Regarding the role of vegetation in nature and the balance of natural ecosystems, understanding the interactions between plants and environmental factors is essential for sustainability and preservation of ecosystems (Mozafariyan, 1382). Therefore, understanding of distribution and patterns of vegetation along with the affecting factors in those areas are important and have been studied by many researchers (Adel et al., 2014; Alvani Nejad et al., 2012). Plant species grow and survival under a specific ecological condition, so the presence of a species in a habitat means nutrition, humidity, temperature, light necessaries providence (Wang, 2000). Plant communities are dynamic inherently and change on factors environmental such as climate, topography and soil changed of dynamics the Plant communities (Dirnböck et al., 2002). Description and vegetation classification as pursue many goals for example: monitoring plant communities, Planning for conservation, Protection of forests, register species needs, determine the species at risk, and the development red List species to protect them (Rodríguez et al,. 2011). Classification of plant communities shows their relationship with environmental factors and One of the ways that specify the structure of ecosystem (Peters et al,. 2009). The use classification and gradient analysis of vegetation provides a clear picture of the relationship between groups ecological and environmental around in the landscape (Enright et al., 2005). Plants that are presence frequently together in areas of similar compounds from soil moisture, nutrients, light and other factors are the same ecological needs and tolerance in a group, this groups in ecology call ecological species groups (Barnes., 1982).). Plant communities are recognized using diagnostic species (Westhoff and Van der Maarel 1978). Ecological species groups represent the relation between plant community and site environment. Variations in soil resources are foundational and important to the distribution and abundance of plants and the communities that they form on specific sites. In addition, in phytosociological studies, the concept of ecological species groups is useful in classifying natural communities, determining changes in vegetation, understanding vegetation distribution and environmental factors, estimating species niches, calibrating indicator value for species, modeling potential distribution of species and plant communities and assessing habitat quality (Asri, 1995; Najafi et al., 2007; Cox et al., 1973). Indicator species can be among the most sensitive species to environmental change or degradation in a region, acting as an early warning for monitoring. Also, they can be used to predict differences in site productivity, which can be used to assess site suitability for species and support decision making in forest restoration, management and planning (Fontaine et al., 2007). The use of natural vegetation as an indicator of site quality provides good results due to the close relationship it has with abiotic site characteristics (Waring et al., 2006). Zagros forests with an area of 5 million hectares cover ca. 40 % of Iran's forests (Sagheb-talebi et al, 2004), These forests are widest forest regions of Iran. It shows the value of such studies.. This study aimed to identify ecological groups factors with relation to topography factors (slope, elevation, aspect) were to manage in accordance with the ecological conditions, assuming there was no significant relationship between topography and the establishment of ecological species groups.

Materials and methods

Study area

This research was carried out in mountain area Kouhmare Sorkhi in the Malé Galle protected area. This area is located at south Zagros, Fars province. Which is about 300 ha. The study area is located between 51° 33' 37″ - 52 ° 25' 56″ E longitude, 29°15' 57″ - 30°36' 5″ N latitude in the Southwest part of Iran. This region has semiarid temperate climate with the average annual precipitation of 593/4 mm and the mean annual temperature of 15.6 °C. In the describe area, the dominant forest species is *Quercus brantii* Lindl. In addition, some species such as *Pistacia atlantica* Desf, *Amygdalus scoparia* Spach, *Pistacia khinjuk* Stocks, *Acer monspessulanum* L, *Cerasus microcarpa*, and *Daphne mucronata Royle* have were also found. *Quercus brantii* (covering more than 50% of the Zagros forest area) is the most important tree species of this region growing at 1000-2000 m a.s.l. (SaghebTalebi, 2004).

Methods

For this purpose, a random systematic 150 m × 150m survey gird was used to establish 96 plots, in the four elevational classes. The size of sampling plots was 1000 m^2 for the tree and shrub species and 64 m^2 for herbaceous species**.** We used a sub-sampling method according to the Whittaker nested plot sampling protocol and minimal areas method (Cain, 1938). Aspect data were transformed using the equation $A = \cos(45 - A) + 1$(Beers, and Dress, 1986). For a better comparison of the data, while the elevation of the area is divided into four height classes

(1050-1150, 1150-1250, 1250-1350, 1350-1450), the slope of it is divided into three classes (0-30, 30-60, 60 <). Dominant aspect was measured in two aspects (North East and South West). To effective analysis of the species and environmental factors, both classification and ordination are employed. These considerations are applied by PC _ORD5 and CANOCO 4/5 software. In order to reduce the subjective factor, vegetation classification is applied by numerical methods as a method of objective. For classification, Two-Way Indicator Species Analysis (TWINSPAN) is used. At first, TWINSPAN analysis was carried out in order to classify vegetation by using PC-ORD software (Me Cune, 1999). The main idea of TWINSPAN analysis is based on primary phytosociology hypothesis that believes each group of samples is distinguished by a group of different species. These species are placed in bilateral table. In this method, plots are compared based on presence or absence of species and factor that called pseudo species and plots which have more similarity, are grouped into one group. Stopping point for the formation of groups was considered the third level based on experience and the highest similarity with the conditions of the study area (Mc Nab et al., 1999). Group names were considered based on indicator species in each group. (Pitkanen, 1998). In plant communities ordination, Deterended Correspondence Analysis (DCA) is used to obtain peripheral length of gradient. Since the obtained gradient length is less than 3 and the number of measured environmental variables is less than 4, the ordination is done using Hybrid Redundancy Analysis (HRDA). HRDA is a direct and indirect linear method in which species and environmental factors are shown by some arrows (Tahmasebi, 2011; Lepš and Šmilauer, 2003). After classification and identification of ecological groups, Indicator Species Analysis (ISA) is employed to determine the important species of each group. Indeed, if the value of P obtained from Mont Carlo examination is less than 0.05, species with the most important species (IVmax) are defined as the group species indexes (Buck-Diaz and Evens, 2011). In order to comparison the ecological groups from the vegetation composition and environmental variables, Multiple Response Permutation Analysis (MRPP) is employed (Mielke and Berry, 2007). In this comparison, if, statistically, there are no significant differences between the two groups, they will be merged. It should be noticed that MRPP is a nonparametric approach. The merit of this analysis is that the assumptions of the normal distribution of vegetation data and the homogeneity of variances, which rarely occur in vegetation data, is not necessary (Legendre and Gallagher, 1998). The statistics and indicators of this analysis are as follows :T statistic: It shows the degree of differentiation of groups. The more T is negative, the greater is the distance between the groups. A indicator: It denotes the homogeneity between groups. If the value of A is one, it reveals that, among the groups, all sample portions are the same in terms of frequency and the presence or absence of species or environment variables. By increasing the homogeneity between groups, the value of this indicator tends to be negative.

P statistic: Indicating how much difference between the two delta is due to chance. If it is less than 0.05, it means that the difference between groups is significant and the integration of them is not required (Me cune and Mefford, 1997).

Results and Discussion

According to the results of the MRPP (Table 1), there is a difference among all groups in terms of both vegetation composition and environmental factors. While there are more differences in terms of the vegetation composition between the first and third, second and seventh, and third and seventh groups compared to the second and sixth groups (A= 0/03), and fourth and eight groups are more different in terms of environmental factors (A= -3/1). Thereupon, the groups are well separated, no group is integrated into the others, and the eight ecological groups resulted from TWINSPAN are confirmed.

Table 1. Results of Multiple Response Permutation (MRPP) Analysis

results Based on topographic factors			results Based on vegetation composition			**Groups**
P	A statistic	T statistic	P	A statistic	T statistic	
0/00013	0/2	-4/45	0/000	0/051	-6/25	2,1
0/001	0/21	-4/6	0/000	0/079	-9/79	3,1
0/0001	0/19	-4/18	0/000	0/072	-8/81	4,1
0/00014	0/2	-4/41	0/000	0/069	-8/73	5,1
0/0001	0/11	-2/7	0/000	0/055	-7/46	6,1
0/0001	0/19	-4/3	0/000	0/071	-9/6	7,1
0/0001	0/163	-3/69	0/000	0/071	-8/86	8,1
0/0001	0/29	-6/07	0/000	0/052	-6/02	3,2
0/0002	0/26	-5/6	0/000	0/043	-4/87	4,2
0/0001	0/29	-6/17	0/000	0/047	- 5/51	5,2
0/0001	0/22	-4/9	0/0001	0/03	-4/1	6,2
0/0001	0/27	-6/01	0/000	0/071	-9/071	7,2
0/00003	0/24	-5/3	0/0001	0/04	-5/1	8,2
0/0001	0/26	-5/5	0/000	0/071	-8/11	4,3
0/000	0/31	-6/3	0/000	0/069	-8/16	5,3
0/0001	0/27	-6/1	0/000	0/05	-7/02	6,3
0/0001	0/27	-6/1	0/000	0/071	-9/01	7,3
0/00004	0/23	-5/1	0/000	0/07	-7/09	8,3
0/0001	0/29	-6/1	0/000	0/06	-7/43	5,4
0/001	0/2	-4/6	0/000	0/051	-6/31	6,4
0/00002	0/25	-5/7	0/000	0/06	-8/2	7,4
0/007	-3/1	-3/2	0/000	0/06	-7/2	8,4
0/0001	0/22	-4/9	0/000	0/04	-5/2	6/5
0/0001	0/28	-6/1	0/000	0/058	-7/71	7,5
0/0001	0/24	-5/7	0/000	0/06	-7/3	8,5
0/002	0/2	-4/8	0/000	0/04	-6/62	7,6
0/0001	0/18	-4/1	0/000	0/05	-6/4	8,6
0/00003	0/23	-5/3	0/000	0/06	-7/97	8,7

A total of 162 plant species and 43 families and 122 genera were identified in this research. In this research, 74 species were identified species indicator. 30 species indicator have been introduced in Table 2. Which is included: five trees, three shrubs, two bushs, and twenty herbaceous. The herbs are generally annual.

Table 2. Results of ISA and Monte Carlo permutation test (p <0.05)

Indicaitor Speices	**IV**	**p**	**Groups**							
			1	2	3	4	5	6	7	8
Acer monspessulanum	55/3	0/009			*					
Ajuga astro-iranica	43/5	0/012				*				
Artemisia ausherii	32/3	0/004					*			
Astragalus glaucacanthus	47/5	0/001			*					
Avena fatua	27/6	0/028								
Amygdalus scoparia	59/8	0/001	*							
Anthemis altissima	38/9	0/0041						*		
Brassica deflexa	36/4	0/042				*				
Bongardia chrysogonum	34/4	0/003			*					
Carduus arabicus	45/3	0/0001		*						
Crepis sancta	42/3	0/002		*						
Cerasus microcarpa	41/8	0/0001								*
Daphne mucronata	46/1	0/0085					*			
Ebenus stellata	42/9	0/0091					*			
Erodium gruinum	34/2	0/042								*
Erodium cicularium	40/46	0/0001							*	
Lactuca serriola	45/3	0/0001	*							
Muscari tenuiflorum	48/2	0/0066				*				
Medicago minima	33/4	0/008						*		
Otostegia persica	47/9	0/0043							*	
Oliveria decumbens	46/1	0/004	*							
Plantago psyllium	35/7	0/002			*					
Pistacia atlantica	64/3	0/001				*				
Pimpinella barbata	36/8	0/013								*
Plantago lagopus	43/6	0/005							*	
Pistacia khinjuk	51/4	0/002						*		
Quercus brantii	61/5	0/008		*						
Tulipa stylosa	2/29	0/052								*
Ziziphus nummularia	40/46	0/001					*			
Ziziphora tenuir	29/8	0/002							*	

HRDA is a method that has a linear response and is one of the hybrid tests. If the number of measured variables is less than 4 and the environmental variables cannot justify an important contribution of the variance, hybrid methods are used. It should be noted that the selection of direct and indirect methods depends on the goals of the researcher and the existence of the environmental variables matrix. (Naderi and Sharafatmandrad, 2017). However, the choice of linear and nonlinear approaches not only depends on the length of the environmental gradient, it depends on variety of beta and its calculation as well. Ordination methods provide efficient models for the analysis and graphical visualization of the relationships between a large number of plant species with environmental variables, so that their position in the graphical diagrams is a representative of their homogeneity (Tahmasebi, 2011). While a larger arrow has a more positive or negative effect, a shorter arrow has a less positive and negative effect. Tow align arrows represent the positive effect and two opposing arrows with a maximum angle of 180 degrees indicate a negative and reciprocal effect of the two parameters (Tahmasebi, 2011, Amiri et al., 2008). In HRDA analysis, the species that are in a quadrant are more correlated. Further, species that are in opposite quadrants (one is 180 degrees lag behind another) have a negative correlation, and species that are 90 degrees apart have a zero correlation. When a species has a correlation with a factor, with the increase of the factor, the percentage of the species' present increases. On the contrary, when there is a negative correlation between the environmental factors and a species, with the increase of the factor, the percentage of the species' present decreases. When there is no correlation or a negative correlation between a species and the environmental factor, that factor is a limiting factor for growth and presence of the species. Indeed, when there is no correlation (the angle between the species and the environmental factors is 90 degrees) or negative correlation (the angle between the arrows of species and the environmental factors is 180 degrees) between topographical factors and vegetation species, the factor is a limiting factor for growth and presence of the species (Naderi and Sharafatmandrad, 2017, Leps and Smilauer, 2003, Tahmasebi, 2011, Monitoring, 2011).

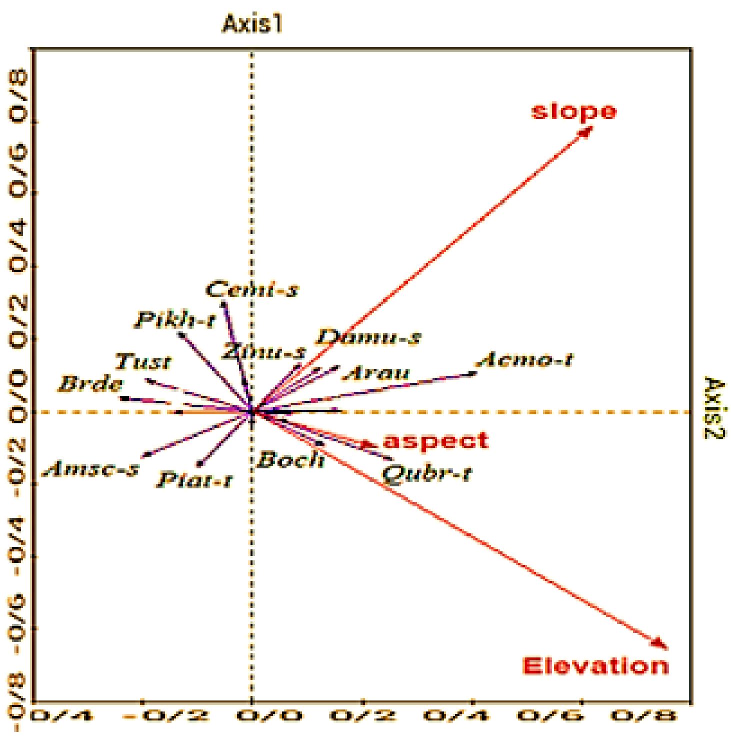

Fig 1. Ordination diagram showing the result of HRDA analysis of vegetation and thopographycal factors. Qubr-t: *Quercus brantii*, Piat-t: *Pistacia atlantica*, Amsc-s: *Amygdalus scoparia*, Pikh-t: *Pistacia khinjuk*, Cemi-s: *Cerasus microcarpa*, Zinu-s: *Ziziphus nummularia*, Damu-s: *Daphne Mucronata*, Acmo-t: *Acer Monspessulanum*, Arau: *Artmisia aucheri*, Boch: *Bongardia chrysognum*, Brde: *Brassica deflexa*, Tust: *Tulipa stylosa*.

Based on the results obtained from HRDA analysis the first and second axis which accounted for 85/6% of the change and variation. In cases where there is no correlation or very poor correlation between environmental factors and plots, the factors are limiting factors for growth and presence of the plant species of those plots. The *Brassica deflexa* has a negative correlation with aspect and elevation factors (Fig 1), and at the same time, is not correlated with slope factor. As described above, the relationship between species and sample plots with environmental factors can be interpreted. From shrub species, *Daphne Mucronata*, and *ZIziphus Mummularia* from the fifth group (Table 2) are correlated with slope factor (Fig 1). Conversely, they are not correlated with elevation and aspect factors. While the *Pistacia atlantica* and *Amygdalus scoparia* species are negative correlation with slope factor, *Pistacia khinjuk* and *Cerasus microcarpa* species have a negative correlation with the elevation and aspect factors. Furthermore, *Cerasus microcarpa* and *Pistacia khinjuk* speacies are slightly correlated with slope factor (Fig 1). In a study by Tavakoli Neco *et al*. (2012) aspect is the most important dispersion factor of *Amygdalus Scoparia* species. Based on this study, *Acer Monspessulanum* species has a moderate correlation with the all three factors. In addition (Fig 1), aspect and elevation have approximately equal influence on *Acer monspessulanum* species, however, this species has a positive correlation with the slope, especially at elevations, has a major influence on the formation and development of plant communities (Ghorbani *et al*., 2008). Although *Acer monspessulanum* species is generally known as a xerophile species, it has a good ecological flexibility. Despite the fact that there is a dry and low rainfall climate in the northern, western and eastern directions of Firozabad, Shiraz, the height of this species in this area is as equal as the same species grown in Sepidan. The humidity and low rainfall of Sepidan is compensated by the aspect, one of the ecological factor (Pourbabaei *et al*., 2014). Hence, aspect and elevation have influence on establishment of this species as an indicator species in the third group. *Quercus brantii* species with elevation and aspect factors is well correlated (Fig 1). However, it has a lower correlation with slope factor. Owing to the presence of this species in the steep and far-reaching slopes, and thus, reduction of degradation factors such as human impact and animal grazing, the slope has had a very significant influence on the distribution and dispersion of this species as a dominant species of the region. *Tulipa stylosa* species, from the eighth group, has a negative correlation with aspect and elevation factors and no correlation with slope factor. *Artmisia aucheri*, from the fifth group (Table 2), is highly correlated with slope factor (Fig 1). It should be noted that, the plots, where this species is present, mostly are rocky and boulder (Mohtashmnnia *et al.*, 2007). Topographical factors could be interpreted as a restrictor factor for this species presence. Vegetation can be a reflection of many environmental factors (Microclimate, soil, human impact) that their direct measurement is costly (Daubenmire, 1976).

Soil texture, acidity, soil moisture, and lime in plain lands, slopes, and topographical elevaitions are of the most important environmental factors affecting the establishment and dispersion of vegetation ecological groups. As one approaches more and more from plains towards highlands, while the intensity of the edaphic factors decreases, the influence of topographic factors increases. *Ziziphus nummularia* species, one of the fifth group indicators, grows in very shallow soils such as plains, sand dunes, rocky areas and valleys up to 1700 meters above the sea level and creates a favorable condition for herbaceous species' growth (Pandey *et al*, 2010). *Bongardia chrysognum* species, one of the most important species of the third group (Table 2), can be grown in sandy drainage and sunshiny soil. It also grows in the mountain slopes where the summer is dry and the winter is snowy (Lord, 2003). This species has a strong correlation with aspect and elevaition factors (Fig 1). However, it is not correlated with slope factor. Topographic factors of the region have had influence on the presence and absence of plant species, especially the indicator species of these eight groups. According to the results of ordination, slope and elevation are the most influential topographic factors on the establishment of species. However, the aspect and elevation have a strong correlation with the dominant species of the area (*Quercus brantii* Lindl). Since the flora of each region is a reflection of various ecosystem factors during the geological period, vegetation studies in relation to environmental factors is very importance. Inasmuch as the case study is a part of the protected areas in Iran, the importance of this research is becoming more and more evident. Most plant species are annual. Annual plants increase when the weather is favorable for their growth and destruction of vegetation occurs in the forest. (Veiskarami *et al*., 2012). We found that topographic variables were useful in separating eight ecological species groups. The results of this study are consistent with Adel *et al*. (2014) and Alvani Nejad *et al*. (2012). Topography is the principal controlling factor in vegetation growth and that the type of soils and the amount of rainfalls play secondary roles at the scale of hillslopes (O'Longhlin 1981; Wood *et al*. 1988; Dawes and Short 1994). Elevation, aspect, and slope are the three main topographic factors that control the distribution and patterns of vegetation in mountain areas (Titshall *et al*. 2000). So, Elevation along with aspect in many respects determines the microclimate and thus large-scale spatial distribution and patterns of vegetation (Day and Monk 1974; Busing *et al*., 1992).

Conclusion

The results of this study showed that vegetation can be used as a suitable tool for classification of habitats with heterogeneous characteristics. Eight ecological species groups (eight sites) were recognized based on the multivariate analysis (TWINSPAN, MRPP, HRDA, i.e.). The environmental factors of slope, elevation, aspect were the most important factors in separaiting ecological species groups respectively. So, According to the results of this study,topography is of the most important environmental factors highly affecting the formation and establishment of vegetation communities. Thus, the zero hypothesis is rejected and the initial supposition, i.e., the effect of topography on the establishment of ecological species group, is accepted. Generally, vegetation analysis and perception of the impact of different factors such as topography, soil, climate, fire, and human impact on the establishment of vegetation and their ecological conditions is considered as a basic science in understanding habitats and ecosystems. Thereupon, paying a special attention to such studies for plant communities' recognition and ecological groups in relation to environmental factors in development and management of vegetation plans such as: conservation, forestry, reforestation, forestation is necessary.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

Adel M. N., Pourbabaei, H. & Dey, D.D. (2014) Ecological species group Environmental factors relationships in unharvested beech forests in the north of Iran. Ecological engineering, 69: 1-7. https://doi.org/10.1016/j.ecoleng.2014.03.008

Alvani N.S., Aghayi, R., Basiri, R. & Zolfaghari, R. (2012) Relationship between plant ecological groups and environmental factors (Case study: Woods habitat in southeast of Yasuj). Journal of Applied Ecology, 1 (2): 63-53. (In Persian).

Amiri F. A. Z. E. L., Khajeddin, J. & Mokhtari, K. (2008) Determination of effective environmental factors on Bromus tomentellus species establishment using ordination method. JWSS-Isfahan University of Technology, 12(44): 347-356. (In Persian).

Asri, Y. (1995) Phytososciology, Research Institute of Forestry and Rangeland285pp.

Beers T.W., P.E. Dress. & Wensel L.C. (1996) Aspect transformation in site productivity research. Journal of Forestry, 80: 493–498.

Brang, P., Schönenberger, W., Ott, E. & Gardner, B. A. R. R. Y. (2001) Forests as protection from natural hazards. The forests handbook, *2*: 53-81.

Busing, R. T., White, P. S. & MacKenzie, M. D. (1993) Gradient analysis of old spruce–fir forests of the Great Smoky Mountains circa 1935. Canadian Journal of Botany, *71*(7): 951-958. https://doi.org/10.1139/b93-107

Cain S.A. (1938) The species–area curve. Am. Midland Nat. 19: 81–573.

Cox C, Ian N. H & Moore Peter .D. (1973) Biogeography: An ecological and evolutionary approach. Blackwell Scientific Publication. 179 pp.

Dawes, W. R., & Short, D. (1994) The significance of topology for modeling the surface hydrology of fluvial landscapes. Water Resources Research, *30*(4): 1045-1055. https://doi.org/10.1029/93WR02479

Daubenmire, R. F. (1976) The use of vegetation in assessing the productivity of forest lands. The botanical review, 42(2): 115-143. https://doi.org/10.1007/BF02860720

Day, F. P., & Monk, C. D. (1974)Vegetation patterns on a southern Appalachian watershed. Ecology, 55(5): 1064-1074. https://doi.org/10.2307/1940356

Dirnböck, T., Hobbs, R. J., Lambeck, R. J., & Caccetta, P. A. (2002) Vegetation distribution in relation to topographically driven processes in southwestern Australia. Applied Vegetation Science, *5*(1): 147-158. https://doi.org/10.1111/j.1654-109X.2002.tb00544.x

Fontaine, M., Aerts, R., Özkan, K., Mert, A., Gülsoy, S., Süel, H., Muys, B. (2007) Elevation and exposition rather than soil types determine communities and site suitability in Mediterranean mountain forests of southern Anatolia, Turkey. Forest Ecology and Management, 247(1-3): 18-25. https://doi.org/10.1016/j.foreco.2007.04.021

Lord, T. (2003) Flora: the gardener's bible: more than 20,000 garden plants from around the world. Cassell.

Legendre, P. & Legendre, L. (1998) Numerical ecology: second English edition. Developments in environmental modelling, 20.

Lepš, J. & Šmilauer, P. (2003) Multivariate analysis of ecological data using CANOCO. Cambridge university press.

Mccune, B. & Mefford, M. J. (1997) PC-ORD. Versión 3.0. MjM Softwre Design. Gleneden Beach, Oregon.

McNab, W. H., Browning, S. A., Simon, S. A., & Fouts, P. E. (1999) An unconventional approach to ecosystem unit classification in western North Carolina, USA. Forest Ecology and Management, 114(2-3): 405-420. https://doi.org/10.1016/S0378-1127(98)00371-5

Mozaffarian V. 2003. Trees and Segments of Iran, Tehran, Farhang-e-Moosere Publishing House, 671 pages. (In Persian).

Mohtashamnia, S., Zahedi, G. & Arzani, H. (2007). Vegetation ordination of step pic rangelands in relation to edaphical and physiographical factors (case study: Abadeh rangelands, Fars). (In Persian).

Naderi, H. & Sharafatmandrad, M. (2017) Change of Species Diversity in Vascular Plants Across Ecological Species Groups. Journal of Rangeland Science, 7(2): 107-121.

Najafi tire Shabankareh k., Jalili, AH., Khorasani, N., Asri,Y & jamzad, Z. (2007) Plant associations of Geno protected area. Pajouhesh & Sazandegi No 75 pp: 17-27.

O'loughlin, E. M. (1981) Saturation regions in catchments and their relations to soil and topographic properties. Journal of hydrology, 53(3-4): 229-246. https://doi.org/10.1016/0022-1694(81)90003-2

Pandey, A., Singh, R., Radhamani, J., & Bhandari, D. C. (2010) Exploring the potential of Ziziphus nummularia (Burm. f.) Wight et Arn. from drier regions of India. Genetic resources and crop evolution, 57(6): 929-936. https://doi.org/10.1007/s10722-010-9566-4

Peters, J., Verhoest, N. E., Samson, R., Van Meirvenne, M., Cockx, L., & De Baets, B. (2009) Uncertainty propagation in vegetation distribution models based on ensemble classifiers. Ecological Modelling, 220(6):791-804. https://doi.org/10.1016/j.ecolmodel.2008.12.022

Pitkänen, S. (1998) The use of diversity indices to assess the diversity of vegetation in managed boreal forests. Forest ecology and management, 112(1-2): 121-137. https://doi.org/10.1016/S0378-1127(98)00319-3

Pourbabai H., Babaian, M., Foundation, M. & Adil, M. (1393) Autecology of Montpellier maple (Acer monspessulanum subsp. cinerascens) in forests of Fars Province. Journal of Plant Research, 27 (3): 385-376.

Pourbabaei H., Cheraghi, R., Ebrahimi, S. (2014) The Study of Woody Species Structure and Diversity in the Persian Oak (Quercus brantii Lindl.) Site, Dashtak, Yasouj, Western Iran, Journal of Zagros Forests Researches, 2(1):1-17. (In Persian).

Rodríguez, J. P., Rodriguez-Clark, K. M., Baillie, J. E., Ash, N., Benson, J., Boucher, T., .. & Keith, D. A. (2011) Establishing IUCN red list criteria for threatened ecosystems. Conservation Biology, 25(1): 21-29.

Saghebtalebi Kh., Sajedi, D & Yazdanian, F. (2004) A look at the forests of Iran, Forest research institute and pastures, Tehran, 56 pp. (In Persian).

Tahmasebi P. (2011) Ordination (Multivariate Analysis in Environmental Sciences and Natural Resources). Shahrekord University Press, 196 pp.

Tavakoli Neko H., Pourmeydani, A., Adnani, S.M & Sagheb-Talebi, KH. (2012) Impact of some important ecological factors on presence of Mountain Almond (Amygdalus scoparia Spach.) in Qom province, Iran. Iranian Journal of Forest and Poplar Research, 19(4): 524-542. (In Persian).

Titshall L.W., T.G. O'Connor, T.G. & Morris, C.D. (2000) Effect of long-term exclusion of fire and herbivory on the soils and vegetation of sour grassland. African Journal of Range and Forage Science, 17: 70–80. https://doi.org/10.2989/10220110009485742

Veiskarami Z., B. Pilehvar, J. Soosani, G.H. Veiskarami, H. Zeinivand, H. (2012) Study of flora, life form and chorology of Perk forest in Lorestan province, Iran. Natural ecosystems of iran. 3(1): 27-38. (In Persian).

Wang, G. G. (2000) Use of understory vegetation in classifying soil moisture and nutrient regimes. Forest Ecology and Management, 129(1-3): 93-100.

Wood, E. F., Sivapalan, M., Beven, K., & Band, L. (1988) Effects of spatial variability and scale with implications to hydrologic modeling. Journal of hydrology, 102(1-4): 29-47.

Waring, R. H., Milner, K. S., Jolly, W. M., Phillips, L., & McWethy, D. (2006) Assessment of site index and forest growth capacity across the Pacific and Inland Northwest USA with a MODIS satellite-derived vegetation index. Forest Ecology and Management, 228(1-3): 285-291.