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Papadimitriou M., Sklavou P.

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Effect of woody plant cover on understory vegetation diversity in Mediterranean shrublands

M. Papadimitriou[1] and P. Sklavou[2]

[1] Aristotle University of Thessaloniki, School of Forestry and Natural Environment, Laboratory of Rangeland Ecology, P.O. Box 286, GR - 54124, Thessaloniki, Greece

[2] Aristotle University of Thessaloniki, School of Forestry and Natural Environment, Laboratory of Range Science, P.O. Box 236, GR - 54124, Thessaloniki, Greece

Abstract. The aim of this study was to investigate the effect of woody plant species cover on the diversity of the understory vegetation in Mediterranean shrublands. The research was conducted in Northern Greece, at the area of Ossa, Lagadas, Thessaloniki. Three different shrub cover classes were identified: open (10-40%), medium (41-70%) and dense (71-100%). Understory species vegetation measurements were conducted in four plots per each shrub cover class. Cover and composition were measured along two transects in each plot while α and β diversity indices were calculated. For α diversity the indices: a) species richness (S), b) Shannon-Wiener index (H´), c) Evenness (J), d) Simpson (D) and e) Berger-Parker index of dominance (d) were used. For β diversity the indices: a) Sorensen's (Cs) and b) Jaccard's (Cj), as well as Pielou's (PS) percentage similarity were calculated for each pair among the three shrub cover classes. The results showed that α diversity of the understory vegetation decreased from open to dense shrub cover. β diversity revealed that the three shrub cover classes differed in terms of species similarity of the understory vegetation. These findings lead to the conclusion that the diversity of the understory vegetation in Mediterranean shrublands is declined as woody species cover increase and a diversified landscape can contribute to the preservation of species richness in these ecosystems.

Keywords. Species richness, Shannon-Wiener index, Evenness, Floristic similarity

Effet du couvert végétal ligneux sur la diversité de la végétation du sous-bois dans les formations arbustives méditerranéennes

Résumé. *Le but de cette étude était de suivre l'effet de la couverture végétale ligneuse sur la diversité de la végétation du sous-étage dans les maquis méditerranéens. La recherche a été menée dans le nord de la Grèce, dans la région d'Ossa, Lagadas, Thessalonique. Trois classes de couvert arbustif différentes ont été identifiées : ouvert (10-40 %), moyen (41-70 %) et dense (71-100 %). Des mesures de la végétation des espèces de sous-bois ont été effectuées dans quatre parcelles pour chaque classe. La couverture et la composition ont été mesurées le long de deux transects dans chaque parcelle tandis que les indices de diversité α et β ont été calculés. Pour la diversité α, les indices : a) richesse spécifique (S), b) indice Shannon-Wiener (H´), c) régularité (J), d) Simpson (D) et e) indice de dominance Berger-Parker (d) ont été utilisés. Pour la diversité β, les indices : a) de Sorensen (Cs) et b) de Jaccard (Cj), ainsi que le pourcentage de similarité de Pielou (PS) ont été calculés pour chaque paire parmi les trois classes étudiées. Les résultats ont montré que la diversité α de la végétation du sous-étage a diminué d'un couvert arbustif ouvert à dense. La diversité β a révélé que les trois classes de couvert arbustif différaient en termes de similarité des espèces de la végétation du sous-étage. Ces résultats conduisent à la conclusion que la diversité de la végétation du sous-étage dans les formations arbustives méditerranéennes diminue à mesure que le couvert d'espèces ligneuses augmente et qu'un paysage diversifié peut contribuer à la préservation de la richesse spécifique de ces écosystèmes.*

Mots-clés. *Richesse en espèces, Indice de Shannon-Wiener, Uniformité, Similitude floristique*

I - Introduction

Shrublands constitute a land use type that plays an important role in the Mediterranean area. Woody species are a major component of them. They contribute in the production of wood, fruits and forage for the animals, especially during the unfavourable time in winter and summer, as well as they protect the ecosystem from soil erosion, they help in the retention of the hydrological balance of the water basins and they improve the landscape in terms of recreation and aesthetic value (Papanastasis, 1999; Ispikoudis and Chouvardas, 2005).

Furthermore, in shrubland communities, woody species cover plays an important role in shaping the microclimate of the understory vegetation. They affect the temperature and the humidity of the ground layer, especially during periods of extreme environmental conditions such as the low temperature values in winter and the hot and dry season in late spring and summer (Moro *et al*., 1997; Eviner and Chapin III, 2003). They also affect the quantity and the quality of the light that reaches the ground layer, modifying the growth conditions of the understory plants (Martens *et al*., 2000; Valladares and Guzman, 2006).

In Mediterranean area, during the last decades, traditional land uses extensification and/ or abandonment has been taking place (Naveh and Lieberman, 1984; Barbero *et al*., 1990; Pinto Correia, 1993; Farina, 1998; Caraveli, 2000). This has had as a result the encroachment of woody species in open areas (Tasser and Tappeiner, 2002; Ispikoudis and Chouvardas, 2005; Papanastasis and Chouvardas, 2005) and the consequently increase of woody species cover in shrublands that is expected to continue happening in the future (Chouvardas and Vrahnakis, 2009).

Plant diversity has been found to increase in the first stages of vegetation succession and to decrease as succession proceeded (Bonet and Pausas, 2004; Papadimitriou *et al*., 2004; Dolle *et al*., 2008). Nonetheless not many researches have focussed on the influence of the increase of woody plant species in the Mediterranean shrublands on the diversity of the understory vegetation. The aim of this study was to investigate the effect of woody plant species cover on the diversity of the understory vegetation in Mediterranean shrublands.

II - Materials and methods

The research was conducted in North Greece, at the area of Ossa in Lagadas County nearby the city of Thessaloniki (Figure 1). The altitude of the study area reaches a mean of 550m a.s.l.. The mean annual precipitation is approximately 586mm and the mean annual air temperature is 12.1ºC. There, three different shrub cover classes were identified: open (10-40%), medium (41-70%) and dense (71-100%). These classes followed the classification of Papanastasis and Chouvardas (2005) that studied the land use changes in the wider area. The dominant species was *Quercus coccifera* L. in its shrub form, while *Quercus pubescens* Willd. co-existed on the woody species layer, as well as there were scattered shrubs of *Pyrus amygdaliformis* Vill. and *Cistus incanus* L.

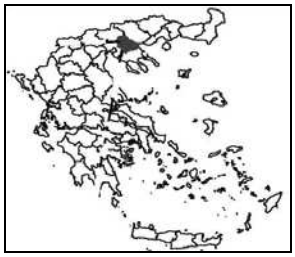

Figure 1. Study area

For each of the three above shrub cover classes, four plots of 0.1ha were selected resulting in a total of twelve plots under study. In each plot cover and composition of the understory vegetation were measured along two transects. The line-point method was used (Cook and Stubbendieck, 1986), while multiple contacts were recorded when species were overlapping in

a point. The following α diversity indices were calculated using the composition data (Magurran, 1988; 2004):

$H' = -\sum_{i=1}^{s} p_i \, lnp_i$a) species richness (S)

b) Shannon-Wiener index (H´):

$$J = \frac{H'}{ln\, S}$$

c) Evenness (J):

$$D = \sum_{i=1}^{s} p_i^2$$

d) Simpson (D):

$$d = \frac{N_{max}}{N}$$

e) Berger-Parker index of dominance (d):

where pi: the proportion of individuals of species i in the sample,
N_{max}: the number of individuals of the most abundant species,
N: the total number of individuals in the sample.

Furthermore, for β diversity the following similarity indices were calculated (Magurran, 1988; 2004) for each pair of the three shrub cover classes:

$C_s = \frac{2j}{a+b}$a) Sorensen's (Cs) index:

$$C_j = \frac{j}{a + b - j}$$

b) Jaccard's (Cj) index:

where j: the number of species present in both areas (A and B) under comparison
a: the total number of species present in A area and
b: the total number of species present in B area

These similarity indices take values from 0 (no common species between the two areas) to 1 (all species common in both areas)

As well as, Pielou's percentage similarity (PS) (Pielou, 1984) for each pair of the three shrub cover classes:

$$PS = 200 \times \frac{a}{2a + b + c} = 100 \times \frac{2a}{2a + b + c}$$

where a: the number of species present in both areas (A and B) under comparison
b: the number of species present only in A area and
c: the number of species present only in B area

One way Anova was used for the investigation of statistical differences of the mean of the α diversity indices between the three classes. When significantly differences were found, they were further investigated with Duncan multiple range test at the 0.05 probability level (Fowler *et al.*, 1998). The software package SPSS Statistics 25.0 was used for all the analyses.

III - Results and discussion

The α diversity indices of the understory vegetation of the three shrub cover classes are presented in table 1. Species richness (S) and Shannon-Wiener index (H´) decreased as shrub cover increased. More specifically, species richness was significantly higher in the open shrubland, followed by the medium and lower in the dense shrubland. Additionally, Shannon-Wiener index (H´) appeared the largest value in the open shrubland, while it did not differ significantly among the other two shrub cover classes.

On the other hand, the Evenness (J), Simpson (D) and Berger-Parker index of dominance (d) did not show any significant difference between the three classes (Table 1). Evenness (J) had a mean value of approximately 0.79 in all classes. As far as, Simpson (D) and Berger-Parker (d) indices are concerned, they followed the same trend and they increased from open to dense shrub cover class even though not significantly.

These results indicate that the open shrubland showed the highest α diversity on the understory vegetation and it decreased with the increase of shrub cover. Furthermore, low values of the Simpson (D) index expresses higher diversity (Magurran, 2004) and the above indications are supported by the trend that this index followed. Additionally, Berger-Parker index of dominance (d) revealed that as shrub cover decreased, understory vegetation tended to have less dominant species. Finally, Evenness (J) of the species of the understory did not seem to differentiate among the three classes. A decline of species diversity with the increase of shrub cover was also found by Vrahnakis *et al.* (2005) in kermes oak shrublands. Furthermore, our results come in agreement with other researches such as Bonet and Pausas (2004), Papadimitriou *et al.* (2004) and Dolle *et al.* (2008) who found that higher woody species cover caused by succession after land use extensification and/ or abandonment had a negative impact on floristic diversity.

Table 1. α diversity indices of the understory vegetation of the three shrub cover classes

Diversity indices	Open shrubland	Medium shrubland	Dense shrubland
Species richness (S)	18.25a[1]	8.75b	5.50c
Shannon-Wiener index (H´)	2.35a	1.65b	1.40b
Evenness (J)	0.81a	0.76a	0.79a
Simpson (D)	0.15a	0.27a	0.34a
Berger-Parker index of dominance (d)	0.28a	0.40a	0.44a

[1]Different letters in the same line indicate significant differences ($p \leq 0.05$) according to the Duncan test.

The Sorensen's similarity index (Cs), the Jaccard's similarity index (Cj) and the Pielou's percentage similarity (PS) of the understory vegetation for each pair of the three shrub cover classes are shown in tables 2, 3 and 4 respectively. As far as, the Sorensen index (Cs) is concerned, open shrubland showed the highest similarity with the medium shrubland and the lowest with the dense shrubland. On the other hand, the medium and the dense shrublands had the highest value for this index.

Table 2. Sorensen's similarity index (Cs) of the understory vegetation for each pair of the three shrub cover classes

Sorensen's (Cs)	Open shrubland	Medium shrubland	Dense shrubland
Open shrubland	1.00		

Medium shrubland	0.54	1.00	
Dense shrubland	0.48	0.62	1.00

The Jaccard's similarity index (Cj) followed the same trend with the Sorensen's similarity index (Cs) (Table 3). Even though the values of this index were smaller, the highest similarity of the understory vegetation was among the medium and the dense shrublands, too.

Table 3. Jaccard's similarity index (Cj) of the understory vegetation for each pair of the three shrub cover classes

Jaccard's (Cj)	Open shrubland	Medium shrubland	Dense shrubland
Open shrubland	1.00		
Medium shrubland	0.37	1.00	
Dense shrubland	0.31	0.44	1.00

The Pielou's percentage similarity (PS) expresses β diversity as a percentage (Pielou, 1984). Its values had the same trend as the previous two indices (Table 4). Open shrubland showed a little more than 50% similarity with medium shrubland, while medium and dense shrublands had approximately 60% similarity in the species of the understory vegetation.

Table 4. Pielou's percentage similarity (PS) of the understory vegetation for each pair of the three shrub cover classes

Pielou's (PS)	Open shrubland	Medium shrubland	Dense shrubland
Open shrubland	100		
Medium shrubland	54.29	100	
Dense shrubland	47.76	61.54	100

The study of the β diversity revealed that the three shrub cover classes differed in terms of species similarity of the understory vegetation. Similar results have been found by Papadimitriou *et al.* (2007) during the study of secondary succession in Mediterranean landscapes. It should be noted that in terms of the similarity of the understory vegetation, the medium and the dense shrublands appeared with the highest values than any other pair of the three classes.

IV - Conclusions

Our results suggest that the diversity of the understory vegetation in Mediterranean shrublands is declined as woody species cover increase. Open shrublands have the highest α diversity on the understory vegetation. As shrub cover increase, more dominant species appear in the understory. These findings are in relation with the β diversity outcomes and indicate that a diversified landscape can contribute to the preservation of species richness in these ecosystems.

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