Plant diversity of grazed and reforested Mediterranean rangelands

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Abstract

Rangelands cover a large area in the Mediterranean region but are largely degraded due to their improper grazing management. The aim of this study was to investigate the effect of various management practices applied for restoration of degraded Mediterranean rangelands on plant diversity. The research was conducted in rangelands of Lagadas county, in North Greece, dominated by evergreen shrublands. The management practices studied were: moderate grazing, overgrazing, control (banning of grazing), partial and full reforestation with pines (*Pinus pinaster*). Three transects were established on each management practice. Plant cover was recorded along each transect using the line-point method and species composition was calculated. Additionally, species presence /absence was measured using 10 quadrats per transect. The recorded species were classified into five *a priori* groups (trees, shrubs, grasses, legumes, forbs). Furthermore, three plant diversity indices (Shannon-Wiener, evenness and species richness) were calculated for each transect. The five management practices had high plant cover, with the exception of the overgrazed one. The composition of the vegetation however differed in terms of the dominant plant group in each practice. As far as plant diversity is concerned, the moderately grazed practice had the highest values followed by the control while the full reforestation had the lowest. It is concluded that the various management practices for restoration of degraded Mediterranean rangelands affect differently plant species composition and diversity. However moderate grazing can contribute to restoration of plant diversity without resorting to other management practices such as pine plantations.

Key words: Shannon-Wiener index, evenness, species richness, grazing, reforestation

Introduction

Rangelands cover a large area in the Mediterranean region and constitute a dominant land use type (Le Houerou 1981). They have a long history of grazing by livestock that has resulted in high biological diversity (Papanastasis et al. 1998). Most of these areas, however, are degraded due to the improper grazing use, especially overgrazing, which affects the structure and function of the ecosystem. For this reason, several management interventions are implemented for their restoration including appropriate grazing management (Papanastasis 2009). In Greece, restoration practices involve regulation of grazing to the grazing capacity of

rangelands, total banning of grazing and partial or full pine plantation followed by banning of grazing for at least ten years after tree seedling establishment. The aim of this study was to investigate the effects of these management practices on plant diversity of Mediterranean rangelands.

Material and Methods

The research was carried out in Lagadas county, North Greece, on rangelands dominated by evergreen shrublands. It involved five management practices that were applied, over the last 30 years: moderate grazing, overgrazing, no grazing (abandoned rangeland - control), partial and full reforestation with pines (*Pinus pinaster*). On each management practice, three transects (50 m long each) were established. Plant cover was recorded along each transect using the line-point method (Cook and Stubbendieck 1986). Species overlapping in each point were also recorded (multiple contacts) and species composition was calculated. The recorded species were classified into five *a priori* groups: trees, shrubs, grasses, legumes, forbs and their contribution in each transect was calculated. Furthermore, the Shannon-Wiener diversity index and evenness (Magurran 2004) were calculated for each transect. Additionally, species presence/ absence was measured using 10 equally distributed quadrats (50 x 50 cm each) systematically (every 5 m) placed along each transect. Species richness was estimated as the mean number of species recorded in the ten quadrats of each transect. All data were analysed using one way ANOVA. Duncan multiple range test was applied to detect the differences among the means at 0.05 level of significance. Plant cover and *a priori* group contribution data were previously transformed using arcsine transformation (Sokal and Rohlf 1995). All analyses were carried out using the software package PASW Statistics 18.0 (SPSSInc. 2009).

Results and Discussion

High plant cover, ranging from 93.3% (full reforestation) to 98.0% (moderate grazing) (Table 1) was recorded for all the management practices except the overgrazed one, which had the lowest plant cover (56.67%). On the contrary, the overgrazed practice had the highest cover of rock and bare soil (39.4%). High rock and bare soil and low vegetation cover in freely grazed areas have been also reported by Alrababah et al. (2007). Litter had a mean cover of 3.5% in all practices and did not differ significantly among them.

Full and partial reforestation had the highest tree cover. Shrubs covered a large area in the overgrazed rangeland, but they were absent from the

canopy cover of the full reforestation. All other practices had an intermediate shrub cover reaching a mean of 13%. Herbaceous cover was maximum in the moderate grazing and minimum in the partial reforestation. A reduction in herbaceous species cover with the simultaneous increase of woody plant (trees and shrubs) cover is also reported by Karakosta et al. (2010).

Table 1. Mean plant cover (%) of the five management practices

Management practice	Trees	Shrubs	Herbaceous species	Litter	Rock	Bare soil
Moderate	0.00c[1]	16.67b	81.33a	1.67a	0.00	0.33b
Overgrazing	0.00c	38.33a	18.33bc	4.00a	12.3	27.00
Control area	63.33b	12.00b	21.67b	2.67a	0.00	0.33b
Partial	86.00a	10.33b	1.33d	2.34a	0.00	0.00b
Full	85.67a	0.00c	7.67cd	6.66a	0.00	0.00b

[1] Different letters in the same column indicate significant differences among the five practices ($p \leq 0.05$)

The contribution of the five *a priori* groups in each management practice is shown in table 2. Grasses had the highest representation in the moderately grazed practice, while it did not differ significantly among the other practices. Grasses have been found to be also reduced with increasing grazing intensity by other researchers (e.g. Noy-Meir et al. 1989, Hadar et al. 1999, Sternberg et al. 2000), as well as in the case of grassland and shrubland afforestation (Chirino et al. 2006). Legumes contributed more in the two grazing and the control practices, while they were almost absent in the full reforestation practice. The effect of grazing on legumes has been found to vary by Hadar et al. (1999), while no significant effect of grazing intensity on legumes was found by Sternberg et al. (2000) and Papanastasis et al. (2002). Forbs representation was significantly greater in the control area than in the two reforestation practices, while their contribution did not significantly differ between the control and the two grazing practices.

The overgrazed practice had the highest shrub representation, as in the case of plant cover, followed by partial reforestation (Table 2). On the contrary, shrub contribution was almost absent in the full reforestation practice. As far as trees are concerned, they were proportionally more in the full reforestation, followed by the partial reforestation. The control area had significantly less trees than the two former practices, while the two

grazing practices did not have any trees. These results indicate that the reforestation practices had greater vertical plant stratification due to the presence of the tree stratum, than the grazing practices. Similar results have been reported by Chirino et al. (2006). It should be noted that partial reforestation had a better vertical stratification than full reforestation where the shrub stratum was actually absent. The fact that the control area had a vertical vegetation structure, suggests that suspension of grazing can also contribute to the restoration of grazing lands (Papanastasis 2009).

Table 2. Mean contribution (%) of the various *a-priori* groups to the five management practices

Management practice	Grasses	Legumes	Forbs	Shrubs	Trees
Moderate	61.93a[1]	15.82a	10.53a	11.72c	0.00d
Overgrazing	15.78b	9.61ab	9.88ab	64.72a	0.00d
Control area	19.60b	14.60a	12.49a	18.43c	34.87c
Partial	9.28b	2.52bc	3.61c	32.20b	52.40b
Full	18.08b	0.31c	6.58bc	0.56d	74.47a

[1] Different letters in the same column indicate significant differences among the five practices ($p \leq 0.05$)

Shannon-Wiener diversity index was highest in the control and the moderate grazing practices and lowest in the full reforestation. Species richness had the maximum value in moderate grazing, followed by the control area and the minimum in the full reforestation, showing a similar trend with the Shannon index. On the other hand, evenness did not significantly differ between the management practices, except full reforestation where it was significantly lower. In general, moderate grazing had the highest plant diversity followed by the control area and full reforestation the lowest. Higher diversity values have been also found in grazed as compared to ungrazed areas by other researchers (e.g. Noy-Meir 1995, Castro et al. 2010). Noy-Meir (1998) reports that several studies in Mediterranean grasslands confirm that species diversity increases at intermediate grazing intensity and decreases at high intensity. As far as reforestation is concerned, a negative impact of afforestation on plant diversity has been also reported by Chirino et al. (2006) and Alrababah et al. (2007).

Table 3. Mean values of Shannon-Wiener diversity index, evenness and species richness of the five management practices

Management practice	Shannon-Wiener (H)	Evenness (J)	Species richness (no. species/ 0.25m^2)
Moderate grazing	2.29ab[1]	0.70a	11.30a
Overgrazing	1.66c	0.68a	5.47c
Control area	2.42a	0.69a	7.77b
Partial reforestation	1.93bc	0.64a	3.43cd
Full reforestation	1.08d	0.42b	2.93d

[1] Different letters in the same column indicate significant differences among the five practices ($p \leq 0.05$)

Conclusions

1. Management practices to restore degraded Mediterranean rangelands affect differently plant structure and diversity.
2. Moderate grazing results in higher plant diversity than no grazing (control) and, especially, overgrazing while full reforestation with pines ends up with the lowest values.
3. Appropriate grazing management can contribute to restoration of degraded rangelands without having to resort to reforestation with pines.

Acknowledgements

The research is part of the European support action PRACTICE (Prevention and Restoration Actions to Combat Desertification. An Integrated Assessment, Grant Agreement no. 226818).

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