Productivity of grazed and restored Mediterranean rangelands of Lagadas County in northern Greece

Mantzanas K.[1], Papaioannou A.[2], Chouvardas D.[1], Papadimitriou M.[1], Koukioumi P.[1], Papanastasis V.P.[1]

[1]Lab. of Rangeland Ecology (286), Aristotle University, 54124 Thessaloniki, Greece
[2]Lab. of Forest Soil Science (271), Aristotle University, 54124 Thessaloniki, Greece

Abstract

Livestock grazing is an old practice in the Mediterranean Basin, while continuous overgrazing increases the risk to land degradation. Several management actions are applied in the Mediterranean rangelands in order to reduce this risk. Five such actions were evaluated in Lagadas County (Northern Greece), for their impact on primary standing productivity. They involved overgrazed, moderately grazed and control areas, as well as partially and fully reforested areas with rangeland pines. Measurements included soil characteristics and plant biomass. Samples were taken from areas where each action was implemented in order to estimate soil texture and organic matter content. For plant biomass (herbs and shrubs), three transects of 50m each were established in each of the five actions and 10 quadrats were taken in each transect. The double sampling technique of visual weight estimation calibrated by harvesting was applied. For the tree biomass, two representative plots, (0.1 ha each), were selected in the three actions that had trees, i.e. the control area, and the partial and full reforestation areas. Allometric equations related to the diameter at breast height, the average tree height and the form factor were applied for the tree biomass estimation. The results showed that actions promoting grazing tended to result in shallower soil and less organic matter content than the other. Shrub biomass was highest in the overgrazed area, while herbaceous biomass was highest in the moderately grazed area. The reforestation actions resulted in the highest pine biomass, while the highest oak biomass was recorded in the control area.

Keywords: management actions, soil characteristics, plant biomass, plant height

Introduction

Rangelands are the largest type of land use in Greece covering 40% of the whole country, approximately; they include four main vegetation types: grasslands, shrublands, forest ranges and phrygana (Papanastasis 1999). Mediterranean rangelands can provide a large variety of goods and services such as wood products, fruits for human consumption, improvement of soil fertility, erosion control, water conservation, forage and habitat to wildlife, land reclamation, landscaping and amenities (Le Houerou 1993). Over the last decades, there is a gradual degradation of rangelands for animal production due to over-utilization or abandonment of grazing. Various management practices have been introduced to reverse this degradation

such as reforestation with pines, application of grazing with appropriate stocking rates and abandonment (Papanastasis 2009). The aim of the present study was to investigate the soil dynamics and plant biomass production of different management actions applied to restore degraded Mediterranean rangelands.

Materials and methods

The study area is located in Lagadas County, northern Greece. Climate is semi-arid to sub-humid Mediterranean, with cold winters, resulting in at least 3 months-long hot and dry summer period. Soils are acid and have been derived from metamorphic rocks. For prevention of land degradation the applied restoration management resulted into five (5) l types that will be called actions (i) a moderately grazed area, dominated by *Quercus coccifera*, *Pyrus amygdaliformis* and *Q. pubescens* (stocking rate 1 sheep equivalent / ha/ year), (ii) an overgrazed shrubland dominated by *Q. coccifera, Cistus incanus* and *Q. pubescens* (3 sheep equivalents / ha/ year), (iii) an abandoned rangeland (control) dominated by *Q. pubescens* and *Q. coccifera*, (iv) a partially reforested rangeland with pines (*Pinus pinaster*) 30 years old (other woody species were *Q. pubescens* and *Q. coccifera*), where trees were planted at the openings of oak species and (v) a fully reforested rangeland with pines (*P. pinaster*) 20 years old, where the area were totally cleaned from vegetation. The last three types were not grazed by domestic animals over the last 30 years.

Measurements taken in these actions included soil characteristics and plant biomass (herbaceous plants, shrubs and trees). For the soil texture, soil samples were taken from a depth of 0-5 cm. In addition, soil samples were taken from the various soil horizons after appropriate diggings in order to measure soil organic matter. All soil samples were air dried and sieved through 2 mm mesh screens. Particle size distribution of mineral soil was determined according to Bouyocos (1962) and soil organic matter was determined by means of wet oxidation (Nelson and Sommers 1982). Herbaceous and shrubby biomass was measured along a 50 m transect in three (3) replications per action. Specifically, 10 quadrats were systematically (every 5 m) taken in each transect. The size of the quadrat was 1x1 m for shrubs within which a 0.50x0.50 m quadrat was randomly placed for the herbaceous plants. The double sampling technique of visual weight estimation calibrated by harvesting was applied for measuring the biomass (Tadmor et al. 1975). Specifically, in two (2) quadrats the biomass was harvested, oven dried and weighed, while the standing biomass, framed by the rest eight (8) quadrats, was visually estimated.

For the tree biomass, two (2) representative plots, 30x30 m each, were selected in the three (3) actions that had trees, namely the control area, the partial and full reforestation. In each of these plots, the diameter at the breast height (DBH) of all the trees was measured (with more than 5 cm DBH). Also, the height of the average tree and its form factor was estimated in order to calculate the wood stock. Then the following allometric relations were used in order to estimate the total tree biomass:

(a) For the oak trees (Jenkins et al. 2003): Y=Exp(B0+B1*lnD)

Y: Above ground dry biomass (Kg)

B0, B1: Parameters

D: Diameter at breast height (cm)

(b) For the pine trees (Roussou et al. 2008): ln(BDW) = (12.196-(31.377/DBH))

BDW: Above ground biomass (without stem) (gr)

DBH: Diameter at breast height (cm)

The results were statistically analysed using the program SPSS 17.

Results and discussion

Soil characteristics

The soil in most areas were relatively shallow (Table 1), indigenous, developed on weathered gneiss. It has sandy-clay to sandy texture, rich in pebbles. Regarding the concentration of organic matter (OM) there were statistical significant differences between the five actions. Specifically, the highest concentration of OM was found under the control and the partially reforested actions and the lowest in overgrazed one, while moderate grazing and full reforestation resulted in intermediate values. The lack of management and the diversity of plant species and forms under control and partial reforestation actions (combination of herbages, shrubs and coniferous and broadleaved trees) resulted in the accumulation of plant residues on the ground and the gradual decomposition supplies the soil with OM. The intermediate values of OM measured under the moderately grazing can be attributed to rich herbaceous vegetation, which is known to renew each year a large proportion of the small rooting system. Actually it is rhizomull; a type of mull formed mainly in areas with herbaceous vegetation (grasses) (Papamichos 1985).

The low OM in the overgrazed type was almost expected, as the high intensity of grazing negatively affects it, due to the consumption of a significant part of the vegetation (Papamichos 1985).

Table 1. Soil depth and organic matter

Actions	Soil depth (m)	Organic matter (%)
Moderately grazing	0.21	2.39 ab[1]
Overgrazing	0.25	1.95 b
Control	0.37	2.92 a
Partial reforestation	0.29	2.74 a
Full reforestation	0.35	2.25 ab

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

Plant biomass

Partial reforestation and overgrazing resulted in significantly higher shrub biomass than the moderate grazing and control actions, while shrubs were absent from full reforestation (Table 2).

Table 2. Above ground dry biomass (t/ha) produced under the five (5) management actions

	Moderate grazing	Overgrazing	Control	Partial reforestation	Full reforestation
Shrubs	4.09 b[1]	17.46 a	5.04 b	16.88 a	0.00 b
Herbs	4.49 a	0.48 bc	0.73 b	0.14 c	0.55 b

[1] Different letters in the same row indicate significant differences of biomass produced after the implementation of the five (5) management actions ($p \leq 0.05$).

Under overgrazing and partial reforestation the shrub layer was mainly consisted of *Quercus coccifera*, while in the moderately grazed area *Pyrus amygdaliformis* was also present. The cover of *Q. pubescens* at the control area was higher than that of *Q. coccifera* shrubs. Regarding herbaceous biomass, moderate grazing resulted in the highest shrub cover, while the control and full reforested area had intermediate values and overgrazied and partially reforested area the lowest ones. The higher shrub biomass in the overgrazed than in the moderately grazed area should be attributed to the higher nutritive value of herbaceous species compared to the shrub *Q. coccifera* (Yiakoulaki 1997), which eventually led to the increase of the latter at the expense of herbaceous species. As far as the decreased presence of herbaceous biomass in the fully reforested action concerns, this

may be explained by the increased shading of the pine canopy (Mantzanas and Papanastasis 2011).

The partially reforested action resulted in the highest amount of tree biomass, probably because it included both pines (planted) and deciduous oaks (indigenous). The control area had only oaks (indigenous) and the fully reforested only pines (planted) (Table 3).

Table 3. Tree biomass (t/ha) produced under three (3) management actions.

	Control	Partial reforestation	Full reforestation
Pines	–	61.08	63.18
Oaks	50.37	36.33	–

Conclusions

1. Livestock grazing, especially overgrazing tends to reduce soil depth and soil organic matter content, while no grazing as well as the establishment of pine plantation have an opposite effect.
2. Overgrazing results in the reduction of herbaceous biomass in favour of evergreen shrubs such as *Quercus coccifera*, thus decreasing their grazing value; the same effect is caused by suspension of grazing or pine introduction.
3. Banning of grazing can lead to recovery of indigenous forest vegetation and biomass, thus suggesting that there is no need to plant pines, if the objective of their establishment is ecosystem restoration.

Acknowledgements

The research was part of the European research project PRACTICE (Prevention and Restoration Actions to Combat Desertification. An Integrated Assessment - GA no.: 226818).

References

Bouyoucos G.J., 1962. Hydrometer method improved for making particle size analysis of soil. *Agronomy Journal*, 54:464-465.

Le Houerou H.N., 1993. Environmental aspects of fodder trees and shrubs plantation in the Mediterranean basin. In: V. Papanastasis (ed.). Fodder Trees and Shrubs in the Mediterranean Production Systems: Objectives and Expected Results of the EC Research Contract. pp. 11-34. Agrimed Research Programme, Commission of the European Communities, EUR 14459 EN.

Mantzanas K. and V.P. Papanastasis, 2011. Relation between thinning and understory plant cover and biomass in a brutia pine plantation in northern Greece. In E. Rigolot (ed.) Book of Abstracts, Medpine 4th International Conference in Mediterranean Pines, Avignon-France

Nelson D.W. and L.E. Sommers, 1982. Total carbon, organic carbon and organic matter. In: Methods of Soil Analysis, Part 2, A.L. Page (ed.), American Society of Agronomy and Soil Science Society of America, Madison, Wisconsin, USA, pp. 539-577.

Papamichos N.T., 1985. Forest Soils-Formation, Characteristics, Behavior. Aristotle University of Thessaloniki, Publication Office. 384 p.

Papanastasis V.P., 2009. Restoration of degraded grazing lands through grazing management: Can it work? *Restoration Ecology*, 17:441-445.

Papanastasis V.P., 1999. Grasslands and woody plants in Europe with special reference to Greece. In: V.P. Papanastasis, J. Frame and A.S. Nastis (eds.) Grasslands and Woody Plants in Europe. pp. 15-24. Grassland Science in Europe. Volume 4.

Tadmor N.H., A. Briechet, I. Noy-Meier, R.W. Benzamin and A. Eyal, 1975. An evaluation of the Calibrated Weight-Estimate Method for Measuring Production in Annual Vegetation. *Journal of Range Management*, 28(1): 65-69.

Yiakoulaki M.D., 1997. Nutritive value of forage species and shrubland utilization by goats. In V.P. Papanastasis (ed.) Sustained utilization of rangelands and pastures. Proceedings of the 1st Panhellenic Rangeland Congress. pp 257-262.