Αναφορά

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Components of floristic diversity in kermes oak shrublands

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Abstract
Kermes oak (*Quercus coccifera* L.) shrublands are valuable land resources in Greece. Despite their low commercial value in terms of wood production they are important feeding resources for domestic and wild animals, provide fuel to local people of remote areas, and play significant role in preventing soil erosion. The complexity and stability of kermes oak ecosystems are approached in this research by analysing the components of floristic diversity. Four shrubland sub-types were identified in northern Greece according to their scaling to shrub density. Nine plots (0.1 ha each) per each shrub cover class were randomly selected and two 50-m transects were randomly assigned in each plot. Four quadrats per each transect were systematically taken and floral composition and the taxa richness were recorded. A total of 288 quadrats were taken and differences among the four shrubland sub-types in terms of Shannon-Weiner index of diversity, evenness, Berger-Parker index of dominance, and the first order jackknife plant richness estimator were explored. Finally, the diversity ordering of the four communities based on Renyi index was made. It was found that a total of 372 taxa will be potentially sustained by the kermes oak shrublands of the area, and the denser shrublands are the lower in terms of floristic α-diversity are.

Keywords: *Quercus coccifera*, Jackknife first order estimator, diversity ordering, shrublands stability.

Introduction
The importance of retaining high levels of biodiversity is incumbent upon ecosystems' stability point of view (Aarts and Nienhuis 1999). There are studies demonstrated that in grazed Mediterranean shrubland ecosystems floristic diversity may be a result of the spatial distribution of dominant species. Merou and Vrahnakis (1999) have found that in kermes oak (*Quercus coccifera* L.) shrublands of northern Greece floristic diversity may significantly altered with the distance from the kermes oak plants. In addition, Alados *et al*. (2004), in northern Greece, have found that *Q. coccifera* plants became significantly more random with grazing impact. Consequently, given the importance of kermes oak shrublands for sustaining husbandry in les favoured area of Greece (Papanastasis 1999), the changes of floristic diversity in relation to kermes oak density is of major scientific concern.

The objective of the study was to quantify the components of floristic α-diversity in kermes oak shrublnds of northern Greece, and to explore the impact of grazing on these components as it is determined by shrub cover.

Study area and methods
The study was conducted in kermes oak (*Quercus coccifera* L.) shrublands of Lagadas county, Macedonia, northern Greece (23°19´00´´, 40°43´36´´, WGS84), late of May/early of June 2004.

Lagadas county is inhabited by five village communities covering an area of about 25 km^2 and extends from less than 100 to more than 1000 m altitude. The area has a mean annual precipitation of about 500 mm and a mean minimum air temperature of the coldest month below 0ºC, suggesting a sub-humid Mediterranean climate with cold winters. Gneiss is the dominant parent material and soils' pH does not exceed 5.5. The main land uses are rangelands (47%), agricultural land (34%) and forests (18%) (Chouvardas *et al*. in press). Shrublands (8515.7 ha, or 73.85% of the total rangeland area) are dominated by kermes oak and used by 14,950 goats. The extensive use of complementary feeding determines the applied husbandry system as semi-intensive, meaning that herbage production in the shurblands is under-used and as a consequence, they are considerably apt to long-term degradation.

Four rangeland sub-types were distinguished, namely S0 (grasslands with sporadic kermes oak plants), S1 (shrublands with kermes oak cover less than 10%), S2 (shrublands with kermes oak cover 10-40%), and S3 (shrublands with kermes oak cover more than 40%). Nine polygons per each shrubland sub-type were randomly selected in a map of the area by using accuracy of 30%, and a plot of 0.1 ha was randomly selected in each polygon. Two transects (50-m each) were randomly assigned on the ground. In each transect four quadrats (50 x 50 cm) were assigned in distances of 5, 20, 35 and 50 m from the edge of each transect. The quadrats were divided in 25 (5 x 5) smaller grids. In order to avoid difficulties of individuals' counting, the relative taxa abundance was determined by the number of grids intercepted by them (Sandra Lavorel, pers. com., 25 May 2004). A total of 288 quadrats were finally used (4 sub-types x 9 plots x 2 transects x 4 quadrats). The scientific names of the taxa were based exclusively on the Flora Europea (Tutin *et al*. 1964-1980).

Floristic diversity was determined by Shannon-Weiner index of α-diversity (1), evenness of Shannor-Weiner index of diversity (2), Berger-Parker index of dominance (3), and the first order jackknife plant richness estimator (4). Finally, the diversity ordering of the four communities based on Renyi index (5) was made. The formulae of the indices are given below (Henderson 2003):

$$H' = -\sum_{i=1}^{S} p_i \ln p_i \quad (1)$$

$$E = \frac{H'}{H_{\max}} = \frac{H'}{\ln S} \quad (2)$$

$$d = \frac{N_{\max}}{N} \quad (3)$$

$$S_{\max} = S + \left(\frac{n-1}{n}\right)k \quad (4)$$

$$H_\alpha = \frac{\ln \sum_{i=1}^{S} p_i^\alpha}{1-\alpha} \quad (5)$$

where H′, E, d, S_{max}, and H_α are the Shannon-Weiner index of α-diversity, evenness of Shannor-Weiner index of α-diversity, Berger-Parker index of dominance, first order jackknife plant richness estimator, and Renyi's family generator, respectively. Yet, S is the maximum recorded number of taxa, p_i is the proportional abundance of the i-th taxa, N_{max} is the number of records of the dominant taxon, *N* is the total number of records, *n* is the order of the sub-type starting from S0, *k* is the number of taxa only found in one sub-type, and *α* is the order.

Results and Discussion

A total of 287 taxa were recorded in all shrubland sub-types. From them 237 identified as species and five were subspecies. Thirty four taxa were identified at genus level, eight were identified at family level, two were totally unidentified, while Bryophyta were all summed as a single record (data not shown). In S0 sub-type a total of 165 taxa were recorded. The three dominant taxa in S0 were *Cynodon dactylon* (502 records), *Festuca* cf *valesiaca* (317), and *Trifolium campestre* (204) in a total of 6852 records. *Quercus coccifera* was present with only six records. The number of recorded taxa attained its highest value in S1 sub-type as 188 taxa were recorded. *C. dactylon* was again the dominant taxa with 357 records, followed by *Dactylis glomerata* (354 records), and *Q. coccifera* (335 records) in a total of 5681 records. The latter taxon was the dominant one in S2 sub-type (700 records) followed by *Thymus sibthorpii* (212 records) and *Anthemis parnassica* (203 records). In S2 sub-type 164 taxa were recorded in a total of 4178 records. The lowest number of taxa (139) was recorded in S3 sub-type, with *Q. coccifera* the dominant taxon (1351) followed by *D. glomerata* (223 records) and *T. sibthorpii* (102 records) in a total of 3554 records. It seems that kermes oak is strongly associated with perennial winter grasses, while it is negatively correlated with warm season grasses; results that are in accordance with prior findings (Merou and Vrahnakis 1999).

The highest value of Shannon-Weiner index of diversity has found in the S1 sub-type (4.774) and the lowest in S3 sub-type (3.268) (Table 1). The evenness of number of individuals distributed into taxa in the shrublands of S1 sub-type (0.773) has found to approximate the maximum value presented in S0 one (0.780). As the inspection of the Berger-Parker index of dominance suggests, S1 exhibits the highest diversity; in S1 *Cynodon dactylon* appears the lowest relative dominance (0.063) in respect to the rest dominant taxa of the other sub-types. The relative importance of dominance increases as the cover of kermes oak increases, resulted in lower diversity. S_{max} indicates the non parametric taxa-richness potentially sustained by a community (Henderson 2003). The rate of change of S_{max} expresses the potential number of taxa should be added to the S0 sub-type, where kermes oak plants can be found only sporadically, moving to the S3 sub-type, where kermes oak plants dominates. Consequently, it figures out the overall potential number of taxa potentially found in kermes oak rangelands of Lagadas county (i.e. 372 taxa).

Table 1. Main components of floristic diversity of the sub-types of kermes oak shrublands of Lagadas county.

Sub-type	H′	Variance (H′) (x 10^{-3})	*E* (H′)	*d*	S_{max}	St. Dev. (S_{max})
S0	4.415	0.163	0.780	0.073	165	0
S1	4.774	0.273	0.773	0.063	295	5
S2	4.107	0.503	0.725	0.168	347	67
S3	3.268	1.138	0.577	0.380	372	13

The results pointed out some discrepancies in the use of different diversity indices (data not shown). This was in accordance with the arguments of Tóthméresz (1995) that different diversity indices may differ in ranking of communities. The diversity ordering diagram offers a graphical solution for safe interpretations (Henderson 2003). It was found that the S0 and S1 sub-types attained highest diversity values followed by the S1 and S2 ones (Figure 1). No safe conclusions concerning the ranking of S0 and S1 sub-types can be drawn as their diversity lines intersected each other; i.e. they are non-comparable in terms of α-diversity.

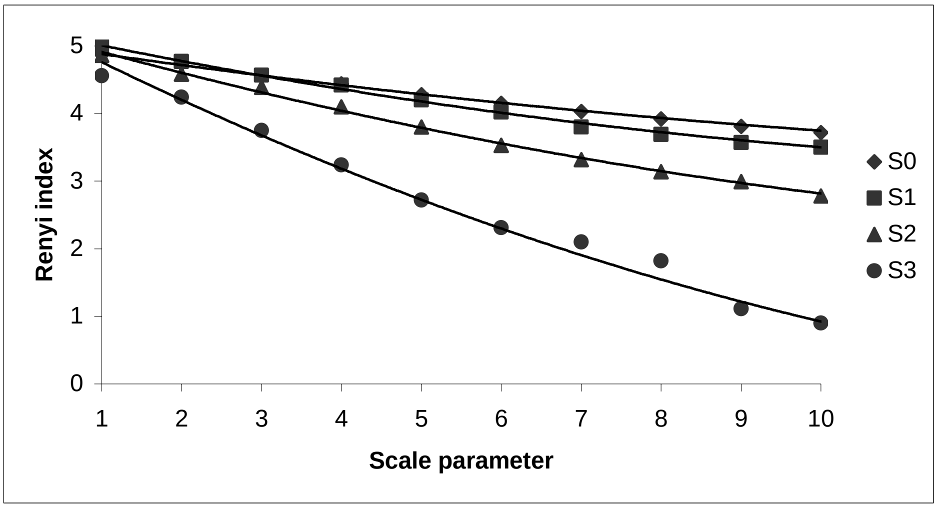

Figure 1. Diversity ordering diagram for the four sub-types (S0-S4) of the kermes oak shrublands of Lagadas county.

Conclusions

Shrublands with kermes oak cover less than 10% sustain high values of diversity and consequently are more stable and well functioning in relation to the denser ones. The abandonment of the traditional husbandry of the area has resulted in less stable ecosystems and special care must be drawn to sustain an extensified type of use.

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