ECOLOGIA BALKANICA

2013, Vol. 5, Issue 1 June 2013 pp. 37-47

Plant Species Groups in Chestnut (Castanea sativa Mill.) Sites, Hyrcanian Forests of Iran

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Abstract. The aim of this study was to identify floristic composition, introduce main plants species, classify vegetation and determine species groups (types) in the chestnut (*Castanea sativa* Mill.) sites in Guilan province, north of Iran. Sampling was done in selective method and 68 sampling plots were taken to access the information of vegetation cover in Shafarood (10 Plots) and Emamzadeh-Ebrahim (58 plots). Results indicated that there were 45 and 55 plant species in Shafarood and Emamzadeh-Ebrahim, respectively. Two-Way Indicator Species Analysis (TWINSPAN) revealed 6 plant species groups in woody and herbaceous layer separately. Also, the main plant specie were *Ilex spinigera*, *Carpinus betulus*, *Castanea sativa*, *Diospyros lotus*, *Gleditsia caspica* and *Prunus divaricata* in woody species layer and *Poa* sp., *Pteridium aquilinum*, *Oplismenus undulatifolius*, *Mentha aquatica*, *Pteris cretica*, *Oxalis corniculata* and *Hypericum androsaemum* in herbaceous layer according to species important value index (SIV).

Keywords: Chestnut (*Castanea sativa* Mill.), Vegetation classification, TWINSPAN, SIV, Emamzadeh-Ebrahim, Shafarood.

Introduction

The findings of the vegetation study have implications for the design of rehabilitation programs (BARRETT, 2006). Assessment of vegetation changes is an important component of many large-scale environmental monitoring programs (RINGVALL *et al*., 2005). Successful long-term monitoring of habitats is best achieved when using quantitative analysis for precise determination of changes in vegetation over time (BENHOUHOU *et al*., 2003).

Forest managers, forest scientists and forest policy makers all rely on accumulated knowledge of the forest in order to make decisions. This knowledge may be based on their own experience or that of others, but will have originated from information collected from the forest. A quantitative understanding of the forest requires quantitative data to support it. The botanical composition of a forest may affect decisions related to forest management (logging operations or silvicultural planning), forest policy (annual allowable cut and perhaps the minimum logging cycle) or conservation (biodiversity and wildlife habitats). In order to carry out its nature conservation policy in the best possible way, the managers required information on the distribution of plant species and communities (WITTE & MEIJDEN, 2000).

Distinguishing plant associations has been at the heart of vegetation science for centuries, with a traditional focus on the distribution, composition and classification of plant communities. An important subject of vegetation science is 'vegetation

classification': the derivation of vegetation units from the natural plant covers. Ecological species groups are groups of plants that repeatedly occur together in areas with similar combinations of site factors, and that are perceived to have similar ecological requirements or tolerance ranges. Also, ecological species groups may also provide the ecological basis for distinguishing ecosystems at broader scales. Once species groups are characterized for an area, their distribution can be used for inferring soil properties and other variables relatively difficult to measure (RAD & SHAFIEI, 2010).

Two-Way Indicator Species Analysis (TWINSPAN) is a numerical method for classification of vegetation belonging to similar groups (DAI *et al*., 2006; TICHY *et al*., 2007; LEPS & SMILAUAR, 2009; JELOUDAR *et al*., 2010). This allows the investigator to recognize the homogenous groups (JAFARI *et al*., 2004). TWINSPAN as a vegetation study technique was used to many purposes such as vegetation classification to compare the effects of different management approaches in forest (JANTUNEN & SAARINEN, 2002), to classify the landscape fire succession models and vegetation dynamics (KEANE *et al*., 2002), study on the vegetation associations, structure and composition (OOSTERHOORN & KAPPELLE, 2000; BENHOUHOU *et al*., 2003; BARRETT, 2006; MAINGI & MARSH, 2006), Vegetation restoration patterns and their relationships with disturbance (YONGJIAN *et al*., 2006), relationships of vegetation and environmental factors like landform, soil, physiography, to assess the sites typology and etc. (ROLECEK, 2005; COOPER *et al*., 2006; GARCIA-AGUIRRE *et al*., 2007). In addition, classification of plots using TWINSPAN displayed five vegetation groups of *Alnus glutinosa* ssp. *barbata*, each with specific indicator species in Hyrcanian (Caspian) lowland forests (northern Iran) include alderwood communities, dominated by *Alnus glutinosa* ssp. *barbata* (NAQINEZHAD *et al*., 2008). Identify and compare the forest communities were characterized in deciduous forests in the experimental forests of Tehran University, north of Iran. Four communities, including *Querco-Carpinetum betulii*, *Carpineto-Fagetum oriental*, *Rusco-Fagetum oriental* and *Fagetum Oriental* were recognized and plant species diversity was quantified in the different communities (RAD *et al*., 2009).

The widespread range of chestnut trees in the Europe is mainly related to the fruit production. Chestnut wood is one of the preferred choices in making high quality furniture. Additionally, over the last decade another important income associated with these trees has emerged the collection and commercialization of wild edible mushrooms growing in chestnut stands (BAPTISTA *et al*., 2010). Chestnut (*Castanea sativa* Mill.) is very interesting species for timber production (LUIS & MONTEIRO, 1998; CUTINI, 2001). Chestnut was introduced as the most common species used for building construction in central Italy and it appears to be a suitable species for performing dendrochronological analysis because of missing its annual rings are rarely shown (ROMAGNOLI *et al*., 2004). Chestnut stands have considered because of the spread of disease and decreased the stand areas in the world (MARTINS *et al*., 1997; POURBABAEI, 2002; HEDAYATI *et al*., 2003; NARAGHI, 2003; AREFIPOUR *et al*., 2006; GOMES-LARANJO *et al*., 2006; DINIS *et al*., 2011). Due to the importance of this species, The aim of this study was to identify floristic composition, introduce main plants species, classify vegetation and determine species groups (types) to help the protection of natural vegetation in the chestnut sites in Guilan province, north of Iran.

Material and Methods

Study area. The study areas are located in Shafarood and Emamzadeh-Ebrahim regions in the west of Guilan province, north of Iran. The Shafarood region covers approximately 100 ha of the chestnut stand (37° 02′ 30″ N latitude and 49° 18′ 47″ E longitude) and Emamzadeh-Ebrahim is included about 500 ha (37° 31′ 10″ N latitude and 49° 02′ 48″ E longitude) (Fig.1). General aspect is northern in the both regions, altitude ranges from 261 to 480 m a.s.l. in the Shafarood and from 193 to 745 m a.s.l. in Emamzadeh-Ebrahim region. The Mean annual precipitation and temperature is 1400.6 mm and 15.4°C in the

Shafarood and 1693 mm and 15.4°C in Emamzadeh-Ebrahim region, respectively. Edaphically, soil type is acidic brown forest soil and texture is mostly silt, clay, loam to silt and loam, pH ranges from 5.05 to 6.67 in the studied sites (HEDAYATI, 2001).

Fig. 1. The location of the study areas (Shafarood and Emamzadeh-Ebrahim)

Sampling strategy. The study area was sampled using selective method (ESMAILZADEH *et al*., 2007). 68 sampling plots were surveyed in the study areas (10 and 58 sampling plots in Shafarood and Emamazadeh-Ebrahim, respectively). The area of plots was 2500 m² (50 m × 50 m) (CHIARUCCI *et al*., 2001; POORBABAEI & RANJAVAR, 2008). In each plot all trees with DBH ≥ 10 cm were measured and the number of shrub species was counted. List and estimate of percent cover of each herbaceous species were recorded using the Braun-Blanquet criterion in 64 m² (8 m × 8 m) subplots that obtained minimal area method in the center of each plot (Table 1). The Braun-Blanquet criterion is a method of describing an area of vegetation devised by Braun-Blanquet in 1927. It is used to survey large areas very rapidly. That consists of a plus sign and a series of numbers from 1 to 5 denoting both the degree of presence of a plant species and the proportion of the area covered by that species, ranging from + (sparse and covering a small area) to 5 (covering more than 75% of the area) (http://botanydictionary.org/braun-blanquet-scale.html).

Table 1. Braun-Blanquet cover-abundance criterion (WIKUM & SHANHOLTZER, 1978)

Braun-Blanquet criterion	Ranges of cover (%)
5	75 – 100
4	50 – 75
3	25 – 50
2	5- 25
1	< 5 (numerous individuals)
+	< 5 (few individuals)

Data analysis. Woody and herbaceous layers were separately classified. So, the floristic data matrices consist of 68 plots and 24 woody species (trees and shrubs) and 34 herbaceous species. To classify species groups present in the studied areas, the vegetation data were analyzed using Two-Way Indicator Species Analysis (TWINSPAN) with PC-ORD version 4.17 (MCCUNE & MEFFORD, 1999). The classification was stopped at the third level of division, so that the resulting groups would contain a sufficient number of samples to characterize each vegetation group (KHAZNADAR *et al*., 2009) and also eigenvalue of each division (JAFARI *et al*., 2004; MANJILI *et al*., 2009). Species important value index (SIV) was used to name each group and defined as formula (1) to (5) for woody and herbaceous species (COROI *et al*., 2004; MESDAGHI, 2006; YONGJIAN *et al*., 2006; ADAM *et al*., 2007; ABEDI & POURBABAEI, 2010):

(1) SIV (tree and shrub) = Relative frequency (RF) + Relative density (RD) + Relative dominance (RDo)

(2) SIV (herb) = RF + RDo

$$(3)\ RF = \frac{\text{Number of plots that contain a species}}{\text{Number of all plots}} \times 100$$

$$(4)\ RD = \frac{\text{Individual number of a species in all plots}}{\text{Total individual number of species in all plots}} \times 100$$

$$(5)\ RDo = \frac{\text{Basal area (or cover percentage) of a species in all plots}}{\text{Total basal area (or cover percentage) of all species in all plots}} \times 100$$

Results

Flora. Floristic study revealed that there were 45 plant species including 15 trees, 5 shrubs and 25 herbaceous species in Shafarood, and 55 plant species including 18

trees, 5 shrubs and 32 herbaceous species identified in Emamzadeh-Ebrahim region. The presence and absence of plant species in each family were shown in Table 2 to 4. The families with most abundant plant species were the Lamiaceae and Rosaceae (Fig. 2).

Table 2. List of tree species in the studied areas (+: presence, -: absence)

Scientific name	Family	Shafarood	Emamzadeh-Ebrahim
Acer cappadocicum Gled.	Aceracea	+	+
Acer velutinum Boiss.	Aceracea	+	+
Albizia julibrissin (Willd.) Benth.	Fabaceae	+	-
Alnus subcordata C.A.Mey.	Betulaceae	+	+
Buxus hyrcana Pojark.	Buxaceae	-	+
Carpinus betulus L.	Betulaceae	+	+
Castanea sativa Mill.	Fagaceae	+	+
Diospyros lotus L.	Ebenaceae	+	+
Fagus orientalis Lipsky.	Fagacea	+	+
Ficus carica L. var. *genuine* Boiss.	Moracea	+	+
Fraxinus excelsior Scheele.	Oleaceae	+	+
Gleditsia caspica Desf.	Fabaceae	+	+
Parrotia persica (DC.) C.A.Mey.	Hammamelidaceae	+	+
Quercus castaneifolia C. A. Mey.	Fagaceae	+	+
Robinia pseudoacacia L.	Papilionaceae	-	+
Taxus baccata L.	Taxaceae	-	+
Tilia platyphyllos Scop.	Tiliaceae	+	+
Ulmus glabra Huds.	Ulmaceae	+	+
Zelkova carpinifolia (Pall.) Dipp.	Ulmaceae	-	+

Table 3. List of shrub species in the studied areas (+: presence, -: absence)

Scientific name	Family	Shafarood	Emamzadeh-Ebrahim
Crataegus microphylla C. Koch.	Rosaceae	+	+
Ilex spinigera Loes.	Aquifoliaceae	+	+
Mespilus germanica L.	Rosaceae	+	+
Prunus divaricata Ledeb.	Rosaceae	+	+
Ruscus hyrcanus Juz.	Liliaceae	+	+

TWINSPAN outputs. The results of the TWINSPAN analysis are summarized in Fig. 3 and 4. Based on floristic composition, the 68 sampling plots were classified into six groups in woody and herbaceous layers.

The 68 plots in woody species layer (trees and shrubs) were firstly classified into two groups. In the first level, the negative (left) group (including 39 plots) was determined by species like *Ilex spinigera* and *Diospyros lotus* and the positive (right) group (including 29 plots) by *Tilia platyphyllos*. In the second level, 39 plots divided to 9 plots in negative group and characterized by *Ilex spinigera* and positive group include 30 plots characterized by *Castanea sativa*. Also, 29 plots classified in two groups in this level, negative group including 18 plots characterized by *Carpinus betulus* and positive group (including 11 plots) was characterized by *Prunus divaricata* and *Acer velutinum*. In third level (as the last level of division), 30 plots divided to 18 and 12 plots as negative and positive groups that *Diospyros lotus* in left and *Castanea sativa* in right was determined. In this level, 18 plots classified in two groups including 9 plots that *Gleditsia caspica* was determined in negative group and no species was presented in positive group.

Table 4. List of herbaceous species in the studied areas (+: presence, -: absence)

Scientific name	Family	Shafarood	Emamzadeh-Ebrahim
Acalypha australis L.	Euphorbiacea	+	+
Artemisia annua L.	Astraceae	-	+
Bidens tripartita L.	Astraceae	-	+
Brachypodium pinnatum L.	Poaceae	+	+
Calamintha arvensis Lam.	Lamiaceae	-	+
Campanula rapunculus L.	Campanulaceae	+	+
Centarium minus Moench.	Gentinaceae	-	+
Cerasus avium (L.) Moench.	Rosaceae	+	+
Conyza canadensis (L.) Cronquist.	Astraceae	-	+
Daphne mezereum L.	Thymeleaceae	+	+
Fragaria vesca L.	Rosaceae	+	-
Geum urbanum L.	Rosaceae	+	+
Hypericum androsaemum L.	Hypericaceae	+	+
Hypericum perforatum L.	Hypericaceae	-	+
Lallemantia iberica	Lamiaceae	+	+
Mentha aquatic L.	Lamiaceae	+	+
Nepeta invulucrata (Bunge) Bornm.	Lamiaceae	+	+
Oplismenus undulatifolius (Ard.) P.	Poaceae	+	+
Origanum vulgare L.	Lamiaceae	+	+
Oxalis corniculata L.	Oxalidaceae	+	+
Perilla frutescens (L.) Britt.	Lamiaceae	-	+
Persicaria hydropiper (L.) Delarbre	Polygonaceae	+	+
Pimpinella saxifraga L.	Apiceaceae	+	+
Plantago major L.	Plantaginaceae	+	+
Poa sp.	Poaceae	+	+
Prunella vulgaris L.	Lamiaceae	+	+
Pteridium aquilinum L. Kuhn	Hypolepidaceae	+	+
Pteris cretica L.	Polypodiaceae	+	+
Rumex acetosella L.	Polygonaceae	+	+
Sambucus ebulus L.	Caprifoliaceae	-	+
Solanum nigrum L.	Solanaceae	+	+
Trifolium compester Schreb.	Fabaceae	+	-
Urtica pilulifera L.	Urticaceae	+	+
Xanthum strumarium L.	Astracae	-	+

Thus, woody species were classified into six ecological species group in the studied areas. In order to separate and recognize each group in every site, the number of sampling plots bring out and record in the final level of classification (1 to 58 was located in Emamzadeh-Ebrahim and 59-68 was located in Shafarood) (Fig. 3).

The results of TWINSPAN classification in herbaceous species layer was revealed that 68 plots divided to 22 and 46 plots in negative and positive groups, respectively. At the first level, *Hypericum androsaemum* and *Pteridium aquilinum* were the negative group of species and *Pteris cretica* was the positive. In the second level of division, negative group was classified in two groups that 7 plots were in negative group that *Poa* sp. was characterized the only species in this group and 15 plots were in the positive group that there was no indicator species. In this level, 46 plots were classified to 30 plot groups that were determined by *Brachypodium pinnatum*, *Oxalis corniculata* and *Poa* sp. and 16 plot groups have no species.

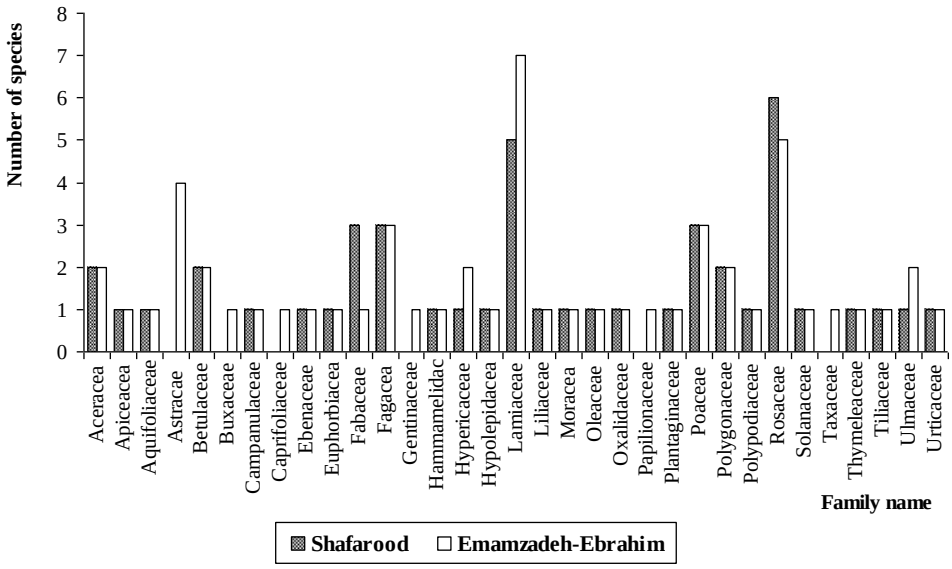

Fig 2. Number of species in each family

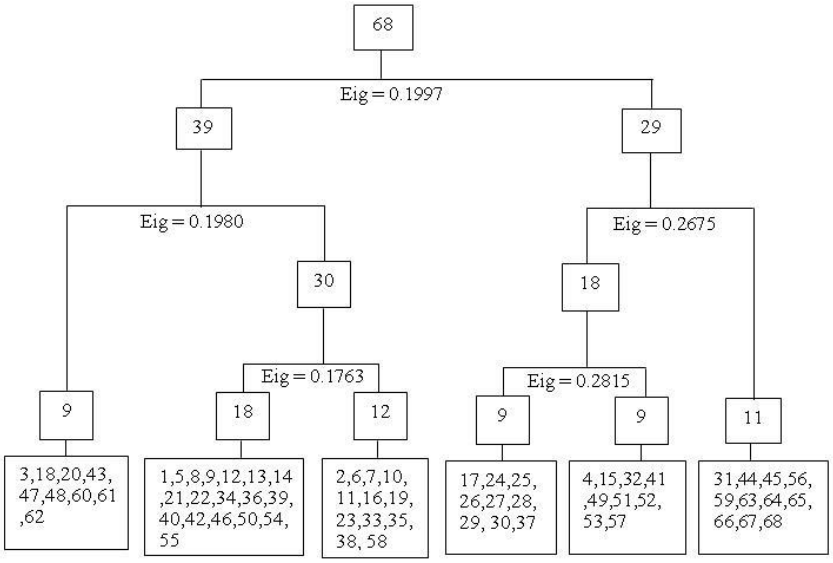

Fig 3. Dendrogram derived from the TWINSPAN analysis in the woody species layer. Numbers in the final level indicated the number of sampling plots in each group. Plant species groups were named according to SIV in woody species layer as follows:

Group 1: *Ilex spinigera* - *Diospyros lotus*
Group 2: *Diospyros lotus* - *Ilex spinigera* - *Castanea sativa*
Group 3: *Castanea sativa* - *Ilex spinigera* - *Carpinus betulus*
Group 4: *Carpinus betulus* - *Gleditsia caspica* - *Castanea sativa*
Group 5: *Carpinus betulus* - *Castanea sativa*
Group 6: *Castanea sativa* - *Carpinus betulus* - *Prunus divaricate*

In third level of division (as the last level), 15 plots were divided in 7 plot group in negative and characterized by *Daphne mezereum* and *Poa* sp. but there were no indicator species in 8 plots group in positive group. 30 plot groups was classified by 15 plots group as negative and positive group and was determined by *Mentha aquatica* and *Conyza canadensis*, respectively.

Finally, 6 ecological species groups were identified in herbaceous layer. Also, the number of sampling plots recorded in the final level due to recognize the position of plots in each study area (Fig. 4).

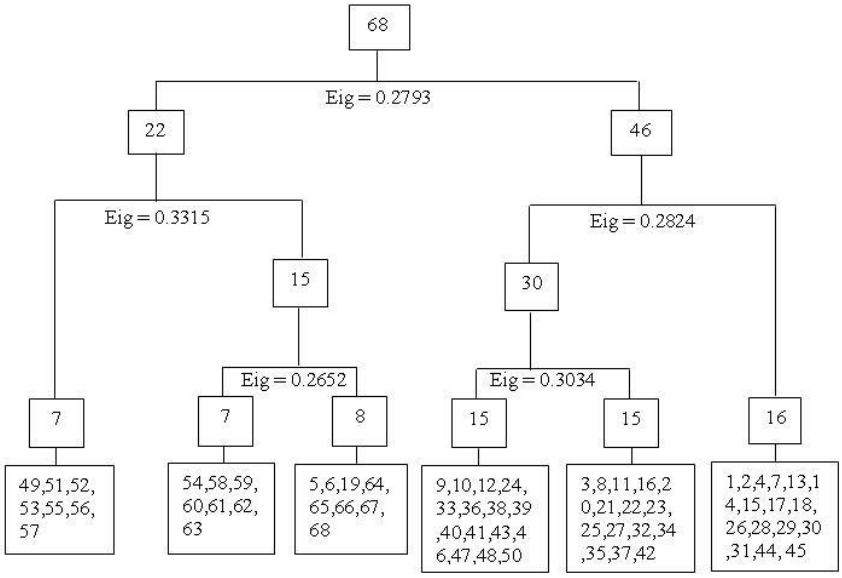

Fig 4. Dendrogram derived from the TWINSPAN analysis in herbaceous layer. Numbers in the final level indicated the number of sampling plots in each groups. Plant species groups were named according to SIV herbaceous layer as follows:

Group 1: *Poa* sp. - *Oplismenus undulatifolius*
Group 2: *Pteridium aquilinum* - *Poa* sp. - *Oplismenus undulatifolius*
Group 3: *Pteridium aquilinum* - *Mentha aquatica* - *Hypericum androsaemum*
Group 4: *Mentha aquatica* - *Oplismenus undulatifolius*
Group 5: *Oplismenus undulatifolius* - *Pteris cretica* - *Oxalis corniculata*
Group 6: *Pteris cretica* - *Oplismenus undulatifolius* - *Mentha aquatica*

In woody species layer, Group 2 was the largest group includes 18 plots. The characterized species in this group was *Diospyros lotus*, *Ilex spinigera* and *Castanea sativa*. This group contains 26.5% of total plots. The smallest groups (group 1, 4 and 5) include just 6 plots (i.e., 13.3% of total plots).

In herbaceous layer, the largest group was contained 16 plots and occupied 23.5% of plots in the study areas (Group 6). The characterized species in the largest group were *Pteris cretica*, *Oplismenus undulatifolius* and *Mentha aquatica*. The smallest group has 7 plots and included 10.3% of plots (Group 1 and Group 2).

Discussion

Some simple stand variables, such as structure and composition can be used as reliable indicators of the conservation status of chestnut woodlands (DIAZ-VARELA *et al.*, 2011). Therefore, this study was carried out to identify floristic composition, introduce main plants species, classify vegetation and determine species groups (types) to help the protection of natural vegetation in the chestnut sites in Guilan province, north of Iran.

According to the results of our study, Group 2 (*Diospyros lotus* - *Ilex spinigera* - *Castanea sativa*) was dominance group in woody species layer in the studied areas because contained the most area of sites. Furthermore, *Castanea sativa* was repeated in five groups that showed the dominance of this species, so SIV index was an efficient index in named of groups in this study. Studies considered that *Castanea sativa* responds well to competitive pressure and show a higher productivity in mixed stands (LUIS & MONTEIRO, 1998).

Buxus hyrcana and *Taxus baccata* had dispersal distribution in Emamzadeh-Ebrahim; these are threatened endangered species in Iran. On the other hand, *Fraxinus excelsior*, *Zelkova carpinifolia* and *Daphne mezereum* will be threatened if they don't be in conservation measures (JALILI & JAMZAD, 1999). Previous study on woody species diversity in these sites showed that *Albizia*

julibrissin, *Cerasus avium*, *Fraxinus excelsior*, *Tilia begonifolia* and *Ulmus glabra* in Shafarood and *Taxus baccata* and *Zelkova carpinifolia* in Emamzadeh-Ebrahim were introduced as the rare species and sites have remarkable diversity measures thus it is necessary to be considered as protected sites (POURBABAEI, 2002).

Four tree species were characterized as the main species and occurred mostly in groups including *Castanea sativa*, *Diospyros lotus*, *Gleditsia caspica* and *Carpinus betulus*.

Studies have shown that the development of the shrub layer greatly depends on the methods and intensity of forest management (ROLECEK, 2005). So, five shrub species were identified that two species of them were characterized the main species in groups in our studied areas. This seems that the lack of shrub species in our study area was due to the lack of management and sylvicultural treatments. POURBABAEI (2002) has been revealed that woody species richness was higher in Shafarood, because cattle grazing and anthropogenic disturbance were lower in there and the richness and diversity of woody species in the studied sites were found higher than abandoned chestnut (*Castanea sativa*) groves in southern France (GONDARD *et al*., 2001).

Group 6 (*Pteris cretica* - *Oplismenus undulatifolius* - *Mentha aquatica*) was dominance group in herbaceous layer in the studied areas and contained the most area of sites.

Conclusion

Based on the results of this study, the natural vegetation cover has a reliable condition in our studied areas but need more conservation. The preserving this species in their native habitat could help their survival and natural regeneration. Changes in the abundance of common species are likely to affect the living conditions of many other species that depend on it and may hence have a high influence on ecosystem processes. Therefore, it has been considered as a major point to protect the natural vegetation of this stands because the first step of design management strategies to maintain stands is investigation and identification the natural vegetation cover. We hope that introduce the main plant species in this study could help the conservation of this stands. In addition, protect the livestock grazing and investigate about pests and diseases of this species are helpful to growth good quality trees, produce healthy seeds and growth the natural regeneration.

References

ABEDI R., H. POURBABAEI. 2010. Plant diversity in natural forest of Guilan Rural Heritage Museum in Iran. - *Biodiversitas*, 11(4): 182-186.

ADAM J.H., A.M. MAHMUD, N.E. MUSLIM. 2007. Cluster analysis on floristic and forest structure of hilly lowland forest in Lak Kawi, Sabah of Malasia. – *Intern. Journal of Botany*, 3(4): 351-358.

AREFIPOUR M.R., H. ASKARY, H. ZAGHANI, M. NIKNEJAT, A.N. SALARI, F. JAMI. 2006. Report of *Cryphonectria parasitica* causing agent of chestnut blight from Iran. - *Iranian Journal of forest and range protection research*, 4 (1): 41-43. (In Persian, English summary)

BAPTISTA P., A. MARTINS, R. TAVARES, M.T. LINO-NETO. 2010. Diversity and fruiting pattern of macrofungi associated with chestnut (*Castanea sativa*) in the trasosmontes region (Portugal). - *Fungal Ecology*, 3: 9 – 19.

BARRETT G. 2006. Vegetation communities on the shores of a salt lake in semi-arid Western Australia. - *Journal of Arid Environments*, 67: 77-89.

BENHOUHOU S., T. DARGIE, O. GILBERT. 2003. Vegetation associations in the Ougarta Mountains and Dayas of the Guir hamada, Algerian Sahara. - *Journal of Arid Environments*, 54: 739-753.

CHIARUCCI A., V.D. DOMINICIS, J.B. WILSON. 2001. Structure and floristic diversity in permanent monitoring plots in forest ecosystems of Tuscany. - *Forest Ecology and Management*, 141: 201-210.

COROI M., M.S. SKEFFINGTON, P. GILLER, C. SMITH, M. GORMALLY, G. O'DONOVAN. 2004. Vegetation diversity and stand structure in streamside forests in the

south of Ireland. - *Forest Ecology and Management*, 202: 39–57.

COOPER A., T. SHINEA, T. MCCANNA, D.A. TIDANE. 2006. An ecological basis for sustainable land use of Eastern Mauritanian wetlands. - *Journal of Arid Environments*, 67: 116–141.

CUTINI A. 2001. New management options in chestnut coppices: an evaluation on ecological bases. - *Forest Ecology and Management*, 141: 165-174.

DAI X., B. PAGE, K.J. DUFFY. 2006. Indicator value analysis as a group prediction technique in community classification. - *South African Journal of Botany*, 72: 589–596.

DIAZ-VARELA R.A., P.Á. ALVAREZ-ALVAREZ, E. DIAZ-VARELA, S. CALVO-IGLESIAS. 2011. Prediction of stand quality characteristics in sweet chest nut forests in NW Spain by combining terrain attributes spectral textural features and landscape metrics. - *Forest Ecology and Management*, 261: 1962-1972.

DINIS L.T., F. PEIXOTO, T. PINTO, R. COSTA, R.N. BENNETT, J. GOMES-LARANJO. 2011. Study of morphological and phenological diversity in chestnut trees ('Judia' variety) as a function of temperature sum. - *Environmental and Experimental Botany*, 70: 110-120.

RAD J., M. MANTHEY, A. MATAJI. 2009. Comparison of plant species diversity with different plant communities in deciduous forests. - *International Journal of Environmental Science and Technology*, 6 (3): 389-394.

ESMAILZADEH O., S.M. HOSSEINI, M. TABARI. 2007. A phytosociological study of English yew (*Taxus baccata* L.) in Afratakhteh reserve. - *Pajouhesh &Sazandegi*, 74: 17-24. (In Persian, English summary).

GARCIA-AGUIRRE, M.C., M.A. ORTIZ, J.J. ZAMORANO, Y. REYES. 2007. Vegetation and landform relationships at Ajusco volcano Mexico, using a geographic information system (GIS). - *Forest Ecology and Management*, 239: 1–12.

GHARAVI MANJILI S., A. SALEHI, H. POURBABAEI, F. ESPANDI. 2009. Classification of tree and shrub covers and determination of their relation to some soil characteristics and topographic conditions in Shafarood forests, Guilan province. - *Iranian Journal of Forest and Poplar Research*, 17 (3): 436-449. (In Persian, English summary).

GOMES-LARANJO J., F. PEIXOTO, H.W.W.F. SANG, J. TORRES-PEREIRA. 2006. Study of the temperature effect in three chesnut (*Castanea sativa* Mill.) cultivars' behaviour. - *Journal of Plant Physiology*, 163: 945–955.

GONDARD H., F. ROMANE, M. GRANDJANNY, J. LI. J. ARONSON. 2001. Plant species diversity changes in abandoned chestnut (*Castanea sativa*) groves in southern France. - *Biodiversity and Conservation*, 10: 189-207.

HEDAYATI M.A. 2001. Study on siviculture of Sweet chestnut (*Castanea sativa*) tree and its propagation in the Guilan province. Ph.D. Dissertation of Forestry, Faculty of Natural Resources, Tehran University. 199 p. (In Persian, English summary).

HEDAYATI M.A., M.R. MARVI MOHAJER, M.H DJAZIREIE, M. ZOBEIRI. 2003. An investigation of chestnut (*Castanea sativa* Mill) seedling production in Guilan province. - *Iranian Journal of natural resources*, 56 (3): 229-244. (In Persian, English summary).

JAFARI M., M.A. ZARE CHAHOUKI, A. TAVILI, H. AZARNIVAND, GH. ZAHEDI AMIRI. 2004. Effective environmental factors in the distribution of vegetation types in Poshtkouh rangelands of Yazd Province (Iran). - *Journal of Arid Environments*, 56: 627–641.

JAFARIAN JELOUDAR Z., H. ARZANI, M. JAFARI, A. KAVIAN, GH. ZAHEDI, H. AZARNIVAND. 2010. Vegetation community in relation to the soil characteristics of Rineh rangeland, Iran. - *Caspian Journal of Environmental Science*, 8 (2): 141-150.

JALILI A., Z. JAMZAD. 1999. *Red data book of Iran*. Research Institute of Forest and Rangelands Press, Tehran. 748 p.

JANTUNEN J., K. SAARINEN. 2002. Vegetation of uncultivated arable land under different management in Finnish and Russian Karelia. - *Agriculture, Ecosystems and Environment*, 92: 225–233.

KEANE R.E., G.J. CARY, I.D. DAVIES, M.D. FLANNIGAN, R.H. GARDNER, S. LAVOREL, J.M. LENIHAN, C. LI, T.S. RUPP. 2004. A classification of landscape fire succession models: spatial simulations of fire and vegetation dynamics. - *Ecological Modeling*, 179: 3–27.

KHAZNADAR M., I.N. VOGIATZAKIS, G.H. GRIFFITHS. 2009. Land degradation and vegetation distribution in Chott El Beida wetland, Algeria. - *Journal of Arid Environments*, 73, 369-377.

LEPS J., P. SMILAUAR. 2009. *Multivariate analysis ecological data using CANOCO*. Cambridge University Press, Cambridge. 269 p.

MAINGI J.K., S.E. MARSH. 2006. Composition, structure, and regeneration patterns in a gallery forest along the Tana River near Bura, Kenya. - *Forest Ecology and Management*, 236: 211-228.

MARTINS A., A. CASIMIRO, M.M.S. PAIS. 1997. Influence of mycorrhization on physiological parameters of micropropagated *Castanea sativa* Mill. - *Plants Mycorrhiza*, 7: 161–165.

MCCUNE B., M.J. MEFFORD. 1999. *PC-ORD*, Multivariate analysis of ecological data, vers. 4.17. MJM software, Gleneden beach. [http://home.centurytel.net/~mjm/].

MESDAGHI M. 2006. *Plant Ecology*. Jahad Daneshgahi of MashHad Press. MashHad, Iran. 187 p. (In Persian, English summary).

NAQINEZHAD A., B. HAMZEH'EE, F. ATTAR. 2008. Vegetation - environment relationships in the alderwood communities of Caspian lowlands, N. Iran (toward an ecological classification). - *Flora*, 203: 567–577.

NARAGHI T.S. 2003. Asexual regeneration *of Castanea sativa* Mill. (Chestnut) by shoot tip culture. - *Iranian rangelands and forests plant breeding and genetic research*, 10: 69-89. (In Persian, English summary).

OOSTERHOORN M., M. KAPPELLE. 2000. Vegetation structure and composition along an interior-edge-exterior gradient in a Costa Rican montane cloud forest. - *Forest Ecology and Management*, 126: 291-307.

POORBABAEI H., A. RANJAVAR. 2008. Effect of shelterwood silvicultural method on plant species diversity in beech (*Fagus orientalis* Lipsky.) forests in Shafaroud, Guilan province. - *Iranian Journal of Forest and Poplar Research*, 16 (1): 61-73. (In Persian, English summary).

POURBABAEI H. 2002. Diversity of woody species (trees and shrubs) in Sweet chestnut tree (*Castanea sativa* Mill.), Hazel-tree (*Corylus avellana* L.) and Italian cypress (*Cupressus sempervirens* var. *horizontalis*) ecosystems in the Guilan forests, north of IRAN. - In: *The 3rd International IRAN and RUSSIA Conference "Agriculture and Natural Resources"*.

RAD J.E., A.B. SHAFIEI. 2010. The distribution of ecological species groups in Fagetum communities of Caspian forests: Determination of effective environmental factors. - *Flora*, 205: 721–727.

RINGVALL A., H. PETERSSON, G. STAHL, T. LAMAS. 2005. Surveyor consistency in presence/absence sampling for monitoring vegetation in a boreal forest. - *Forest Ecology and Management*, 212:109–117.

ROLECEK J. 2005. Vegetation types of dry-mesic oak forests in Slovakia. - *Preslia Praha*, 77: 241-261.

ROMAGNOLI M., M. NOCETTI, M. SARLATTO, L. EVANGELISTELLA. 2004. Dendrochronological assessment of chestnut (*Castanea sativa* Mill.) for dating purposes in central Italy. - *Dendrochronologia*, 21 (3): 117-130.

LUIS J.F., M.D. MONTEIRO. 1998. Dynamics of a broadleaved (*Castanea sativa*), conifer (*Pseudotsuga menziesii*) mixed stands in Northern Portugal. - *Forest Ecology and Management*, 107: 183–190.

TICHY L., J. ROLECEK. D. ZELENY. M. CHYTRY. 2007. New stopping rules for TWINSPAN. - In: *European Vegetation Survey, 16th Workshop*, Rome (Italy).

WIKUM D.A., G.F. SHANHOLTZER. 1978. Application of the Braun-Blanquet cover-abundance scale for vegetation analysis in land development studies. - *Environmental Management*, 2 (4): 323-329.

WITTE J.P.M., R.V. MEIJDEN. 2000. Mapping ecosystem types by means of ecological species groups. - *Ecological Engineering*, 16: 143–152.

YONGJIAN W., T. JIANPING, Z. WEIYIN, Z. RUNGUO, D. YI, L. YUAN, W. WEI. 2006. Vegetation restoration patterns and their relationships with disturbance on the Giant Panda Corridor of Tudiling, Southwest China. - *Acta Ecologica Sinica*, 26(11): 3525−3532.

Received: 09.12.2012
Accepted: 18.05.2013