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Effect of stand types on understory vegetation

Sena I. Ister and Ferhat Gokbulak

Department of Watershed Management, Faculty of Forestry, Istanbul University, Bahcekoy 34473, Turkey

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Abstract: *The objective of this study was to compare density, vegetative cover, basal area, height growth, aboveground biomass production, frequency, floristic composition, and species diversity of understory vegetation growing in Hungarian oak (Quercus frainetto Ten.), Oriental beech (Fagus orientalis L.) and a mixed stand of both species (90% Hungarian oak and 10% Oriental beech) with the same crown closure. Understory vegetation was sampled with a quadrat of 0.5 m x 1 m along the 25 m-long transect lines in each stand. A total of seventeen perennial plant species from thirteen different families were found in the three stand types and all of them were present in Hungarian oak stand, eleven in Oriental beech stand, and seven in the mixed stand of Hungarian oak and Oriental beech trees. Results showed that stand types had a statistically significant effect on density, vegetative cover, basal area, height growth, biomass production, frequency, floristic composition, and species diversity of understory vegetation. Total understory vegetation density was the highest for Hungarian oak stand with about 136 plants* m^{-2} *and the lowest for the mixed stand of Hungarian oak and Oriental beech with 44 plants* m^{-2}*. In addition, the Hungarian oak stand had the most diverse understory vegetation with about 4.3 different plant* m^{-2}*, followed by the Oriental beech stand with 3.7 plants* m^{-2}*, and the mixed stand of the Hungarian oak and Oriental beech with 2.7 plants* m^{-2}*. Species density and diversity were the highest in Hungarian oak stand whereas aboveground biomass production and height growth of understory vegetation were highest in the mixed stand.*

Key words: *Vegetative cover, Understory vegetation, Species diversity, Plant density, Biomass production*
PDF of full length paper is available online

Introduction

Forest ecosystems provide forage and shelter for wildlife in addition to some services such as soil and water conservation, recreation, timber production and aesthetic benefits for people. In the absence of forest gaps and rangelands, wildlife animals can graze on understory vegetation in forestlands, which can vary depending on stand types. Svenning and Skov (2002) reported that stand structure and types were important factors affecting overall species similarity. Furthermore, old and untouched stands contained fewer species than younger and managed stands (Graae and Heskjaer, 1997; Pitkanen, 1997; Behara and Misra, 2006). Additionally, structure, composition and age of the forest cover can have an influence on the understory plant community due to its effect on microclimate, quality and quantity of litter and decomposition. Pieper (1990) and Macdonald and Fenniak (2007) reported that canopy cover was one of the main factors responsible for the reduction in understory biomass in forestlands since dominant trees compete with the understory vegetation for both above and underground resources. Depending upon the tree density that affects canopy cover, growth performance and the amount of understory vegetation can be decreased as a result of increases in competition for water, light and nutrients (Koukoura and Kyriazopoulos, 2007). Moreover, dense canopy cover favors shade-tolerant species in understory vegetation (Pieper, 1990; Nilsson *et al.*, 2008). Similarly, a proportion of the broadleaf and conifer trees in a stand can influence diversity and composition of an understory plant community (Jobidon *et al.*, 2004; Macdonald and Fenniak, 2007). In forest-covered areas, forest litter is also an important factor influencing the establishment, development, and survival of understory vegetation (Graae and Heskjaer, 1997). Deciduous and evergreen species differ in their litter quantity and quality and hence in understory vegetation composition (Svenning and Skov, 2002) because of differences in the rate of decomposition and the cycle of nutrients in the stands (Macdonald and Fenniak, 2007). Each tree species has different chemical contents, which affect the rate of litter decomposition and accumulation on the ground. Nilsson *et al.* (2008) compared *Pinus contorta* with *Pinus sylvestris* stands and found that because of the higher lignin and the lower nitrogen concentrations in the needles, the litter in *P. contorta* stand had higher decomposition rate than litter in *P. sylvestris* stand. Due to extensive litter accumulation in some stands as a result of slow decomposition, the depth of the forest litter can increase and influence understory plant populations by inhibiting penetration of seedlings from the litter layer.

Detailed information is available about the effect of structure, composition, and age of stands on understory flora (Graae and Heskjaer, 1997; Pitkanen, 1997; Svenning and Skov, 2002; Behara and Misra, 2006) but limited information is available about individual plant attributes such as basal area, height growth, biomass production, frequency, species density, and floristic composition under different stand types. Therefore, the objective of this study was to determine how understory vegetation attributes such as plant density, vegetative cover, basal area, floristic composition, aboveground biomass production, frequency, and height growth and species diversity differ with respect to stand types.

Materials and Methods

Study site: This study was carried out in Belgrad Forest which lies between 41°09' 44" and 41° 14' 40" northern latitudes and between 28°53' 25" and 29° 00' 55" eastern longitudes.

Parent material of the site is mainly composed of Neocene deposits and Carboniferous clay schists. The soils developed from Carboniferous clay schists are generally shallow to moderately deep, gravely, loamy clay with good permeability rates while the soils derived from Neocene deposits are deep, loamy clay in surface horizons and clay in the subsoil with medium permeability rates and organic matter content of 3.2% (Balci *et al.,* 1986). The area has mull type forest floor having an average depth of greater than 5 cm. Mean elevation is around 140 m and ranges from 40 to 230 meters (Ozhan, 1977). The topography of the site is generally not too steep and the mean slope is around 16%.

According to the Thornthwaite classification system, the study site has a humid, mesothermal and oceanic climate with a moderate water deficit in summer months. Annual precipitation averages around 1091 mm and most of it falls between October and March. The mean annual temperature is 12.8°C (Balci *et al.,* 1986).

The Belgrad forest is an old preserved deciduous forest ecosystem in Istanbul. Because of protection, the study site has a high forest cover mainly composed of stands of various oak, oriental beech and mixed of these species together with a low proportion of other tree species. In other words, the dominant vegetation consists of completely deciduous woody species including *Quercus frainetto* Ten., *Q. cerris* L., and *Fagus orientalis* Lipsky. mixed with varying amount of *Populus tremula* L., *Alnus glutinosa* L., *Carpinus betulus* L., *Acer trautvetteri* Med., *Castanea sativa* Miller, *Acer campestre* L., *Ulmus campestris* L., and shrubs like *Sorbus torminalis* Crantz., *Laurus nobilis* L., *Erica arborea* L., *Genista carinalis* Griseb., *Daphne pontica* L., *Cistus creticus* L., *C. salviifolius* L., *Arbutus unedo* L., *Crataegus monogyna* Jacq., *Mespilus germanica* L. and *Prunus avium* L. with a crown closure of around 75-100% (Yaltirik, 1966).

Additionally, Belgrad forest is home for and provides shelter, food and forage for some wildlife animals including wild pig (*Sus scrofa*), golden jackal (*Canis aureus*), fox (*Vulpes vulpes*), roedeer (*Capreolus capreolus*), Eastern European hedgehog (*Erinaceus concolor*), European Mole (*Talpa europaea*), and red deer *Cervus elaphus* L. Especially, Rodeer and red deer are common wildlife species that graze understory vegetation in the area. Therefore, it is important to document how amount and diversity of understory vegetation vary depending on different stand types in terms of wildlife management aspect in the site.

For this purpose, a hungarian oak stand (*Quercus frainetto* Ten.), an oriental beech stand (*Fagus orientalis* Lipsky.) and a mixed stand of both species (90% Hungarian oak and 10% Oriental beech) were chosen as study areas (Table 1) and sampling was conducted in the summer of 2007. The study sites were not subject to livestock grazing and well-protected from human activities such as recreation.

In each stand type, three transect lines with a length of 25 m were established randomly and a half square meter quadrat of 1 m x 0.5 m was placed at twelve points with an interval of 2 m along the transect lines. This procedure was replicated three times for each stand type.

The plant species rooted within the quadrat were identified, counted and their basal area, vegetative cover and heights were recorded on the field form for each quadrat (Bonham, 1989; USDA Forest Service, 1999). In addition, to estimate aboveground biomass production for each plant species, a quadrat of 0.5 m x 1 m was systematically placed along each transect line at five sampling points for each stand type, and plants within the quadrats were clipped (Chambers and Brown, 1983; Bonham, 1989). Clipped plant species were separated, oven-dried at 70°C for 24 hr, and then weighted to within an accuracy of 0.1g. Data collected were used for estimating plant density, species composition, vegetative cover, height growth, frequency, biomass production, and basal area of plant species in the understory vegetation of Hungarian oak stand, oriental beech stand, and mixed stand of Hungarian oak and Oriental beech trees. Measurements of plant characteristics were made according to guidelines explained by Bonham (1989) and USDA Forest Service (1999). Species diversity of the understory vegetation were also compared between stands by using Shannon's Diversity Index with the following formula:

$$H' = \frac{n \log n - \sum_{i=1}^{k} f_i \log f_i}{n}$$

where; H´ is Shannon's diversity index, k is the number of categories, n is the sample size and f_i is the number of observations found in category i (Zar, 1996).

Experiment was completely randomized block design with three replications for each stand. Data were analyzed using ANOVA and means were separated with Tukey's test ($p<0.05$). If necessary, arcsine and square root transformations were performed on data consisting of percentages and numerical values respectively prior to analysis of variance (Zar, 1996).

Results and Discussion

Results showed that stand types have significant effect on density, frequency, biomass production, vegetative cover, floristic composition, basal area, height growth, and species diversity of understory vegetation as found in other studies too ($p<0.05$) (Macdonald and Fenniak, 2007). Since various forest stand types create different micro or local climates and understory conditions and hence the effect on the understory flora (Ozyuvaci, 1999). That is why, overstory plant communities shape understory plant communities in the ecosystems. This can be mainly attributed to the shading effect of canopy cover, the accumulation of a deep litter layer, and the competition between overstory and understory vegetation for aboveground and underground resources.

Table-1: Characteristics of Hungarian oak stand, Oriental beech stand and mixed stand of Hungarian oak and Oriental beech trees (Directorate of Istanbul Forest District, DIFD, 2003)

Stand type	Average slope (%)	Density (No. of trees ha^{-1})	Crown closure (%)	Average litter depth (cm)
Oriental beech	25	24.72	75-95	>5
Hungarian oak	16.67	43.80	75-90	>5
Mixed stand (90% Hungarian oak and 10% Oriental beech)	26.67	25.91	75-95	>5

Table - 2: Species found in the stands during the sampling, overall density (No. of plants m^{-2}) and density (No. of plants m^{-2}) for each common plant species in the stands

Plant species[1]	Stand type			Family name	Common name	Life forms
	Oriental beech	Hungarian oak	Mixed stand			
Ornithogalum umbellatum	0.78[a2]	74.44[b]	0.13[a]	Liliaceae	Staf of bethlehem	Perennial
Epimedium pubigerum	27.30[a]	29.13[a]	26.56[a]	Berberidaceae	Bishop's hat	Perennial
Viola canina	0.09[a]	1.59[b]	0.20[a]	Violaceae	Dog violet	Perennial
Ruscus hypoglossum	0.56[a]	0.35[a]	3.13[b]	Liliaceae	Horse tongue	Perennial
Rubus hirtus	5.94 [a]	1.54 [b]	11.46[c]	Rosaceae	Blackberry	Perennial
Smilax excelsa	3.06[a]	7.65[b]	2.31[a]	Liliaceae	Unknown	Perennial
Trachysteman orientalis	0.59[a]	0.093 [b]	0.13[b]	Boraginaceae	Eastern borage	Perennial
Bromus diandrus	11.15	2.15	0.00	Gramineae	Ripgut brome	Perennial
Stellaria holostea	0.00	5.15	0.00	Caryophyllaceae	Greater stitchwort	Perennial
Hypericum calycinum	0.00	5.15	0.00	Clusiaceae	Goldflower	Perennial
Poa pratensis	0.00	2.15	0.00	Gramineae	Kentucky bluegrass	Perennial
Pteridium aquilinum	0.00	11.15	0.00	Dennstaedtiaceae	Bracken fern	Perennial
Hedera helix	55.04	13.81	0.00	Araliaceae	English ivy	Perennial
Luzula forsteri	0.19	0.56	0.00	Juncaceae	Wood-rush	Perennial
Doronicum caucasicum	0.00	1.00	0.00	Compositae	Leopard's bane	Perennial
Ruscus aculeatus	0.96	1.22	0.00	Liliaceae	Butcher's broom	Perennial
Veronica montana	0.00	0.04	0.00	Scrophulariaceae	Wood speedwell	Perennial
Overall density	71.98[a]	135.98[b]	44.09[c]			

[1]Only those plant species, which were common in all stands, were statistically compared
[2]Means with different letters are statistically significant between stands within each row for the same species as determined with Tukey's test ($p<0.05$)

A total of seventeen perennial plant species from thirteen different families were found in the three stands and all of them were present in the Hungarian oak stand, eleven in the Oriental beech stand, and only seven in the mixed stand. The Hungarian oak stand had higher and more diverse understory vegetation among the stands and this could be attributed to the loose structure of litter layer of the Hungarian oak stand which can favor seedling penetration. Only seven out of seventeen plant species collected were common in all stands and they were *Ornithogalum umbellatum* L., *Epimedium pubigerum* (D.C.) Moren Decaisne, *Viola canina* L., *Ruscus hypoglossum* L., *Rubus hirtus* Waldst and Kil, *Smilax excelsa* L., and *Trachystemon orientalis* L.G. Don (Table 2). Although there are many understory plant species growing in the study site (Yaltirik, 1966), only seventeen of them were found in the study site and all of them were perennial, shade tolerant species. Several factors may be responsible for the sampling of the low number of species during the study. One of the factors could be the sampling method. Sampling for this study was done when canopy cover was in the optimum level and shading was more intense. In addition, sampling procedure was conducted only once rather than long term monitoring. Therefore, it was too late to encounter annual understory plants in the area where moisture deficit occurs and most of the annual plants disappear early to mid summer. Another factor would be litter depth in the stands which can inhibit penetration of seedlings and seeds reaching seedbank. The other factor would be the management of the stands. Belgrad forest, where the study stands are located, is an old preserved and untouched forest ecosystem in Istanbul and its main function is water production for the city. Old stand age could be a factor for poor plant diversity in the stands as reported by Graae and Heskjaer (1997). Finally, the lower number of understory plant species in all stands could be because of the competition among the species.

Total density of understory plants was the most diverse and densest in the Hungarian oak stand with 136 plants m^{-2}, followed by the Oriental beech stand with 72 plants m^{-2}, and the mixed stand with 44 plants m^{-2} (Table 2). A similar trend was also found for species density as well. About 4.3 different plant species were present in the Hungarian oak stand, 3.7 plants in the Oriental beech stand, and 2.6 plants in the mixed stand of both tree species in per square meter area (Fig. 1). Similarly, the Shannon Diversity Index was found to be 0.6569 for the Hungarian oak stand, 0.6306 for the

Table - 3: Average values of frequency, biomass production, and vegetative cover of only common understory plant species found in the stand types

Plant species	Stand types		
	Oriental beech	Hungarian oak	Mixed stand of Hungarian oak and Oriental beech
	Frequency (%)		
Ornithogalum umbellatum	0.67^{a}[3]	11.11^{b}	0.44^{a}
Epimedium pubigerum	10.78^{a}	7.56^{a}	10.44^{a}
Viola canina	0.11^{a}	1.55^{a}	0.11^{a}
Ruscus hypoglossum	1.56^{a}	1.00^{a}	4.33^{b}
Rubus hirtus	8.44^{a}	1.89^{b}	10.78^{a}
Smilax excelsa	5.11^{a}	4.67^{a}	3.89^{a}
Trachystemon orientalis	2.00^{a}	0.22^{b}	0.11^{b}
	Biomass production (g m^{-2})		
Epimedium pubigerum	28.55^{a}	26.44^{a}	38.98^{b}
Viola canina	0.56^{a}	3.28^{b}	0.64^{a}
Ruscus hypoglossum	1.91^{a}	2.43^{a}	18.64^{b}
Rubus hirtus	20.47^{a}	6.69^{b}	44.74^{c}
Smilax excelsa	12.93^{a}	14.35^{a}	11.69^{a}
	Vegetative cover (%)		
Ornithogalum umbellatum	10.95^{a}	34.57^{b}	10.16^{a}
Epimedium pubigerum	45.96^{a}	30.67^{b}	39.92^{b}
Viola canina	10.17^{a}	11.65^{b}	10.21^{a}
Ruscus hypoglossum	13.29^{a}	11.87^{a}	18.77^{b}
Rubus hirtus	33.53^{a}	16.06^{b}	55.19^{c}
Smilax excelsa	18.99^{a}	30.13^{b}	17.71^{a}
Trachystemon orientalis	13.23^{a}	10.22^{b}	10.39^{b}

[3]Mean values with different superscript letters are statistically significant between stand types for the same species within a row as determined with Tukey's test ($p<0.05$)

Table – 4: Average values of floristic composition, plant height, and basal area of only common understory plant species found in the stand types

Plant species	Stand types		
	Oriental beech	Hungarian oak	Mixed stand of Hungarian oak and Oriental beech
	Floristic composition (%)		
Ornithogalum umbellatum	10.70^{a}[4]	32.24^{b}	8.52^{a}
Epimedium pubigerum	22.54^{a}	16.51^{b}	61.02^{c}
Viola canina	7.81^{a}	22.89^{b}	19.30^{a}
Ruscus hypoglossum	3.02^{a}	1.57^{a}	17.93^{b}
Rubus hirtus	4.85^{a}	4.75^{b}	35.03^{c}
Smilax excelsa	5.01^{a}	7.90^{a}	14.51^{a}
Trachystemon orientalis	2.80^{a}	2.04^{a}	50.00^{b}
	Plant height (cm)		
Ornithogalum umbellatum	36.80^{a}	36.13^{b}	40.90^{a}
Epimedium pubigerum	32.74^{a}	15.17^{b}	30.61^{a}
Viola canina	14.70^{a}	12.24^{b}	21.20^{a}
Ruscus hypoglossum	33.39^{a}	101.75^{a}	46.76^{b}
Rubus hirtus	58.84^{a}	40.39^{b}	69.81^{c}
Smilax excelsa	59.91^{a}	87.57^{a}	68.63^{a}
Trachystemon orientalis	29.41^{a}	16.65^{b}	44.30^{b}
	Basal area (cm^2 m^{-2})		
Ornithogalum umbellatum	0.42^{a}	0.10^{b}	0.40^{a}
Epimedium pubigerum	0.12^{a}	0.06^{b}	0.18^{c}
Viola canina	0.14^{a}	0.12^{b}	0.14^{a}
Ruscus hypoglossum	0.52^{a}	1.02^{b}	0.64^{a}
Rubus hirtus	0.62^{a}	0.82^{b}	0.74^{c}
Smilax excelsa	0.14^{a}	0.44^{b}	0.16^{a}
Trachystemon orientalis	0.38^{a}	0.10^{b}	0.40^{a}

[4]Mean values with different superscript letters are statistically significant between stand types for the same species within a row as determined with Tukey's test ($p<0.05$)

Oriental beech stand and 0.4683 for the mixed stand. Understory species diversity indexes were statistically similar for the Hungarian oak and Oriental beech stands but they differed significantly from this of the mixed stand of Hungarian oak and Oriental beech trees. This situation could be the result of the differences in edafic and ecological factors of the stands. Even though study sites were chosen from similar areas in terms of climate and soil conditions, the Hungarian oak stands were in a south eastern aspect with less of an incline than the other two. In the northern hemisphere, south and south eastern aspects receive much more solar energy than others (Ozyuvaci, 1999). This fact can accelarate the decomposition rate of forest litter, increase the organic matter content and soil temperature, and decrease soil moisture due to higher evaporation from the soil surface. Eruz (1980) compared chemical and physical soil properties in the oak and Oriental beech stands and found that the rate of litter decomposition, plant nutrients, and organic matter content in the soils were higher in the Hungarian oak stand than in the Oriental beech stand. Therefore, understory climatic conditions of the stands can differ and it may affect understory conditions depending on the stand attributes.

Densities of the common species found in the mentioned three stands differed significantly with respect to stand type except for *Epimedium pubigerum* and they were significantly or numerically higher in the Hungarian oak stand than in other two stand types except for *Rubus hirtus*, *Ruscus hypoglossum*, and *Trachystemon orientalis* (Table 2). Among the common species found in all stands, *Epimedium pubigerum* had the highest density values in the Oriental beech and in the mixed stands and *Ornithogalum umbellatum* had only in the Hungarian oak stand (Table 2). In general, the dominant understory plant species were *Ornithogalum umbellatum* in the Hungarian oak stand, *Hedera helix* in the Oriental beech stand, and *Epimedium pubigerum* in the mixed stand.

Species showed significant differences for frequency with respect to the stand types ($p<0.05$) except for *Epimedium pubigerum*, *Viola canina*, and *Smilax excelsa* that had statistically similar frequency values in all three stand types (Table 3). Plants with the highest frequency values were also different for each stand. For instance, *Epimedium pubigerum* had the highest frequency values in the Oriental beech stand, *Ornithogalum umbellatum* had the highest in the Hungarian oak stand and *Rubus hirtus* had the highest in the mixed stand.

Statistical analysis was modified based on the presence of plant species in the quadrats. *Ornithogalum umbellatum* and *Trachystemon orientalis* were excluded from biomass analyses since both species were not encountered within the five quadrats placed along the transect lines during the biomass sampling. Therefore, instead of the seven plant species, only five of them were used to compare the effect of stand types on biomass production of the individual plants. Overall average aboveground biomass production was significantly different among the stand types and they were 286.87 g m^{-2} in the Hungarian oak stand, 230.70 g m^{-2} in the mixed stand of Hungarian oak and Oriental beech, and 216.99 g m^{-2} in the Oriental beech stand. On the individual plant basis,

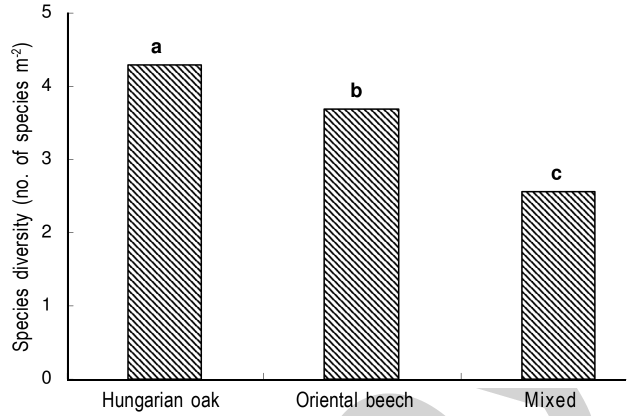

Fig. 1: Species diversity in the stand types. Mean with different letters are statistically significant between stand types as determined with Tukey's test ($p<0.05$)

three out of five understory plant species had the highest aboveground biomass production in the mixed stand (Table 3). In other words, the majority of the common understory plant species showed a better growth performance in the mixed stand than pure ones and understory species had significantly different biomass production with respect to stand types except for *Smilax excelsa* (Table 3). Among the plant species, *Epimedium pubigerum* had the highest and *Viola canina* had the lowest biomass production than the other plants in the stands (Table 3). *Epimedium pubigerum*, *Ruscus hypoglossum*, and *Rubus hirtus* plants produced more aboveground biomass in the mixed stand while *Viola canina* produced biomass in the Hungarian oak stand as compared to the other stands. In this study, the mixed stand provided better understory conditions for aboveground biomass production and heigth growth than the pure Hungarian oak and Oriental beech stands. But results of other studies showed that rate of decomposition can be more slow and hence nutrient content of the soils can be lower in the litter of pure stands than in the litter of the mixed stands which can favor more diverse and dense understory vegetation (Sariyildiz *et al.*, 2005; Polyakova and Billor, 2007).

On the other hand, results showed that stand types had a significant effect on vegetative cover values of understory vegetation. But there was no clear trend for vegetative cover of species with respect to different stand types, and the cover values varied depending on the density of the same plant species in the stands. For instance, *Epimedium pubigerum* had higher vegetative cover values among the plants in all stand types except for *Rubus hirtus* in the mixed stand due to generally having greater density values in three stands (Table 3). Among the common plants found in the understory vegetation of all stands, *Epimedium pubigerum* had the highest vegetation cover in the Oriental beech stand, *Ornithogalum umbellatum* had the highest in the Hungarian oak stand and *Rubus hirtus* had the highest in the mixed stand of Hungarian oak and Oriental beech trees (Table 3).

Participation of each common plant species in the floristic composition was different in each stand types except for *Similax* *excelsa* and majority of the species had either numerically or statistically greater participation percentages in the floristic composition of understory vegetation in the mixed stand than those in the pure stands (Table 4). Floristic composition of understory vegetation was also different for each stand type. For instance, *Epimedium pubigerum* was the dominant plant species in the floristic composition of understory vegetation in the Oriental beech stand, *Ornithogalum umbellatum* in Hungarian oak stand and *Trachystemon orientalis* in the mixed stand among the common understory plant species found in all stands (Table 4). Plant species except for *Similax excelsa* differed significantly for height growth with respect to stand types. Height growth of the common understory plant species varied depending on growth form of the species, and four out of seven had a better height growth performance in the mixed stand than in the other stands (Table 4). Although stand types significantly affected the basal area of the understory vegetation, understory plant species had similar basal area values both in the mixed and Oriental beech stands except for *Epimedium pubigerum* and *Rubus hirtus*. Overall average basal area per plant in one square meter area was about 1.5 cm^2 in the Hungarian oak stand, 1 cm^2 in the Oriental beech stand, and 1.2 cm^2 in the mixed stand of Hungarian oak and Oriental beech. The understory plant species in the Oriental beech stand had a significantly smaller basal area than plants in the other two stands. Plant species had very low (less than 1 cm^2) basal area values except for *Ruscus hypoglossum* in the Hungarian oak stand (Table 4).

In conclusion, it can be said that stands with different tree species can establish different understory conditions and hence affect plant communities. These results could be explained by differences in the canopy light transmission and that can influence soil conditions. Therefore, each stand can have its own unique flora and fauna communities. According to the results of this study as well as those from the literature (Sariyildiz *et al.*, 2005; Polyakova and Billor, 2007), mixed stands provide better understory conditions for plant growth while the pure stands provide a understory environment that favors denser and more diverse vegetation. However, in order to better understand how individual plants perform understory conditions, where competition for aboveground and underground resources is a limiting factor, studies should cover longer periods and should deal with individual plants as well. Then, stands with different tree species can be established to include too many and more diverse understory plant communities.

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