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Impact of pastoralism on desertification of Psilorites mountain in Crete, Greece

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Summary: Psilorites, the highest mountain of Crete, is the most desertified part of the island. Pastoralism is the main activity which is practiced in a traditional and uncontrolled way thus afflicting severe damages to vegetation. The regression analysis between woody plant cover and stocking density of sheep and goats produced significant but not particularly high coefficients of determination suggesting that other factors besides pastoralism have been involved in the deforestation and desertification process of Psilorites.

Key-words: Livestock husbandry, stocking density, desertification index, phrygana, woody cover.

INTRODUCTION

Among the major land uses in the Mediterranean region, rangelands rank first in the proportion of their area being moderately or severely desertified. The main reason for their desertification is overgrazing by livestock which means that too many animals are trying to be fed on a limited supply of forage (Dregne, 1978).

Rangelands are the dominant land use in Crete which amount to 4,427 km^2 namely half the entire island, and grazed by more than one million sheep and goats. As a result of a complex land tenure system, high stocking density and a long history of communal grazing use, these rangelands have been seriously degraded resulting in poor range condition and low productivity (Papanastasis et al., 1990).

Psilorites, the highest mountain of Crete (2,456 m), represents the most desertified part of the island. Pastoralism is the main human activity practiced in a traditional and uncontrolled way thus afflicting severe damages to vegetation and soils.

The aim of this paper was to investigate whether stocking density is correlated with woody plant cover so that overstocking is established as an index of desertification.

METHODS

Psilorites (30°13' latitude, 25°06' longitude) covers more than 500 km^2 and is occupied by 20 village communities. Its main bedrock is hard limestone exposed throughout most of the area while dominant vegetation is dwarf shrubs (scrubs named phrygana) with a few scattered forest stands. Climate is of mediterranean-type with an average annual precipitation 800 mm.

Thirty pairs of 1989 panchromatic air photos with a scale of 1/30,000°, covering the whole area of Psilorites, were visually interpreted by using a stereoscope and making ground checks for land cover types identification (Karteris and Vila, 1994). Rangelands were classified into: open, medium and dense forests with 10-40%, 40-70% and >70% crown cover respectively; open, medium and dense scrub lands (predominantly phrygana) with 10-40%, 30-70% and >70% crown cover; grasslands; and bare rocks. In addition, artificial surfaces (ex. settlements), arable lands (largely abandoned), fruit trees (mainly olive groves), and crops

(cultivated fields) were identified. Cover classes were expressed as percentages within each village community territory.

Information on the number of animals (sheep and goats) and the grazing period in each village community was collected in 1992 by interviewing the President and Secretary of the village as well as local shepherds. Stocking density was calculated within village communities by dividing the total number of grazing sheep and goats or only goats, calibrated with their respective grazing period, with the grazed area, i.e. rangelands and forests. It was expressed in animals/ha/year.

Cover percentages were transformed to angular (arcsin) data and correlated with stocking densities by means of regression analysis (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Cover of the various land cover classes was found to be different among the 20 village communities. The areas covered by each type on the whole study area are shown on table 1. It is clear that the main land types were medium and dense scrub lands (phrygana) dominated by *Sarcopoterium spinosum* (L.). Spach, *Euphorbia acanthothamnus* Heldr., and *Coridothymus_capitatus* (L.) Rchb., which covered almost 63% of the study area. They were mainly distributed on relatively gentle slopes from low to medium elevations, while open scrub lands were covering only 5% of the whole area and tended to be associated with steeper slopes and higher elevations. Grasslands were very limited (0.5%) and bare rocks occupied 0.5% of the area, mainly distributed on high elevations and steep slopes. Forests were dominated by open to medium density stands of *Quercus coccifera* L. and *Acer creticum* L. and occupied only 9% of the whole area of Psilorites. Agricultural lands were covering about 21% and settlements less than half percent. All these data clearly show that Psilorites is a truly deforested and desertified mountain.

Table 1. *Area covered by the different land classes in Psilorites (Karteris and Vila, 1994).*

No.	Land classes	Area(ha)
0	No data	324.66
1	Artificial surfaces	248.65
2	Arable lands	29.92
3	Fruit trees	3804.42
4	Annual and permanent crops	7722.45
5	Open forests (10-40% density)	3216.70
6	Medium forests (41-70% density)	1834.84
7	Dense forests (71-100% density)	47.68
8	Open scrubs (10-40% density)	2914.44
9	Medium scrubs (41-70% density)	16966.60
10	Dense scrubs (71-100% density)	18140.76
11	Grasslands	272.98
12	Bare rock	247.86
	Total	55771.96

The total number of sheep and goats grazing in the study area were about 450,000 in 1992 (Table 2). Only 40% of the sheep and 27% of the goats stay permanently in the villages the whole year round. The remaining of them visit Psilorites during the summer period, while they move out of the mountain, to the coastal areas, during the winter period (transhumance). Grazing is practiced in a communal way within each village community while occupational burning is applied sometimes to control the dense scrub lands, particularly in the lower elevations.

Stocking density varied widely among the 20 village communities, namely from 0.6 to 19.8 sheep equivalents per hectare and year (Table 2). If we consider that the grazing

capacity of rangelands is no more than 1 sheep equivalent/ha/yr (Papanastasis et al., 1990), it comes out that the majority of the villages are overstocked. Considerable but less wide was the variation in the stocking density of goats.

The regression analysis between cover and stocking density resulted in several linear and no-linear equations. The majority of them were found to have low or non-significant coefficients of determination thus suggesting a low correlation between vegetative cover and stocking density. The only equations with relatively high and significant R^2 are shown on table 3. They indicate that stocking density of sheep and goats or only goats is negatively correlated with total forest cover and it can explain up to 30% of the total variation. Total cover (forests and scrubs) produced much lower coefficient of determination, while bare rocks cover resulted in the highest R^2 found (66%) indicating a positive correlation with the stocking density of goats.

Table 2. *Number of grazing animals (sheep and goats) and stocking density (animals/ha/yr) in each village community*

No.	Village	Number of sheep and goats	Sheep equivalents Sheep & Goats)	Only goats
1	Gonies	8,915	2.4	1.4
2	Krousonas	26,000	7.0	3.2
3	Gergeri	24,600	4.6	1.1
4	Zaros	6,950	2.0	0.7
5	Vorizia	10,100	1.7	0.5
6	Kamares	13,000	2.3	1.2
7	Lohriae	13,640	4.7	1.3
8	Platanus	10,000	4.3	1.8
9	Nithavris	3,900	1.2	0.1
10	Kouroutes	3,850	2.7	0.6
11	Fourfouras	1,470	0.7	0.3
12	Platania	4,450	1.7	0.3
13	Vistagi	4,700	0.6	0.4
14	Prines	1,600	1.3	0.2
15	Margarites	3,720	3.1	1.5
16	Agios Mamas	6,300	2.0	0.6
17	Kalyvos	2,800	9.6	1.9
18	Livadia	8,600	12.8	5.2
19	Zoniana	6,900	19.8	1.7
20	Anogia	140,300	7.6	1.6

Table 3. *Relation between cover (Y) (in arcsin) and stocking density (X) (in animals/ha/year).*

Equation	R^2	P
Y(Forest cover) = 21.04 - 1.08 X (sheep & goats)	0.30	0.01
Y(Forest cover) = 20.679 - 3.59 X (only goats)	0.21	0.04
Y(Total cover) = 58.89 - 7.82 X (sheep & goats)	0.19	0.05
Y(Bare rocks) = 3.76 - 3.45 X+0.10 X^2(only goats)	0.66	0.0001

CONCLUSIONS

Desertification of Psilorites is a cumulative phenomenon having developed after a long period of environmental perturbation caused by human activities including pastoralism. Irrational livestock husbandry must have been an important driving force to degradation but not the only one. Other activities such as clearing, wood cutting and arsonal wildfires must have been also involved. Stocking density constitutes a potential index of desertification in rangelands of the mediterranean basin provided that it can also take into account the history of use for which reliable data are not usually available in the mediterranean countries.

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