

## Plant ecological groups and soil properties of common hazel (*Corylus avellana* L.) stand in Safagashteh forest, north of Iran

Hassan Pourbabaei ✉, Mohammad Naghi Adel

University of Guilan, Faculty of Natural Resources, Department of Forestry, Sowmehsara, P.O. Box 1144, Guilan, Iran, phone: +981344323599, fax: 981344323600, e-mail: hpourbabaei@gmail.com

### ABSTRACT

In Safagashteh forest of Fuman in north of Iran, there is a hazel stand, which has grown naturally. The aim of this research was to evaluate the plant communities and soil characteristics in the area. This study included 50 ha of hazel protected area. A selective sampling method was utilized to record 30 400 m<sup>2</sup> for tree and shrub layers, and sub-plots of 100 m<sup>2</sup> for herbaceous species. Soil samples were collected at the 30 plots. We found three ecological species groups in the study area. *Corylus avellana* and *Epimedium pinnatum* in first group, *Fagus orientalis*, *Asperula odorata*, *Euphorbia amygdaloides*, *Carex* sp., *Fragaria vesca* and *Viola sylvestris* in second group, and *Crataegus microphylla*, *Ilex spinigera*, *Primula heterochroma*, *Sedum stoloniferum* and *Vicia crocea* in third group were the indicator species. Sand percent was significantly highest in *Corylus avellana* group, while clay, nutrients elements, pH and SP were significantly highest in the other groups. Biodiversity indices in *Corylus avellana* group were significantly less than other stands. We recommend to provide comprehensive conservation and management programs in order to protect of common hazel, associated plant species, and to prevent of human activities such as recreational use and livestock.

### KEY WORDS

*Corylus avellana* L., ecological species groups, conservation, soil properties, north of Iran

### INTRODUCTION

Mountains are generally biologically diverse, support a high proportion of endemic species and harbor most of the world's protected areas (Khuroo et al. 2011). The biodiversity of plants in mountain ecosystems and their geographical distribution have received considerable interest from ecology and biogeography researchers over the last decade because understanding biodiversity patterns is important for biodiversity conservation,

sustainable use and natural reserve area planning and management (Lee and Chun 2015). The lack of detailed information about spatial distribution of organisms often hampers an effective selection of conservation or management activities. Complete inventories of genes, species and ecosystems are almost impossible to be achieved, given the time and cost constraints (Reyers et al. 2000). Despite a considerable amount of scientific efforts, quantifying biodiversity at coarse scales still remains difficult, especially for rich communities such as

tropical invertebrates or plants. Standards in measuring the completeness of species lists are still lacking and this affects the capacity to assess and monitor biodiversity at coarse scales in short time periods. As a consequence, biodiversity surrogates with easily recordable data are necessary to detect spatial and temporal patterns of biodiversity (Giorgini et al. 2015).

Diversity relationships and interactions between forest strata are currently an important research topic. It is particularly crucial to study the effects of tree-layer composition variations on herb-layer vegetation, since herb-layer vegetation contributes significantly to the ecosystem functioning and biodiversity in forests (McEwan and Muller, 2011). Productive and species-rich herb-layer vegetation can contain significant amounts of aboveground biomass and nutrients, during periods of high potential leaching, the temporary storage of elements by ground-layer herbs reduces nutrient losses into surface water (Mölder et al. 2014). Furthermore, many forest plant species are specially protected and high valued in nature conservation (Hermy et al. 1999; Jolls 2003). In general, the tree-layer composition has an effect on ground vegetation due to its influence on various ecosystem processes, e.g. nutrient cycles, light transmittance, and soil water supply (Chávez and Macdonald 2010).

Understory plants provide a crucial role in maintaining the structure and function of forest ecosystems. They contribute to forest biodiversity, generate the initial competitive interactions with regeneration phases of dominant canopy species, determine energy flow and nutrient cycling, and respond complexly to both natural and anthropogenic disturbances (Gilliam 2007). The ecosystem integrity of temperate forests depends on understory plant species conservation, as well as the stability and survival of other organisms, such as micro- and meso-fauna (Clement 2001). However, understory plant species have heterogeneous abundance and distribution patterns, which depends on the over-story species and structure (e.g., site quality of the stands or gap presence) (Lencinas et al. 2011).

Hazel with the scientific name of "*Corylus avellana* L." is a shrub belonging to "Fagales" phylum, from "Betulaceae" family and "Coryluideae" subfamily. Turkey is in the first position by producing 70 percent of hazelnuts of the world, and Italy is in the second position by producing 20 percent. After these countries, U.S.A, Azer-

baijan, Georgia, Iran, Spain, China and French are the most significant countries producing the hazelnuts (Hosein Ava and Pir Khezri 2011). Due to its need to light, this plant cannot survive inside the forests and it usually grows at the edge of the forests (Moraghebi et al. 2010). Native hazel species are grown in the northwest of Iran and they are planted in north of Iran as garden products. In Safagashteh forest of Fuman in north of Iran, there is a hazel stand, which has grown naturally. According to the fact that no research has ever been conducted in this region, the aim of this research was to determine plant ecological groups and soil properties in the study area.

## MATERIAL AND METHODS

### Study area

The study area (Safagashteh forest) is located in Masouleh, near Fouman City, which is in Guilan Province, north of Iran (37°09'13" N and 48°59'14" E). Elevation ranges from 950 to 1150 m a.s.l., with 55% slopes that generally face east. Parent materials include limestone and shill. The mean annual precipitation and temperature is 1200 mm and 12°C, respectively.

### Data collection

This study carried out in 50 ha of hazel protected area. A selective sampling method was used to record 30 400 m<sup>2</sup>. We recorded slope percentage, geographical aspect, elevation, crown canopy percentage and individual number of tree and shrub species in each plot. In addition, litter depth was measured within each plot. Subplots of 100 m<sup>2</sup> were utilized for herbaceous species measurements, which consisted of percent cover of each species in the basis of the Domin criterion. Soil samples were taken at these 30 sampling plots in the study area. At each sampling plot, soil samples were collected from 0 to 20 cm depth to studying physical and chemical properties. Soil factors including soil texture, N, P, K, pH, OC, OM, C/N were analyzed in the laboratory.

### Data analysis

At first, TWINSpan (Two Way Indicator Species Analysis) was applied to classify the 30 sampling plots. The cut-off level of 'pseudo-species' followed the software's default. We then used ISA (Indicator Species Analysis) to extract those significantly associated with each group.

TWINSPAN and ISA were performed by PC-Ord 5.10. CANOCO 4.5 was performed to explore the relationship between the soil factors and the plant ecological groups in hazel forest. To evaluate herbaceous diversity, we used three indices. Species diversity was assessed with the Shannon–Wiener index, species richness was estimated according to the Margalef index. In addition, the Smith–Wilson index was utilized to calculate species evenness. All three indices were computed using Ecological Methodology and PAST softwares. Significance of differences between means was analyzed by one-way ANOVA, followed by Tukey test at 95% confidence level. All statistical analyses were conducted using SPSS software (version 22.0).

## RESULTS

### TWINSPAN outputs

The outputs of TWINSPAN revealed three ecological groups: the first group, was characterized by *Corylus avellana* and *Epimedium pinnatum* which were included in sixteen sampling plots. The second group comprised of six sampling plots in which *Fagus orientalis*, *Asperula odorata*, *Euphorbia amygdaloides*, *Carex* sp., *Fragaria vesca* and *Viola sylvestris* were the indicator species. The third group consisted of eight plots in which *Crataegus microphylla*, *Ilex spinigera*, *Primula heterochroma*, *Sedum stoloniferum* and *Vicia crocea* were the indicator species (Tab. 1).

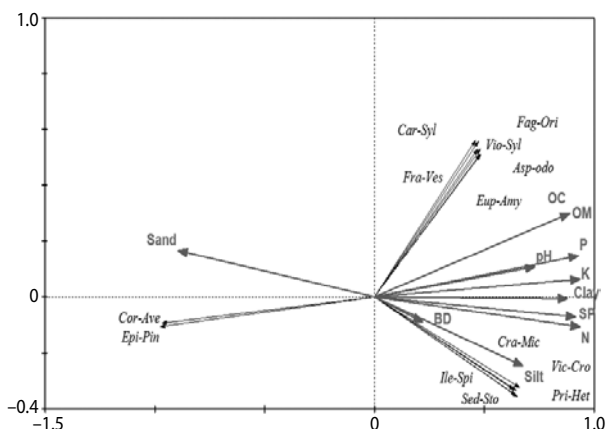
**Table 1.** Results of TWINSPAN and ISA analyses of study area

Species Group	Number of Plots	Indicator Species
1	16	<i>Corylus avellana</i> , <i>Epimedium pinnatum</i>
2	6	<i>Fagus orientalis</i> , <i>Asperula odorata</i> , <i>Euphorbia amygdaloides</i> , <i>Carex</i> sp., <i>Fragaria vesca</i> and <i>Viola sylvestris</i>
3	8	<i>Crataegus microphylla</i> , <i>Ilex spinigera</i> , <i>Primula heterochroma</i> , <i>Sedum stoloniferum</i> and <i>Vicia crocea</i>

### RDA ordination results

The RDA ordination was used because the length of the gradient was calculated (2.94) to be less than 3. The first (0.305) and second (0.173) axes had the largest eigenval-

ues, which accounted for 60.5% of the change and variation. The results of RDA indicated that only sand was the most important factor in the first group. Phosphorus, nitrogen, potassium, carbon, organic material, clay, silt, BD, SP and pH were the most important factors in the second and third group (Fig. 1).



**Figure 1.** Result of RDA analysis of ecological species groups and soil variables in the study area

### ANOVA results of soils

Clay, phosphorus, nitrogen, potassium, carbon, organic material, pH and SP were significantly the highest value in the second and third group. In contrast, Sand was significantly the highest value in the first group. In addition, BD and silt were significantly higher in first group than other groups (Tab. 2).

**Table 2.** Comparison of the soil variables amongst the species groups

	Group 1	Group 2	Group 3
N	0.18 <sup>b</sup>	0.29 <sup>a</sup>	0.32 <sup>a</sup>
P	6.5 <sup>b</sup>	12 <sup>a</sup>	11.8 <sup>a</sup>
K	123 <sup>b</sup>	180 <sup>a</sup>	176 <sup>a</sup>
OC	1.72 <sup>b</sup>	2.73 <sup>a</sup>	2.67 <sup>a</sup>
OM	2.65 <sup>b</sup>	3.88 <sup>a</sup>	3.7 <sup>a</sup>
Sand	70 <sup>a</sup>	54.5 <sup>b</sup>	59 <sup>b</sup>
Silt	14 <sup>c</sup>	18.5 <sup>b</sup>	25 <sup>a</sup>
Clay	8.75 <sup>b</sup>	18.75 <sup>a</sup>	17.25 <sup>a</sup>
BD	0.8 <sup>c</sup>	0.93 <sup>b</sup>	1.05 <sup>a</sup>
SP	40.37 <sup>b</sup>	49.5 <sup>a</sup>	51.6 <sup>a</sup>
pH	6.62 <sup>b</sup>	7.03 <sup>a</sup>	6.92 <sup>a</sup>

### ANOVA results of diversity indices

Biodiversity indices (diversity, richness and evenness) for the second and third groups were significantly higher than first group, but there was no significant difference between second and third groups (Tab. 3).

**Table 3.** Means ( $\pm$ SE) of biodiversity indices in the study area

	Group 1	Group 2	Group 3
Shannon-Wiener diversity	1.09 $\pm$ 0.23	2.21 $\pm$ 0.65	2.14 $\pm$ 0.71
Pielou evenness	0.56 $\pm$ 0.03	0.872 $\pm$ 0.18	0.858 $\pm$ 0.29
Margalef richness	1.3 $\pm$ 0.09	2.39 $\pm$ 0.52	2.26 $\pm$ 0.11

### DISCUSSION

The results are evident that almost half of the study area is dominated by hazel species, and it has created a pure community of hazel. However, in other parts they have grown sporadically and they are dominated by *Fagus orientalis* Lipsky tree and *Ilex spinigera* Loes and *Crataegus microphylla* C. Koch shrub species. Pena et al. (2011) in the Basque region of the northern Iberian Peninsula, and Boulanger et al. (2015) in the Haute-Marne administrative region in north-eastern France found that *Corylus avellana* L. is an accompany species with beech. Onaindia and Mitxelena (2009) showed that *Corylus avellana* is accompany species with *Fagus sylvatica*, *Ilex aquifolium* and *Crataegus monogyna* at the Ibaizabal river basin in Basque region in the north of Spain. In fact, hazel is not able to compete with other species and it grows in site where other species are present less. In the study area, *Fagus orientalis*, *Ilex spinigera* and *Crataegus microphylla* were found the most of the forest, but hazel grew in higher altitudes.

The results of analyzing soil indicated that hazel is grown in habitats with sandy soil and little nutrient elements. As seen in Figure 1 and Table 2, *Fagus orientalis* and *Ilex spinigera* and *Crataegus microphylla* species in contrast to hazel, prefer more fertility soils. Moreover, the hazel is usually found in soils with less nutrient elements such as NPK. On the other hand, results revealed that hazel live in habitats with almost acidic condition. Koorem and Moora (2010) showed that nitrogen, phosphor and pH in hazel community were less than other

communities. Coroi et al. (2004) observed that *Corylus avellana*. Is an indicator species in the area and inhabit on sandy soils in south of Ireland. Adel et al. (2014) and Eshaghi Rad (2010) identified soil texture, pH, N, P, K, C and organic material as the main factors that affect the distribution of beech communities in northern Iran.

Diversity of herbaceous species in hazel stand was lower than the two other ecologic groups. The most important reason of this seems to be the high percentage of canopy cover of hazel stand which doesn't allow light reaches the ground well. Understory vegetation composition in temperate forests is largely determined by soil fertility, light conditions and water availability (Hardtle et al. 2005). In addition, woody plants also affect understory composition by modifying the abiotic microclimate and resource availability (Augusto et al. 2003). For example, light is commonly an important factor which impacts on forest understory richness and composition, and available light depends on canopy structure (Scheller and Mladenoff 2002). The other reason might be presence of *Epimedium pinnatum* Fisch which is the indicator species in the understory of pure hazel community and it has a significant role in competition with other species and to prevent in their growth. In a research in Koeru, central Estonia, Koorem and Moora (2010) found that indicator species composition in *Corylus avellana* understory were different from other communities. The other reason seems to be deficiency of nutrient elements in this community. As a result, these species prefer to grow in a more suitable environmental condition with higher nutrient elements, as we can see in *Fagus orientalis* and *Ilex spinigera* and *Crataegus microphylla* sites which have a better situation than hazel habitats. The presence of more indicator herbaceous species in the two other ecologic groups might be the indicative of this fact. Different tree and shrub species influence on species richness and understory composition through modification of local soil properties (Wulf and Naaf 2009).

In this research, we have conducted early identification of the study area. Hazel forests play an important role in protecting habitat against rockfall hazard, therefore conservation programs should be applied to it (Jancke et al. 2009). Considering the fact that hazel natural stands are rare in the forests of northern Iran, we recommend to provide comprehensive conservation and management programs in order to protect of common

hazel, associated plant species, and to prevent of human activities such as recreational use and livestock.

## ACKNOWLEDGMENT

This contribution originates in part from the “Study on vegetation and some ecological factors in the common hazel (*Corylus avellana* L.) Forest Reservoir in the Saf-aghasteh region, Fuman, Guilan province” project. We would like to thank Research Affaires of University of Guilan for supporting this project.

## REFERENCES

- Adel M.N., Pourbabaei H., Dey D.C. 2014. Ecological species group–Environmental factors relationships in unharvested beech forests in the north of Iran. *Ecological Engineering*, 69, 1–7.
- Augusto L., Dupouey J.L., Ranger J. 2003. Effects of tree species on understory vegetation and environmental conditions in temperate forests. *Annals of Forest Science*, 60, 823–831.
- Boulanger V., Baltzinger C., Saïd S., Ballon P., Picard J.F., Dupouey J.L. 2015. Decreasing deer browsing pressure influenced understory vegetation dynamics over 30 years. *Annals of Forest Science*, 72, 367–378.
- Chang-Bae Lee C.B., Chun J.H. 2015. Patterns and determinants of plant richness by elevation in a mountain ecosystem in South Korea: area, mid-domain effect, climate and productivity. *Journal of Forestry Research*, 26 (4), 905–917. DOI 10.1007/s11676-015-0115-z.
- Chávez V., Macdonald S.E. 2012. Partitioning vascular understory diversity in mixedwood boreal forests: The importance of mixed canopies for diversity conservation. *Forest Ecology and Management*, 271, 19–26.
- Clement Ch. 2001. The ecological importance of understory herbaceous plants. The Effects of Land-Use change on the biodiversity of the Highlands Plateau: a Carolina Environmental Program Report, 32–42.
- Coroi M., Skeffington M.S., Giller P., Smith C., Gormally M., O'Donovan G. 2004. Vegetation diversity and stand structure in streamside forests in the south of Ireland. *Forest Ecology and Management*, 202, 39–57.
- Eshaghi Rad J., Banj Shafiei A. 2010. The distribution of ecological species groups in Fagetum communities of Caspian forests: determination of effective environmental factors. *Flora*, 205 (11), 721–727.
- Gilliam F.S. 2007. The ecological significance of the herbaceous layer in temperate forest ecosystems. *BioScience*, 57 (10), 845–858.
- Giorgini D., Giordani P., Casazza G., Amici V., Mariotti M.G., Chiarucci A. 2015. Woody species diversity as predictor of vascular plant species diversity in forest ecosystems. *Forest Ecology and Management*, 345, 50–55.
- Hardtle W., von Oheimb G., Westphal C. 2005. Relationships between the vegetation and soil conditions in beech and beech-oak forests of northern Germany. *Plant Ecology*, 177, 113–124.
- Hermly M., Honnay O., Firbank L., Grashof-Bokdam C., Lawesson J.E. 1999. An ecological comparison between ancient and other forest plant species of Europe, and the implications for forest conservation. *Biological Conservation*, 91, 9–22.
- Hosein Ava S., Pir Khezri M. 2011. Evaluation of Quantitative and Quality Characteristics in Some Hazelnut (*Corylus avellana* L.) Varieties in Karaj Climatic Conditions. *Iranian Journal of Seed and Plant Production*, 26 (2), 329–342.
- Jancke O., Dorren L.K.A., Berger F., Fuhr M., Kohl M. 2009. Implications of coppice stand characteristics on the rockfall protection function. *Forest Ecology and Management*, 259, 124–131.
- Jolls C.L. 2003. Populations of and threats to rare plants of the herb layer: more challenges and opportunities for conservation biologists. In: *The Herbaceous Layer in Forests of Eastern North America* (eds.: F.S. Gilliam, M.R. Roberts). Oxford University Press, New York.
- Khuroo A.A., Weber E., Malik A.H., Reshi Z.A., Dar G.H. 2011. Altitudinal distribution patterns of the native and alien woody flora in Kashmir Himalaya, India. *Environmental Research*, 111, 967–977.
- Koorem K., Moora M. 2010. Positive association between understory species richness and a dominant shrub species (*Corylus avellana*) in a boreonemoral spruce forest. *Forest Ecology and Management*, 260, 1407–1413.

- Lencinasa M.V., Pastur G.M., Gallo E., Cellini J.M. 2011. Alternative silvicultural practices with variable retention to improve understory plant diversity conservation in southern Patagonian forests. *Forest Ecology and Management*, 262, 1236–1250.
- McEwan R.W., Muller R.N. 2011. Dynamics, diversity, and resource gradient relationships in the herbaceous layer of an old-growth Appalachian forest. *Plant Ecology*, 212, 1179–1191.
- Mölder A., Streit M., Schmidt W. 2014. When beech strikes back: How strict nature conservation reduces herb-layer diversity and productivity in Central European deciduous forests. *Forest Ecology and Management*, 319, 51–61.
- Moraghebi F., Matinizade M., Khanjani Shiraz B. 2010. Mycorrhizal symbiosis hazelnut (*Corylus avellana* L.) and acid phosphatase activity in two regions suction and Fandoglo. *Iranian Journal of Plant and Ecosystem*, 6 (24), 13–23.
- Onaindia M., Mitxelena A. 2009. Potential use of pine plantations to restore native forests in a highly fragmented river basin. *Annals of Forest Science*, 66 (305), 1–8.
- Pena L., Amezaga I., Onaindia M. 2011. At which spatial scale are plant species composition and diversity affected in beech forests? *Annals of Forest Science*, 68, 1351–1362.
- Reyers B., Van Jaarsveld A.S., Krüger M. 2000. Complementarity as a biodiversity indicator strategy. *Proceedings of the Royal Society B: Biological Sciences*, 267, 505–513.
- Scheller R.M., Mladenoff D.J. 2002. Understory species patterns and diversity in old-growth and managed northern hardwood forests. *Ecological Applications*, 12, 1329–1343.
- Wulf M., Naaf T. 2009. Herb layer response to broad-leaf tree species with different leaf litter quality and canopy structure in temperate forests. *Journal of Vegetation Science*, 20, 517–526.