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Impact of animal sheds on vegetation configuration in Mediterranean landscapes

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Abstract. Animal sheds function as oikospheres, namely focal points, in Mediterranean landscapes. This is because livestock tend to spend more time grazing near them rather than away from them. Consequently, vegetation is impacted differently around animal sheds resulting in the creation of distinct patches. This impact was investigated in a grazed landscape located in Lagadas county, northern Greece. The dominant vegetation type was kermes oak (*Quercus coccifera* L.) shrublands. Out of a total of 60 sheds found in an area of 150 km^2, three representative sheds housing goats or sheep were selected. Two line transects 800 m long each were placed on each shed in opposite directions and plots of 30 x 30 m were identified at distances 0, 50, 100, 200 and 800 m away from the sheds. Within each plot, plant height and ground cover of the various plant functional types were measured. Plant height and cover of the woody species increased as the distance from the sheds increased ($P < 0.0064$ and $P < 0.0193$, respectively) while the cover of herbaceous species, both annual and perennial, decreased ($P < 0.0320$ and $P < 0.0049$, respectively). The results indicate that animal sheds are a means of opening up dense shrublands by favoring short vegetation (mainly herbaceous) and thus creating a heterogeneous landscape with a high variety of habitats very resistant to wildfires, a major threat to Mediterranean ecosystems.

Keywords. Height – Cover – Goats – Sheep – Shrublands – Oikospheres – Greece.

Impact de la mise à l'ombre des animaux sur la configuration de la végétation dans les paysages méditerranéens

Résumé. *Les abris fonctionnent comme des oikosphères, c'est-à-dire des points centraux, dans les paysages méditerranéens. Ceci s'explique par le fait que le bétail a tendance à passer plus de temps près des abris. En conséquence, la végétation à proximité de ces abris subit plus de pression que celle loin de ces refuges. Il en résulte la création de milieux distincts. Cet impact a été étudié dans un paysage pâturé situé dans la province de Lagadas, au nord de la Grèce. Le type de végétation dominant était la garrigue à chêne kermès (*Quercus coccifera *L.). A partir de 60 abris dans une surface de 150 km^2, trois abris représentatifs occupés par des chèvres et des moutons ont été sélectionnés. Deux transects linéaires, de 800 m de long chacun, ont été placés au niveau de chaque abri dans des directions opposées, et des parcelles de 30 x 30 m situées à 0, 50, 100, 200 et 800 m des abris ont été utilisées. Dans chaque parcelle, la hauteur des plantes et la couverture du sol par les différents types fonctionnels ont été mesurées. Cette étude a montré que la hauteur des plantes et la couverture d'espèces ligneuses augmentent en fonction de l'éloignement par rapport aux abris ($P < 0,0064$ et $P < 0,0193$ respectivement) tandis que la couverture des espèces herbacées, annuelles et vivaces, diminue ($P < 0,0320$ et $P < 0,0049$ respectivement). Les résultats indiquent que les abris sont une voie d'ouverture et par conséquent d'exploitation efficace des garrigues denses en favorisant le développement d'une végétation basse (principalement herbacée). Cela permet la création d'un paysage hétérogène avec une diversification importante des habitats résistant bien aux incendies qui constituent une menace sérieuse pour les écosystèmes méditerranéens.*

Mots-clés. *Hauteur – Couverture – Chèvres – Moutons – Garrigue – Oikosphères – Grèce.*

I – Introduction

The Mediterranean landscapes are complex entities that have been resulted from the close interaction between human activities and natural environment over the centuries (Naveh and

Lieberman, 1994). Among these activities, livestock husbandry has been instrumental in affecting species composition and shaping vegetation cover. Grazing animals often select the landscape unit which is richest in resources, then the most productive communities within the landscape and so on, down to the most palatable species within a feeding station (Senft *et al*., 1987). Consequently, they open gaps, favor grazing tolerant species, reduce plant cover and expose soil to erosion. Social behavior such as herding can increase the probability of concentrated grazing pressure (McNaughton, 1984).

In the Mediterranean landscapes, animal sheds are points of livestock concentration, which modify the impact of grazing. They correspond to places where animals are housed during night, fed with supplementary feed (hay and concentrates) and watered. They are the bases from which animals start their grazing activity every morning and where they return in the evening. Although shepherds decide to which direction animals will move every day, their decisions are always conditioned by the location of the sheds. Therefore, animal sheds act as oikospheres (from the Greek word oikos = house) with an increased grazing pressure near and a reduced one away from them. By quantifying woody vegetation cover from remote sensing data and applying a cost surface model, involving a combined friction surface around the sheds, Röder *et al.* (2007) have found a decreasing grazing pressure away from animal sheds in the Mediterranean rangelands of Lagadas county, northern Greece. No information is given, however, of the particular species involved as well as the response of herbaceous species to this decreased pressure away from animal sheds. In this paper, the impact of animal sheds on plant height and ground cover is investigated and their effect on landscape structure is discussed.

II – Materials and methods

1. Study area

The study area is located in Lagadas County, Central Macedonia, in northern Greece. It includes 5 village communities: Kolchiko, Kryoneri, Lofiskos, Ossa and Pente Vrisses covering a surface of 254 km^2. The main land uses of the study area are: rangelands (62.2%), forests (5.4%), agricultural lands (30.4%) and other areas (2%) (National Statistical Service of Greece, 1995). Mean annual precipitation is 585 mm and the mean minimum air temperature of the coldest month is below 1°C suggesting a semi arid Mediterranean-type climate with cold winters. The geological substrate is dominated by metamorphic rocks.

Kermes oak (*Quercus coccifera* L.) shrublands are dominating the study area. Besides evergreen species, though, deciduous trees and shrubs as well as several herbaceous species are also found (Ghossoub, 2003).

Rangelands are mainly grazed by goats and sheep. There are about 14,950 goats and 11,248 sheep in the 5 villages' communities of the study area (Yiakoulaki *et al.*, 2003). Most of these animals stay in permanent sheds during the night and graze in the rangelands during the day. The majority of sheds are located around the villages and only a few of them are found away from the settlements. The sheds are housing pure or mixed flocks of sheep and goats.

Animal sheds are the centers of pastoral activity because besides housing, they are also used for supplementary feeding of the animals with hay and concentrates the whole year round and especially during the winter period.

2. Survey methodology

In spring 2002, an inventory of the animal sheds in rangelands was carried out as well as of the maximum distance that animals are traveling every day using the Global Positioning System (GPS). Sixty animal sheds were recorded. It was found that animals were moving around the sheds within a distance of about 800 m. This information was then used to create a zone of 800 m width around all animal sheds recorded. Out of the 60 animal sheds, 3 were selected as representative for vegetation analyses. They were: (i) a 450 goat shed in the low altitude village community of

Kolchiko; (ii) a 300 sheep shed in the middle altitude village community of Lofiskos; and (iii) a 450 goat shed in the higher altitude village community of Kryoneri (Ghossoub, 2003).

In June 2002, two-line transects, 800 m long each, were taken in each of the three test sheds place upon different shrub vegetation densities around the sheds (e.g. sparse and dense shrub cover). Along the transects, 6 plots 30 x 30 m in size were established at 0 (at the vicinity of the shed), 50, 100, 200, 400 and 800 m away from the shed. Along each diagonal of every plot, 8 circle quadrats of 1 m diameter were placed with a mean distance of 5 m between two consecutive quadrats. In each circle quadrat, the three dominant plant species in terms of cover were visually recorded by two independent observers and the frequencies of the three dominant plant species over each transect were determined. In addition, plant height (maximum) was measured with a tape. Also the ground cover of annual and perennial herbaceous species, woody plants, litter, cryptogams, rocks and bare ground was visually estimated by two independent observers.

Data were subjected to regression analysis by correlating all dependant variables measured in the six transects of the three sheds with the distance from the shed (Sokal and Rohlf, 1996). Linear, quadratic and cubic equations were and those allowing best correlation were considered.

III – Results and discussion

The dominant plant species within each class of distance away from the animal sheds are shown in Table 1. It is clear that kermes oak was the pre-dominant species in all distances except the ones near the sheds where only herbaceous species were dominating. Several authors (e.g. Dyksterhuis, 1949; Papanastasis and Noitsakis, 1992; Heady and Child, 1994) have reported that annual unpalatable species are associated with high stocking rate. This may explain the dominance of the annual forb *Capsella bursa-pastoris*, a less preferred species, near and at 50 m far from the shed where animals normally exert the highest grazing pressure. The same pressure is indicated by the presence of *Poa bulbosa*, a biennial but with a low forage production and nutritive value (Ofir and Kigel, 2003). Perennial herbs such as *Dactylis glomerata*, *Thymus striatus* and *Stipa bromoidies* were dominating away from the sheds apparently reflecting a moderate impact of grazing animals (Table 1). Rosenstock (1996) states that undisturbed and lightly grazed areas have a higher percentage of perennials and litter than the disturbed ones.

Table 1. Mean frequency (5) of the three dominant species in relation to distance from the animals sheds

Distance (m)	Plant species	Frequency (%)	Distance (m)	Plant species	Frequency (%)
0	*Capsella bursa-pastoris* (L.) Medicus	27.1	200	*Quercus coccifera* L.	55.2
	Poa bulbosa L.	25.0		*Thymus striatus* Vahl	12.5
	Cynodon dactylon (L.) Pers.	22.9		*Stipa bromoides* (L.) Dörfler	11.5
50	*Quercus coccifera* L.	35.4	400	*Quercus coccifera* L.	44.8
	Poa bulbosa L.	31.3		*Thymus striatus* Vahl	17.7
	Capsella bursa-pastoris (L.) Medicus	21.9		*Dactylis glomerata* L.	16.7
100	*Quercus coccifera* L.	34.4	800	*Quercus coccifera* L.	59.4
	Poa bulbosa L.	28.1		*Dactylis glomerata* L.	20.8
	Hordeum murinum L.	19.8		*Thymus striatus* Vahl	13.5

Mean plant height ranged from 47.5 cm at the sheds to 215 cm 800 m away for them. Regression analysis produced a high correlation between plant height and distance from the sheds in all equations tested (Table 2). These equations show that plant height increased as we moved away from the shed but at a decreasing rate. Plant height plays an important role in animal distribution. Goats cannot reach shrubs taller than 150 cm while they prefer to graze them when they are as

short as possible (Liacos *et al.*, 1980), because they can find more available forage than in taller shrubs (Platis and Papanastasis, 2003). This means that goats are expected to graze and thus affect the areas near the sheds more than the ones away from them.

Table 2. Linear, quadratic and cubic equations produced by relating plant height and ground cover parameters with the distance (X) in meters from the sheds

Parameter	Equation	R^2	P
Plant height (cm)	$Y_1 = 62.969 + 0.2016X$	0.9363	0.0016
	$Y_2 = 52.72 + 0.334X + 2E\text{-}04X^2$	0.9655	0.0064
	$Y_3 = 47.905 + 0.4495X - 6E\text{-}04X^2 + 4E\text{-}07X^3$	0.9690	0.0462
Annual herbs (%)	$Y_1 = 26.64 + 0.0296X$	0.8050	0.0153
	$Y_2 = 29.73 - 0.0671X + 5E\text{-}05X^2$	0.8989	0.0320
	$Y_3 = 30.63 - 0.0921X + 1E\text{-}04X^2 - 8E\text{-}08X^3$	0.9054	0.1385
Perennial herbs (%)	$Y_1 = 24.711 - 0.0108X$	0.8903	0.0049
	$Y_2 = 25.055 - 0.015X + 5E\text{-}06X^2$	0.8999	0.0325
	$Y_3 = 25.241 - 0.021X + 3E\text{-}05X^2 - 2E\text{-}08X^3$	0.9022	0.1453
Woody plants (%)	$Y_1 = 17.875 + 0.039X$	0.8976	0.0042
	$Y_2 = 15.651 + 0.066X - 3E\text{-}05X^2$	0.9286	0.0193
	$Y_3 = 14.163 + 0.1073X - 2E\text{-}04X^2 + 1E\text{-}07X^3$	0.9400	0.0893
Litter (%)	$Y_1 = 14.583 - 9E\text{-}05X$	0.0065	0.8787
	$Y_2 = 14.511 + 0.0008X - 1E\text{-}06X^2$	0.0645	0.9048
	$Y_3 = 14.478 + 0.0017X - 5E\text{-}06X^2 + 3E\text{-}09X^3$	0.0742	0.9798
Cryptogams (%)	$Y_1 = 3.3572 - 0.0007X$	0.0556	0.6698
	$Y_2 = 3.1539 + 0.0018X - 3E\text{-}06X^2$	0.1085	0.8485
	$Y_3 = 2.9915 - 0.0063X - 2E\text{-}05X^2 + 2E\text{-}08X^3$	0.1362	0.9510
Bare ground (%)	$Y_1 = 12.504 - 0.005X$	0.4609	0.1385
	$Y_2 = 12.023 + 0.0009X - 7E\text{-}06X^2$	0.5067	0.3479
	$Y_3 = 12.969 - 0.0254X + 9E\text{-}05X^2 - 9E\text{-}08X^3$	0.6517	0.4712
Rocks and gravel (%)	$Y_1 = 5.5358 + 0.0007X$	0.0114	0.8292
	$Y_2 = 4.4725 + 0.0136X - 2E\text{-}05X^2$	0.3336	0.5385
	$Y_3 = 5.9082 - 0.0262X + 1E\text{-}04X^2 - 1E\text{-}07X^3$	0.8143	0.2727

As far as the ground cover of the vegetation parameters are concerned, the results of regression analysis are shown on Table 2. Annual herb cover including grasses and forbs was decreased from about 30% at the shed to less than 4% 800 m away. Only the linear and quadratic relations produced significantly different coefficients of determination but the latter had higher R^2 than the former. This quadratic equation indicates a continuous negative reduction of annual herb cover with a rate of 0.067%. Apparently, such a reduction reflects a decrease of grazing activity as we move away from the shed since annual species are generally associated with high grazing pressure and designate early stages of the secondary succession (Dyksterhuis, 1949; Papanastasis and Noitsakis, 1992; Heady and Child, 1994). Perennial herbs including grasses and forbs followed also a negative trend, from about 24% cover at the shed to about 14% 800 m away, namely a less sharp decline than annual herbs. Again, only the linear and quadratic equations produced significantly different coefficients of determination with the former having almost as high R^2 and the latter equation indicating a slow decrease of perennial herb cover with the distance from the sheds. This reduction of perennials could be attributed to the encroachment of shrubs, which shaded away most of the perennial herbaceous species.

Woody plants, on the contrary, including shrubs and trees, were clearly increased from about 17% at the shed to more than 49% 800 m away. Only the linear and quadratic equations produced statistically significant coefficients of determination with the quadratic equation having higher R^2 than the linear. The quadratic equation shows an increase of shrub cover with a rate of 0.065%.

Litter was making an average of 14% cover along the transect without showing any pattern.

Consequently, the regression analysis did not produce any significant results. Cryptogams averaged about 3% cover without showing a clear trend, either. Bare ground cover decreased from about 12.5% at the shed to 8.5% 800 m away. Apparently, such a reduction reflects a reduction of the grazing activity as we move away from the shed since grazing causes a reduction in vegetative cover (Pluhar *et al.*, 1987). However, this reduction did not produce significant results. Rocks and gravel cover were increased from about 5% on the shed to 8% at 400 m, but then it was decreased to 5% at 800 m. Again these differences did not produce significant correlation (Table 2).

According to Naveh and Lieberman (1994), one of the main problems of dynamic conservation management of Mediterranean landscapes is the re-dominance of woody vegetation following the abandonment of traditional agro-pastoral activities. With their proper distribution, goat and sheep sheds can prevent the expansion of woody species and the homogenization of Mediterranean landscapes by creating mosaics of open (with herbaceous and low shrubby species near the sheds) and closed (tall shrubs and trees away from the sheds) habitats that ensure increased forage production and quality as well as a reduced fire risk.

IV – Conclusions

Animal sheds in Mediterranean landscapes result in modification of vegetation due to a gradient of decreasing grazing pressure away from them. This gradient is characterized by the dominance of herbaceous species (especially annuals) near the sheds and of perennials (especially woody species) away from them. Such a modification results in the creation of open and closed habitats respectively that ensure heterogeneous, productive and fire resistant landscapes.

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