Floristic diversity of the understory in Pinus brutia plantations as affected by elevation and grazing intensity

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Floristic diversity of the understory in *Pinus brutia* plantations as affected by elevation and grazing intensity

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Abstract. Floristic diversity of the understory vegetation in *Pinus brutia* plantations in Serres, Northern Greece, was studied in order to accurately assess the effect of grazing intensity. Two southern neighboring slopes of different elevation at mountain Vrodou were selected: ''Elaionas'' (on average 200 m a.s.l.) and ''Chrysopigi'' (on average 400 m a.s.l.) and three sampling sites at each slope were selected, representing, three grazing intensities: ungrazed, moderate and heavy. Each sampling site consisted of two plots of similar canopy cover conditions. Plant cover was measured, therefore species composition, and plant diversity indices (Species Richness, Shannon's Index, Evenness, Berger-Parker's index of Dominance and Morisita's Index of Similarity) were calculated for each plot. Number of species and Shannon index was lower at low elevation slope (Elaionas) and at ungrazed sites, while there was no significant difference at sites of moderate and heavy grazing intensity. The diversity of the vegetation followed the same trend in terms of evenness and dominance. Generally, floristic diversity was higher at the slope (Chrysopigi) of higher elevation. Furthermore, the lower value of Morisita's Index of Similarity was recorded between the heavy grazing intensity site of high elevation slope (Chrysopigi) and the ungrazed sites of low elevation slope (Elaionas).
Keywords. Grazing pressure – Diversity indices – Eastern Mediterranean region - Calabrian pine

Diversité floristique du sous-étage de plantations de* Pinus brutia *Ten. affectées par l'élévation et l'intensité du pâturage

Résumé. *La diversité floristique de la végétation du sous-étage dans les plantations de* Pinus brutia *à Serres, nord de la Grèce, a été étudiée afin d'évaluer avec précision l'effet de l'intensité du pâturage. Deux pentes voisines orientées au sud, d'altitude différente, dans la montagne Vrodou, ont été sélectionnées: " Elaionas " (en moyenne 200 m d'altitude) et " Chrysopigi " (en moyenne 400 m d'altitude) et trois sites d'échantillonnage pour chaque pente ont été sélectionnés, représentant trois intensités de pâturage: non pâturées, modérées et fortes. Chaque site d'échantillonnage se composait de deux parcelles de conditions similaires de couverture de la canopée. La couverture végétale a été mesurée, la composition des espèces, et les indices de diversité végétale (richesse, indice de Shannon, équitabilité, indice de Berger-Parker de position dominante et indice Morisita de similarité) ont été calculés pour chaque parcelle. Le nombre d'espèces et l'indice de Shannon étaient inférieurs sur la pente à basse altitude (Elaionas) et sur les sites non pâturés, alors qu'il n'y avait pas de différence significative dans les sites à intensité de pâturage modérée et forte. La diversité de la végétation a suivi la même tendance en termes de régularité et de domination. Généralement, la diversité floristique était plus grande sur la pente (Chrysopigi) d'altitude plus élevée. En outre, la valeur inférieure de l'Indice Morisita de similitude a été enregistrée entre le site à forte intensité de pâturage et pente à haute altitude (Chrysopigi) et les sites non pâturés sur pente à faible élévation (Elaionas).*

Mots-clés. *Pression de pâturage – Indices de diversité – Méditerranée orientale – Pin de Calabre*

I – Introduction

Calabrian pine (*Pinus brutia* Ten.) is a warm Mediterranean coniferous species, which has been used in large scale reforestation projects for catchment protection (Vallejo *et al*., 2006). Moreover, Calabrian pine forests are classified as silvopastoral systems because they provide forest products as well as forage (Papanastasis *et al*., 2009).

Natural disturbances, such as grazing, influence compositional, structural and functional diversity in forested ecosystems (Roberts and Gilliam, 1995). Usually, grazing reduces the abundance of palatable species which are replaced by less palatable ones (Vallentine, 1990). According to Alados *et al*. (2004) woodland and dense shrublands are more resistant to species loss than middle and low dense shrublands, or grasslands. Furthermore, species composition and diversity can be affected differently by various management restoration practices of degraded Mediterranean rangelands (Papadimitriou *et al*. 2013).

Given the fact that species composition and diversity of the plant community must be carefully examined in order to accurately assess the effect of a certain disturbance (Onaindia *et al*. 2004), it is important to determine the floristic diversity in *Pinus brutia* plantations in order to accurately assess the effect of grazing intensity in these silvopastoral systems.

II – Materials and methods

The study was carried out in the area of Elaionas in Serres, Northern Greece (41°13΄N, 23°55΄E), in *Pinus brutia* plantations, aged between 60 and 70 years. Altitude varies between 200 and 600 m a.s.l., with a mean air temperature of 14.1 °C and an annual rainfall of 438.9 mm. The study area is part of emanation basins of two neighboring torrents (Ag. Anargyron and Ag. Georgiou) located at the southern slopes of mountain Vrodou. Thus, Forestry Service has applied extensive reforestation projects to protect from soil erosion (Caballero *et al*. 2009). As a result Calabrian pine plantations, shrublands dominated by evergreen (*Quercus coccifera, Juniperus oxycedrus*, etc) as well as deciduous (*Fraxinus ornus, Carpinus orientalis*, etc) species and fields constitute a silvopastoral system. The area is grazed mainly by goats and sheep. Forested areas at two southern neighboring slopes of different elevation were selected: ''Elaionas'' (on average 200 m a.s.l.) and ''Chrysopigi'' (on average 400 m a.s.l.) and three sampling sites at each slope were established, representing three grazing intensities: ungrazed, moderate and heavy grazing. Each sampling site consisted of two 0.05 ha (20 m by 25 m) plots of similar canopy cover conditions.

Plant cover measurements were made in May 2015 using the line-point method (Cook and Stubbendieck, 1986). Within each plot five 25 m transects were placed and the contacts were obtained every 25 cm (100 contacts per transect). Species composition and plant diversity indices [Species Richness (N), Shannon-Wiener diversity index (H΄), Evenness (J), Berger-Parker's index of Dominance (d) and Morisita's Index of Similarity (C_λ)] were calculated for each plot. The formulae of the indices are given below (Shannon and Weaver, 1949; Morisita, 1959; Pielou, 1966; Henderson, 2003):

$$H' = -\sum_{i=1}^{S} p_i \ln p_i \qquad J = \frac{H}{H_{max}} \qquad d = \frac{N_{max}}{N_T} \qquad C_\lambda = \frac{2\sum n_{i1} n_{i2}}{(\lambda_1 + \lambda_2) N_1 N_2}$$

where S is the maximum recorded number of taxa, p_i is the proportional abundance of the i-th taxa, H is the observed species diversity, H_{max} is the diversity when the individuals are divided among the species as evenly as possible, N_{max} is the number of records of the dominant taxon, N_T is the total number of records, n_{i1} is the number of individuals of species i in sample 1, n_{i2} is the number of individuals of species i in sample 2, N_1= the number of individuals in sample 1, N_2= the number of individuals in sample 2, and:

$$\lambda_j = \frac{\sum n_{ji}(n_{ji} - 1)}{N_j(N_j - 1)}$$

where n_{ij} is the number of individuals of species i in sample j and *Nj* is the number of individuals in sample j.

General linear models procedure (SPSS 19 for Windows) was used for ANOVA. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III – Results and discussion

Species diversity, in terms of the number of species and Shannon's diversity index, were lower at ungrazed sites (Table 1). Although this result agrees with previous evidence that moderate grazing intensity contributes to improve diversity (Klimek *et al*. 2007), there was no significant difference between sites of moderate and heavy grazing intensity. However, the number of species and Shannon's index reached their maximum values at the moderate grazing intensity site at the high elevation slope (Chrysopigi) and at the heavy grazing intensity site at the low elevation slope (Elaionas) (Data not shown). Number of species and Shannon's index were also lower at the low elevation slope (Elaionas) (Table 1). This result is in accordance with Prodofikas *et al*. (2013), who found that the elevation slope position (belt) is a factor that affects richness, density, abundance – cover and diversity of woody species.

The floristic diversity followed the same trend in terms of evenness and of dominance. Evenness index was lower at ungrazed sites and at the low elevation slope (Elaionas) (Table 1). Respectively, dominance (Berger-Parker's index) was higher at ungrazed sites and at the low elevation slope (Elaionas) (Table 1). There was no statistical significant difference due to the interaction of grazing intensity and elevation slope to either Evenness or Berger-Parker's index of dominance (Data not shown).

Table 1. Species diversity indices (N, H´, J, d) of the different grazing intensities and elevation slopes

	Grazing intensities			**Elevation slope**	
	Ungrazed	**Moderate**	**Heavy**	**"Elaionas"**	**"Chrysopigi"**
Species richness (N)	5.46b	13.95a	12.83a	5.53b	15.97a
Shannon's index (H´)	0.93b	2.12a	2.25a	1.16b	2.37a
Evenness (J)	0.58b	0.77a	0.85a	0.66b	0.80a
Berger-Parker's index (d)	0.73a	0.38b	0.29b	0.60a	0.33b

Means in the same row and for the same parameter followed by the same letter are not significantly different (P ≤ 0.05).

The lower values of Morisita's Index of Similarity (0.15, 0.16) were recorded between the heavy grazing intensity site of high elevation slope (Chrysopigi) and the low grazing intensity sites of low elevation slope (Elaionas). The higher value of Morisita's Index of Similarity (0.99) was recorded between the low grazing intensity sites of low elevation slope (Elaionas).

IV – Conclusions

The floristic diversity of the understory in Calabrian pine plantations was altered by different elevation and grazing intensity. It was recorded reduced at the low elevation slope and under low grazing intensity. Regarding the similarity of floristic composition, low grazing intensity sites of low elevation slope were the most similar and both of them were found more dissimilar to the

heavy grazing intensity sites of high elevation slope. It seems that, both grazing and elevation were important drivers affecting species composition. However, as other factors could probably shaped the floristic diversity in the area further research is needed.

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