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# Short Communication: Floristic composition and relationships between plant species abundance and soil properties in common hazel (*Corylus avellana*) mountainous forest of northern Iran

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**Abstract.** *Pourrahmati G, Mataji A, Pourbabaei H, Salehi A. 2018. Short Communication: Floristic composition and relationships between plant species abundance and soil properties in common hazel (Corylus avellana) mountainous forest of northern Iran. Biodiversitas 19: 1835-1841.* Mountainous forests are valuable terrestrial ecosystems because of their useful services for the human being. Here, we explored the floristic composition and the relationships between plant species abundance distribution and soil physical and chemical properties in common hazel (*Corylus avellana* L.) in the mountainous forest of northern Iran. Within the forest stand, 30 quadrats (20 m × 20 m and 1 m × 1 m for woody and herbaceous species, respectively) were selectively sampled along an altitudinal range from 1300 m to 1800 m a.s.l. to assess plant species composition and abundance, and soil samples were taken to perform chemical and physical analyses. The results showed that a total of 43 herbaceous and 15 woody species belonging to 23 and 8 families were identified. The abundance of herbaceous species was significantly correlated with soil properties (pH and total N). Furthermore, the abundance of woody species had a non-significant correlation with soil properties.

**Keywords:** CCA, *Corylus avellana*, distribution, mountainous forests, soil physical and chemical properties, species abundance

## INTRODUCTION

Mountainous areas have been introduced as the prominent ecosystems since the Earth Summit in Rio de Janeiro in 1992. The services of mountainous forests, including provisioning, regulating, and cultural, are very vital for the human being (Price et al. 2011; Smith et al. 2015). The natural geographical distribution of the common hazel covers a vast area in the world, including Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France (Corsica, France (mainland)), Georgia, Germany, Greece (Greece (mainland)), Hungary, Iran, Italy (Italy (mainland), Sardegna, Sicilia), Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Moldova, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation (Central European Russia, Chechnya, Dagestan, East European Russia, European Russia, Ingushetiya, Kabardino-Balkariya, Kaliningrad, Karachaevo-Cherkessiya, Krasnodar, North European Russia, Northwest European Russia, Severo-Osetiya, South European Russia, Stavropol), Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey (Turkey-in-Asia), Ukraine (Krym, Ukraine (main part)), United Kingdom (Great Britain, Northern Ireland) (Thompson et al. 1996). Naturally, common hazel grows in habitats with sandy soil and little nutrient elements in some mountainous areas in the north of Iran (Pourbabaei and Adel 2015).

The plant species are known as a primary component of ecosystem functioning, which are affected by the environmental factors (Montoya and Raffaelli 2010). According to the tolerance theory, each plant species is able to survive and reproduce successfully only within a definite range of environmental conditions (Good 1931). There is an interrelationship between plants and soil (Kirkpatrick et al. 2014; Srinivasan et al. 2015), so that, the vegetation growth correlates with some soil properties and vegetation also affects the soil properties (Johnson et al. 2014; Lee et al. 2014). Soil controls the hydrological, erosional, biological, and geochemical cycles in an ecosystem (Keesstra et al. 2012; Brevik et al. 2015; Smith et al. 2015) thereby affecting the plant species richness and composition (Rankin et al. 2007; Silva et al. 2013; Keymer and Lankau 2017). In mountainous areas, soil properties (i.e., physical and chemical features) along with topography can play an important role to develop plant communities (Miyamoto et al. 2003; Ravanbakhsh and Moshki 2016). According to the previous studies, the soil properties have been introduced as effective factors on variations in species abundance (Marcuzzo et al. 2013; Qian et al. 2014; Toure et al. 2015; An et al. 2015; Noumi 2015; Ghaderi et al. 2016). Vegetation is one of the most important factors affecting the stability of ecosystems (Ghaderi et al. 2016). Therefore, understanding the factors that govern patterns of plant species distribution and abundance is a mandatory requirement to control the establishment and distribution of plant communities in the mountainous areas of Iran.

In the mountainous ecosystems of northern Iran, the main soil challenges which impose particular constraints to plant establishment include the rocky substrates, soil scarcity, low water content, and low levels of nutrients. Hazel forests are unique and rare ecosystems in northern Iran and highly valuable because of their major contribution to the improvement of livelihoods and welfare of rural communities, protective function against natural hazards and conservation of many endemic and rare plant species. The most studies related to plant and soil relationships focused on tropical rainforests (Peña-Claros et al. 2011); there is less data base about temperate mountainous forests. As far as we know, there is no studies have paid attention to floristic composition and plant and soil relationships in the common hazel forest of Talesh in northern Iran. This study aimed to identify the floristic composition and investigate the relationships between plant species abundance and soil properties to address the following main question: Is there any relationships between the herbaceous and woody species abundance and soil physical and chemical properties?

## MATERIALS AND METHODS

### Study area

We conducted our study in the common hazel forest which is located on the northern slopes of the Alborz Mountains overlooking the Caspian Sea. The forest stand is located on the mountainous regions of Talesh (latitude: 37˚53′16″ N, longitude: 48˚39′28″ E) along an altitudinal gradient from 1300 m to 1800 m asl. (Figure 1). In this region, mean annual precipitation, temperature, and relative humidity were about 1300 mm, 13.19˚C, and 55%, respectively, and also soil pH was moderately acidic to neutral, soil texture was sandy loam, soil colour was dark brown (7.5YR4/2), and maximum soil depth was 60 cm.


**Figure 1**. The geographical location of study area in the mountainous areas of Talesh, Guilan, northern Iran

## Data collection

*Sampling of understory vegetation*

We took a total of 30 sample plots (20 m × 20 m) selectively in the forest stand along an altitudinal range from 1300 m to 1800 m a.s.l. (Pourbabaei et al. 2012; Zhang et al. 2016). The forest stand was divided into five zones based on 100 m interval in the altitudinal gradient. The woody species with diameter at breast height (≥ 10 cm) in the plots were measured and the species was identified. Furthermore, individual shrubs and saplings (< 10 cm) were enumerated within the plots (Ihlen et al. 2001; Poorbabaei and Poorrahmati 2009). In order to survey the herbaceous layer, the sampling plot area (1 m × 1 m) was obtained according to the method of species/area curve (Cencini et al. 2012). The coverage percent and type of each herbaceous species was estimated using Van der Maarel criterion (Acosta et al. 2007).

*Soil sampling and analysis*

After litter removal from the mineral soil, we collected three soil samples (12.8 cm diameter, 0-20 cm depth) at three locations near the plot center using a soil auger for assessment of the soil chemical and physical properties. Then samples corresponding to each sampling plot were mixed to create a single sample (Vockenhuber et al. 2011). The soil samples were air-dried and sieved to pass a 2 mm sieve to remove the rocks, gravel and debris. The soil samples were analyzed for organic carbon (OC), electrical conductivity (EC), saturation moisture percentage (SP), texture, pH, total N, potassium ($K^+$), phosphorus ($P^+$), bulk density (BD), particle density (PD). The soil analyses were conducted in the Soil Testing Laboratory of Natural Recourses Faculty at University of Guilan. The percentage of organic carbon (OC) was determined using the Walkley and Black method (Lo et al. 2011), total N using the Kjeldahl procedure (Flowers and Bremner 1991), phosphorus (P) test was based on extraction with ammonium lactate (AL) at acidic pH (Olsen and Sommers 1982), available K was analyzed using a flame atomic absorption spectrophotometer (Cox et al. 1993), electrical conductivity (EC) was determined using the sodium saturation ratio (Van Reeuwijk 1992), pH was determined in a 1:5 soil water ratio suspensions using a digital pH-meter (Model 691, Metrohm AG Herisau Switzerland) (Thomas 1996), bulk density, particle density, water content, and total porosity were determined by oven-drying method, and the soil texture was determined by the hydrometer method (Bouyoucos 1962).

## Data analysis

The CCA method was performed using a PC-Ord software version 5 (McCune et al. 2002) to study the plant abundance and soil relationship (Ter Braak 1986). The significance of axes was tested using the Monte Carlo permutation test (Ter Braak and Šmilauer 2002). The significance of eigenvalues of first canonical axis was tested using the Monte Carlo permutation test. The inter-set correlations from the ordination analysis were evaluated to assess the importance of various soil properties, including organic carbon (OC), electrical conductivity (EC), saturation moisture percentage (SP), texture, pH, total N, potassium ($K^+$), phosphorus ($P^+$), bulk density (BD), and particle density (PD) (Gazer 2011).

# RESULTS AND DISCUSSION

## Species composition

The results indicated that a total of 43 herbaceous and 15 woody species belonging to 23 and 8 families were found in the forest stand. The most species-rich families were the Asteraceae, Fabaceae, and Rosaceae, with 4, 3, and 11 genera and 5, 7, and 11 species, respectively (Tables 1 and 2).

## Plant and soil relationship

*Herbaceous species abundance and soil relationship*

To analyze the herbaceous species abundance distribution and soil relationship, the CCA method was performed. The cumulative percentage variances for the axes of CCA (and their eigenvalues) are: 13.6 (0.26), 23.0 (0.18), and 29.4 (0.12) for axes 1, 2, and 3, respectively (Table 3). The correlation calculated for the first three axes of CCA includes: 0.94, 0.87, and 0.83. The Monte Carlo permutation test showed that the relationship was significant (Table 4; $p$ = 0.03). Furthermore the effects of pH and total N on species abundance distribution were significant (Figure 2; $P < 0.05$).

*Woody species abundance and soil relationship*

The CCA method was performed to analyze the woody species abundance distribution and soil relationship. The cumulative percentage variances for axes of CCA (and their eigenvalues) are: 16.7 (0.05), 25.1 (0.02), and 29.8 (0.01) for axes 1, 2, and 3, respectively (Table 5). The correlation calculated for the first three axes of CCA includes: 0.80, 0.64, and 0.59. The Monte Carlo permutation test showed that the relationship was non-significant (Figure 3; Table 6; $P$ = 0.49).

**Table 2.** The recorded woody species in the study area

| Family | Scientific name | Abbrev. | Life form |
|---|---|---|---|
| Aceraceae | *Acer campestre* L. | Acer cam | Ph |
| Caprifoliaceae | *Viburnum lantana* L. | Vibu lan | Ph |
| Corylaceae | *Corylus avellana* L. | Cory ave | Ph |
| Cornaceae | *Cornus mas* L. | Corn mas | Ph |
| Ebenaceae | *Diospyros lotus* L. | Dios lot | Ph |
| Fagaceae | *Quercus iberica* M.Bieb. | Quer ibe | Ph |
| Oleaceae | *Fraxinus excelsior* L. | Frax exc | Ph |
| Rosaceae | *Cerasus avium* (L.) Moench. | Cera avi | Ph |
| | *Crataegus ambigua* A.K.Becker. | Crat amb | Ph |
| | *Malus orientalis* Uglitzk. | Malu ori | Ph |
| | *Mespilus germanica* L. | Mesp ger | Ph |
| | *Prunus divaricata* Ledeb. | Prun div | Ph |
| | *Rosa canina* L. | Rosa can | Ph |
| | *Sorbus torminalis* (L.) Crantz. | Sorb tor | Ph |

**Table 1.** The recorded herbaceous species in the study area

| Family | Scientific name | Abbreviations | Life form |
|---|---|---|---|
| Alliaceae | *Allium ursinum* L. | Alli urs | Geo |
| | *Allium paradoxum* (M.Bieb.) G.Don. | Alli par | Geo |
| Apiaceae | *Heracleum persicum* Desf. | Hera per | Hem |
| Aspleniaceae | *Phyllitis scolopendrium* (L.) Newman. | Phyl sco | Geo |
| | *Asplenium adiantum lanceolatum Hoffm.* | Aspl adi | Geo |
| Asteraceae | *Achillea millefolium* L. | Achi mil | Hem |
| | *Centaurea hyrcanica* Bornm. | Cent hyr | Hem |
| | *Hieracium lactucella* Wallr. | Hier lac | Hem |
| | *Hieracium umbrosum* Jord. | Hier umb | Hem |
| | *Taraxacum officinale* F. H. Wigg. | Tara off | Hem |
| Campanulaceae | *Campanula latifolia* L. | Camp lat | Hem |
| Caprifoliaceae | *Sambucus ebulus* L. | Samb ebu | Geo |
| Clusiaceae | *Hypericum androsaemum* L. | Hype and | Ch |
| Convolvulaceae | *Calystegia sepium* (L.) R.Br. | Calys sep | Geo |
| Cyperaceae | *Carex stenophylla* Wahlenb.. | Care ste | Hem |
| Dennstaedtiaceae | *Pteridium aquilinum* (L.) Kuhn. | Pter aqu | Geo |
| Fabaceae | *Lathyrus latifolius* L. | Lath lat | Hem |
| | *Lathyrus laxiflorus* Kuntze. | Lath lax | Hem |
| | *Trifolium medium* L. | Trif med | Hem |
| | *Trifolium pratense* L. | Trif pra | Hem |
| | *Trifolium repens* L. | Trif rep | Cr |
| | *Vicia sativa* L. | Vici sat | Hem |
| | *Vicia orobus* DC. | Vici oro | Hem |
| Lamiaceae | *Mentha pulegium* L. | Ment pul | Hem |
| | *Nepeta involucrata* Bornm. | Nepe inv | Hem |
| Liliaceae | *Convallaria majalis* L. | Conv maj | Geo |
| Orchidaceae | *Epipactis atrorubens* (Hoffm.) Besser. | Epip atr | Geo |
| Poaceae | *Dactylis glomerata* L. | Dact glo | Hem |
| | *Echinochloa crus-galli* (L.) P. Beauv. | Echi cru | Th |
| | *Eremopoa persica* (Trin.) Roshev. | Erem per | Th |
| Polygonaceae | *Rumex crispus* L. | Rume cri | Hem |
| Primulaceae | *Primula veris* L. | Prim ver | Hem |
| | *Primula vulgaris* L. | Prim vul | Hem |
| Ranunculaceae | *Actaea spicata* L. | Acta spi | Hem |
| | *Primula vulgaris* Huds. | Prim vul | Hem |
| Rosaceae | *Agrimonia eupatoria* L. | Agri eup | Hem |
| | *Fragaria vesca* L. | Frag ves | Hem |
| | *Geum heterocarpum* Boiss. | Geum het | Hem |
| Rubiaceae | *Galium aparine* L. | Gali apa | Th |
| | *Galium odoratum* Scop. | Gali odo | Geo |
| | *Galium rotundifolium* L. | Gali rot | Geo |
| Scrophulariaceae | *Veronica hederifolia* L. | Vero hed | Th |
| Violaceae | *Viola alba* Besser. | Viol alb | Hem |

**Table 3.** Monte Carlo test results, analyzing eigenvalue significance for herbaceous species

| Axis | Eigenvalue | Mean | Minimum | Maximum | *P* |
|---|---|---|---|---|---|
| 1 | 0.26 | 0.19 | 0.12 | 0.26 | 0.006 |
| 2 | 0.18 | 0.14 | 0.09 | 0.22 | |
| 3 | 0.12 | 0.11 | 0.07 | 0.17 | |

**Table 4.** Monte Carlo test results, analyzing herbaceous species abundance distribution-soil correlation

| Axis | Correlation | Mean | Minimum | Maximum | *P* |
|---|---|---|---|---|---|
| 1 | 0.94 | 0.88 | 0.72 | 0.97 | 0.03 |
| 2 | 0.87 | 0.84 | 0.70 | 0.95 | |
| 3 | 0.83 | 0.82 | 0.65 | 0.94 | |

**Table 5.** Monte Carlo test results, analyzing eigenvalue significance for woody species

| Axis | Eigenvalue | Mean | Minimum | Maximum | *P* |
|---|---|---|---|---|---|
| 1 | 0.05 | 0.04 | 0.02 | 0.07 | 0.3 |
| 2 | 0.02 | 0.03 | 0.01 | 0.05 | |
| 3 | 0.01 | 0.01 | 0.00 | 0.03 | |

**Table 6.** Monte Carlo test results, analyzing woody species abundance distribution-soil correlation

| Axis | Correlation | Mean | Minimum | Maximum | *P* |
|---|---|---|---|---|---|
| 1 | 0.80 | 0.80 | 0.65 | 0.98 | 0.49 |
| 2 | 0.64 | 0.73 | 0.55 | 0.93 | |
| 3 | 0.59 | 0.65 | 0.46 | 0.86 | |

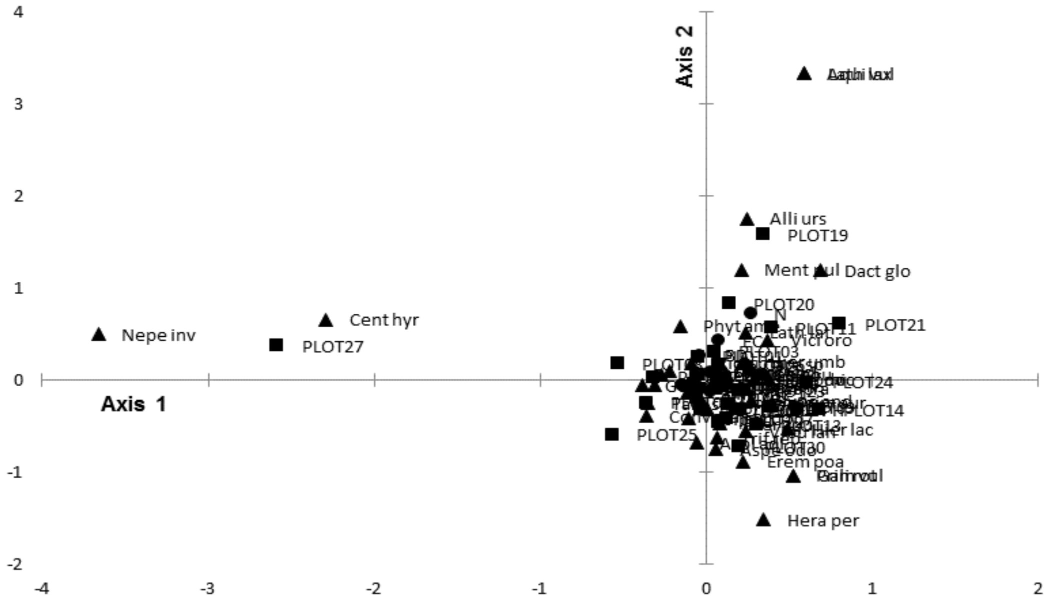


**Figure 2.** CCA-ordination diagram of herbaceous species abundance distribution related to soil physical and chemical properties. EC (electrical conductivity), OC (organic carbon), pH (acidity), SP (saturation moisture percentage), N (nitrogen), P (phosphorus), K (potassium), PD (particle density), S (sand), Si (silt), Cl (clay), and BD (bulk density). The triangles represent species, circles represent soil factors, and squares represent plots.

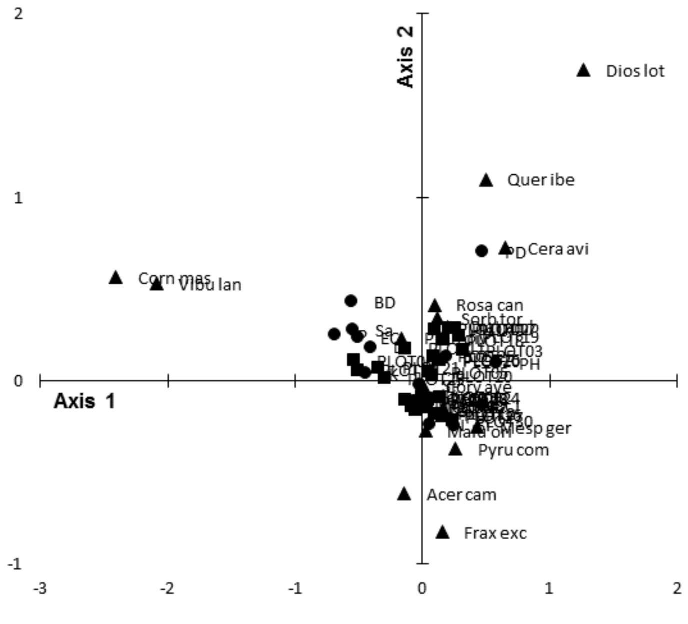


**Figure 3.** CCA-ordination diagram of woody species abundance distribution related to soil physical and chemical properties. EC (electrical conductivity), OC (organic carbon), pH (acidity), SP (saturation moisture percentage), N (nitrogen), P (phosphorus), K (potassium), PD (particle density), S (sand), Si (silt), Cl (clay), and BD (bulk density). The triangles represent species, the circles represent soil factors, and the squares represent plots

## Discussion

The study of relationships between vegetation and environmental factors gives valuable knowledge of why certain plant species are found in some locations but not in others (Ravanbakhsh and Moshki 2016). This knowledge can help us in afforestation planning and biodiversity conservation in mountainous areas of northern Iran. A total of 43 herbaceous and 15 woody species belonging to 23 and 8 families were identified in the forest stand. The most species-rich families were the Asteraceae, Fabaceae, and Rosaceae, with 4, 3, and 11 genera and 5, 7, and 11 species, respectively.

The soil physical and chemical properties have a significant influence on plants growth and development

(Muenchow et al. 2013; Qian et al. 2014; An et al. 2015), and plants mutually play clear and predictable role in determining the soil nutrient (Fu et al. 2015; Novak et al. 2017). The soil properties cause heterogeneity over space and time and regulate the vegetation abundance (Silva and Batalha 2008; Brinkmann et al. 2009; Otýpková et al. 2011; Zhang et al. 2015). According to the previous researches, some soil variables have been identified as a determinant of species abundance distribution, for example, pH (Rodríguez-Loinaz et al. 2008; Hofmeister et al. 2009; Laganière et al. 2009; Royer-Tardif and Bradley 2011; Haberl et al. 2012; Pourbabaei and Adel 2015; Ullah et al. 2015), available K and total N (Qian et al. 2014; An et al. 2015), organic matter (Liu et al. 2012), rock content and bulk density (Wang et al. 2016), soil depth (Zhang et al. 2016), phosphorus content and electrical conductivity (Khan et al. 2016), concentration levels of K, Ca, P, CEC, and fertility index (Nadeau and Sullivan 2015), and CEC, OM, Fe, P, Mg, pH, Mn, Pb, Zn, Cu, sand, and clay proportion (Vincent and Meguro 2008).

The results showed the significant influence of some soil properties on the abundance of herbaceous species within the forest stand. The abundance of herbaceous species was closely correlated with the soil properties including pH and total N, while, we found no relationship between the woody species abundance and soil properties. This result may be due to many woody species are capable of growing across a wide range of soil or it seems that factors other than soil features are influential in the woody species abundance in the forest stand.

In conclusion, Our results provided information about plant diversity and the relationship between plant species abundance and soil physical and chemical properties in the common hazel forest of northern Iran. The distribution of vegetation largely depends on the capacity of plants to adopt resistance strategies in order to colonize the different soil conditions. The results indicated that a total of 43 herbaceous and 15 woody species belonging to 23 and 8 families were identified in the study area. The most species-rich families were the Asteraceae, Fabaceae, and Rosaceae, with 4, 3, and 11 genera and 5, 7, and 11 species, respectively. The herbaceous species abundance distribution was strongly correlated with soil properties, including the soil pH and total N. Furthermore, there was no correlation between the woody species abundance distribution and soil factors.

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