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# Desertification by overgrazing in Greece: The case of Lesvos island

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Grazing activities on Lesvos island (NE Aegean), especially its western part, have resulted in drastic degradation of the landscape. Species like *Quercus macrolepis* have gradually disappeared, with thorny, unpalatable species now dominating. Soil coverage is gradually becoming thinner, and the first signs of erosion have begun to appear. Fires, started by shepherds for pasture improvement act synergistically to the above process. The case of this island exemplifies the problems of overcoming desertification due to overgrazing in Greece.

## Introduction

The problem of land use and land condition are of considerable socio-economic importance. In this context, a considerable amount of land is lost each year to desertification. For example, approximately 65 million ha of productive land in the southern portion of the Sahara alone are estimated to have become desert in the last 50 years (Novikoff, 1983); in a United Nations study (1980) it is reported that, worldwide, 27 million ha of irrigated land, 173 million ha of rainfed cropland and 3071 million ha of rangeland are affected by desertification. It is estimated that the cost of halting this will rise to 4·5 billion $ annually by the year 2000. Overgrazing is a principal factor in the deterioration of land. This results in soil erosion and removal of vegetation, with consumption of plant matter exceeding regrowth over the long term. The process is aggravated by periodic droughts, with the process becoming irreversible and leading to the formation of desert-like landscapes.

In Greece, desertification is closely associated with fire (Margaris, in press), as well as with overgrazing. Shepherds often take advantage of natural fires which occur in the Mediterranean-type landscape of Greece by allowing their herds to graze freely on the tender resproutings and seedlings, thus preventing natural regeneration. They also know that, after a fire, the first plant invaders are species of the Papilionaceae family, which are an excellent nutritive food for the sheep and goats. As a result, they often deliberately introduce fires on the rangelands, in order to increase the availability of these leguminous species. This is not successful since the only plants able to survive repeated burning, due to their underground bulbs, are the geophytes like *Asphodelus* spp., which are not palatable (Arianoutsou-Faraggitaki & Margaris, 1982). The site is thus transformed into an 'asphodel desert' (Walter, 1968; Naveh, 1975).

The case of Lesvos island is typical of many situations in Greece. A total of 213,000 sheep and goats graze over the total area, with 67 per cent of the population located on its western part, where the greatest utilisation occurs (Fig. 1). The grazing activities are unconstrained so that, theoretically, an area of 3500 $m^2$ is available to each feeding animal. The degree of grazing pressure on the natural ecosystems is very high and gradually causes deterioration. This paper is part of a general study on the flow of energy of Lesvos island. It emphasises the current situation and suggests alternative methods of land use.

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**Figure 1.** Map of Lesvos. =, Number of sheep and goats per island section; ◇, sampling sites.

## Study area

The island of Lesvos is in the north-eastern Aegean. The western sector, where there are signs of desertification, covers almost half the total area of the island (1640 $km^2$). The compact dominating mountain mass is called Lepetymnos, and its highest peak reaches 996 m. The climate is typically Mediterranean, with mild–humid winters alternating with hot, dry summers (Fig. 2). On the mountain tops, the climate is more severe.

## Methods

Data concerning plant species composition and coverage were obtained from 35 different sites in the western sector of the island. These sites were selected at random, in areas which were different physiographically, but were of the same soil type and aspect. The difference in their physiography was the result of the intense grazing activities being practiced on them. In each of the 35 sites, four plots of 100 $m^2$ were surveyed for species composition, while their cover was measured in 20 plots of 4 $m^2$ for each site.

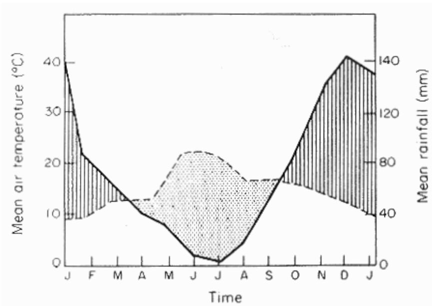


**Figure 2.** The clima-diagram of Lesvos island

## Results and discussion

The flora is typically Mediterranean, having both evergreen-sclerophyllous representatives (*Quercus coccifera*, *Phillyrea media*, *Pistacia lentiscus*) as well as seasonal dimorphic ones (*Sarcopoterium spinosum*, *Cistus incanus*, *Ballota acetabulosa*). Some deciduous species such as *Pistacia terebinthus* and *Quercus macrolepis* also occur (Table 1).

**Table 1.** *List of plant species observed on Lesvos island during June 1983*

| | | | |
|---|---|---|---|
| (1) Pinaceae | *Pinus brutia* | (18) Ericaceae | *Erica* sp. |
| | *Pinus nigra* | | *Arbutus unedo* |
| | *Pinus halepensis* | | *Arbutus adrachne* |
| (2) Fagaceae | *Castanea sativa* | | *Rhododendron luteum* |
| | *Fagus* sp. | (19) Liliaceae | *Ruscus aculeatus* |
| | *Quercus macrolepis* | | *Asphodelus microcarpus* |
| | *Quercus coccifera* | | *Asparagus aphyllous* |
| (3) Platanaceae | *Platanus orientalis* | (20) Compositae | *Centaurea spinosa* var.*tomentosa* |
| (4) Oleaceae | *Olea europea* | | |
| | *Phillyrea media* | | *Centaurea solstitialis* var.*solstitialis* |
| | *Phillyrea angustifolia* | | |
| | *Phillyrea latifolia* | | *Cichorium intybus* |
| (5) Salicaceae | *Salix alba* | | *Carduus pycnocephalus* |
| (6) Moraceae | *Ficus carica* | | *Phagnalon graecum* |
| (7) Anacardiaceae | *Pistacia lentiscus* | (21) Asteraceae | *Helichrysum siculum* |
| | *Pistacia terebinthus* | | *Inula viscosa* |
| (8) Myrtaceae | *Myrtus communis* | | *Inula candida* |
| (9) Apocynaceae | *Nerium oleander* | (22) Verbenaceae | *Vitex agnus-castus* |
| (10) Lauraceae | *Laurus nobilis* | (23) Santalaceae | *Osyris alba* |
| (11) Cupressaceae | *Juniperus oxycedrus* | (24) Caryophylaceae | *Herniaria* sp. |
| (12) Tamaricaceae | *Tamarix* sp. | (25) Scrophulariaceae | *Verbascum* sp. |
| (13) Rosaceae | *Sarcopoterium spinosum* | (26) Salicaceae | *Salicornia europea* |
| | | (27) Apiaceae | *Ferula communis* |
| | *Pyrus amygdaliformis* | (28) Amaryllidaceae | *Pancratium maritimum* |
| | *Crataegus monogyna* | (29) Juncaceae | *Juncus* sp. |
| | *Rubus* sp. | (30) Hypericaceae | *Hypericum empetrifolium* |
| | *Rosa canina* | | |
| | *Prunus domestica* | | *Hypericum perforatum* |
| (14) Labiatae | *Lavandula stoehas* | | *Hypericum* sp. |
| | *Ballota acetabulosa* | (31) Plumbaginaceae | *Limonium* sp. |
| | *Origanum vulgare* | (32) Chenopodiacea | *Salsola kali* |
| | *Micromeria julliana* | | *Halocnemum strobilaceum* |
| | *Thymus capitatus* | | |
| | *Marrubium vulgare* | (33) Polypodiaceae | *Pteridium acquillinum* |
| | *Mentha pullegium* | (34) Solanaceae | *Hyoscyamus niger* |
| | *Mentha* sp. | (35) Rubiaceae | *Rubia peregrina* |
| | *Teucrium polium* | (36) Phytolaccaceae | *Phytolacca americana* |
| | *Teucrium divaricatum* | (37) Saxifragaceae | *Saxifraga* sp. |
| (15) Papilionaceae | *Callycotome villosa* | (38) Caprifoliaceae | *Lonicera* sp. |
| | *Spartium junceum* | | *Lonicera caprifolium* |
| | *Anthyllis hermaniae* | | *Lonicera etrusca santi* |
| | *Genista acanthoclada* | | *Lonicera implexa* |
| | *Doronicum hirsutum* | (39) Umbelliferae | *Ferula communis* |
| (16) Cistaceae | *Cistus incanus* | | *Crithmum maritimum* |
| | *Helianthemum numularum* | | *Eryngium campestre* |
| | | | *Eryngium creticum* |
| (17) Euphorbiaceae | *Euphorbia paralias* | | *Daucus carota* spp.*carota* |
| | *Euphorbia characias* | (40) Capparidaceae | *Capparis spinosa* |

The effects of grazing and overgrazing on the structure of the plant communities are shown in Table 2, where seven of the 35 sites are examined. These represent a sequence from natural to badly deteriorated vegetation. At site No. 2 there is a very well developed floor system with trees (*Quercus macrolepis*), tall shrubs (e.g. *Phillyrea media*) and sub-shrubs (e.g. *Cistus incanus* and *Sarcopoterium spinosum*). At this site there is no evidence of grazing pressure. This is in marked contrast to site No. 7, where only some very low woody shrubs exist (*Centaurea spinosa*, a thorny species and *Euphorbia paralias*, a latex-containing one, and three other spiny species; all these are unpalatable. The remaining five sites are intermediate. The reason for the limited distribution of some species and the over-dominance of some others, which are mainly spiny (*Sarcopoterium spinosum*, *Centaurea spinosa*), or in some cases aromatics (*Mentha* spp.), or latex-containing (*Euphorbia paralias*), is quite obvious. These plant characteristics are believed to serve as defensive mechanisms against animals which would probably try to feed on them. It is also apparent that total coverage is gradually declining. This means that the plant litter covering the soil surface is also becoming thinner, which in turn exposes the soil to trampling by animal hooves. On this part of the island this can result in erosion.

It is known that a soil with a low organic matter content and no structure, is vulnerable to wind erosion. Novikoff (1983) gives an example for the soil of southern Tunisia. This contains 0·2% organic matter, 85% fine sand, 15% coarse sand, and has no structure. During the summer dry season, trampling by animal hooves loosens the soil particles and creates a layer 10 cm deep. Soil particles are blown by the wind, thus creating sand accumulation forms. It is estimated that, in southern Tunisia, with a summer plant cover of 15% of the total area, soil loss attains 12 t/ha.

The minimum plant cover of an area is estimated at about 60% (Orr, 1970). Given that plant cover diminishes year after year in grazed lands on Lesvos, and that strong winds are blowing over the mountainous complex of the western part of the island, it would not be unexpected to see the soil completely removed in the course of time. This soil erosion can be increased by the action of rain. In the Mediterranean-type climate, rain falls irregularly and, in most cases, takes the form of storms. In doing so, it causes leaching and runoff. According to Margaris (1978), the amount of soil lost through erosion in Greece may be about 2–3 t/ha each year.

The final effect of this soil loss is nutrient loss. That is why, on Lesvos island, consideration has been given to fertilizing the natural system, with a view to improving pasture. The effect of introduced fire is even more serious. This is because shepherds continuously light fires in order to get rid of unpalatable spiny shrubs such as *Sarcopoterium spinosum*. This practice does not affect these plants, however, since they possess adaptive mechanisms for regeneration (Naveh, 1973; Papanastasis, 1977; Arianoutsou-Faraggitaki & Margaris, 1981*b*), but it leads to great nutrient loss. This loss is very high (96% in the case of nitrogen: Arianoutsou-Faraggitaki & Margaris, 1981*a*) and is detrimental to the nutrient-poor Mediterranean soils.

As a result, *Quercus macrolepis* is only present as mature aged individuals, because animals eat the young seedlings or destroy them with their hooves. This will gradually lead to the total disappearance of this species from the island. During the past decades, Lesvian people have protected these trees from being eaten because they used their fruits for the tanning industry. However, after adopting modern chemical methods, the traditional one was abandoned and, as a result, the trees are disappearing.

The situation regarding *Quercus macrolepis* is interesting, and reflects the contradictory Greek way of thinking. In general, foresters believe that Greece was once totally covered by forest which disappeared through burning. This is not true. Greece could never have had a complete forest cover, as the typical Mediterranean-type climate does not allow it. There is neither the precipitation needed for a forest system to develop, nor the optimal temperature regime. The climax vegetation covering 40% of the Greek landscape is either evergreen–sclerophyllous (where the precipitation reaches 600–700 mm yearly) or seasonal-dimorphic (where the precipitation is much lower at about 300–400 mm yearly) (Margaris,

**Table 2.** *Percentage cover of plant species at seven representative sites of the western part of Lesvos island. Numbers 1 to 7 represent the seven different sampling sites shown in Fig. 1. The crosses indicate that the species in question was present but with a coverage of less than 0·1%*

| Plant species | Coverage (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *Quercus macrolepis* | 30·0 | 30·0 | 5·0 | 4·0 | 1·5 | | |
| *Olea europea* | 4·0 | | + | + | | | |
| *Phillyrea media* | 10·0 | | | | 5·0 | | |
| *Pistacia lentiscus* | + | | | | | | |
| *Pyrus amydgaliformis* | 2·0 | + | | + | + | | |
| *Spartium junceum* | + | | | | | | |
| *Vitex agnus-castus* | + | | + | | | | |
| *Sarcopoterium spinosum* | 5·0 | 19·5 | 20·0 | 30·0 | 10·5 | 4·5 | |
| *Cistus incanus* | 18·0 | | 25·0 | 12·0 | + | | |
| *Origanum vulgare* | 4·0 | | | | | | |
| *Ballota acetabulosa* | 1·0 | 3·0 | | 0·5 | 4·0 | + | |
| *Ruscus aculeatus* | 1·0 | | | | | | |
| *Asparagus aphyllous* | 1·0 | 0·5 | | 1·0 | + | + | |
| *Rubus* sp. | 1·0 | | | | | | |
| *Verbascum* sp. | + | | | | | | |
| *Rosa canina* | + | | | | | | |
| *Pteridium aquillinum* | + | | | | | | |
| *Quercus coccifera* | | | | + | | | |
| *Inula viscosa* | | | | | + | | |
| *Mentha pullegium* | | | | | + | | |
| *Mentha* sp. | | | | | 4·0 | | |
| *Platanus orientalis* | | | | + | | | |
| *Asphodelus microcarpus* | | | | | | + | |
| *Centaurea spinosa* | | | | | | 15·0 | 25·0 |
| *Nerium oleander* | | | | | | + | |
| *Salix alba* | | | + | | | | |
| *Carduus pycnocephalus* | | | | | | | 8·0 |
| *Crithmum maritimum* | | | | | | | 7·0 |
| *Hyoscyamus niger* | | | | | | | 3·0 |
| *Euphorbia paralias* | | | | | | | |
| Total coverage | 77·0 | 53·0 | 25·0 | 47·5 | 19·5 | 50·0 | 43·0 |

1981). Fire as a natural event is not a catastrophic agent (Arianoutsou-Faraggitaki & Margaris, 1982). Thus, everywhere in Greece where the climatic conditions impose the development of Mediterranean-type ecosystems, the probability of fire is high. These ecosystems are very well adapted to fire and can be considered as 'fire-climax' (Arianoutsou-Faraggitaki & Margaris, 1981*b*). Therefore, it is not fire that causes the degradation of the forest ecosystems, since these forests could not exist everywhere. In other words, it is not necessary to plant trees everywhere in the name of a forest-spirit (which is the practice of the majority of Greek foresters , especially after fire, while at the same time some natural forest ecosystems are gradually deteriorating due to overgrazing and overfrequent burning under the auspices of the same services.

## Conclusions

In theory, overgrazing can be avoided by limiting the number of animals grazing the system, according to range condition parameters, e.g. the condition of soil and vegetation. In practice, the achievement of ecologically sound range management is dependent on a number of other factors. These include the existence of other forage for the 'excess' animals (on Lesvos, they used to send their animals off the island to North Macedonia during summer, but since they were attacked by an infectious disease, they keep them all on Lesvos), the fluctuations in rainfall, which may lead to high or low productivity, and the political priorities set by the authorities. Concerning the last, I believe that a more realistic management policy would be effective enough to control the rate at which desertification takes place.

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## References

Arianoutsou-Faraggitaki, M. & Margaris, N. S. (1981*a*). Fire-induced nutrient losses in a phryganic (East Mediterranean) ecosystem. *International Journal of Biometeorology*, 25: 341–7.

Arianoutsou-Faraggitaki, M. & Margaris, N. S. (1981*b*). Producers and the fire cycle in a phryganic ecosystem. In Margaris, N. S. & Mooney, H. A. (Eds). *Components of Productivity of Mediterranean-climate regions. Basic and Applied Aspects*. pp. 181–90. The Hague, The Netherlands: Dr. W. Junk. 279 pp.

Arianoutsou-Faraggitaki, M. & Margaris, N. S. (1982). Phryganic ecosystems (East Mediterranean) and fire. *Ecologia Mediterranea*, 8: 473–80.

Margaris, N. S. (1978). The problem of Erosion in Greece. UNESCO/MAB Conference on 'Erosion et aménagement integrée des bassins versants', Rabat, Morocco. 17 pp.

Margaris, N. S. (1981). Adaptive strategies in plants dominating Mediterranean-type ecosystems. *In* Di Castri, F., Goodall, D. W. & Specht, R. L. (Eds), *Ecosystems of the World*, Vol. 11. *Mediterranean-type Shrublands*. pp. 309–14. Amsterdam, Oxford, N. York: Elsevier Scientific Publishing Company, 643 pp.

Margaris, N. S. (in press). Desertification in Greece. *Progress in Biometeorology*

Naveh, Z. (1973). The ecology of fire in Israel. In *Proceedings of the 13th Annual Tall Timbers Fire Ecology Conference*. pp. 199–208. Tallahassee, Florida: Tall Timbers Research Station, 521 pp.

Naveh, Z. (1975). The evolutionary significance of fire in the Mediterranean region. *Vegetatio*, 29: 199–208.

Novikoff, G. (1983). Desertification by overgrazing. *Ambio*, 12: 102–5.

Orr, H. K. (1970). Runoff and erosion control by seeded and native vegetation on a forest burn. Rocky Mountains Forest and Range Experimental Station, USDA Forest Service Research Paper RM–60, 12 pp.

Papanastasis, V. P. (1977). Fire ecology and management of phrygana communities in Greece. In *Proceedings of the Symposium on the Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems*. pp. 476–82. Palo Alto, California, USDA Forest Service General Technical Report WO–3, 498 pp.

United Nations Study, (1980). Study on financing the United Nations Plan of Action to Combat Desertification. UN A/35/396, New York: United Nations.

Walter, H. (1968). *Die Vegetation der Erde*. Bd. 2. *Die gemässigten und arktischen Zonen*. Jena: G. Fisher. 1001 pp.