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Ground Vegetation as Indicator of Soil Characteristics for an Ecological Site Classification of Southern Caspian Forests

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ABSTRACT

The objectives of this research were to identify the ecological species groups and study the relationship between topographic and edaphic factors with plant species to determine the main factors affecting the separation of vegetation types in Khanikan lowland forests of Mazandaran province - North of Iran. Vegetation was sampled with randomized - systematic method. Vegetation data including density and cover percentage were estimated quantitatively within each quadrate, and using the two - way indicator species analysis (TWINSPAN). Vegetation was classified into different groups. The topographic conditions were recorded in quadrate locations. Soil samples were taken from organic horizon (litter layer), and mineral layers (0-10, 10-20, and 20-30 cm). Soil acidity, bulk density, saturation moisture, electrical conductivity, organic carbon, total nitrogen, cation exchangeable capacity, available phosphorous, soil texture, lime, biomass of earthworms, litter carbon, and litter nitrogen were measured. Multivariate techniques were used to analyze the collected data. The results indicated that the vegetation distribution pattern was mainly related to soil characteristics such as pH, bulk density, texture, phosphorous, organic carbon, nitrogen and CEC. Totally, considering the habitat conditions and ecological needs, each plant species has a significant relation with soil properties.

Keywords: Forest site classification, species indicator, multivariate statistical analysis, soil characteristics.

INTRODUCTION

Vegetation, and particularly ground - cover vegetation, because of its ability to integrate the effects of climate, soil, and physiographic has been utilized to indicate habitat conditions and forest productivity potential for many years [1, 2, 14, 29]. In ecology of vegetation have used of relation between species combination and environmental factors for determine of ecological species groups [20, 26, 27, 43]. Forest habitat typing is a system of classification widely used in the Michigan oak forests [40] that uses plants to indicate general habitat conditions. Some approaches identify sites using field keys based upon a few indicator plants, often a small subset of the total ground flora [2]. However, when a few plants are used, identification of sites may be

difficult. The absence of the key species can be due to factors unrelated to site quality such as disturbance, past forest history, or chance events. Instead of single species as indicators, species groups have been used to alleviate this problem. The concept of ecological species groups is attributed to Duvigneaud [9], and first applied to intensive forest management in the southern German state of Baden - Wuttemberg [30, 35, 39, 41]. Ground - cover species indicating similar site conditions - for example, soil moisture, nutrients, pH, local climate, etc. are grouped together, named for characteristics species and termed "ecological species group".

It is well known that vegetation presents significant problems [6] because of its sensitivity to disturbance and difficulty in objective quantification. Nevertheless, vegetation is a key ecosystem component that is not only easily recognizable but can be used to measure, through its integrative ability, the response to climate, physiographic, and soil factors. In order to better understand and manage forest ecosystems, it is important to study the relationship between environmental factors and plants in these ecosystems. One of the main components of forest ecosystems is kinds of vegetation which are controlled by environmental variables such as climate, soil and topography [36, 44]. Among different environmental factors, soil is of high importance in plant growth, and is a function of climate, organisms, topography, parent materials and time [21]. Topography (elevation, slope, and aspect) affects soil and climate, in addition to affecting temperature and evapotranspiration (as elements of climate), deeper soil and higher content of comparison to the southern ones [32].

Effects of environmental factors on plant communities have been the subject of many ecological studies in recent years. Salehi [32] found that vegetation cover had strong relationship with temperature and soil moisture. Other soil characteristics, directly or indirectly, influence the two mentioned parameters. Determining which factors control the presence, number, identify, and relative abundance of plant species remains a central goal in ecology. The objectives of this study were to: (1) identify ecological species groups for lowland forests of northern Iran, (2) Study the relationship between edaphical factors with plant species to determine the main factors affecting the separation vegetation types.

MATERIALS AND METHODS

Study area: Khanikan forests are located in the lowland and midland of Mazandaran province in north of Iran with the area of 2807 ha. (Between 36˚ 33́ 15˝, 36˚ 37´ 45˝ latitude, and between 51˚ 23´ 45˝, 51˚ 27´ 45˝ longitude). The maximum elevation is 1400m and the minimum elevation is 50m. Minimum temperature in December (7.5˚C) and the highest temperature in June (24.6˚C) are recorded, respectively. Mean annual precipitation of the study area were from 237.6 to 47.5 mm at the Noushahr city metrological station, which is 10Km far from the study area [3].

Data collection: In order to investigate of vegetation and differentiation plant ecological groups was sampled quadrates in mid - summer 2010. In lowland region 268.7 ha. of this forest was selected. For investigation of tree and shrub covers sixty quadrates (20×20m AR.) [13, 16, 24] and sub quadrate ($1m^2$ AR.) in each quadrate for investigation of herbaceous covers [25], were taken by randomized - systematic method. Considering variation of vegetation and environmental factors, floristic list and canopy cover percentage were determined in each quadrate. Vegetation cover data were recorded using ordinal scale of Van-der-Marel [38]. Soil samples were selected from organic horizon (litter layer), and mineral layers (0-10, 10-20, and 20-30 cm). Soil pH (saturation paste), bulk density (clod method), saturation moisture (weighting method), electrical conductivity (EC)(by conductivity meter), organic carbon (Walkey and Black

rapid titration) [4], total nitrogen (Kjeldahl method), cation exchangeable capacity (CEC)(by using flame photometry method), available phosphorous (Olson method), soil texture (hydrometer method), litter carbon (Walkey and black method), and litter nitrogen (Kjelteck method) were determined [17, 18]. In quadrate locations, elevation and slope (using compass) and aspect were also recorded.

Data analysis method: Data matrix of environmental factors and vegetation type was made. The windows (Ver. 3.0) of PC- ORD [8, 23] were used for classification and ordination of vegetation types in gradient of environmental factors. Data were analyzed by a series of multivariate techniques such as the Two - way indicator species analysis (TWINSPAN), Detrended Correspondence Analysis (DCA) and Principal Component Analysis (PCA). Comparing of means of environmental factors amongst forest types, and also study of inter - relationships between these variables was done by one way ANOVA (Analysis of ANOVA) method in SAS of statistical program. Due to lack of statistical analysis [42], understanding the structure of plant species is associated with considerable mistake, therefore, in the first step, vegetation of data study area was classified using TWINSPAN analysis. To use this analysis, the cover data transformed using an eight – point scale (0 – 1 = 0.5, 1 – 2.5 = 1.75, 2.5 – 5 = 3.75, 5 – 7.5 = 6.25, 7.5 – 12.5 = 10, 12.5 – 17.5 = 15, 17.5 – 22.5 = 20, 22.5 – 27.5 = 25, > 27.5 = 30) [38]. TWINSPAN analysis is a numerical method for classification of vegetation belonging to similar groups. This allows the investigator to recognize the homogenous groups. DCA ordination summarizes species abundance data by assessing the dominant patterns of variation in species composition of sample plots. The abundance of species normally covery in a systematic fashion because they are reacting to the same underlying environmental variables [19]. PCA is the ordination technique that constructs the theoretical variable that minimizes the total residual sum of squares after fitting straight lines to the species data. PCA does so by choosing the best values for the sites. The apply PCA; data standardization is necessary if we are analyzing variables that are measured in different units. Also, species with high variance, often the abundant ones, therefore dominate the PCA solution, whereas species with low variance, often the rate ones, have only minor influence on the solution. These may be reasons for applying the standardized PCA, in which all species receive equal weight [19]. Therefore, data was centered and standardized by standard deviation.

RESULTS

Floristic, life forms and cerotype: In studied area, 56 species of 36 families were recognized that the number of woody species and herbaceous species were14 and 42 respectively (Table 1). Life forms were determined by Raunkiaer system and according to the biological spectrum, phanerophytes and cryptophytes (35.71%), and hemicriptophytes (28.57%) were dominant life forms of the studied area. Also, vegetation chorology showed hyrcanian elements with 55.35% was dominant chorotype of khanikan lowland forests. Number of 8 species (14.287%) was endemic of Iran Flores (Table 1).

Table 1. Species, life form, endemic, family, and mean cover values (%) of the recorded species in the five vegetation groups derived after application of TWINSPAN

Vegetation group / Species	Life form[1]	Cerotype[2]	Endemic	Family	I	II	III	IV	V
Carpinus betulus l.	*Ph*	*H*		*Betulaceae*	85.9	120.2	89.1	96.1	37.3
Parrotia persica (dc.)	*Ph*	*H*	*	*Hamameliadaceae*	0.0	50.6	47.2	62.5	16.6
Cratagus Pentagyna Waldst& kit.	*Ph*	*H,M,IT*		*Rosaceae*	0.0	5.7	2.2	15.5	1.1
Querecus castanifolia c.a.m.	*Ph*	*H,M,IT*		*Fagaceae*	0.0	0.0	0.0	4.0	4.0
Buxus hyrcana pojark.	*Ph*	*H*	*	*Buxaceae*	0.0	24.6	1.8	0.0	0.0
Diospyrus lotus l.	*Ph*	*H,IT*		*Ebenaceae*	1.8	0.0	0.1	0.0	0.0
Ilex aquifolium l.	*Ph*	*H*	*	*Aquifoliaceae*	0.0	0.0	0.2	0.0	0.0
Ulmus glabra huds.	*Ph*	*H*		*Ulmaceae*	0.0	0.0	0.1	0.0	0.0
Mespilus germanica l.	*Ph*	*H,M,IT*		*Rosaceae*	0.0	0.4	0.0	0.7	0.0
Alnus glutinosa (l.)	*Ph*	*H*	*	*Betulaceae*	11.4	0.0	0.0	0.0	0.0
Pterocarya fraxinifolia(lam.)	*Ph*	*H*	*	*Juglandaceae*	2.4	0.0	0.0	0.0	0.0
Acer insign boiss.	*Ph*	*H*		*Acearaceae*	4.4	0.0	2.2	0.0	0.0
Ficus carica l.	*Ph*	*POL*		*Moraceae*	0.0	0.0	0.9	0.0	0.0
Ruscus hyrcanus l.	*Ph*	*H*	*	*liliaceae*	0.0	15.5	6.8	8.7	0.0
Carex grioletia l.	*Cr*	*H,M,IT*		*Cyperaceae*	0.0	13.2	19.6	14.9	5.4
Smilax exelsa l.	*Ph*	*H,IT*		*Asparaginaceae*	0.0	0.0	19.9	2.2	0.0
Primula heterocliroma stapf.	*He*	*H*	*	*primulaceae*	0.0	4.0	3.1	7.4	0.0
Brachypodium pinnatum (l.)	*He*	*H,M,IT*		*Gramineae*	0.0	3.7	2.8	10.8	2.0
Pteris cretica l.	*Cr*	*POL*		*Pteridaceae*	0.0	9.0	9.7	3.4	6.0
Scutellaria tournefortii benth.	*He*	*H,IT*		*Labiatae*	0.0	1.4	3.5	1.2	0.8
Viola odarata l.	*He*	*H,M*		*Violaceae*	24.5	10.5	8.8	17.6	0.7
Asplenium adiantum-nigrum	*Cr*	*H*		*aspleniaceae*	0.0	0.7	14.9	0.0	0.0
Equisetum ramossisimum desf.	*Cr*	*H*		*Equisetaceae*	0.0	8.0	0.2	0.0	0.0
Conyza bonariensis l.	*He*	*POL*		*Compositae*	0.0	0.0	0.6	0.0	0.0
Aspelenium trichomanes l.	*Cr*	*H,IT*		*aspleniaceae*	0.0	0.0	1.4	0.0	0.0
Phylitis scdopendrium l.	*Cr*	*H*		*aspleniaceae*	0.0	3.5	10.1	2.2	0.0
Pteridium aquilinum l.	*Cr*	*H,M*		*Hypolepidaceae*	0.0	0.0	6.1	0.0	0.0
Hedra pustuchovii woron.ex	*Ph*	*H*		*araliaceae*	4.0	4.3	15.9	0.0	0.0
Pteris dentate forssk.	*Cr*	*H*		*Pteridaceae*	0.0	0.0	0.0	0.6	0.0
Circeae lutetiana l.	*He*	*H*		*onagraceae*	0.0	0.0	2.0	0.0	0.0
Oplismenus undulatifolius (ard.)p.	*Cr*	*H,M,IT*		*Graminaceae*	55.0	96.7	8.4	8.9	17.0
Calystesia sepium(l.)r.br.	*He*	*H*		*umbelliferae*	0.0	0.3	0.0	0.0	0.0
Hypericum androsaemus l.	*Ph*	*H,M*		*Hypericaceae*	0.0	3.6	0.8	0.0	0.0
Fragaria vesca l.	*Ph*	*H*		*Rosaceae*	0.0	8.0	0.1	1.0	0.4
Prunlla vulgaris l.	*He*	*H*		*Labiatae*	0.0	0.0	0.0	2.0	0.0
Euphorbia amygdaloides l.	*He*	*H*		*Gramineae*	0.0	16.0	4.6	0.0	0.0
Tamus communis l.	*Cr*	*M*		*Dioscoraceae*	0.0	0.0	2.1	0.2	0.0
Sanicula europaea l.	*He*	*H,M*		*Umbelliferae*	0.0	0.0	0.0	0.8	0.0
Danae racemosa(l.)moench	*Ph*	*H*	*	*Liliaceae*	0.0	0.0	0.4	0.0	0.0
Solanum kieseritzkii c.a.mey.	*Cr*	*H*		*Umbelliferae*	0.0	0.0	0.9	0.0	0.0
Festuca drymeia mert,koch	*Cr*	*H*		*Gramineae*	10.0	16.5	0.0	0.0	0.0
Dryopteris filix-mas(l.)schott	*Cr*	*H*		*Aspidiaceae*	0.0	6.5	0.0	0.0	0.0
Microstegium vimenium(trin.)	*He*	*H,M*		*Gramineae*	0.0	1.5	0.0	0.0	0.0
Ophioglossum vulgatum l.	*Cr*	*H*		*ophioglossaceae*	0.0	0.0	0.0	0.2	0.0
Parieturia officinalis l.	*Cr*	*H,M*		*urticaceae*	15.0	0.0	0.0	0.0	0.0
Geum urbanum l.	*He*	*H,M,IT*		*Rosaceae*	11.5	0.0	0.0	0.0	0.0
Menthe aquatica l.	*He*	*POL*		*Labiatae*	90.0	0.0	0.0	0.0	0.0
Plantago major l.	*He*	*POL*		*Plantaginaceae*	0.0	0.0	0.0	0.0	2.0
Pimpinella affinis ledeb.	*Cr*	*H*		*Umbeliferae*	0.0	0.0	0.0	0.0	0.1
Oxalis corniculata l.	*He*	*H*		*Oxalidaceae*	15.0	0.0	0.4	0.0	0.0
Lamium album l.	*Cr*	*H*		*Labiatae*	4.0	0.0	0.0	0.0	0.0
Mercurialis prennis l.	*He*	*H*		*Euphorbiaceae*	0.0	0.0	6.0	0.0	0.0
Cardamin impatiens l.	*Cr*	*H*		*Cruciferae*	0.0	0.0	0.0	0.1	0.0
Rubus caesius l.	*Ph*	*H*		*Rosaceae*	27.0	31.0	7.0	20.0	50.0
Urtica dioica l.var.dioica.	*Cr*	*POL*		*urticaceae*	0.0	0.0	0.8	0.0	0.0
Carex acutiformis l.	*Cr*	*H,M*		*cyperaceae*	0.0	0.0	0.0	0.0	17.5

Life form[1]: Ph: Phanerophyte. Cr: Cryptophyte. He: Hemicriptophyte. Chorotype[2]: H: Hyrcanian. M: Mediteranian. It: Irano –Touranian. Pol: Poly zonal

TWINSPAN: TWINSPAN was performed for vegetation analysis 60 plots using ordinal scale of Van - der - Marel [38]. The result of TWINSPAN classification is presented in figure 1. According to the above mentioned table, figure, and also Eigen value each division; vegetation of the study area was classified into five types. Each type differs from the other in terms of its environmental needs. They are named after the characterizing species as follows: *Menta aquatica*, *Oplismenus undulatifolius*, *Carex grioletia*, *Viola odarata*, and *Rubus caesius*. Table 2

showing woody and herbaceous indicators for vegetation types in study area. The most number of plant species (36) is relation to III vegetation group and the least of it (15) is relation to I, IV vegetation groups (Fig. 2). Also, III vegetation group and I vegetation group had the most (23.7) and the least (8.3) mean of cover (%), respectively (Fig. 3). Results showed that II, III vegetation groups and I, II vegetation groups had the most (65.5%) and the least (30%) of Sorenson similarity coefficient, respectively (Table 3).

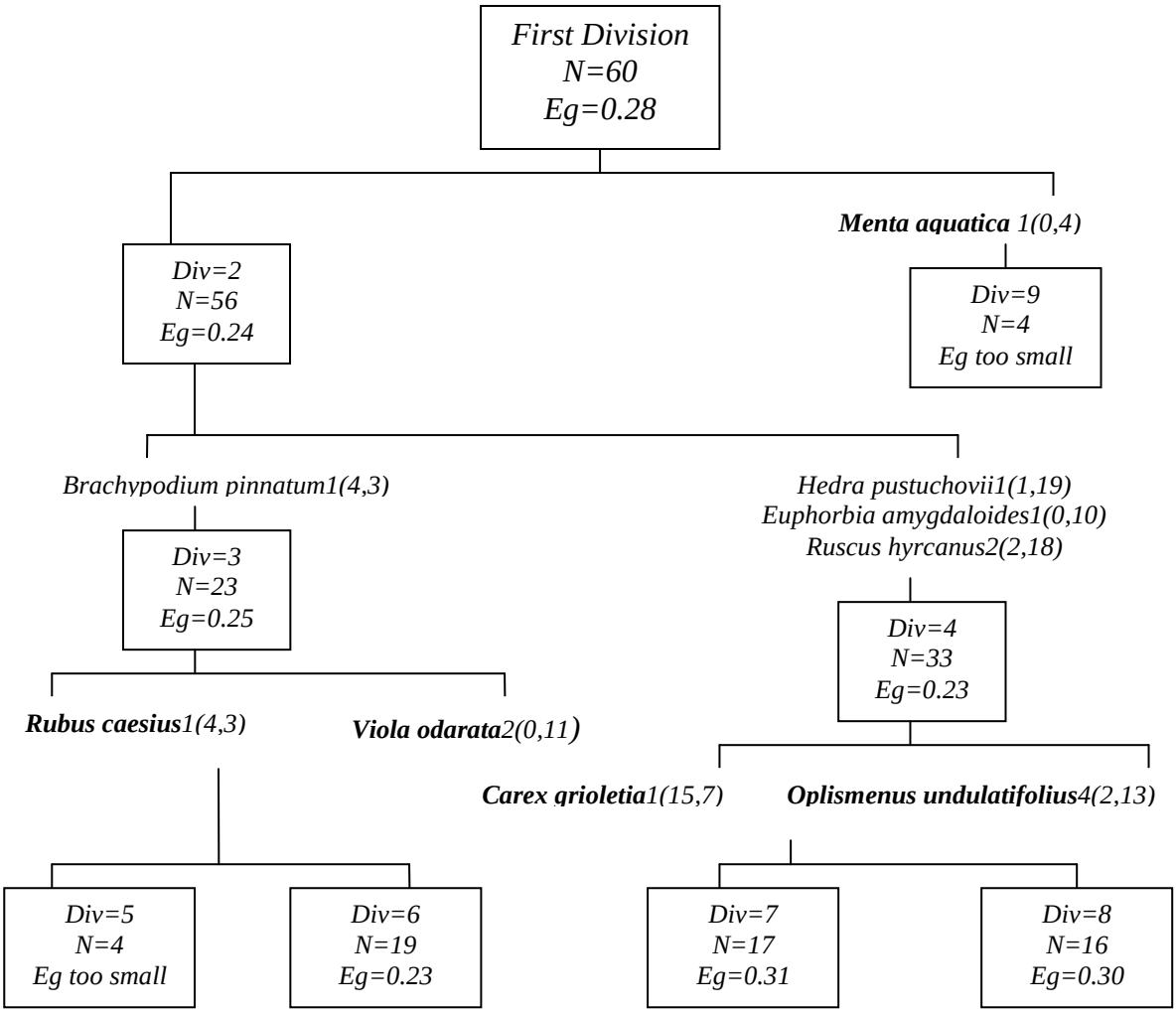

Fig.1. Relationship between the five vegetation groups generated after the application of TWINSPAN classification technique. Number after of species name, and inside bracket indicating of species value in division and presence in right and left directions of division, respectively.

Table 2. Woody and herbaceous indicators for vegetation types in study area. For species abbreviations, see Appendix A.

Woody indicator species	Herbaceous indicator species	Types name
Carpinus betulus L.	*Menta aquatica* L.	I
Parrotia persica (DC.) C. A. Mey. - *Ruscus hyrcanus* L.	*Hedera pastuchovii* L.- *Oplismenus undulatifolius* (AC.)	II
Parrotia persica (DC.) C. A. Mey. - *Ruscus hyrcanus* L.	*Carex grioletia* L.- L. *Hedera Pastuchivii*	III
Parrotia persica (DC.) C. A. Mey. -*Cratagus* SP.	*Brachypodium pinnatum* L. - *Viola odorata* L.	IV
Parrotia persica (DC.) C. A. Mey. - *Cratagus* SP. - *Quercus castaneifolia* C.	*Brachypodium pinnatum* L. - *Rubus caesius* L.	V

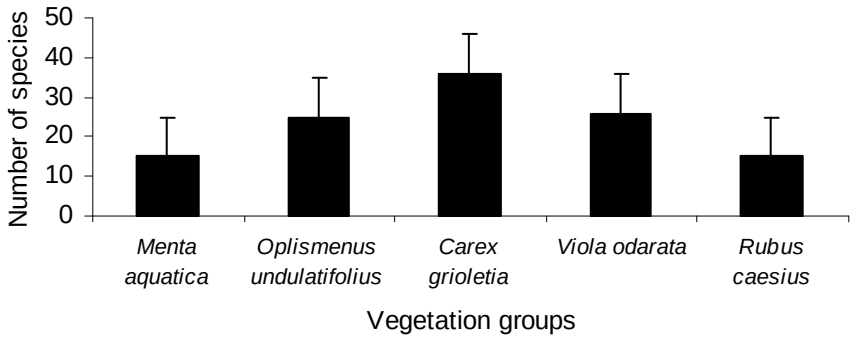

Fig.2. Number of plant species in vegetation groups

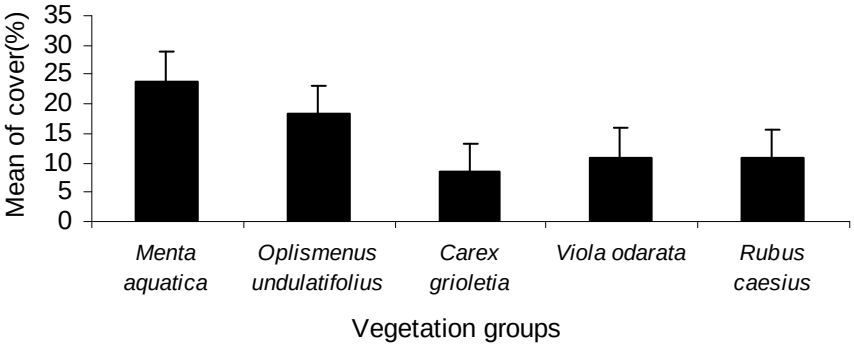

Fig.3. Mean of cover (%) in vegetation groups

Table 3. Percent of Sorenson Index in ecological species groups

Vegetation group	I	II	III	IV	V
I	-	30	31.3	32.4	26.6
II	30	-	65.5	65.3	59.4
III	31.3	65.5	-	64.1	44
IV	32.4	65.3	64.1	-	61.5
V	26.6	59.4	44	61.5	-

DCA: DCA is a kind of technique that shows non-linear relation species with environmental factors. The first DCA is best explained by indicator values for environmental reaction. Eigen value of first, second, third axis is 0.45, 0.33, and 0.17, respectively. Figure 4 has showed spatial distribution of plant species in DCA ordination. The first axis includes soil variables such as clay, organic carbon, nitrogen, and cation exchangeable capacity (CEC) in the positive directions of this axis. In this area of axis, were indicator species *Carex grioletia* and *Viola odarata*. This species have showed positive correlation with mentioned variables. In the negative directions of axis 1, variables pH, bulk density, and the amount of sand were important. In this area of axis, were indicator species *Menta aquatica*. In the positive directions of axis 2 have showed variables such as available phosphorous and the amount of clay. In this area of axis include group with indicator species *Oplismenus undulatifolius*. This group has showed positive correlation with mentioned variables. In the negative directions of axis 2 don't have showed effective environmental factors. Off course this subject returns to complex correlation between species and habitat. In this area of axis is located group with indicator species *Rubus caesius.* Figure 5 has showed spatial distribution of quadrates in DCA ordination.

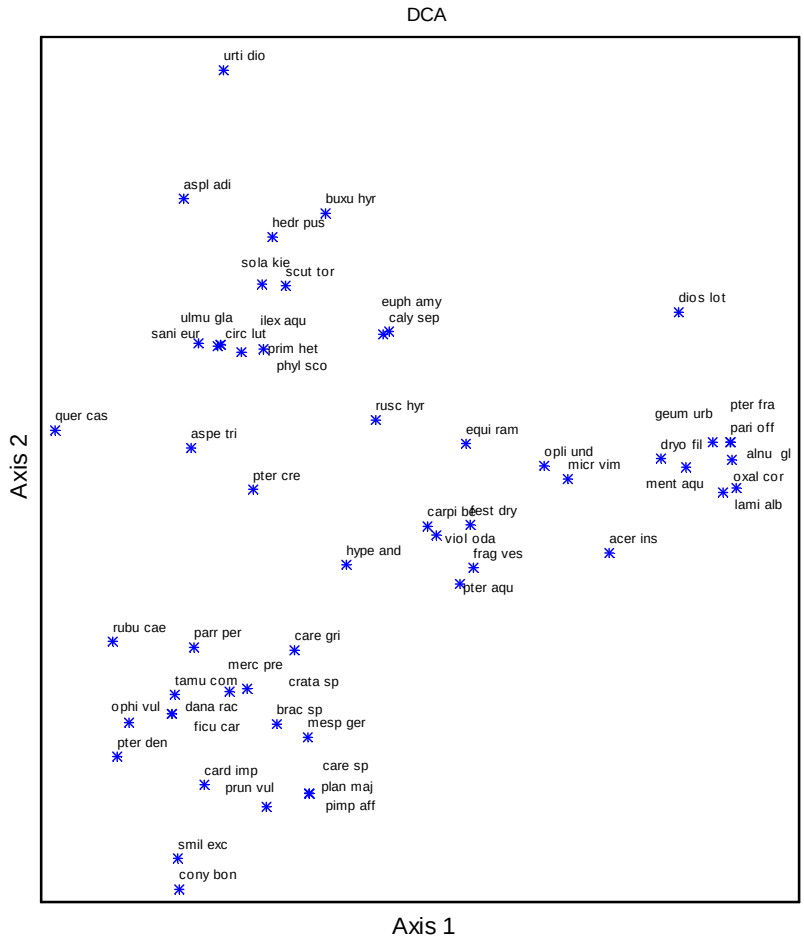

Fig. 4: DCA – ordination of plant species in the study area. For plant species abbreviation, see Appendix A.

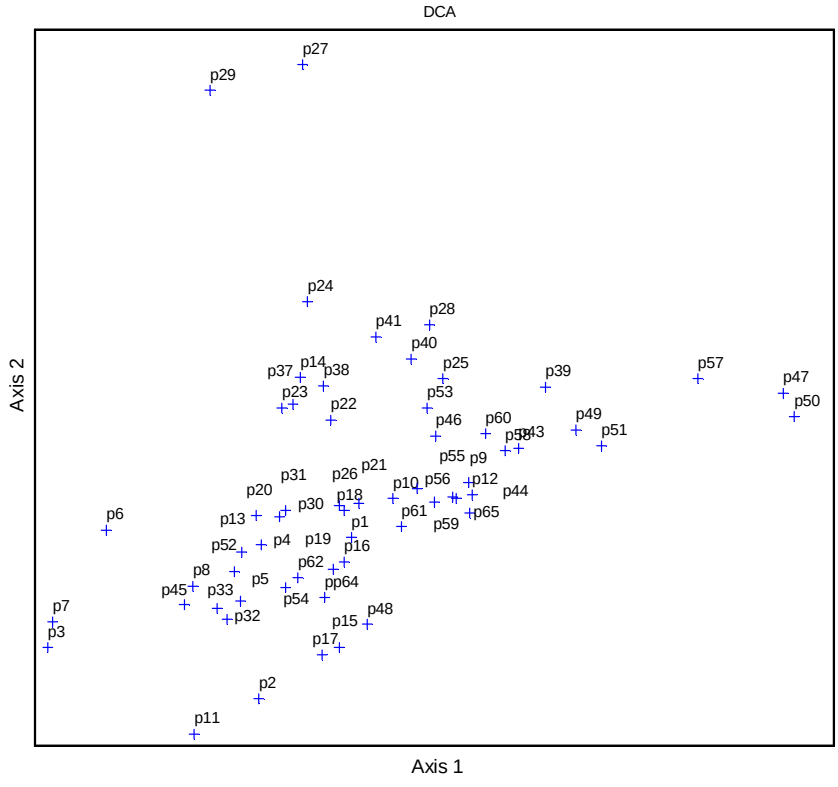

Fig. 5: DCA – ordination of quadrates in the study area

The first DCA axis (Eigen value = 0.45) is the most effective of axis. Quadrates also similar to ordination of species are located in length of axes. Figure 6 has showed spatial distribution of quadrates in each ecological group, resulted of TWINSPAN classification.

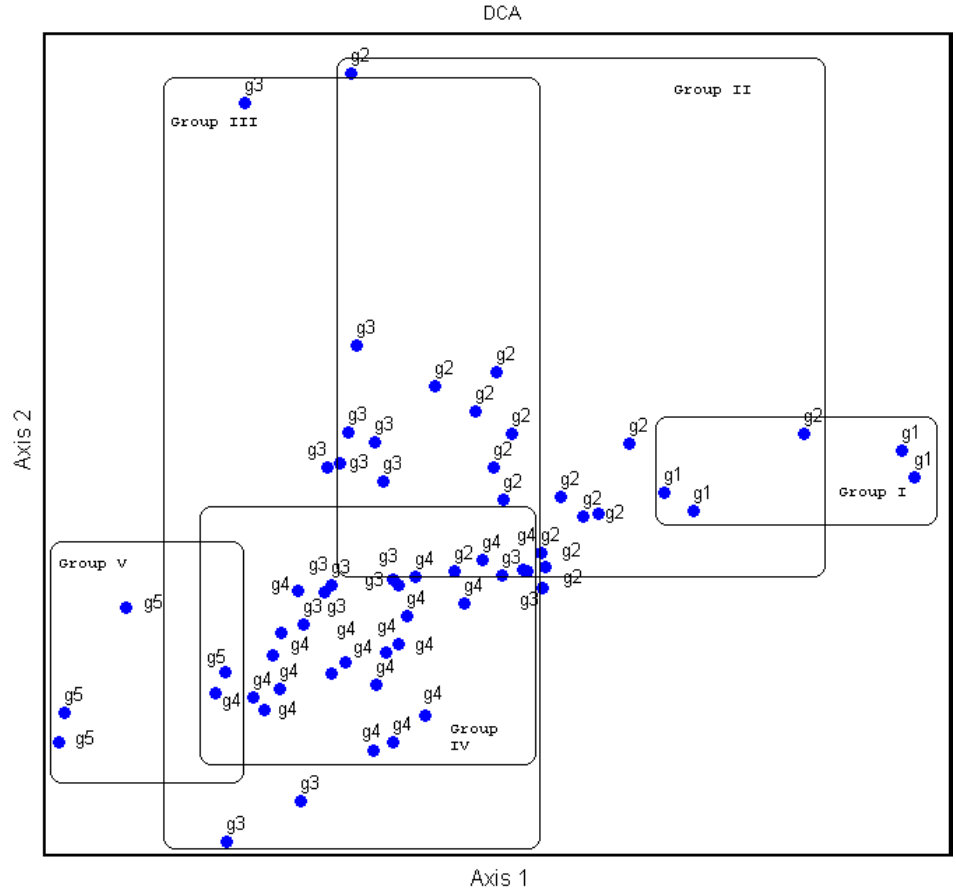

Fig. 6: DCA – ordination of quadrates in each ecological groups resulted of TWINSPAN classification.

PCA: To determine the most effective variables on the separation of vegetation types, PCA was performed for 52 factors in study area. The results of the PCA ordination are presented in table 4 and fig. 7. Eigen values for data set indicate that the first two principal components (PC1 and PC2) resolutely captured more variance that expected by chance. The first two principal components together accounted for 78.55% of the total variance in data set. Therefore, 59.11% and 19.43% variance were accounted for by the first and second principal components, respectively. This means that the first principal component is by far the most important for representing the variation of the five vegetation types. Consideration the correlations between variables and components, the first principal component includes environmental factors such as pH (each three layers), bulk density, sand (second and third layers), biomass of earthworms (third layer) and nitrogen of litters in the negative directions of axis 1, and organic carbon, nitrogen of soil (first layer), clay (second and third layers) and CEC (third layer) in the positive directions of axis 1.While axis 2 is reflecting a gradient of phosphorous and clay (first layer) that are the most effective factors in the distribution of vegetation types.

Figure 7 shows a plot of the five vegetation types against their values for axes 1 and 2. For the interpretation of the diagram and the vegetation types, spatial distribution, in addition of the edaphical factors (Table 4). The following points should also be noted: 1) in the diagram, the distance between the indicators points of the vegetation types show the degree of similarity and dissimilarity in the edaphical factors. 2) Those plant sites that are lying in the positive direction of axis 1 have positive correlation with factors this area of axis, and have inverse relationship

with PC1 factors in the negative direction of axis 1, also this subject exists for second axis. 3) The distance between the indicator points of the vegetation types from axes is representative of the relationship power in the explanation of variations. Whenever the length of vector loading (as indicator of the vegetation types) is bigger, the angle between vectors and axes is smaller. Therefore, the correlation between vegetation types with axes and relation power is large.

In relation to axis 1, the most correlation belongs to first, third and forth groups. That shows axis 1 properties. The first group shows the most correlation with the negative direction of axis 1 and the third, forth groups show the most correlation with the positive direction of axis 1. Also, correlation between the first groups with other groups is negative, namely, exists the least correlation between the first groups with other groups. In addition, in IV, III type's environmental characteristics are approximately similar in the positive direction of axis 1. Therefore, this is clear that the groups that showed the most correlation with the first axis, the least correlation with axis 2 belongs theirs, and vice versa.

Table 4: PCA correlation matrix of the environmental factors for the study area

Axes	Eigenvalue	Percentage of variance
1	30.742	59.119
2	10.107	19.436
3	8.182	15.735
4	2.969	5.710

Continuing of table 4.

Variables	Axes						Variables	Axes					
	1	2	3	4	5	6		1	2	3	4	5	6
Nea	-0.10	-0.16	0.09	0.33	-0.12	-0.01	Nb	0.13	-0.12	0.13	-0.20	-0.04	0.09
Neb	0.11	0.06	0.25	0.03	0.02	0.02	Nc	0.15	0.11	0.11	0.04	0.10	0.10
Nec	-0.09	0.03	0.29	0.00	0.12	-0.24	C/Nlit	0.16	-0.12	-0.04	0.02	-0.11	0.08
Bea	-0.04	0.17	-0.10	0.42	-0.08	-0.00	C/Na	0.11	-0.00	-0.26	0.02	-0.00	0.07
Beb	0.12	0.06	0.24	-0.01	0.02	-0.04	C/Nb	0.11	-0.23	-0.01	0.00	0.05	-0.04
Bec	-0.15	0.08	0.16	-0.05	0.11	-0.11	C/Nc	0.02	-0.29	0.02	-0.15	0.17	0.01
PHa	-0.18	0.01	0.00	-0.00	-0.01	0.20	CECa	0.14	0.15	-0.09	-0.09	-0.00	-0.10
PHb	-0.17	0.06	0.03	-0.00	0.17	0.25	CECb	0.07	0.18	0.03	-0.39	0.02	-0.07
PHc	-0.17	0.09	0.04	-0.03	0.13	-0.20	CECc	0.16	0.05	-0.09	-0.11	0.00	0.03
Wa	-0.10	0.20	0.16	-0.05	-0.01	-0.07	Pa	0.12	0.18	-0.12	0.11	-0.08	0.03
Wb	-0.17	-0.06	0.03	0.02	0.07	0.14	Pb	0.12	0.22	-0.05	-0.04	0.00	-0.07
Wc	-0.16	0.02	0.02	-0.22	-0.34	0.00	Pc	0.11	0.18	-0.16	0.05	-0.06	-0.04
Spa	0.16	-0.09	-0.12	-0.00	-0.04	-0.12	Sana	-0.15	0.15	-0.03	-0.11	-0.21	-0.17
Spb	-0.10	0.01	-0.28	0.04	0.19	0.10	Sandb	-0.16	-0.05	-0.11	-0.09	-0.02	-0.08
Spc	0.17	-0.06	-0.00	-0.05	0.05	-0.03	Sandc	-0.13	-0.05	-0.22	-0.03	-0.04	0.01
Eca	-0.09	0.25	-0.00	0.15	-0.07	0.08	Silta	0.13	-0.20	0.04	0.09	-0.03	-0.07
Ecb	-0.13	0.05	0.21	0.06	0.03	-0.11	Siltb	0.13	-0.03	0.19	0.17	-0.05	0.04
Ecc	-0.14	0.15	0.09	-0.10	0.00	0.02	Siltc	-0.02	0.07	0.32	0.12	0.10	0.03
Clit	-0.12	-0.12	0.17	-0.18	-0.65	0.10	Claya	0.06	0.28	-0.03	0.07	-0.29	0.05
Ca	0.17	-0.04	-0.00	-0.10	-0.02	-0.05	Clayb	0.17	0.04	0.01	0.07	-0.05	0.29
Cb	0.13	-0.15	0.12	-0.16	-0.04	0.02	Clayc	0.17	0.01	0.04	-0.02	0.07	-0.02
Cc	0.15	0.05	0.16	-0.04	0.03	0.18	La	-0.16	-0.12	0.00	0.02	0.03	0.01
Nlit	-0.16	0.06	0.08	-0.06	0.12	-0.19	Lb	-0.16	-0.02	0.10	-0.11	0.08	0.60
Na	0.17	-0.05	0.07	-0.06	-0.08	-0.13	Lc	-0.11	0.15	-0.16	-0.20	0.06	0.07

For abbreviation and units, see Appendix A.

The study area, environmental conditions in *M. aquatica* type differ from the others (Tables 5 and 6). With attention to the position of this type in the second quarter of the diagram, it has a high correlation with negative direction of axis 1. Therefore, this type has the most relation with variables of this direction of axis 1 (pH, bulk density, sand, biomass of earthworms). Because of the bigger distance of *M.aquatica* type from the second axis, this type has a weak relation with factors such as phosphorous and clay. *O. undulatifolius* type has the most relation with variables phosphorous and clay in the positive direction of axis 2. *C. grioletia* and *V. odarata* types have the most relation with variables the positive direction of axis 1 (organic carbon, nitrogen, CEC

and clay). Indicator environmental factors of *C. grioletia* and *V. odarata* types are approximately similar. For *R. caesius* type in the negative direction of axis 2 don't discriminate any effective factors. Off course that is due to complex correlation between species and habitat that their discriminate of ecological viewpoints is difficult. Although, *R. caesius* type was inversely relate with positive factors of the direction of axis two.

Table 5: Mean of soil chemical properties in study area (in different vegetation types)

Vegetation type	Depth (cm)	pH	BD	SP (%)	Ec (ds/m)	C (%)	N (%)	C/N	CEC (p.p.m)	P (p.p.m)
Men . aqu	0-10	6.95	1.26	29.45	0.87	1.71	0.15	10.06	11.40	3.51
	10-20	7.18	1.32	64.90	0.82	1.64	0.14	11.52	20.70	2.73
	20-30	7.15	1.35	33.57	0.80	0.92	0.08	10.74	10.40	2.02
Opl . und	0-10	5.59	0.80	60.74	0.85	3.22	0.24	13.35	26.10	20.92
	10-20	5.56	0.94	67.87	0.49	1.69	0.14	12.18	21.50	13.18
	20-30	5.52	0.98	60.21	0.45	1.34	0.14	9.89	24.40	17.63
Car . gri	0-10	5.05	0.90	59.34	0.71	3.95	0.35	11.44	22.18	14.62
	10-20	5.06	0.90	53.12	0.64	2.94	0.22	12.95	21.60	10.51
	20-30	5.02	0.89	72.95	0.41	2.41	0.20	11.04	22.80	10.00
Vio . cae	0-10	5.09	0.83	65.19	0.65	4.34	0.34	12.57	28.40	15.65
	10-20	5.03	0.85	58.76	0.48	2.99	0.23	12.80	28.64	13.62
	20-30	5.12	1.05	76.21	0.45	2.11	0.17	11.41	28.64	13.47
Rub . cae	0-10	5.58	0.45	67.07	0.52	3.65	0.29	12.56	15.60	6.71
	10-20	5.25	1.07	63.45	0.49	2.88	0.21	13.75	17.20	2.06
	20-30	5.01	1.02	69.20	0.29	1.31	0.10	13.08	20.20	4.86

For vegetation types and variables abbreviations and soil characteristics units, see Appendix A.

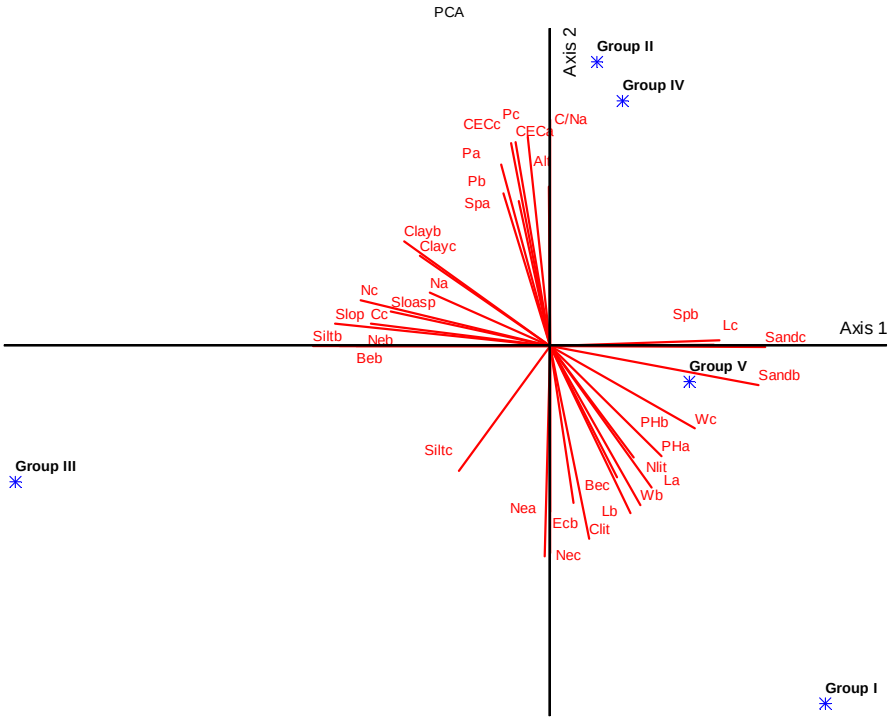

Fig. 7: PCA – ordination diagram of the vegetation types and the environmental factors in the study area. For vegetation types abbreviations, see Appendix A.

DISCUSSION

The ecological species groups were defined for the Khanikan lowland forests of Chaloose. It was the first attempt to develop such species groups in this part of the region, thus making it impossible to compare this study with other studies. The ecological profiles typically showed that each species of a group had similar responses over the range of ecosystems. This confirms

the usefulness of the species- group approach where the user may rely on more than one species to help determine site quality or identify ecosystem types in the field. Therefore, errors due to site characteristics are less likely to occur. The results showed that in the study area, among different environmental factors (topographic and edaphic variables), the distribution of vegetation types was most strongly controlled with some soil characteristics such as pH, bulk density, texture, phosphorous, organic carbon, total nitrogen, and CEC. Result of principal component analysis showed, the first two principal components together accounted for 78.55% of the total variance in data set. Therefore, 59.11% and 19.43% variance were accounted for by the first and second principal components, respectively. The obtained result showed that the first axis has the most correlation with productively factors and the second axis has the most correlation with physical factors of soil. This result has been reported by many investigations [15, 22, 31, 33, 45, 46]. To moving to the positive directions of axis, soil pH was higher, and the species were high acidophilus. In humid and sub humid regions, the relation between species distribution and pH gradient has been reported by many investigators [5, 7, 10, 28, 37, 45, 46].

Table 6: Mean of soil physical and biological properties in study area (in different vegetation types)

Vegetation type	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	L (%)	ne	Be (gr)	Clit (%)	Nlit (%)	C/N Lit
Men . aqu	0-10	79.00	8.50	12.50	10.25	0.5	0.07	7.08	2.17	3.26
	10-20	86.00	11.00	3.00	20.75	0.00	0.00			
	20-30	73.25	22.25	4.50	7.75	1.50	0.99			
Opl . und	0-10	68.87	16.31	14.81	5.00	0.25	0.13	6.31	1.46	4.32
	10-20	68.75	15.43	15.81	3.37	0.00	0.00			
	20-30	70.50	12.93	16.56	7.00	0.25	0.13			
Car . gri	0-10	58.60	27.60	13.80	4.20	0.40	0.06	6.62	1.41	4.69
	10-20	49.80	29.80	20.40	4.60	0.40	0.07			
	20-30	51.40	26.40	24.20	3.20	1.20	0.30			
Vio . cae	0-10	65.20	20.95	13.85	3.60	0.00	0.00	6.62	1.42	4.66
	10-20	61.20	18.90	17.90	5.20	0.20	0.04			
	20-30	60.80	15.70	23.50	6.30	0.60	0.18			
Rub . cae	0-10	59.00	30.00	11.00	8.00	0.50	0.02	6.79	1.40	4.85
	10-20	73.50	18.50	12.50	8.00	0.00	0.00			
	20-30	71.00	12.87	16.12	4.50	0.50	0.05			

For vegetation types and variables abbreviations and soil characteristics units, see Appendix A.

Also, soil texture and bulk density controls distribution of plant species by affecting moisture availability, ventilation and distribution of plant roots. Soil texture is the most fundamental soil physical property controlling water, nutrient and oxygen exchange an uptake [34] and influences the growth and distribution of vegetation [12]. Organic carbon and nitrogen are the effective factors in the differentiation of vegetation types [33, 45]. The role CEC, and available phosphorous, as key elements in the distribution of plant species, is described by Zahedi Amiri and Mohammady Limayee [45]. Totally, each plant species has specific relations with environmental variables. These relations are because of habitat condition, and plant ecological needs. In plain and lowland forests, changes of vegetation is related with soil properties, completely, but effective factor in changes of vegetation don't soil properties alone in high forests, other factors such as elevation, aspect, and slope are effective in during and presence of plant ecological species, too [33, 47]. Understanding the indicator of environmental factors of a given site leads us to recommend adaptable species for reclamation and improvement of that site and similar sites. Since these methods are of high accuracy and have different abilities, they could be used for habitat analysis and determination of effective ecological factors. Analyzing ecological data using ordination methods makes simpler understanding of the complex relationship between plants and environmental gradients. In addition, these methods prevent presence of ineffective factors and data complexity from affecting ecological models. Various disturbances are serious limiting factors to the use of vegetation in species groups for land classification. This is especially true in lowland forests of Iran, where logging, agriculture, fire,

fire exclusion, and grazing often have altered the existing vegetation. Opening the canopy usually results in the invasion of intolerant species that are not representative of site quality. Therefore, soil and physiographic factors must be emphasized in any attempt to classify local ecosystems or evaluate site quality. In this study, multivariate analysis has showed noticeable variations of soil properties in the study site. There exists a close relationship between variations in soil characteristics and plant populations in plain forest areas. In the mountainous forest areas, however, geographical characteristics such as elevation, slope, direction and terrain are complementary to the variations in soil characteristics in determining the changes of ecological systems.

CONCLUSION

All species groups were found in more than one ecosystem, but the relative abundance of the groups varied considerably between ecosystems. Therefore the use of quantitative values (coverage values) was essential in defining and using ecological species groups. There was a certain degree of overlap among the groups; in almost all cases more than one group occurred in a given ecosystem. Such over lapping was observed in different types, nevertheless, some species groups were more characteristic than others of certain types of ecosystems. Ecological classification and grouping of forest habitats was the main subject of forest management since of 1980 decade and many methods had used in order to classification of forest habitat but, they couldn't show the relation of ecosystem components very well. Since, the most of them have been used in one component similar to soil or plant vegetations alone. The ecological profiles typically showed that each species of a group had similar responses over the range of ecosystems. This confirms the usefulness of species - group approach where the user may rely on more than one species to help determine site quality or identify ecosystem types in the field. Therefore, errors due to the occurrence or absence of species caused by factors not related to site characteristics are less likely to occur.

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Appendix A: Using and abbreviations of the vegetation types and environmental factors in the figures and tables.

Carex grioletia L.	*Care gri*	*Carpinus betulus L.*	*Carp bet*
Smilax exelsa L.	*Smil exe*	*Parrotia persica(D.)*	*Parr per*
Primula heterocliroma S.	*Prim het*	*Cratagus L.*	*Crat sp*
Brachypodium pinnatum (L.)	*Brac sp*	*Querecus castanifolia C.*	*Quer cas*
Pteris cretica L.	*Pter cre*	*Buxus hyrcana P.*	*Buxu hyr*
Scutellaria tournefortii B.	*Scut tou*	*Diospyrus lotus L.*	*Dios lot*
Viola odarata L.	*Viol oda*	*Ilex aquifolium L.*	*Ilex aqu*
Asplenium adiantum-nigrum	*Aspl adi*	*Ulmus glabra H.*	*Ulmu gla*
Equisetum ramossisimum D.	*Equi ram*	*Mespilus germanica L.*	*Mesp ger*
Conyza bonariensis L.	*Cony bon*	*Alnus glutinosa (L.)*	*Alnu glu*
Aspelenium trichomanes L.	*Aspe tri*	*Pterocarya fraxinifolia(L.)*	*Pter fra*
Phylitis scdopendrium L.	*Phyl scd*	*Acer insign Boiss.*	*Acer ins*
Pteridium aquilinum Ll.	*Pter aqu*	*Ficus carica L.*	*Ficu car*
Hedra pustuchovii W.	*Hedr pus*	*Ruscus hyrcanus L.*	*Ruscu hyr*
Pteris dentate F.	*Pter den*	*Eigenvalue*	*Eign*
Circeae lutetiana L.	*Circ lut*	*Elevation (m)*	*Alt*
Oplismenus undulatifolius (A).	*Opli und*	*Slope (%)*	*Slope*
Calystesia sepium(L).	*Caly sep*	*Aspect*	*Aspect*
Hypericum androsaemus L.	*Hype and*	*Slope - Aspect*	*Sloasp*
Fragaria vesca L.	*Frag ves*	*pH (acidity)*	*PH*
Prunlla vulgaris L.	*Prun vul*	*Bulk density*	*w*
Euphorbia amygdaloides L.	*Euph amy*	*Saturation moisture (%)*	*Sp*
Tamus communis L.	*Tamu com*	*Electrical conductivity (ds/m)*	*Ec*
Sanicula europaea L.	*Sani eur*	*Organic carbon (%)*	*C*
Danae racemosa(L.)	*Dana rac*	*Total nitrogen (%)*	*N*
Solanum kieseritzkii C.	*Sola kie*	*Ration carbon to nitrogen of soil*	*C/N*
Festuca drymeia M.	*Fest dry*	*Cation exchangeable capacity (p.p.m)*	*CEC*
Dryopteris filix-mas(L.)	*Dryo fil*	*Extractable phosphorous (p.p.m)*	*P*
Microstegium vimenium(T.)	*Micr vim*	*Sand (%)*	*Sand*
Ophioglossum vulgatum L.	*Ophi vulg*	*Silt (%)*	*Silt*
Parieturia officinalis L.	*Pari off*	*Clay (%)*	*Clay*
Geum urbanum L.	*Geum urb*	*Lime (%)*	*L*
Menthe aquatica L.	*Ment aqu*	*Number of earthworm*	*Ne*
Plantago major L.	*Plan maj*	*Biomass of earthworm (gr)*	*Be*
Pimpinella affinis L.	*Pimp aff*	*Carbon of litter (%)*	*Clitt*
Oxalis corniculata L.	*Oxal cor*	*Nitrogen of litter (%)*	*Nlitt*
Lamium album L.	*Lami alb*	*Ration carbon to nitrogen of litter*	*C/N litt*
Mercurialis prennis L.	*Merc pre*		
Cardamin impatiens L.	*Card imp*		
Rubus caesius L.	*Rubu cae*		
Urtica dioica l.var.dioica.	*Urti dio*		
Carex acutiformis L.	*Care acu*		

Code "a" is related to the soil characteristics were measured in the first layer (0-10 cm)
Code "b" is related to the soil characteristics were measured in the second layer (10-20 cm)
Code "c" is related to the soil characteristics were measured in the third layer (20-30 cm)