Plant diversity variation of pure versus mixed Hyrcanian beech Forests

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Abstract: The Hyrcanian vegetation zone of Caspian forests in Iran is stretching over the northern slopes of the Alborz mountain ranges and covers the southern coasts of the Caspian Sea. In this region herbs account for most of the vascular plant diversity which can be used as an easy tool to measure and evaluate biodiversity in order to ecosystem-based forest management. The study focused on following questions: 1) Whether the herbal vegetation composition and diversity varied from mixed Hyrcanian beech stands to pure ones?, 2) How does increasing beech cover affect the understory species?. 27, 11, 10, 6 samples were respectively recorded in pure beech, beech-hornbeam, beech-hornbeam-maple stands and mixed non-beech sites. Plot size for floristic sampling was 400 m² (20* 20 m) in each site. At each sample, a floristic list of the plot and an estimate of percent cover and abundance of all vascular plants were recorded using the Braun-Blanquet scale. At the center of each vegetation plot, two soil samples were taken of 0–10 and 10–30 cm depth levels for physico-chemical analyses including soil pH, total Nitrogen, available phosphorous, calcium carbonate, organic matter, exchangeable bases and C/N ratio. Cluster analysis was used for classify of samples based on understory vegetation data and Multi-response Permutation Procedure (MRPP) was used to test the hypothesis of no differences between predefined overstory categories in the understory species space. Non-metric multidimensional scaling (NMS) was applied to assess the rate and direction of changes on the understory vegetation in the different stands. For measuring plant diversity for each sample, species richness, Evenness and Shannon diversity index were calculated. The results showed that herb-layer vegetation of more diverse deciduous forest stands appeared to be more diverse than herb-layer vegetation of beech-dominated stands. All diversity indices and understory species frequency were lower in pure beech stands but promoted to higher level while decreasing the proportion of beech towards beech-hornbeam, beech-hornbeam-maple and non-beech stands. Frequency of many species such as *Carex divulsa*, *Calystegia sylvestris*, *Lathyrus laxiflorus*, *Lapsana communis*, *Geum urbanum*, *Brachypodium sylvaticum* increased when proportion of beech in the canopy decreased. NMS analysis clearly indicated that major factors accounting for variations in understory vegetation were organic matter and total nitrogen as well as the proportion of beech in tree layer. All diversity indices and distribution of understory species significantly negatively correlated with beech proportion and positively with soil organic matter and total nitrogen. Therefore, Forest managers should pay attention to the natural composition of forest stands and should not try to replace mixed forest stands by pure ones. For conservation of biodiversity, we need a mixture of (natural) beech forest stands with a more diverse canopy composition.
Keywords: Beech, Diversity, Understory species, Hyrcanian forests, Iran

1. Introduction

The Hyrcanian vegetation zone of Caspian forests is stretching over the northern slopes of the Alborz mountain ranges and covers the southern coasts of the Caspian Sea (Sagheb-Talebi, 2004). Although palynologically not evidenced yet, the presence of many elements of the Arcto-Tertiary flora, such as Parrotia persica, Pterocarya fraxinifolia and Zelkova carpinifolia indicates that the Hyrcanian forest was one of the most important refuges for the temperate deciduous broad-leaved forests during Pleistocene glaciations (Ramezani et al., 2008). In Hyrcanian region woodland herbs account for most of the vascular plants diversity, like the deciduous forests of eastern North America (Whigham, 2004) and Europe (Garcia et al., 2007; Vockenhuber et al., 2011). Herbal vegetation play an important role in ecosystem functioning, especially in nutrient cycling (Anderson and Eickmeier, 2000; Bolte et al., 2004). Besides productivity aspects, forest herb-layer species are well-known indicators of site conditions, overstory regeneration patterns and conservation status (Hutchinson et al., 1999; Small and McCarthy, 2002, Lookingbil et al., 2004, Suchar & Crookston, 2010) and relevant indicators for human impact and evaluate biodiversity in ecosystem-based forest management (Schmidt, 2005). During the two last decades foresters have been trying to develop beech (Fagus orientalis Lipsky) stands by operating single selection system at intermediate elevation levels (800–1800 m a.s.l.) because of productivity reasons and economical value (Mohadjer, 2005). In spite of ecological enormous importance of Hyrcanian forests, the effects of increased proportions of beech trees in the overstory composition on understory species in these forests are still unclear. However, it is illustrated that the species composition of the forest canopy affects the distribution of forest understory species (van Oijen et al. 2005). Moelder et al., 2008 reported that herbaceous understory diversity was indirectly influenced by canopy tree species by altering environmental factors like soil pH and litter layer thickness. Vascular species richness is higher in oak species stands compared to beech ones (Brunet et al.,1996; Skov 1997; Nagaike et al. 2005). On the whole, coniferous species from the Pinus and Larix genera showed to support a diverse understory than some broadleaved species (Barbier et al, 2008). Lenie`re and Houle, 2006 indicated the more diverse tree canopy had a positive effect on vascular species richness because the diversity of the tree layer can influence herb layer diversity by creating environmental conditions suitable to understory vegetation (Vockenhuber et al., 2011). While, Ampoorter et al., 2014 didn’t find a clear relation between tree species richness and understory diversity. According to Tinya et al. (2009), transmitted light from the overstory affects significantly species richness of herbs and cover of ground floor in temperate mixed forests, also the quantity and quality of it alter through tree species composition and stand structure which these factors influence thereby silvicultural management. But, Chen et al. (2004) and Moelder et al. (2008) did not find significant relationship between understory light and herb layer vegetation diversity. In general speaking, it can be supposed that mixed stands are more suitable for species in the herbal layer than pure ones. Nevertheless, these assumptions may not always be sound. Furthermore, the mechanisms involved in the impacts of tree species on understory species are not completely comprehended (Barbier et al, 2008). Hence, insight into the effects of tree species variations on herbaceous diversity can be helpful and essential for forest managers in order to management based on close-to-nature forestry and natural forest dynamics in Hyrcanian forests. So, this paper focussed on following questions:

1) Whether the herbal vegetation composition and diversity varied from mixed Hyrcanian beech stands to pure ones?
2) How does increasing beech cover affect the understory species?

2. Materials and Methods

2.1. Study area

The study was conducted in the experimental forest of the University of Tehran. The experimental forest is located in northern Iran (Figure 1). Latitude range: 36º27′-36º40′ N; longitude range: 51º32′-51º43′E.

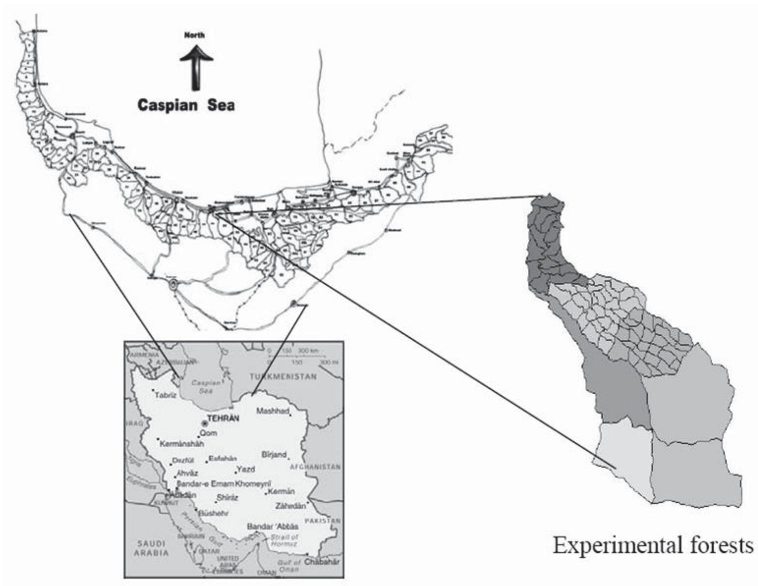

Figure 1. Location of study area

Average annual rainfall is 1300 mm and average annual temperature is 15.3 °C. Relative humidity is also high with an average value of 80 %. The bedrock materials are mainly limestone and soils belong to Inceptisol and Alfisol orders in the study area (Sarmadian and Jafari 2001). The whole study area have been permanently covered by deciduous forest and categorized as ancient forests with multi layers strata (Mohadjer, 2005). In addition to *Fagus orientalis*, major tree species are *Acer velutinum*, *Quercus castanifolis* and *Carpinus betulus*.

2.2. Sampling strategy

For this study, 54 representative sampling plots from 54 research sites were selected based on criteria by experts (according to Moelder et al., 2008). Selection criteria were follows as:

(1) All stands investigated in this study were ancient forests.
(2) Comparable edaphic and climatic conditions. Vegetation composition and habitat conditions within sites should be homogeneous.
(3) No trees have been felled in the plots for at least 10 years;
(4) Tree-layer compositions in pure beech, beech-hornbeam, beech-hornbeam-maple stands. In these, 27, 11, 10 samples were recorded. In order to evaluate the effect of absence of beech from tree layer on understory vegetation, 6 plots were taken in mixed oak, hornbeam and maple stands as mixed non-beech stands.

Nomenclature followed Ghahraman (2001) for all plants observed in the plots.

Plot size for floristic sampling was 400 m² (20* 20 m) in each site (according to Mataji, 2003). Within each plot, the full floristic composition of vascular plants was recorded. Cover classes for each species (using the modified Braun-Blanquet scale, Ellenberg and Mueller-Dombois 1974) were separately estimated for herb and tree layers. As a biotic environmental parameter, the proportion of beech in relation to the other tree species in the tree-layer was calculated for each sample.

At the centre of each sample, two samples were taken from 0-10 and 10-30 cm soil depth from the mineral soil.

Before the laboratory analysis the soil samples were air-dried and sieved with a 2 mm screen. Sand, silt and clay percentages were determined by the hydrometric method. Soil pH (in KCl) was determined by a pH meter. Total N was analyzed by the Kjeldahl method (Zarrinkafsh, 2000). Available P was determined by colorimetry according to Bray-II method (Bray and Kurtz, 1945). Calcium carbonate was determined by calcimetry; organic carbon by the Walkley and Black (1934) method. Organic matter was obtained by multiplying C values by 1.72. Exchangeable bases were extracted with ammonium acetate 1 N and analyzed by atomic spectrometry. Also, C/N ratio was calculated (Zarrinkafsh, 2000).

2.3. Data analysis

In order to recognize understory species groups within predefined overstory categories, cluster analysis was used to classify of samples based on understory vegetation data using a Sørensen distance measurement and flexible beta linkage. Multi-response Permutation Procedure (MRPP) was used to test the hypothesis of no difference between predefined overstory categories in the understory species space (McCune & Mefford, 1999).

Non-metric multidimensional scaling (NMS) was applied to assess the rate and direction of changes on the understory vegetation in different stands. For an ecological interpretation of the ordination result, scores of plots of the first two ordination axes were correlated with corresponding measurements of environmental variables using of Spearman rank correlation (McCune & Mefford, 1999). Before data analysis, species with less than 5% frequency were deleted from the species matrix and the matrix of soil physical and chemical variables was standardized to mean 0 and variance 1 prior to ordination. The cover-abundance-scale for the species was transformed into digital form (for ordination analysis) according to the scale proposed by Van der Maarel (1979).

For measuring plant diversity for each sample, species richness was calculated as the number of species inventoried in the plot. We applied the Shannon diversity index (H') as , where equals the number of species and is the relative cover of ith species And also the Evenness index, E= H'/ H'max with H'max =ln(SR) (Magurran, 2004). The original data was used for calculating the diversity indices.

The computer program PC-ORD for Windows version 4.0 for calculating all diversity indices and the analysis (McCune & Mefford, 1999).

The Spearman correlation was calculated between environmental factors (organic matter, total nitrogen and the proportion of beech) and species with high significant correlation with NMS axis to detect possible relationships.

Mann-Whitney U-test was used to test for significant differences in the species richness, diversity and evenness indices among the different stand types. This analysis was conducted using SPSS 15.0.

Results

Cluster analysis of samples based on understory vegetation recorded in different forest types (Fig. 2) showed that 2 main groups could be separated. The plots of pure beech obtain the first group (in addition to 2 plots of beech-hornbeam stand) and the rest provide the second group in which beech-hornbeam, beech-hornbeam-maple and non-beech samples are included. MRPP analysis (Table 1) detected that there were significant differences between pure beech stands and mixed beech and non-beech stands, also beech-hornbeam versus non-beech and beech-hornbeam-maple versus non-beech stands based on understory species composition but no significant differences observed between mixed beech stands.

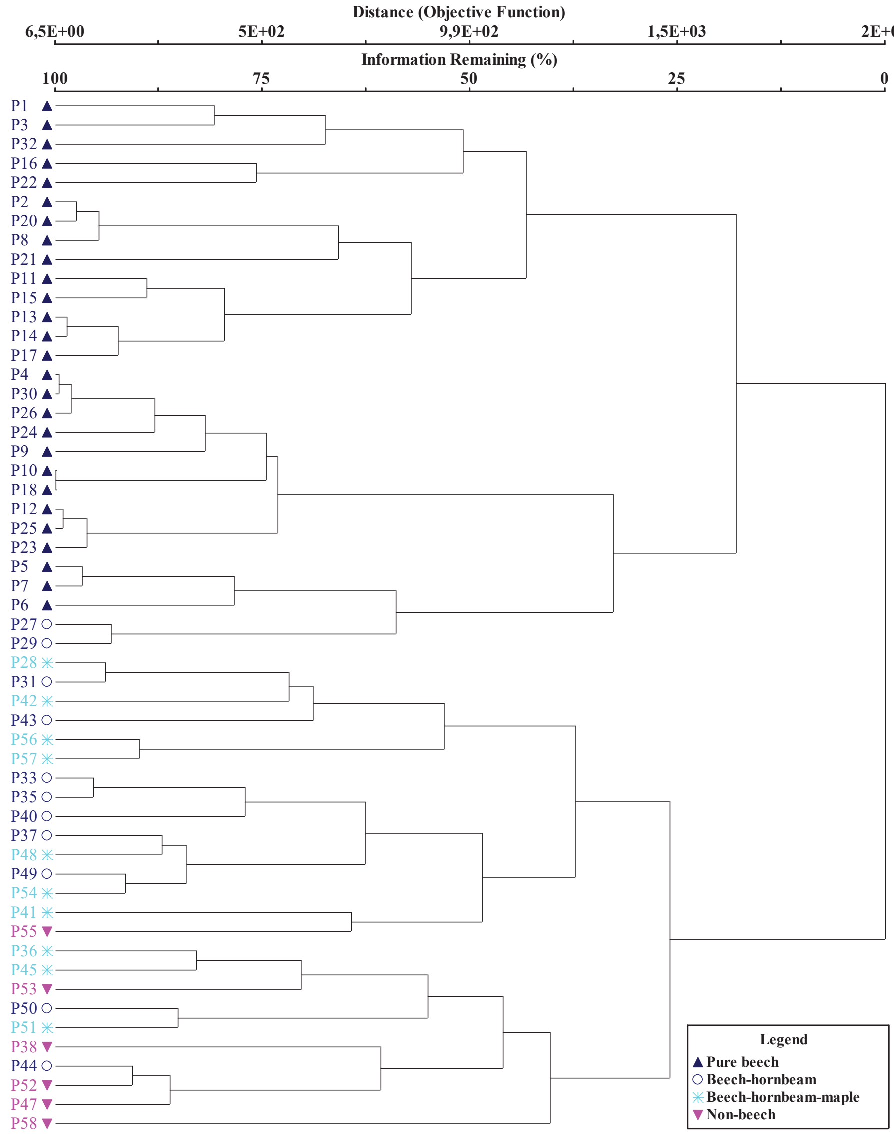

Figure 2. diagram of cluster analyses on 54 sample plots in the study area.

Table 1. multiple pair-wise comparisons of species composition of different stands by MRPP.

	T	A	P
Pure beech *vs.* Beech-hornbeam	-13.312	0.2172	0.00000001
Pure beech *vs.* Beech-hornbeam-maple	-11.041	0.1803	0.00000003
Pure beech *vs.* Non-beech	-12.364	0.2264	0.00000000
Beech-Hornbeam *vs.* Beech-hornbeam-maple	1.386	-0.0411	0.93016211
Beech-Hornbeam *vs.* Non-beech	-3.657	0.1325	0.00263236
Beech-hornbeam-maple *vs.* Non-beech	-2.140	0.0879	0.03019048
Total	-13.799	.2888	0.00000000

The test statistic (T) describes the separation between groups and the chance corrected within-group agreement (A) describes within-group homogeneity compared to random expectation.

Ordination of sampled plots clearly indicated that major factors accounting for variations in understory vegetation were organic matter and total nitrogen as well as the proportion of beech in tree layer (fig 3 & table 2). NMS second axis was significant negative correlated with relative beech proportion. Diversity indices showed a significant positive correlation with this axis. The first axis was positively correlated with soil organic matter and total nitrogen in the first depth. There was no direct relationship between the distribution of understory species with soil texture, exchangeable cations and pH. Correlation analysis showed that understory species diversity indices was significantly positively correlated with soil organic matter and total nitrogen and negatively with relative beech proportion.

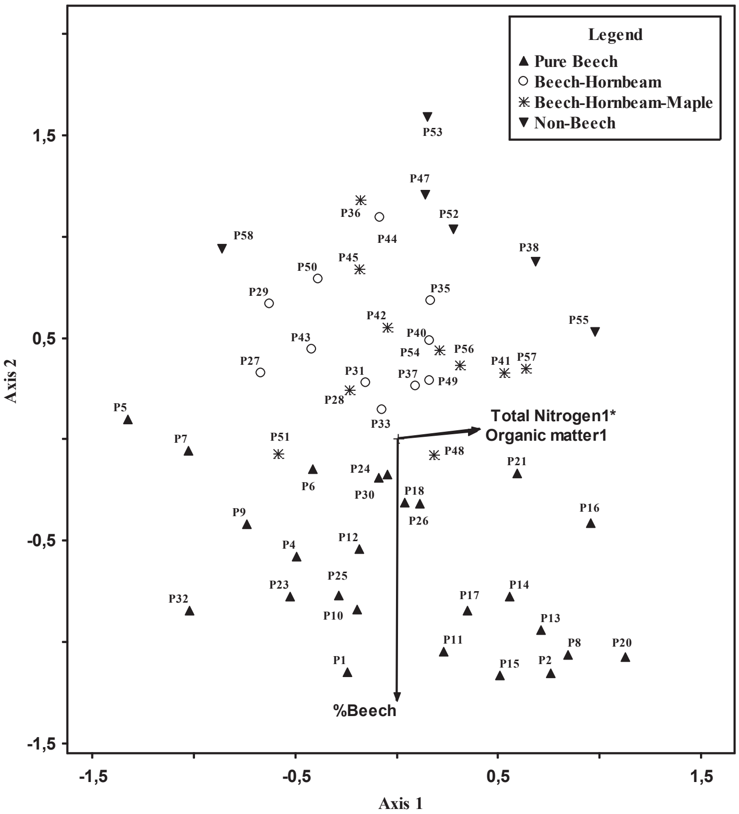

Figure 3. NMS ordination of 54 sample plots in the study area (total organic matter 1 and total nitrogen 1: organic matter content and total nitrogen in the first layer of soil (0-10 cm depth)).

Table 2. Spearman correlations between herb-layer species diversity indices and NMS axis as well as significant environmental parameters

	Oragnic Matter	Total Nitrogen	%Beech	NMS Axis1	NMS Axis2
Oragnic Matter	1	.731**	-.373**	0.250*	.110
Total Nitrogen	.731**	1	-.339*	.274*	-.025
%Beech	-.373**	-.339*	1	.026	-.722**
Species Richness	.303*	.303*	-.821**	-.048	.672**
Shannon-Wiener Diversity index	.336*	.411**	-.839**	.106	.621**
Evennes Index	.350*	.401**	-.825**	.149	.620**

**. Correlation is significant at the 0.01 level.
*. Correlation is significant at the 0.05 level.

NMS first-axis scores were positively correlated with *Cardamine bulbifera, Circaea lutetiana, Mercurialis perennis* and negatively correlated with *Carex sylvatica, Hypericum androsaemum, Epimedium pinnatum* (Table 3, Fig. 4). NMS second-axis scores were significantly positively correlated *with Brachypodium sylvaticum, Calystegia sylvestris, Carex divulsa, Carex sylvatica, Geum urbanum, Hypericum androsaemum, Oplismenus undulatifolius, Scuttellaria tournefortii, Vincetoxicum scandens, Viola odorata, Fragaria vesca* and negatively correlated with *Cardamine bulbifera and Mercurialis perennis*. These species as well as other effective parameters (beech proportion in tree layer, soil organic matter and total nitrogen in the first layer and diversity indices) were tested for significant correlations using of Spearman correlation (Table 3). *Brachypodium sylvaticum and Vincetoxicum scandens* showed significant positive correlation with organic matter and the same for correlation between *Brachypodium sylvaticum, Circaea lutetiana* and total nitrogen. Generally speaking, except for *Cardamine bulbifera* which indicated positive correlation, there were negative correlations between the rests of species with beech proportion. The correlation results for correlations between understory species and diversity indices were vice versa (in most cases) with what were observed to beech proportion.

All diversity indices were significantly negative correlated with beech proportion in the canopy and positively with soil organic matter and total nitrogen (table 2). *Calystegia sylvestris Carex divulsa, Serratula quinquefolia, Sedum stoloniferum, Prunella vulgaris*, *Danae racemosa, Polystichum vulgaris, Lathyrus laxiflorus, Lapsana communis, Geum urbanum, Geranium sylvaticum, Geranium robertianum, Carex remota and Lathyrus vernus* were not recorded in pure beech stands (Table 4).

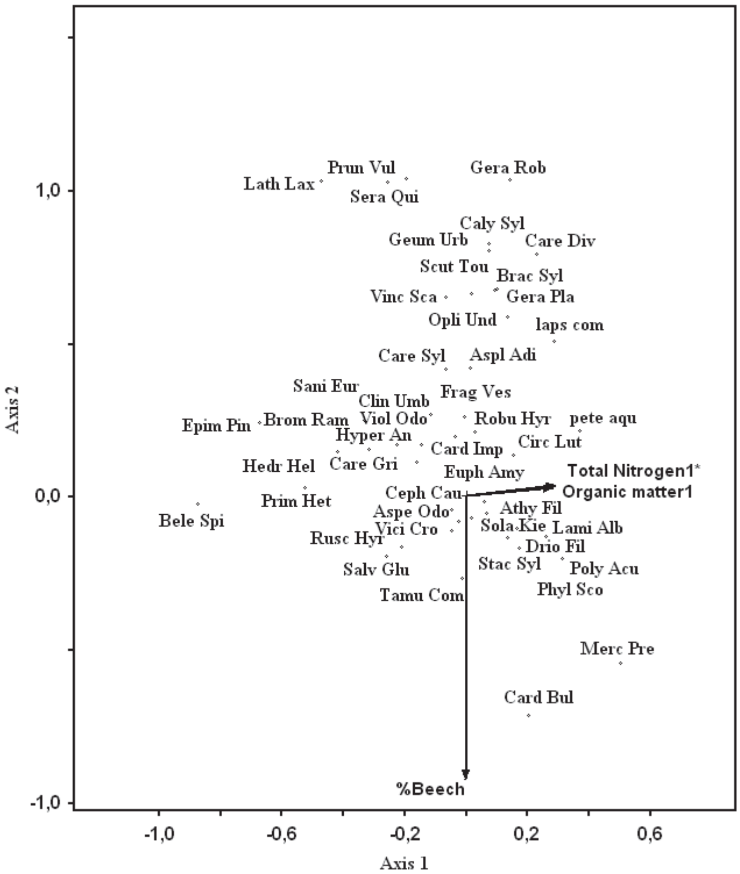

Figure 4. NMS ordination of the understory species (total organic matter 1 and total nitrogen 1: organic matter content and total nitrogen in the first layer of soil (0-10 cm depth); the abbreviations of species scientific name are cited in table 4).

Table 3. Spearman correlations between understory species and environmental parameters as well as diversity indices and NMS axis

	Organic Matter	Total Nitrogen	Species Richness	Shannon-Wiener Diversity index	Evennes Index	%Beech	DCA Axis1	DCA Axis2
Brachypodium sylvaticum	.383**	.310*	.736**	.790**	.803**	-.782**	0.123	.688**
Calystegia sylvestris	0.244	0.113	.574**	.497**	.480**	-.547**	0.007	.555**
Cardamine bulbifera	-0.107	-0.076	-.286*	-.297*	-.314*	.463**	.289*	-.466**
Carex divulsa	0.134	0.246	.500**	.536**	.520**	-.566**	0.179	.473**
Carex sylvatica	0.142	0.137	.583**	.690**	.682**	-.672**	-.275*	.607**
Circaea lutetiana	0.264	.300*	.498**	.530**	.514**	-.418**	.352*	0.265
Geum urbanum	0.273	0.127	.676**	.683**	.722**	-.756**	-0.012	.703**
Hypericum androsaemum	-0.145	-0.213	.323*	.227	0.182	-.311*	-.406**	.455**
Mercurialis perennis	0.104	0.268	-0.240	-.115	-0.133	0.253	.456**	-.525**
Oplismenus undulatifolius	0.158	0.242	.650**	.737**	.749**	-.756**	0.100	.588**
Scuttellaria tournefortii	0.182	0.182	.569**	.538**	.495**	-.567**	-0.066	.454**
Vincetoxicum scandens	.285*	0.209	.489**	.433**	.367**	-.624**	-0.148	.401**
Viola odorata	0.230	0.169	.610**	.605**	.623**	-.652**	-0.263	.622**
Epimedium pinnatum	-0.171	-0.133	0.167	.093	0.011	-0.097	-.573**	0.132
Fragaria vesca	0.130	0.101	.536**	.639**	.643**	-.558**	-0.0003	.618**

**. Correlation is significant at the 0.01 level.

*. Correlation is significant at the 0.05 level.

Table 4. Species frequency percentage in different stands

	Abbreviation	pure beech	beech-hornbeam	beech-hornbeam-maple	non-beech
Euphorbia amygdaloides	*Euph amy*	100	100	100	100
Asperula odorata	*Aspe odo*	100	100	100	67
Rubus hyrcanus	*Rubu hyr*	96	100	90	100
Dryopteris filix-mass	*Dryo fli*	96	82	90	100
Athyrum filix-femina	*Athy fil*	93	91	100	67
Solanum kieseritzki	*Sola kie*	85	100	90	83
Stachys sylvatica	*Stac syl*	81	64	70	17
Viola odorata	*Viol odo*	74	100	100	100
Lamium album	*Lami alb*	74	82	90	83
Circaea lutetiana	*Circ lut*	67	91	100	83
Hypericum androsaemum	*Hyper and*	63	100	90	100
Cephalanthera caucasica	*Ceph cau*	63	64	60	33
Fragaria vesca	*Frag ves*	59	91	100	100
Bromus ramosus	*Brom ram*	56	91	80	67
Mercurialis perennis	*Merc pre*	52	9	30	33
Tamus communis	*Tamu com*	48	27	40	50
Cardamine bulbifera	*Card bul*	48	18	0	0
Vicia crocea	*Vici cro*	41	27	30	50
Carex sylvatica	*Care syl*	37	100	90	100
Salvia glutinosa	*Salv glu*	33	9	40	17
Polystichum aculeatum	*Polys acu*	33	36	40	50
Ruscus hyrcanus	*Rusc hyr*	30	9	30	33
Phyllitis scolopendrium	*Phyl sco*	22	27	30	0
Peteridum aquilinium	*Pete aqu*	22	9	20	33
Clinopodium umbrosum	*Clin umb*	22	82	50	50
Cardamine impatiens	*Card imp*	22	55	20	0
Sanicula europaea	*Sani eur*	19	36	20	17
Carex grioletti	*Care gri*	19	45	30	0
Epimedium pinnatum	*Epim pin*	15	36	20	17
Blechnum spicant	*Blec spi*	11	0	0	0
Vincetoxicum scandens	*Vinc sca*	4	45	30	83
Symphyandra odontosepala	*Symp odo*	4	9	0	0
Scuttellaria tournefortii	*Scut tou*	4	55	40	50
Ptera cretica	*Pter cre*	4	0	0	0
Primula heterochroma	*Prim het*	4	18	0	0
Oplismenus undulatifolius	*Opli und*	4	82	80	83
Hedera Pastuchovii	*Hedr pas*	4	0	10	17
Carex strigosa	*Care str*	4	0	10	0
Brachypodium sylvaticum	*Brac syl*	4	73	80	100
Asplenium adiantum-nigrum	*Aspl adi*	4	18	10	17
Serratula quinquefolia	*Serr qui*	0	0	10	33
Sedum stoloniferum	*Sedu sto*	0	0	0	33
Prunella vulgareis	*Prun vul*	0	9	20	33
Danae racemosa	*Dana rac*	0	9	0	0
Polystichum woronowii	*Poly wor*	0	9	0	0
Carex divulsa	*Care div*	0	27	40	67
Calystegia sylvestris	*Caly syl*	0	36	50	50
Lathyrus laxiflorus	*Lath lax*	0	9	10	33
Lapsana communis	*Laps com*	0	18	30	17
Geum urbanum	*Geum urb*	0	64	70	100
Geranium sylvaticum	*Gera syl*	0	36	40	50
Geranium robertianum	*Gera rob*	0	9	0	17
Carex remota	*Care rem*	0	0	10	0
Mentha aquatica	*Ment aqu*	0	0	0	17
Lathyrus vernus	*Lath ver*	0	0	0	17

All diversity indices increased while the beech proportion decreased so that the lowest amount of all diversity indices were observed in pure beech stands but the highest in non-beech stands (fig.4).

3. Discussion

This study indicated that compositional dissimilarities in the overstory tree types resulted in differences between the understory species except beech-hornbeam versus beech-hornbeam-maple (table1). The cluster analysis (Fig. 2) revealed that pure beech stands was classified quite separately from mixed beech plots with specific understory composition. As NMS analysis (Fig. 3 & Fig. 4) illustrated the variation of ground vegetation in different stands can be explained by a combination of soil organic matter and total nitrogen of upper 10 cm and proportion of beech in the tree layer. Frequency of many species such as *Carex divulsa,* *Calystegia sylvestris, Lathyrus laxiflorus, Lapsana communis, Geum urbanum, Brachypodium sylvaticum* increase when proportion of beech in the canopy decreases (table4). Light transmittance from the overstory is related to tree species characteristics (such as leaf area index and spatial arrangement of leaves) and crown structure as well as density of crown (Horn 1971; Planchais & Sinoquet 1998; Jennings et al. 1999). Beech crowns transmit a small amount of light to the forest floor (Barbier et al., 2008).

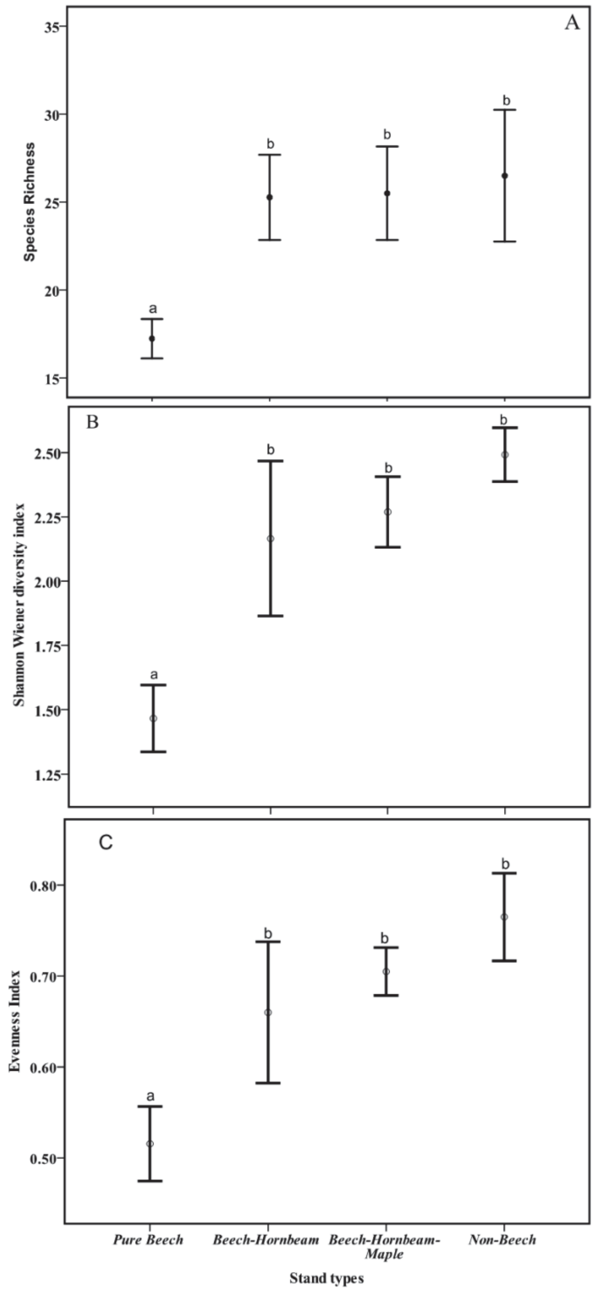

Figure 5. Species Richness (A), Shannon Evenness index (B), Shannon diversity index(C) in the different stand types. Significant differences (at 0.01 level) are depicted by different letters.

Therefore, it can be hypothesized that, lower beech proportion or higher other canopy species result in higher light availability and higher herb-layer diversity (Moelder et al., 2008). Our findings agree with Tinya et al. 2009, who declared that lighter forest patches provide relevant conditions for survive of more herbal species. Also shade-tolerant species which are characteristic for low light condition (e.g. *Cardamine bulbifera* and *Mercurialis perennis*) mainly occur with high frequency in beech stands. Furthermore, all diversity indices significantly positively correlated with soil organic matter and total nitrogen (table2). Fu et al. (2004) found that soil organic matter content was a suitable index of soil fertility and nutrient availability. Increasing of soil nutrient and equalizing the distribution of it will allow more vascular species to co-exist at small scale (Bruno et al., 2002; Hart, et al., 2003). In a comprehensive study of local and regional trends in the ground vegetation of five ancient beech from northwest France, Lalanne et al. 2010 showed that soil nutrient regime explains a large proportion of the variation in the floristic composition of beech forests. We detected that in addition to beech proportion, organic matter and total nitrogen were major factors for variations of understory vegetation. Haerdtle et al. (2003) indicated in the meso- to eutrophic beech forests (beech forests of the alliance Fagion sylvaticae) that species richness is closely correlated with the nutrient supply. The present study showed no significant correlations between soil pH and herb layer species richness and diversity. However, some other studies such as van Oijen et al. 2005, Moelder et al., 2008 and Vockenhuber et al., 2011 showed herb layer species richness was positively related to increasing soil pH under variety of tree species *including Tilia platyphyllos, Carpinus betulus, Fraxinus excelsior, Fagus sylvatica, Quercus robur* in the Central Europe. The correlation analysis demonstrated that there were significantly negative correlations between soil organic matter and total nitrogen and proportion of beech in the tree layer. Moreover, herb layer diversity indices and species richness were significantly negatively correlation with beech proportion. Litter quality between tree species is different, litter mixtures decompose at a different rate (Seastedt, 1984). Sariyildiz & Kucuk (2009) demonstrated that litter decomposition and nutrient release processes in the pure oriental beech stands (*Fagus orientalis Lipsky*) were lower than mixed ones resulted in greater concentrations of N and net N mineralization rates in the forest floor of the mixed beech stands. In temperate forest, there is a report of the higher organic horizon thickness in the pure beech mature stands in contrast with mixed beech-hornbeam stand that it indicated slower decomposition processes in pure beech forest (Aubert et al., 2004). Furthermore transmission of photosynthetically active radiation in beech canopies is significantly lower than in canopies of other deciduous tree species. This inhibits both the establishment and development of shade-intolerant herb-layer (Schmidt, 2005). In particular, pure beech stands had lower species richness and diversity compared mixed beech stand. Moelder et al., 2008 reported that herb-layer vegetation of more diverse deciduous forest stands appeared to be more diverse than herb-layer vegetation of beech-dominated stands in Hainich National Park (Thuringia, Germany). In the study of Aubert et al., 2004 a pure beech stand had a homogenizing effect on herb-layer composition compared mixed beech-hornbeam stand. Generally, all diversity indices and understory species frequency were lower in pure beech stands but promoted to higher level while decreasing the proportion of beech towards beech-hornbeam, beech-hornbeam-maple and non-beech stands.

Therefore, it can be stated that, tree species significantly influenced herb layer diversity by altering environmental conditions (such as soil variables and light transmittance) and variation of tree species has ecological effects over the time. Concluding, Forest managers should pay attention to the natural composition of forest stands and should not try to replace pure mixed forest stands by pure ones. For conservation of biodiversity, we need a mixture of (natural) beech forest stands, but also a mixture of utilized forest with a more diverse canopy composition.

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