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Phytosociological Study in *Quercus libani* Oliv.'s Site by Analyzing Environmental Factors in West Azerbaijan, Iran

Raza Basiri
Department of Forest Ecology, Faculty of Natural Resources,
Behbahan Higher Educational Complex, Khoozestan Province, Iran

Abstract: In this study, *Quercus libani* Oliv.'s site in Sardasht has been studied phytosociologically. The vegetation has been carefully studied in Braun-Blanquet method. The relationship between environmental factors including topography and some of the most current physicochemical features of soil and plant associations was researched by means of multiple discriminant analysis. Based on AFC and CAH methods, 8 associations and 1 sub-association were achieved including: *Trifolio stellati-Quercetum brantii, Pistacio atlanticae-Quercetum brantii, Violo modestue-Quercetum brantii, Trifolio campestri-Quercetum brantii, Quercetum brantii, Thalictro sultanabadensi-Quercetum libani, Quercetum libani-acerotosum cinerascens, Quercos boissieri-Quercetum libani* and *Quercetum libani.* These plant associations belong to Quercetea persicae class and *Quercetalia persicae* order. The effective environmental factors in division of plant associations based on multiple discriminant analysis include respectively: pH, landform index, Terrain shape index and aspect.

Key words: Phytosociology, BRAUN-BLANQUET method, environmental factors, multiple discriminant analysis

INTRODUCTION

Like other sciences, vegetation description and analysis shall be studies under a special logic and system (Kent and Coker, 1992). In the recent years, the study of plant associations has made great developments in perception, summarization and facilitation of environment-vegetation relations and the studies consider two major goals:

(1) To provide a state-of-the-art overview of all vegetation types in its territory that are dominated by vascular plants; (2) To give a detailed assessment of these types for conservation purposes (Dengler *et al.*, 2005).

Many methods have developed into different schools to describe characteristics of plant association, among which Zurich-Montpellier school is of special importance (Kent and Coker, 1992). The general goal of BRAUN-BLANQUET method is classification of plant associations based on floristic composition which is performed by ordering floristic data in phytosociology tables (Mueller-Dombois and Ellenberg, 1974). Braun Blanquet used association expression for characteristic species which is a basic unit for describing vegetation (Pignatti *et al.*, 1997). Plant associations are changeable and can be seen as mosaic of vegetation units. This changeability relates to environmental variants at any time (Cook and Irwin, 1992; Comstock and Ehleringer, 1992). The analysis of species-environment relationship has always been considered as a central axis in the studies of ecology (Guisan and Zimmermann, 2000).

Physicochemical features of soil and topography have been discriminated as effective environmental factors on growth of species (Barnes *et al.*, 1998; Barbour *et al.*, 1999; Abd El-Ghani *et al.*, 2003; Solon *et al.*, 2007; Hee *et al.*, 2007). *Quercus libani* Oliv.'s site in Sardasht is located in the North West of Iran in the range of north Zagros mountains (Maroofi, 2000; Fattahi, 2000). Considering distributed ecology in *Quercus libani* site indicates a general description of quality of the relationship between vegetation types and environmental factors such as topography and soil in a wide (Maroofi, 2000). *Quercus libani* is one of species which have been in Iran and Tourani and merely seen in North Zagros (Sardasht in West Azerbaijan province, Baneh and Marivan in Kordestan province). The West Azarbayejan with 69% distributional area of this species, it is very important (Maroofi, 2000). The current study is to recognize and manage vegetation of this region to protect, restore and progress of plant associations of *Quercus libani* and covers the following major goals.

Discriminating and dividing plant associations and sub-associations based on Braun-Blanquet method to gain detailed information about vegetation progress in *Quercus libani*'s site.

Quantity analysis of relationships between these associations and environmental factors, topography and common factors of soil chemistry by means of multiple-discriminant analysis.

MATERIALS AND METHODS

The study area: The study area is located in North West of Iran in West Azerbaijan; between (45E and 16′ and 52′′) and (45E and 29′ and 58′′) Eastern longitude and (36° and 9′ and 45′′) and (36° and 25′ and 45′′) Northern latitude (Fig. 1). The considered study site covers an area of 320 ha. The altitude of the study area is from 1400 to 1950 m above sea level. The slope in the area differs from 25 to 60% and most of mountain peaks are made of alkaline and andesite. Distribution of vegetation types can be divided into two major types in the entire area: *Quercus libani* type in the northern side and *Quercus brantii* Lindl. type in the southern side at importance value idex of : 146.3 and 160.3 accordingly (Basiri, 2003).

Methods of vegetation sampling: The study area was measured by the method of preferential sampling (Botta-Dukat *et al*., 2007) in 2007. First, plant formations were distinguished based on physiognomy and then by means of floristic standard, the vegetation type was carefully selected and then in each unit, 56 releves were picked. Releves with an area of 256 3 were found suitable. Species and Abundance were considered as measuring standards for vegetation (Okland, 1990). In this method, abundance dada was converted into Braun-Blanquet scale (Braun-Blanquet, 1932).

Method of sampling from soil and factors of topography: The sampling was performed in all releves at the depth from 0 to 20 cm; that is, a sample was taken from the entire thickness of 20 cm of the soil (Robertson *et al*., 1999). Some of the most important chemical and physical variables such as pH, EC at3, organic materials (%), nitrogen (%), C/N, phosphorus (mg kg^{-1}), potassium (mg kg^{-1}), calcium (mg kg^{-1}), magnesium (mg kg^{-1}), iron (mg kg^{-1}), manganese (mg kg^{-1}), copper (mg kg^{-1}) and soil content were measured. In each releve, topography variables of the altitude (m) and aspect were converted by means of Beers *et al*. (1966). The percentage of the slope, the slope position and slope-aspect, were applied by means of formula of Brosfske *et al*. (2001), landform index, (McNab, 1993) and Terrain shape index (McNab, 1989).

The method of vegetation data analysis: To discriminate plant association, Anaphyto Ver.95 was used (Briane, 1995). In this software, first AFC ordination (Analyse Factoriell des Correspondance) was used and it resulted in 5 axes of coordinates for releve and species. For the purpose of clear division of groups, CAH classification (Classification Ascendant Hierarchique) was used. To discriminate subgroups, Partial Analysis was performed. In this system, after discrimination of main groups, each group was individually analyzed for the second time. This phase continues until no other division of groups is possible. Based on the resulted groups, first, the raw table and then synthetic table were formatted and releve and species in them were arranged based on previous analysis (CAH and AFC) and constancy coefficient and

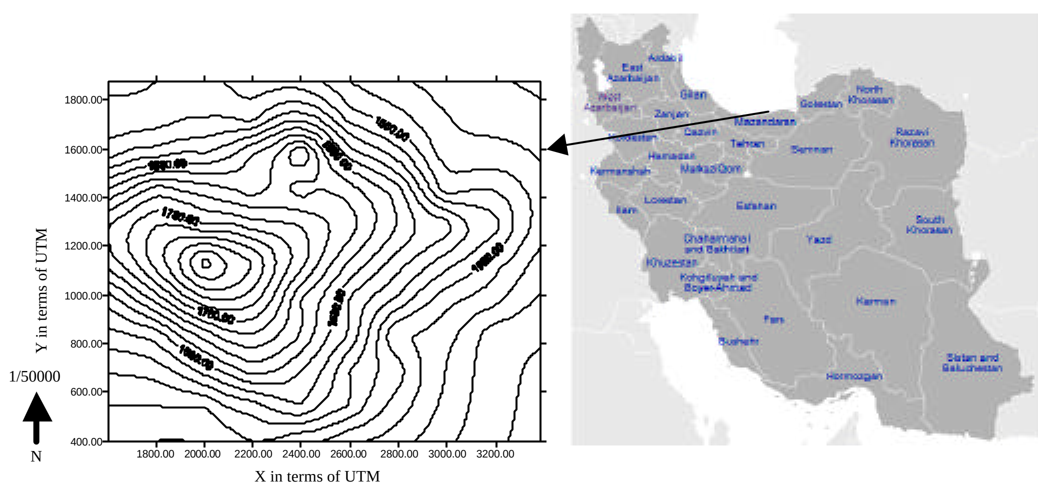

Fig. 1: Situation of the study area

eventually, the final phytosociological table was drawn up based on professional knowledge of botany and ecology by introducing characteristic species and transgrasive character species and association and subassociation were identified according to naming regulations in Phytosociology (Barkman *et al*., 1986).

Multiple discriminant analysis method: To discover the relationships between environmental factors and plant association, multiple discriminant analysis method was applied. To study the power of environmental variables in discrimination of plant groups, One-way ANOVA test was used. After performing the above hypothesis and One-way ANOVA test, a composition of the environmental variables which have the least collinearity and the most Hit ratio were selected for multiple discriminant analysis. Based on Johnson (1998), the Stepwise method was used for determining the discriminant model. In this method, the best effective independent variables in discrimination and classification or prediction of group membership are recognized. After calculating the function of discrimination, Wilks lambda statistic was used to test the significant level of functions (Hair *et al*., 1995). To calculate the power of discriminant function, the classification matrices were used. The matrix presents the Hit ratio which is equal to the R-square coefficient in multiple regressions. The Hit ratio was approved by benefiting from the proportional by chance accuracy rate. If the Hit ratio is 25% more than the proportional by chance accuracy rate, it is acceptable. The Press'sQ statistic was applied to test the predictive accuracy of discriminant functions. By comparing the measured Q with the quantity of chi-square for the degree of freedom on a special error level, if the measured Q is more than crisis ratio of Chi-square, the predictive accuracy is statistically approved (Hair *et al*., 1995).

RESULTS

Results of AFC ordination: The result of AFC ordination for releve on axis of multiple coordinates indicates that the studied releve, especially those on axis (1 and 2) discriminate 3 major groups: group 1, 2 and 3 (Fig. 2). Axis 1 indicates 39.3%, axis 2 shows 24.8% of the total variances. The reason of discriminating these three groups, as the species in releve indicates, is the effective

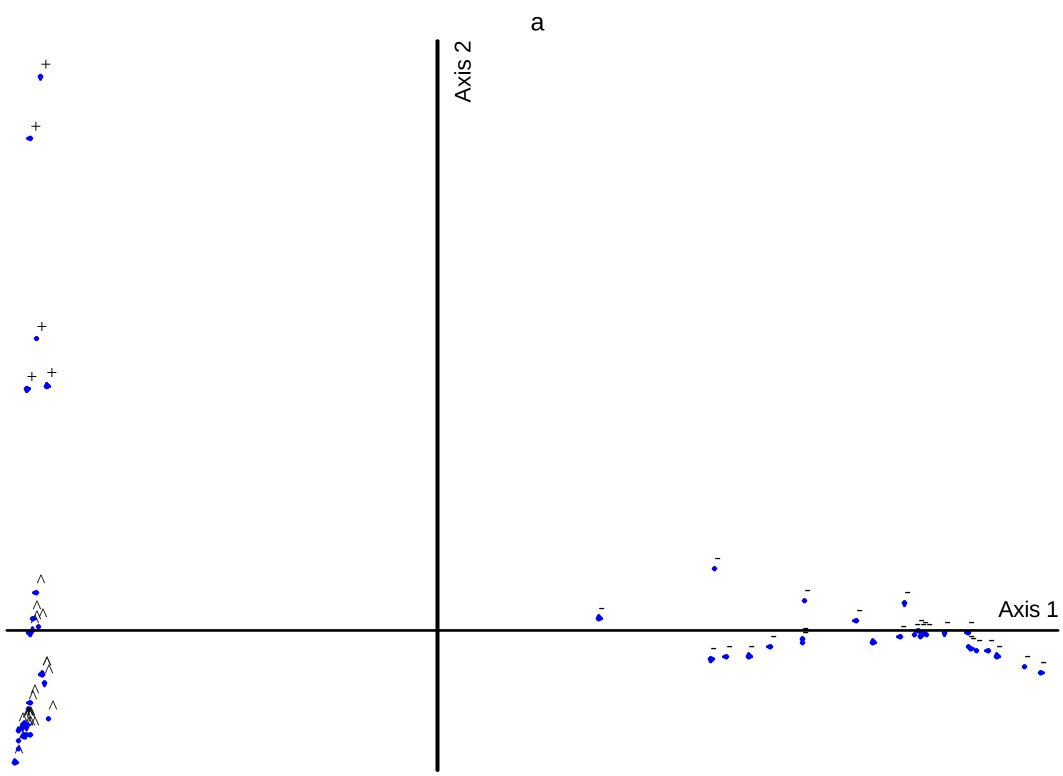

Fig. 2: Ordination of releve for axes 1 and 2 (-: group1 *Quercetum brantii* association, ^: group2 *Quercetum libani* association, +: group3 *Thalictro sultanabadensi-Quersetum libani- acerotosum cinerascens* subassociation)

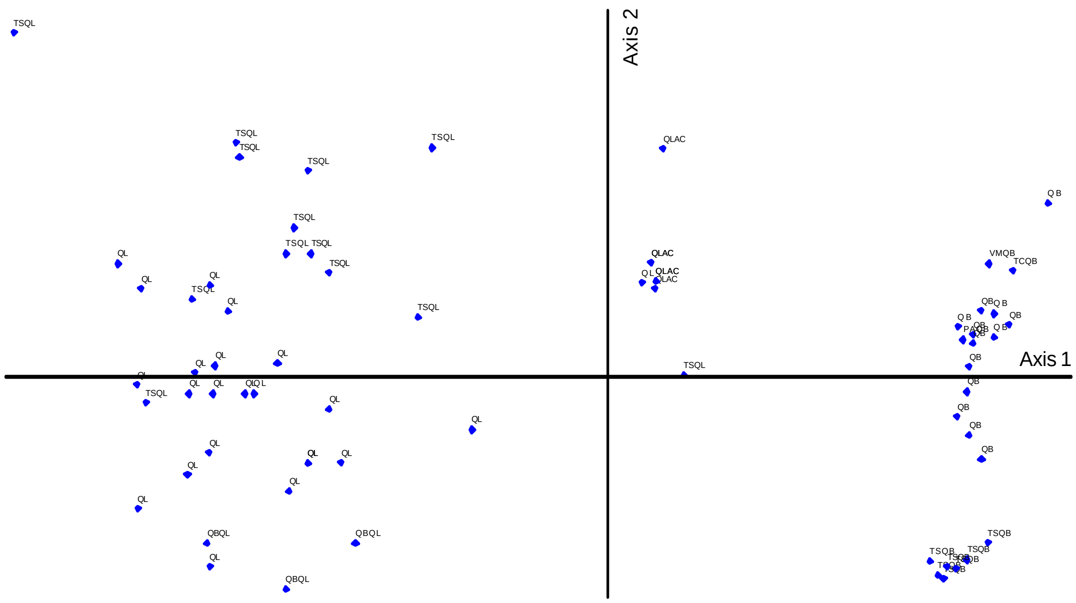

Fig. 3: Ordination of species for axes 1 and 2 (TSQB: *Trifolio stellati-Quercetum brantii*, PAQB: *Pistacio atlanticae-Quercetum brantii*, VMQB: *Violo modestue-Quercetum brantii*, TCQB: *Trifolio campestri-Quercetum brantii*, QB: *Quercetum brantii*, TSQL: *Thalictro sultanabadensi-Quercetum libani*, QLAC: *Quercetum libani-acerotosum cinerascens*, QBQL: *Quercus boissieri-Quercetum libani*, QL: *Quercetum libani*)

ecological factors. Considering axis of species and coordinating it with axis of releve, it is understood that species such as *Pistacia atlantica*, *Quercus brantii* and *Guandelia tournifortii* in group 1 and species such as *Quercus libani*, *Quercus infectoria* and *Euphorbia denticulata* in group 2 with different ecological features are located next to each other and it is resulted by the existence of smaller groups in these two major groups. Axis 1 and 2 with the highest eigenvalue was used for achieving the results. Based on axis 1, groups 1 and 2 are discriminated with 13.088 eigenvalue and based on axis 2, group 3 is discriminated from group 2 with 8.272 eigenvalue. Group 3 is not divisible to smaller groups (Fig. 3). To discriminate subgroups in groups 1 and 2, each of the groups were individually studied in details. The results of the first partial analysis indicate that there are 5 subgroups in group 1. Axis 1 indicates 32.8%, axis 2 shows 29.1% of the total variances. Axis 1 and 2 with the highest eigenvalue was used for achieving the results. Based on axis 1, subgroups 1 and 2 are discriminated with 10.2 eigenvalue and based on axis 2, subgroups 3,4 and 5 is discriminated from group 1 with 6.42 eigenvalue (Fig. 4). The results of partial analysis in major group 2, 3 subgroups are discriminated. Axis 1 indicates 27.5%, axis 2 shows 22.6% of the total variances. Axis 1 indicates 25.9%, axis 2 shows 20.8% of the total variances. Axis 1 and 2 with the highest eigenvalue was used for achieving the results. Based on axis 1, subgroups 1 and 3 are discriminated with 8.2 eigenvalue and based on axis 2, subgroups 2 is discriminated from group 2 with 6.89 eigenvalue (Fig. 5).

Results of CAH classification: Analysis of classification of ascending hierarchy for releve and species indicates adaptation of discriminated groups with discriminated groups in AFC ordination (Fig. 6).

Dendrogram of CAH classification for species was very long thus relinquished it.

Results of phytosociological table: Synthetic table of Phytosociology was made according to data obtained from the two above methods (AFC, CAH). In the table, the ordination of releve and species has the same hierarchy as CAH diagrams. A few changes were made in the rows and columns of the final table based on the data obtained in AFC ordination, environmental knowledge and available resources. The Phytosociological table was drawn up based on falling ordination of abundance coefficients B overcome of species in either one of plant groups and also falling hierarchy of species considering ratio of presence (Table 1). After discriminating syntaxons in the shape of association and sub-association and naming

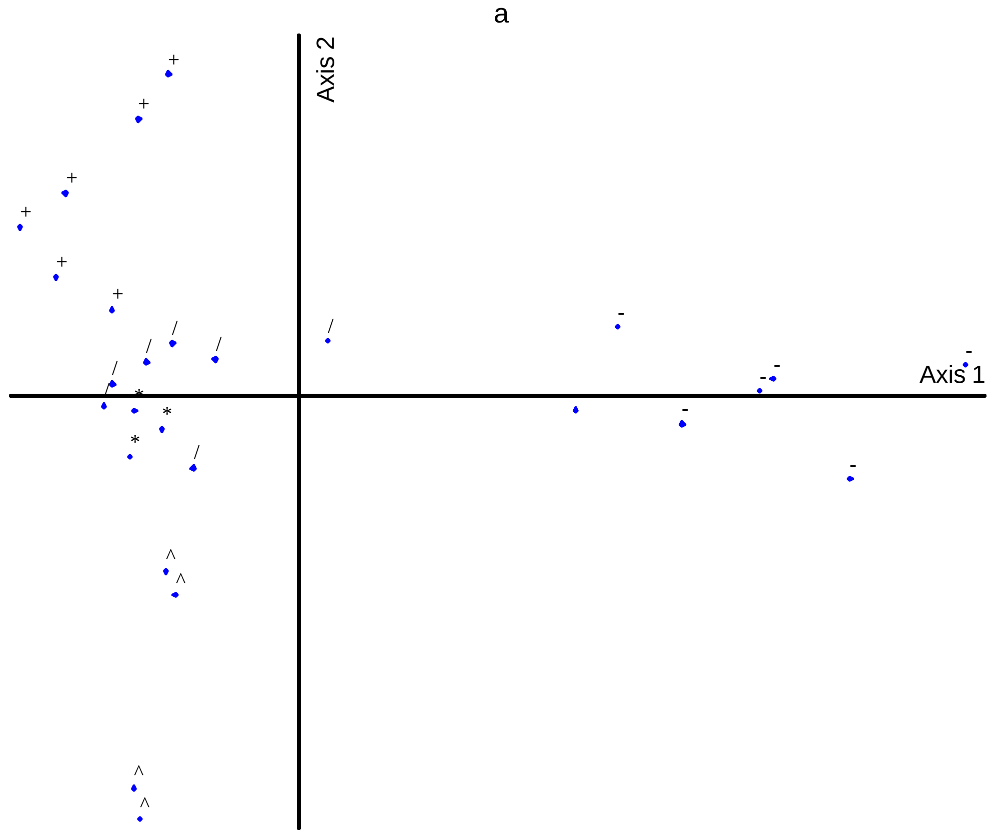

Fig. 4: Ordination of releve in partial analysis of axes 1 and 2 for group1>Quercetum brantii association' by eliminating groups 2 and 3:(-: Subgroup1: *Trifolio stellati-Quercetum brantii*, *: Subgroup2: *Pistacio atlanticae-Quercetum brantii*, +:Subgroup3: *Violo modestue-Quercetum brantii*, ^: Subgroup4: *Trifolio campestri-Quercetum brantii*, /: Subgroup5: *Quercetum brantii*)

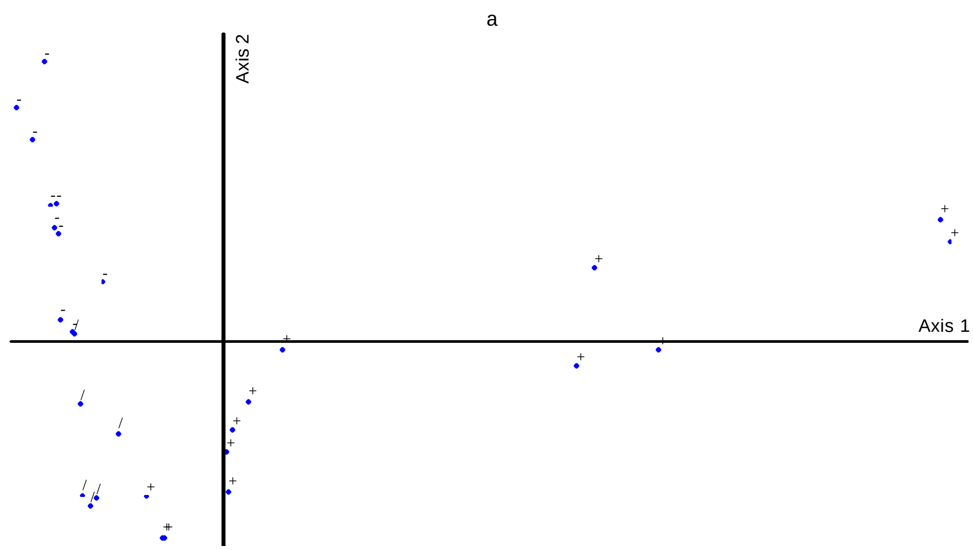

Fig. 5: Ordination of releve in partial analysis of axes 1 and 2 for group2 *Quercetum libani* association' by eliminating groups 1 and 3 (+: Subgroup1: *Thalictro sultanabadensi-Quersetum libani- acerotosum cinerascens*, -: Subgroup 2: *Querco boissieri-Quercetum libani* and /: Subgroup3: *Quercetum libani*)

Table 1: Phytosociological table of sardasht district (West Azerbaijan)

	Frequency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	7	3	5	2	4	6	7	5	4	2	6	3	7	5	3	3	6	4	5	6	7	4	5	6	6	2	8	9	9
		1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	1	0	1	0	1	1	1
		2	7	9	6	7	6	7	9	9	8	8	2	8	1	7	7	0	8	9	5	9	8	0	1	4	0	9	1	2	1
Association																															
Trifolio stellati-Quercetum brantii																															
Characteristic species:																															
7301 *Trifolium stellatum*	12.50%	2	2	2	+	1	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2134 *Ceratocephalus testiculatus*	12.50%	1	1	2	3	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0609 *Anemone coronaria*	12.50%	+	1	1	1	3	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5229 *Ornithogalum cuspidatum*	10.70%	1	+	+	1	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7099 *Teucrium polium*	8.90%	+	+	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4866 *Muscari caucasicum*	5.40%	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1805 *Callipeltis cucularis*	3.60%	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Association																															
Pistacio atlanticae-Quercetum brantii																															
Characteristic species:																															
5563 *Pistacia atlantica*	7.10%	.	.	.	.	.	.	.	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Association																															
Violo modestue-Quercetum brantii																															
Characteristic species:																															
7657 *Viola modesta*	12.50%	.	.	.	.	.	.	.	.	.	.	2	2	1	1	2	3	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Association																															
Trifolio campestri-Quercetum brantii																															
Characteristic species:																															
7256 *Trifolium campestre*	12.50%	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	2	3	2	2	.	.	.	.	.	.	.	.	.	.
Association																															
Quercetum brantii																															
Characteristic species:																															
5886 *Quercus brantii*	48.20%	1	2	2	1	1	2	3	2	2	3	2	4	2	1	2	3	3	3	2	2	2	4	2	3	2	2	2	.	.	.
1712 *Bryonia aspera*	8.90%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	+	.	+	.	+	.	.	.
6571 *Serratula cerinthifolia*	7.10%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	1	.	.	.
Characteristic species of alliance																															
0635 *Anthemis haussknechtii*	30.40%	+	1	1	1	+	+	.	.	+	1	1	.	+	.	.	.	.	+	+	1	+	.	.	+	+	+	.	.	.	.
3803 *Gundelia tournefortii*	25.00%	+	+	+	.	.	.	.	1	+	+	.	+	.	.	.	.	.	.	.	+	+	+	+	1	.	+	+	.	.	.
0294 *Alcea kurdica*	25.00%	+	+	+	.	.	.	.	1	+	+	.	+	.	.	.	.	.	.	.	+	+	+	+	1	.	+	+	.	.	.
2318 *Colchicum speciosum*	16.10%	+	+	.	1	.	1	+	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.
5526 *Picnomon acarna*	14.30%	.	.	+	.	.	.	.	.	.	+	.	.	1	.	.	.	1	.	1	.	.	.	+	+	.	.	+	.	.	.
6751 *Smyrnium cordifolium*	10.70%	.	.	.	.	.	1	.	.	.	2	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8888 *Euphorbia azerbajdzhanica*	10.70%	.	.	.	.	.	.	.	.	.	.	.	1	+	1	.	.	.	.	.	.	.	.	+	1	.	1	.	.	.	.
7261 *Trifolium dasyurum*	10.70%	+	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	1	.	.	.	.	1	.	+	.	.	.	.	.
4101 *Hordeum bulbosum*	8.90%	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	4	.	.	.	.	.	.	+	.	.	.	.	.
0726 *Aristolochia bottae*	7.10%	.	+	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Association																															
Thalictro sultanabadensi-Quercetum libani																															
Characteristic species:																															
7112 *Thalictrum sultanabadense*	30.40%	+	.	.	.	.	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1	3	1
1312 *Astragalus* (Caprini) *piranshahricus*	23.20%	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
1840 *Campanula involucrata*	14.30%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1

Table 1: Countinued

7205 *Tragopogon graminifolius*	12.50%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
6772 *Sonchus asper* subsp. *glaucescens*	12.50%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+
4041 *Hesperis kurdica*	12.50%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+
0430 *Allium scabriscapum*	5.40%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1
2463 *Cotoneaster nummularioides*	5.40%	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0252 *Agropyron panormitanum*	3.60%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3403 *Euphorbia denticulata*	3.60%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
0778 *Arum conophalloides*	3.60%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
3531 *Fibigia macrocarpa*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5909 *Ranunculus cicutarius*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Subassociation																															
Quercetum libani-acerotosum cinerascens																															
Characteristic species:																															
0143 *Acer monspessulanum* subsp. *cinerascens*	8.90%	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0143 *Acer monspessulanum* subsp. *cinerascens*																															
6463 *Scrophularia nervosa* subsp. *nervosa*	5.40%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6750 *Smyrniopsis aucheri*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6094 *Rosularia sempervivoides*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3585 *Fritillaria persica*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0953 *Astragalus* (Astragalus) *caryolobus*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Association																															
Quercus boissieri-Quercetum libani																															
Characteristic species:																															
5891 *Quercus infectoria* subsp. *boissieri*	17.90%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6124 *Rumex conglomeratus*	8.90%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6004 *Rhaponticum insigne*	7.10%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Association																															
Quercetum libani																															
5892 *Quercus libani*	51.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	5	3
5232 *Ornithogalum oligophyllum*	3.60%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6866 *Steptorrhamphus persicus*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4773 *Melica persica* subsp. *persica*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2339 *Comperia comperiana*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Characteristic species of alliance																															
2151 *Chaerophyllum macrospermum*	41.10%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	+	+
2884 *Dactylis glomerata* subsp. *glomerata*	37.50%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	1	1	2
1999 *Centaurea behen*	35.70%	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+
7582 *Veronica polita*	33.90%	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	1	.	.	.	2	1	1
7659 *Viola odorata*	32.10%	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	3	4	.
4390 *Lamium album* subsp. *album*	30.40%	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1	2	.
0224 *Aethionema membranaceum*	30.40%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.
6629 *Silene chlorifolia*	30.40%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	.	.
3398 *Euphorbia condylocarpa*	30.40%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	.
2790 *Cruciata taurica*	26.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
6939 *Symphytum kurdicum*	26.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
4506 *Lepyrodiclis holosteoides*	25.00%	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	3	1	2
3495 *Ferula orientalis*	19.60%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4785 *Mentha longifolia*	16.10%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1207 *Astragalus* (Incani) *lovensis*	16.10%	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

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Table 1: Countinued

9888 *Astragalus compactus*	14.30%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
2892 *Dactylorhiza umbrosa*	8.90%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1471 *Astragalus* (Anthylloidei) *tortuosus*	3.60%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Transgrasive and characteristic species of order and class																															
3649 *Galium aparine*	98.20%	1	1	2	1	1	1	3	1	1	1	1	1	1	1	2	1	2	.	2	3	1	3	1	1	1	1	1	3	3	3
5617 *Poa bulbosa* var. *vivipara*	89.30%	1	1	1	1	1	1	3	1	1	1	.	.	1	1	2	3	1	1	.	1	1	1	1	1	1	1	1	1	.	1
3740 *Geranium tuberosum* subsp. *micranthum*	78.60%	.	.	2	.	1	.	.	1	.	1	.	2	1	1	2	1	2	1	.	1	.	1	.	1	.	1	1	3	1	1
5899 *Ranunculus arvensis*	73.20%	1	+	1	1	1	.	1	1	1	1	1	1	1	.	2	1	1	1	.	1	1	1	1	.	1	.	1	+	.	1
7640 *Vicia variabilis*	71.40%	.	.	1	.	.	+	1	1	1	1	1	1	1	1	2	.	1	2	1	2	1	2	1	1	.	1	.	.	1	.
0489 *Alyssum linifolium* var. *linifolium*	67.90%	+	2	2	.	1	2	1	2	1	2	2	+	2	1	2	2	2	1	1	1	2	2	2	2	3	1	3	.	.	.
1737 *Bunium elegans*	67.90%	.	1	1	.	.	.	.	1	1	.	.	.	.	1	1	+	.	1	1	1	.	1	.	1	+	1	.	+	.	1
7709 *Ziziphora capitata* subsp. *capitata*	66.10%	.	1	1	1	1	2	2	1	1	1	1	1	1	1	2	1	2	1	1	3	1	1	1	1	1	1	2	.	.	.
0683 *Arabis caucasica* subsp. *caucasica*	66.10%	1	+	1	.	.	.	+	1	.	1	1	.	1	1	.	.	1	1	1	.	.	+	1	1	+	1	1	.	1	.
1595 *Bellevalia longistyla*	62.50%	+	+	1	1	1	+	+	+	1	1	1	+	1	1	1	+	+	1	1	1	+	1	1	1	1	+	1	.	.	.
3537 *Ficaria kochii*	60.70%	.	.	.	.	.	.	.	1	.	.	.	1	1	1	1	.	.	.	.	2	1	1	.	1	.	.	.	2	1	1
0161 *Achillea millefolium* subsp. *millefolium*	60.70%	.	+	.	.	1	1	1	.	1	1	.	3	1	.	1	2	2	1	.	2	2	2	1	.	2	.	1	.	.	.
7216 *Tragopogon reticulatus*	58.90%	1	+	1	.	1	.	+	+	+	1	1	.	2	+	.	1	+	1	.	1	1	.	1	.	+	.	1	+	.	1
1704 *Bromus tectorum* var. *tectorum*	53.60%	1	+	2	2	.	1	1	1	.	1	1	1	2	3	1	2	3	1	1	4	1	.	1	1	1	3	1	.	.	.
2758 *Crepis sancta Babcock* subsp. *sancta*	50.00%	1	1	1	2	1	1	1	1	1	1	1	1	1	+	1	2	1	1	1	1	1	1	1	1	3	1	.	.	.	.
3274 *Eremopoa persica* var. *persica*	48.20%	1	.	.	.	.	.	1	.	.	.	.	1	.	.	1	1	.	.	.	.	1	.	.	.	.	1	.	1	.	1
2713 *Crataegus pontica*	48.20%	1	.	.	.	.	2	2	1	.	.	.	.	.	1	.	2	2	1	1	2	1	2	2	1	+	2	3	.	.	.
2112 *Cerastium inflatum*	46.40%	.	.	+	.	.	.	.	.	1	1	.	1	.	1	.	.	1	.	1	.	1	1	1	.	.	1	1	.	.	.
6266 *Salvia suffruticosa*	46.40%	.	.	.	.	.	.	.	.	1	.	.	1	.	1	1	1	.	.	1	.	+	1	.	1	.	1	.	.	.	1
5183 *Onosma sericeum*	46.40%	.	+	.	.	.	.	.	1	.	.	.	1	2	.	1	.	1	1	.	.	1	1	1	1	+	1	.	1	.	1
7442 *Valerianella carinata*	42.90%	1	1	1	1	+	1	1	1	.	1	1	.	.	.	1	.	.	.	1	.	.	.	.	1	.	+	.	.	1	1
		0	0	0	0	1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0				
		8	8	8	8	1	2	9	0	7	8	0	9	2	1	0	2	2	2	1	2	1	1	0	0	9	9				
		1	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	1	1	1	0	0				
		0	2	6	9	8	2	5	9	0	8	7	4	0	9	6	7	1	8	7	9	1	0	2	0	8	9				
Association																															
Trifolio stellati-Quercetum brantii																															
Characteristic species:																															
7301 *Trifolium stellatum*	12.50%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
2134 *Ceratocephalus testiculatus*	12.50%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
0609 *Anemone coronaria*	12.50%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
5229 *Ornithogalum cuspidatum*	10.70%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
7099 *Teucrium polium*	8.90%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
4866 *Muscari caucasicum*	5.40%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
1805 *Callipeltis cucularis*	3.60%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Association																															
Pistacio atlanticae-Quercetum brantii																															
Characteristic species:																															
5563 *Pistacia atlantica*	7.10%	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Association																															
Violo modestue-Quercetum brantii																															
Characteristic species:																															
7657 *Viola modesta*	12.50%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Association																															
Trifolio campestri-Quercetum brantii																															

Table 1: Countinued

Characteristic species:																											
7256 *Trifolium campestre*	12.50%	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Association																											
Quercetum brantii																											
Characteristic species:																											
5886 *Quercus brantii*	48.20%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1712 *Bryonia aspera*	8.90%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6571 *Serratula cerinthifolia*	7.10%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Characteristic species of alliance																											
0635 *Anthemis haussknechtii*	35.70%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3803 *Gundelia tournefortii*	30.40%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0294 *Alcea kurdica*	25.00%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2318 *Colchicum speciosum*	16.10%	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5526 *Picnomon acarna*	14.30%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6751 *Smyrnium cordifolium*	10.70%	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
8888 *Euphorbia azerbajdzhanica*	10.70%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7261 *Trifolium dasyurum*	10.70%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4101 *Hordeum bulbosum*	8.90%	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0726 *Aristolochia bottae*	7.10%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Association																											
Thalictro sultanabadensi-Quercetum libani																											
Characteristic species:																											
7112 *Thalictrum sultanabadense*	30.40%	1	1	3	2	3	1	3	3	1	+	.	.	.	.		.	.	.	.	.	.	.	.		.	+
1312 *Astragalus* (Caprini) *piranshahricus*	23.20%	+	+	.	+	+	+	1	.	1	+	.	.	.	.	.	.	+	.			.	.	.	.		.
1840 *Campanula involucrata*	14.30%	.	1	.	1	1	1	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.
7205 *Tragopogon graminifolius*	12.50%	+	1	.	1	.	.	+	.	.	1	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.
6772 *Sonchus asper* subsp. *glaucescens*	12.50%	.	1	.	.	.	1	.	+	.	1	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.
4041 *Hesperis kurdica*	12.50%	.	+	+	.	+	.	1	.	.	+	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.
0430 *Allium scabriscapum*	5.40%	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2463 *Cotoneaster nummularioides*	5.40%	+	.	.	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0252 *Agropyron panormitanum*	3.60%	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3403 *Euphorbia denticulata*	3.60%	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0778 *Arum conophalloides*	3.60%	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3531 *Fibigia macrocarpa*	1.80%	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5909 *Ranunculus cicutarius*	1.80%	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Subassociation																											
Quercetum libani-acerotosum cinerascens																											
Characteristic species:																											
0143 *Acer monspessulanum* subsp. *cinerascens*	8.90%	.	.	.	.	.	+	+	3	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6463 *Scrophularia nervosa* subsp. *nervosa*	5.40%	.	.	.	.	.		+	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6750 *Smyrniopsis aucheri*	1.80%	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6094 *Rosularia sempervivoides*	1.80%	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3585 *Fritillaria persica*	1.80%	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0953 *Astragalus* (Astragalus) *caryolobus*	1.80%	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Association																											
Quercus boissieri-Quercetum libani																											
Characteristic species:																											
5891 *Quercus infectoria* subsp. *boissieri*	17.90%	.	.	.	.	.	.	.	.	.	.	1	2	1	2	1	1	2	1	+	+	.	.	.	.	.	.
6124 *Rumex conglomeratus*	8.90%	.	.	.	.	.	.	.	.	.	.	3	1	.	.	+	.	.	+	.	1	.	.	.		.	.

Table 1: Countinued

6004 *Rhaponticum insigne*	7.10%	.	.	.	.		.	.	.	.	.	.	1	.	.	+	.	+	.	+	.	.	.	.	.	.	.
Association																											
Quercetum libani																											
5892 *Quercus libani*	51.80%	5	4	3	4	3	4	3	1	2	4	5	2	3	2	4	3	1	4	5	3	4	3	1	5	3	3
5232 *Ornithogalum oligophyllum*	3.60%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+
6866 *Steptorrhamphus persicus*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
4773 *Melica persica* subsp. *persica*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
2339 *Comperia comperiana*	1.80%	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Characteristic species of alliance:																											
2151 *Chaerophyllum macrospermum*	41.10%	1	.	2	+	1	1	1	.	1	1	1	3	.	2	2	.	+	1	1	1	1	.	1	+	.	+
2884 *Dactylis glomerata* subsp. *glomerata*	37.50%	1	1	.	1	1	1	2	.	1	1	2	.	.	.	2	1	.	.	1	.	+	.	1	.	1	1
1999 *Centaurea behen*	35.70%	1	.	+	.	+	1	1	.	.	+	2	2	.	+	1	+	.	1	2	1	+	.	+	.	.	+
7582 *Veronica polita*	33.90%	3	1	1	1	1	1	.	1	.	1	.	.	.	.	2	.	.	.	.	.	.	.	1	1	1	1
7659 *Viola odorata*	32.10%	1	.	.	1	.	2	.	.	.	1	.	.	1	.	2	2	.	1	3	1	.	1	1	1	1	.
4390 *Lamium album* subsp. *album*	30.40%	.	1	.	+	.	1	1	.	1	1	.	1	.	.	.	.	1	.	.	.	1	.	1	1	1	1
0224 *Aethionema membranaceum*	30.40%	1	1	1	.	.	.	1	.	.	1	1	.	+	.	2	+	.	.	1	+	.	.	1	1	1	1
6629 *Silene chlorifolia*	30.40%	.	.	.	1	1	.	+	.	.	1	1	2	1	.	1	1	1	+	1	.	1	+	.	1	.	.
3398 *Euphorbia condylocarpa*	30.40%	+	.	.	.	2	.	+	.	.	1	1	+	.	+	1	1	+	1	1	+	1	.	.	.	.	+
2790 *Cruciata taurica*	26.80%	1	1	1	2	1	.	1	.	.	1	1	.	.	1	1	.	.	.	.	.	1	.	.	.	2	1
6939 *Symphytum kurdicum*	26.80%	.	+	.	.	.	.	+	.	+	1	1	1	.	+	+	+	+	.	1	.	+	.	+	.	1	.
4506 *Lepyrodiclis holosteoides*	25.00%	1	+	1	.	.	1	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	1	1	2	1	.
3495 *Ferula orientalis*	19.60%	.	.	.	+	.	.	1	.	1	.	2	+	.	+	2	.	+	+	1	.	+	.	.	.	.	.
4785 *Mentha longifolia*	16.10%	.	.	1	.	.	.	1	.	.	.	1	1	1	.	.	1	.	.	1	.	.	1	.	.	.	.
1207 *Astragalus* (Incani) *lovensis*	16.10%	.	1	.	.	.	.	1	.	.	.	1	.	1	1	.	1	.	.	1	1	.	.	.	.	.	.
9888 *Astragalus compactus*	14.30%	+	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	1
2892 *Dactylorhiza umbrosa*	8.90%	.	.	.	+	+	.	.	.	.	.	.	+	.	+	.	.	.	.	+	.	.	.	.	.	.	.
1471 *Astragalus* (Anthylloidei) *tortuosus*	3.60%	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Transgrasive and characteristic species of order and class																.	.	.	.	.	.	.	.	.	.	.	
3649 *Galium aparine*	98.20%	2	1	2	1	1	3	3	1	1	2	3	3	3	2	3	3	2	3	2	2	3	3	1	4	3	2
5617 *Poa bulbosa* var. *vivipara*	89.30%	1	1	1	1	1	1	3	1	.	1	2	2	1	1	3	3	1	2	+	1	1	1	1	.	1	1
3740 *Geranium tuberosum* subsp. *micranthum*	78.60%	1	1	3	1	2	3	3	1	.	1	2	3	2	1	4	2	1	1	2	1	2	2	1	1	3	3
5899 *Ranunculus arvensis*	73.20%	+	1	.	.	1	+	.	1	.	.	.	1	1	1	.	1	1	+	1	1	1	.	1	.	1	+
7640 *Vicia variabilis*	71.40%	.	1	3	.	.	2	3	.	.	1	2	2	2	1	1	2	1	1	2	.	3	2	1	1	2	.
0489 *Alyssum linifolium* var. *linifolium*	67.90%	.	1	.	.	.	.	1	+	.	.	.	.	1	1	.	1	1	.	.	1	.	+	1	.	2	1
1737 *Bunium elegans*	67.90%	+	1	1	1	1	+	1	1	1	1	.	1	1	.	1	.	1	1	1	1	1	1	1	.	1	1
7709 *Ziziphora capitata* subsp. *capitata*	66.10%	.	.	.	.	.	.	.	1	.	.	1	1	1	1	3	.	1	.	.	1	.	2	+	.	1	.
0683 *Arabis caucasica* subsp. *caucasica*	66.10%	.	1	1	.	1	1	.	.	1	1	1	.	1	1	.	1	.	+	+	+	1	1	.	1	1	1
1595 *Bellevalia longistyla*	62.50%	.	.	1	.	.	.	.	.	.	.	+	1	1	+	.	+	+	.	.	+	.	.	.	.	.	.
3537 *Ficaria kochii*	60.70%	.	2	3	.	1	.	1	1	.	1	2	2	1	1	3	3	1	3	1	1	3	2	3	1	1	1
0161 *Achillea millefolium* subsp. *millefolium*	60.70%	.	1	3	.	1	1	.	1	.	.	.	.	2	1	2	1	1	.	1	1	3	2	.	.	1	1
7216 *Tragopogon reticulatus*	58.90%	+	.	+	1	1	.	.	.	+	1	1	1	.	.	.	1	+	.	1	+	.	.	.	.	.	.
1704 *Bromus tectorum* var. *tectorum*	53.60%	.	.	.	.	.	.	.	.	.	.	2	.	2	2	.	3	.	.	.	3	.	.	.	.	1	.
2758 *Crepis sancta Babcock* subsp. *sancta*	50.00%	.	.	.	.	.	.	.	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
3274 *Eremopoa persica* var. *persica*	48.20%	1	1	1	1	2	1	2	.	.	1	.	.	2	2	1	.	2	1	.	1	2	2	.	.	1	1
2713 *Crataegus pontica*	48.20%	.	+	2	.	.	.	.	.	.	+	2	2	.	.	+	+	.	.	+	+	.	.	.	.	+	.
2112 *Cerastium inflatum*	46.40%	1	1	.	.	.	.	.	1	.	.	.	.	1	1	.	1	1	.	.	1	1	1	1	1	1	1
6266 *Salvia suffruticosa*	46.40%	1	1	2	.	.	1	.	.	.	1	.	1	1	1	.	.	1	+	+	+	.	1	.	1	.	1
5183 *Onosma sericeum*	46.40%	1	.	1	1	1	.	1	.	.	1	.	.	.	.	1	.	1	.	1	.	1	.	.	.	.	1
7442 *Valerianella carinata*	42.90%	.	.	.	.	.	+	.	.	1	.	.	+	+	.	.	.	.	.	.	+	1	.	+	.	.	+

Asscociation I: *Trifolio stellati-Quercetum brantii*	*Quercetum brantii* (large assiciation 1
Asscociation II: *Pistacio atlanticae-Quercetum brantii*	
Asscociation III: *Violo modestae-Quercetum brantii*	
Asscociation IV: *Trifolio campstri-Quercetum brantii*	
Asscociation V: *Quercetum brantii*	
Sub asscociation I: *Thalictro sultanabadensi-Quercetum libani*	*Quercetum librani* (large assiciation 2
Asscociation VI: *Thalictro sultanabadensi-Quercetum libani*	
Asscociation VII: *Querco biossieri-Quercetum libani*	
Asscociation VIII: *Quercetum libani*	

Fig. 6: Dendrogram of CAH classification for releve

Table 2: Statistical results for variables in discriminant function

Steps	Environmental variates	Lambda	Exact F	p-value
1	pH	0.59	1.5	<0.05
2	Landform index	0.47	18.3	<0.001
3	Terrain shape index	0.38	15.8	<0.001
4	Aspect	0.25	6.5	<0.001

Table 3: Statistical results for discriminant functions

Function	Eigen value	% of variance	Cumulative variance (%)	Canonical correlation	Wilks' lambda	Chi-squared	p-value
1	1.66	77.6	77.6	0.79	0.25	71.9	<0.001
2	0.48	22.4	100	0.60	0.68	20.6	<0.001

them, the growing units were introduced with companion species based on characteristic species.

Results of multiple discriminant analysis in regard to plant association:

Major analysis for 3 groups: According to the result of plant association analysis, first 3 groups (of association) were discriminated. Based on Table 2, variables of pH, landform index, Terrain shape index and aspect were placed in discriminant function in order for importance in group discrimination and all of them were placed on the significant level of 1%.

The two discriminant functions which were the outcome of the four above variables both were significant. The first function which was formed based on variables of pH and aspect indicated canonical correlation of 79%. This function allocated 77.6% of the aforementioned variables of the two functions. The second function which was formed based on variables of landform index and terrain shape index, indicated 60% canonical correlation. This function allocated 22.4% of the aforementioned variance by the two functions (Table 3).

Correlation of variables entered into the model with each of the functions showed that pH and aspect are significant with function 1. Also; landform and terrain shape indices are significant with function 2. pH and aspect variables were more effective in distinguishing associations (Table 4).

This analysis proves that discriminant functions can be produced by means of 4 environmental variables and generally, these functions indicate 87.7% predictive

Table 4: Structure matrix between environmental variates and discriminant functions

	Discriminant functions	
Environmental variates	Function 1	Function 2
pH	64*	0.035ns
Landform index	0.12ns	58*
Terrain shape index	0.18ns	56*
Aspect	-73*	0.11ns

*Indicates significant correlation at level of 0.01. (ns) Indicates non-significant at level of 0.05

Table 5: Results of One-way ANOVA for variables in discriminant functions model

Variables	Source	Sum of square	df	Mean square	F-value	p-value
pH	Between groups	8.37	2	4.190	18.55	<0.01
	Within groups	12.18	54	0.230		
	Total	20.56	56			
Landform index	Between groups	0.04	2	0.020	7.37	<0.01
	Within groups	0.14	54	0.003		
	Total	0.18	56			
Terrain shape index	Between groups	0.03	2	0.020	7.68	<0.01
	Within groups	0.11	54	0.002		
	Total	0.14	56			
Aspect	Between groups	14.85	2	7.430	24.2	<0.01
	Within groups	16.57	54	0.310		
	Total	31.42	56			

accuracy in classification of variables; that is, based on environmental variables, about 87.7% of 3 classified groups are accurately classified. The predictive accuracy was proved in Press'Q statistic (Q = 66.4 and p<0.01). Cohen's Kappa standard was applied for reliability of classification. Measuring Kappa of 72.4% and its significant level (p<0.01) indicates that the classification was performed based on the method of Phytosociology and it is in discriminant analysis.

The results of One-way ANOVA for the above 4 environmental variables indicates that there is a difference between 3 groups in significant level of 1% (p<0.01) (Table 5).

Results of Duncan test for pH showed that the *Quercetum brantii* association was more significant than other associations (Fig. 7a). Results of Duncan test for Terrain shape index and landform index, showed that the Talictro sultanabadensi-Quercetum libani-acerotosum cinerascens association was more significant than other associations (Fig. 7b, c). Results of Duncan test for aspect showed that the *Quercetum brantii* association was more significant than other associations (Fig. 7d).

Partial analysis for group 1: To gain smaller groups, partial analysis was used, after eliminating group 2 and 3 in Fig. 2 and 3, the partial analysis was performed for group 1 and totally 5 subgroups were discriminated. In multiple discriminant analysis, no environmental variables played a role in discriminating these 5 subgroups.

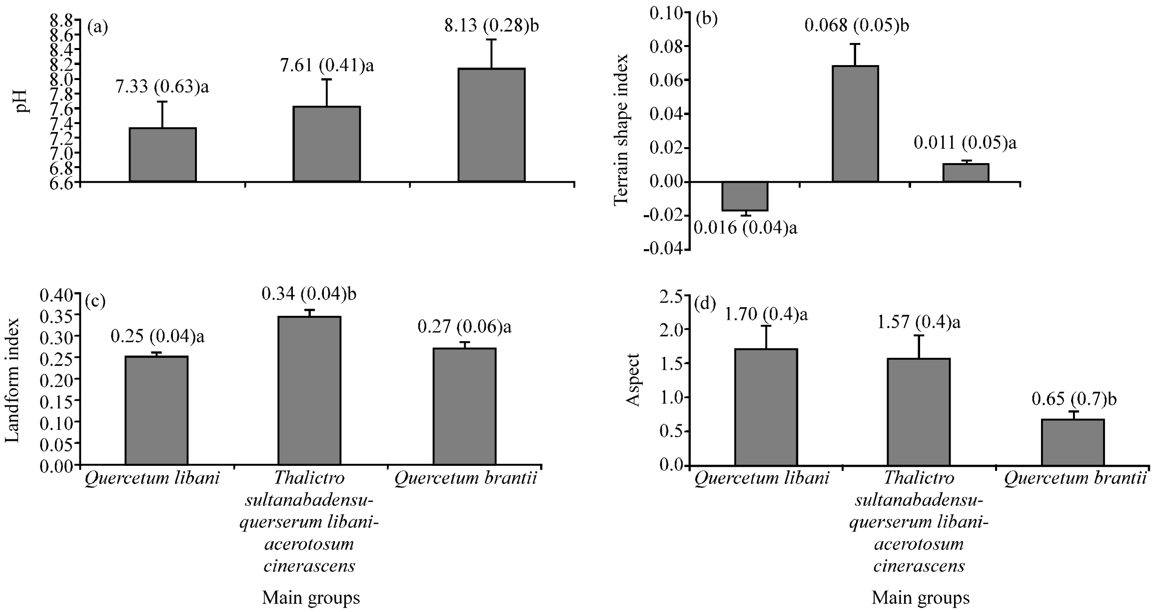

Fig. 7: Bar chart of environmental variables in discriminant functions for 3 major groups (the written numbers on columns shows mean and standard deviation), (a) pH variable, (b) terrain shape index variable, (c) landform index variable and (d) aspect variable

Partial analysis for group 2: By eliminating group1, 3 subgroups were discriminated in group2 (Fig. 5). In multiple discriminant analysis, no environmental variables played a role in discriminating these 3 subgroups.

Description of association and subassociation

The association (I) (subgroup 1): *Trifolio stellati-Quercetum brantii.*

Characteristic species include: *Trifolium stellatum, Ceratocephalus testiculatus, Anemone coronaria, Ornithogalum cuspidatum, Teucrium polium, Muscari caucasicum, Callipeltis cucularis.*

The association (II) (subgroup 2): Pistacio atlanticae-*Quercetum brantii.*

Characteristic species include: *Pistacia atlantica.*

The association (III) (subgroup 3): Violo modestae-*Quercetum brantii.*

Characteristic species include: *Viola modesta*

The association (IV) (subgroup 4): Trifolio campestri-*Quercetum brantii.*

Characteristic species include: *Trifolium campestre.*

The association (V) (subgroup 5): *Quercetum brantii*

Characteristic species include: *Quercus brantii, Anthemis hassknechtii, Gundelia tournifortii, Alkea kurdica, Colchicum speciosum, Picnomon acarna, Smyrnium cordifolium, Euphorbia azerbajdzhanica, Trifolium dasyurum, Hordeum bulbosum, Bryonia aspera, Aristolochia bottae, Serratula cerinthifolia, Bryonia aspera.*

The association (VI) (subgroup 1): Thalictro sultanabadensi-Quercetum libani.

Characteristic species include: *Thalictrum sultanabadense, Astragalus piranshahricus, Campanula involucrata, Tragapogon gramifolius, Sonchus asper* subsp.glaucescens, *Hesperis kurdica, Allium scabricapum, Cotoneaster nummularioides, Agropyrum panormitanum, Euphorbia denticulate, Arum conophalloides, Fibigia macrocarpa, Ranunculus cicutarius.*

The subassociation (I): Thalictro sultanabadensi-Quersetum libani- acerotosum cinerascens.

Characteristic species include: *Acer monspesulanum* subsp.cinerascens, *Scrophularia nervosa* subsp.nervosa, *Smyrniopsis aucheri, Rosularia sempervivoides, Fritialaria persica, Astragalus cariolobus.*

The association (VII) (subgroup 2): Querco boissieri-Quercetum libani.

Characteristic species include: *Quercus infectoria* subsp.boissieri, *Rumex conglomeratus, Rhaponticum insigne.*

The association (VIII) (subgroup 3): Quercetum libani.

Characteristic species include: *Quercus libani, Chaerophyllum macrospermum, Dactylis glomerata* subsp. *glomerata, Centaurea behen, Veronica polita, Viola odorata, Lamium album* subsp. *Album, Aethionema memberanaceum, Silene chlorifolia, Euphorbia condylocarpa, Cruciata taurica, Symphytum kurdicum, Lepyrodiclis holosteoides, Ferula orientalis, Mentha longifolia, Astragalus lovensis, Astragalus compactus, Dactylorhiza umberosa, Astragalus tortuosus, Comperia comperiana, Ornithogalum oligophyllum, Steptorhamphus persica* and *Melica persica* subsp.persica.

Transgrasive and characteristic species and class: *Galium aparine, Poa bulbosa* subsp. vivipara, *Geranium tuberosum* subsp. *micranthum, Ranunculus arvensis, Vicia variabilis, Alyssum linifolium* subsp. *linifolium, Bunium elegans, Ziziphora capitata* subsp. *Capitata, Arabis caucasica* subsp. *caucasica, Bellevalia longistyla, Ficaria kochii, Achillea millefolium* subsp. *millefolium, Tragopogon retriculatus, Bromus tectorum* var. *tectorum, Crepis sancta* subsp. *sancta, Eremopoa persica* var. *persica, Crataegus pontica, Cerastium inflatum, Salvia suffruticosa, Onosma sericeum, Valerianella carinata, Pyrus syriaca, Trifolium pilulare, Milium pedicellare, Chardiana orientalis, Echinops orientalis, Gentiana olivieri, Inula thapsoides, Cerasus microcarpa, Falcaria vulgaris, Ranunculus pinardi, Phlomis olivieri, Allium eriophyllum* var. *eriophyllum, Lonicera nummularifolia, Helianthemum ledifolium, Holosteum umbellatum, Hypericum scabrum, Senecio vernalis, Bongardia chrysogonum, Lactuca serriola, Geranium rotundifolium, Silene ampullta, Chaerophyllum macropodon, Eremostachys lacinata, Taraxacum montanum, Echium italicum* var. *italicum, Lallemantia peltata, Pterocephalus plumosus, Nasturtium officinale, Medicago regidula, Ferulago stellata, Eremorus spectabilis* subsp. *spectabilis, Orobanche aegyptica, Papaver dubium, Rosa canina, Adonis* sp., *Trifolium arvense* var. *arvense, Lens orientalis, Lens cyanea, Vicia narbonensis* var. *narbonensis, Torilis leptophylla, Gladiolus kotschyanus, Onopordon acanthium, Lathyrus cicera, Scandix pectin-veneris, Sorbus persica, Prangus ferulacea, Chamaegron oligocephalus, Onosma microcarpum, Conringia perfoliata, Alopecurus myosuroides* var. *myosuroides.*

DISCUSSION

Kurdo-Zagrosian site in Iran with open forest and shrub lands is part of a mountain range at latitude of 4000 m parallel to Zagros (Kordestan and some parts of Azerbaijan) (Zohary, 1973). Flore of this area has been studied by many researchers (Guest, 1953; Pabot, 1960). Zohary (1973) considers the vegetation of this area of Quercetea brantii type while Mobayyen and Djavanshir (1971) consider these societies of Quercetea persicae type and have introduced two orders of Quercetalia infectoria and *Quercetalia persicae*. The first order includes various species of *Quercus brantii* Lindl. and characteristic species of this order is *Quercus infectoria* which covers the area from the North of Kermanshah to Oroumiyeh forests; the second order covers the area from Kermanshah to around Shiraz and its main species is *Quercus brantii* var. *persicae*. *Quercus infectoria* is never seen in this order. The first order indicates the Mediterranean and relatively mild climate and covers most of forests in the west of Iran and in the areas where the sunshine is at its most, it covers the foot of mountain toward the north where it is cooler and more humid while the second order is placed at the low longitude and includes species resistive to dry climate and it is seen in the southern and southwestern terrains where semi-dry climate joins the subtropical regions. The soil in the areas of the first order is very much alkaline while the soil in the areas of the second order is made of sandy-clay soil. Some of the reported forest associations in these areas include the following:

Quercetum libani, Quercetum infectoria, Quercetum brantii, Querceto-pistacietum (Sabeti, 1976; Djavanshir, 1999; Fattahi, 2000; Asri and Mehrnia, 2001; Browicz, 1994; Zohary, 1973).

Based on the results achieved in this research, the gained 8 associations are included in the class of Quercetea persicae and order of Quercetalia persicae; except for 3 associations: *Quercetum libani, Quercetum infectoria and Quercetum brantii* which have been reported in different sources, in other cases because of shortage of information, they are considered documentary merely based on real observations in the nature, phytosociologists and unpublished studies. Based on the final table of phytosociology, characteristic species have been introduced for each association; it shall be taken into consideration that characteristic species of alliance based on observations in the areas and phytosociologists and until comprehensive and accurate information on all areas of Zagros have not been obtained in this regard, no certain claim can be made. Meanwhile based on the above reasons, some of the species such as *Pyrus syriaca* and *Crataegus pontica* which are characteristic order and class and accompanied with such species so that in the future comprehensive studies in these areas, comments can be given on them.

The initial analysis of major groups (Fig. 2, 3) indicates that 82.4% of the releves are correctly classified; that is, the releves belong to those groups that existed in the phytosociological classification analysis. Variables which were significant at 5% error level in this analysis include: pH, landform index, terrain shape index and aspect. pH in group 2 (*Quercetum libani*) and groupe 3 (*Thalictro sultanabadensi-Quersetum libani- acerotsum cinerascens*) indicated significant difference in comparison with group 1 (*Quercetum brantii*) ($p<0.01$). Brosfske *et al.* (2001) and Gough (2001) have considered acidity as an important factor in dispersion and distribution of associations. Based on the studies, *Quercetum libani* exists on soils with pH of nearly acid (Maroofi, 2000; Varol and Tatli, 2001; Abella and Springer, 2008) and it is true according to the achieved results in this research. Group 1 exists on soil with pH of nearly alkaline and the presented reports indicate the result (Talebi *et al.*, 2006).

The landform index in group 3 (*Thalictro sultanabadensi-Quersetum libani-acerotosum cinerascens*) indicated significant difference in comparison with two other groups ($p<0.01$). The much landform index for group 3 (0.34), indicates the position of this group near the edge while the quantity of this index for other two groups (0.27 for group 1 and 0.25 for group 2) indicates the position of these two groups at the median of altitude. Several studies have indicated that the effect of landform index on distinguishing of vegetation (Odom and McNab, 2000; McNab *et al.*, 1999; Ford *et al.*, 2002; Abella, 2003). The studies by Assareh in 2005 indicated the existence of tree characteristic species of group 3; that is *Acer monspessulanum* subsp. Cinerascens in mountainous areas and edges. The tree characteristic species of group 1; that is, *Quercus brantii* Lindl. exists in all types of landform shapes including valleys, slope and edges, but tree characteristic species of group 2 (*Quercus libani* Oliv.) are reported to be available on reported middle slope and the results accords with the result of this research (Assareh, 2005).

Terrain shape index indicates a significant difference between group 2 (*Quercetum libani*) and group3 (*Thalictro sultanabadensi-Quersetum libani- acerotosum cinerascens*) ($p<0.01$). Several studies are on the effect of this index in distinguishing of associations (McNab, 1989; McNab *et al*, 1999; Abella, 2003). The (+) sign in the quantity of this index for group 3 (+0.068) indicates convex site of group 3. The subassociation is located upper slope (on the edge); the landform upper slope is usually concave (Barnes *et al.*, 1998) and accords with the achieved results. The (-) sign in the quantity of this index for group 2 (-0.016) indicates concave site of group 2. Concave shape in ecological point of view indicates concentration of moisture and nutrients in the site (Barnes *et al.*, 1998); on the other hand, this association requires such a desired conditions (Fattahi, 2000; Maroofi, 2000). The quantity of this index for group 1 (*Quercetum brantii*) is (+0.011) that has no significant difference with group 2 and also this association has a great ecological endurance (Fattahi, 2000) and can exist in undesirable conditions as well. Adaptation of oak associations with moisture gradient has been identified in several studies (Seng and Deil, 1999).

The aspect in group 1 (*Quercetum brantii*) indicated a significant difference from two other groups ($p<0.01$). Several studies have been done about the effect of aspect on separation of plant associations (McNab *et al.*, 1999; McEvan *et al.*, 2005; Zhang *et al.*, 2006; Collins and Carson, 2004). The existence of *Quercetum brantii* in the southern direction and *Quercetum libani* in the northern direction has been reported in many of the studies (Fattahi, 2000; Sagheb-Talebi *et al.*, 2005; Zohary, 1973). group 3 is mostly seen in the humid regions, valleys and stony grounds in the northern and Northeastern terrains (Zohary, 1973; Assareh, 2005).

Partial analysis of vegetation in group 1 (*Quercetum brantii*) proved the existence of subgroups (Fig. 4). The partial analysis on group 1 (*Quercetum brantii*) resulted into 5 subgroups. But due to the destructive condition, open condition of the forest and overgrazing of cattle on this association, no environmental variables indicated having a role in the taking a part.

The partial analysis on group 2 (*Quercetum libani*) proved the existence of 3 subgroups. Multiple discriminant analysis indicated effectiveness of altitude variable and the C/N in this distinguishing. The studies in the site of Zagros indicated the effectiveness of altitude and C/N in *Quercetum libani* association's separation (Heydari and Mahdavi, 2009; Jazerehei and Ebrahimirastaghi, 2003). The existence of three associations of *Quercus boissieri-Quercetum libani, Quercetum libani and Thalictro sultanabadensi-Quercetum libani* has been specified in group 2. The association of *Quercus boissieri-Quercetum libani* has been severally reported to exist at lower altitude in comparison with *Quercetum libani* association

(Browicz, 1994; Maroofi, 2000; Assareh, 2005). *Thalictro sultanabadensi-Quercetum libani* with its characteristic species such as *Hesperis kurdica* (1150-2200 m), *Fibijia macrocarpa* (1000-2400 m), *Campanula inolucrata* (2300-3100 m), *Cotoneaster nummularioides* (800-2800m) and *Agropyron panormitanum* (550-1625 m) (Nazarian *et al*., 2004; Onal and Behset, 2007; Malekmohammadi *et al*., 2007; Gücel *et al*., 2008) indicate the existence of species of this association at different altitudes.

The existence of *Quercetum libani* association at middle altitude (mean altitude = 1650 m) with slope at mean of 45% which makes it impossible for cattle to climb up, causes high density of forest (in most of places of this association, 90% cover has been seen) and ecological needs of *Quercus libani* including high moisture of soil and nutritious soil (Maroofi, 2000; Assareh, 2005; Zohary, 1973; Heydari and Mahdavi, 2009), all are because of significant of C/N in this association in comparison with other subgroups. Generally, Christine and McCarthy (2005) stated that C/N has correlation with distribution of herbaceous species. Based on researches by Oner and Oflas (1977), the plant association (*Quercus boissieri-Quercetum libani*) grows on fertile sites and high water table. In this area, because of growth of this association at low altitude (mean altitude =1590 m), cattle and people living there have more access to it and it caused knocking of the soil, reducing of organic materials and decreasing of C/N and finally, it has led to significant with *Quercetum libani* (Tabatabai and Ghasriani, 1992).

CONCLUSIONS

Based on AFC and CAH methods, experiences and literature review, 8 associations and 1 sub-association were achieved including: *Trifolio stellati-Quercetum brantii, Pistacio atlanticae-Quercetum brantii, Violo modestue-Quercetum brantii, Trifolio campestri-Quercetum brantii, Quercetum brantii, Thalictro sultanabadensi-Quercetum libani, Quercetum libani-acerotosum cinerascens, Quercos boissieri-Quercetum libani* and *Quercetum libani.* These plant associations belong to Quercetea persicae class and *Quercetalia persicae* order.

On the bases of discriminant analysis, the effective and significant environmental factors in division of plant associations include respectively: pH, landform index, Terrain shape index and aspect.

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