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Biological indicators of land degradation along an altitudinal gradient of western Crete

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Summary

This contribution is part of the European Project ERMES II, "An Integrated Methodology for Projecting the Impact of Climate Change and Human Activity on Soil Erosion and Ecosystem Degradation in the Mediterranean: a Climatological Gradient and Dynamic Systems Approach", ENV4-CT95-0181. Four study sites were established along an altitudinal gradient of Western Crete ranging from almost sea level (Rodopos) up to 1100m (Omalos plateau), all overlying on limestone and located on south facing slopes. Field measurements and experiments aimed to the identification and measurement of physical degradation based on biological parameters of the vegetation and the soil components of the terrestrial ecosystems and their correlation with the actual stresses imposed over them (climate, fire, grazing).

Keywords: biological indicators, land degradation, species richness, diversity index, Crete.

Introduction

The general factors leading to land degradation and desertification in the Mediterranean are resulting from various agents including climatic variations and human activities. In this context, land is considered as the complex bio-productive system that compromises soil, vegetation, other biota, as well as the processes that operate within the system. The most important cause of land degradation is soil erosion. Climate is important as it defines the conditions in which soil erosion occurs. Human factors were shaping the Mediterranean for thousands of years, but it is only after the Second World War that major changes are encountered. Extensive rural migrations, agricultural intensification with new machinery, excess use of fertilisers, irrigation technology, international commerce are among the trigger factors of the land use changes which often result to desertification (Arianoutsou, 1985; Fantechi & Margaris, 1986; Thornes & Burke, 1996; Papanastasis et al. in press).

Indicators of desertification are expected to be related to the causing factors. These indices are not easily measurable neither they act upon the same scale in time and space. The aim of this study is to identify biological indices of land equilibrium along an altitudinal gradient at western Crete. Biological indices are thought to concern the ecosystem structure and function at the level of plant and soil biota communities.

Methods

Four sites have been selected (Omalos, Lakkoi, Rodopos, Kolympari) along the climatological gradient of Western Crete coinciding as much as possible with those where some geological and pedological experiments had been performed during the first phase (ERMES I) of the project (Boix et al., Pers. Com.). All sites were located on south-facing slopes and on limestone substrate (Table 1). The major stressful agent acting upon those sites was grazing, while fire was occasionally interacting with it. In each site two subsites were chosen representing a patch of different cases, being either the higher and the lower parts of the respective slopes, or a burned versus unburned patch.

Table 1. Site description

Sites	Altitude (m)	Precipit. (mm)	Dominant Plant species in cover	Dominant Plant species in density	Ground Cover Veget.	Ground Cover Rocks	Ground Cover Soil
OMALOS							
OM (high, h)	1100	1000	*Quercus coccifera* *Acer sempervirens*	*Phlomis cretica* *Quercus coccifera* *Acer sempervirens*	26%	41%	32%
OM (low, l)	1070	1000	*Quercus coccifera* *Acer sempervirens*	*Phlomis cretica* *Quercus coccifera* *Acer sempervirens*	64%	12%	23%
LAKKOI							
LA (high, h)	780	800	*Quercus coccifera*	*Quercus coccifera*	40%	48%	12%
LA (low, l)	700	800	*Genista acanthoclada*	*Coridothymus capitatus* *Sarcopoterium spinosum*	62%	12%	26%
RODOPOS							
RO (unburned, u)	300	350	*Sarcopoterium spinosum*	*Sarcopoterium spinosum*	61%	14%	25%
RO (burned, b)	300	350	*Sarcopoterium spinosum*	*Sarcopoterium spinosum*	44%	27%	29%
KOLYMPARI							
KO (burned, b)	50	150	*Sarcopoterium spinosum*	*Sarcopoterium spinosum*	40%	29%	31%

The methods followed were standard ecological techniques:

- Transect establishment for the floristics,
- Quadrats for the plant community structure,
- Biomass measurement for the productivity estimation,
- Soil samples collection for the analysis of the soil arthropods fauna,
- Cellulose decomposition experiments for the determination of soil biological activity.

The study was performed for one year, from June 1996 to May 1997.

Results and discussion

Sets of the data collected are presented in Figures 1, 2, 3, 4, 5, 6, 7, 8 and 9

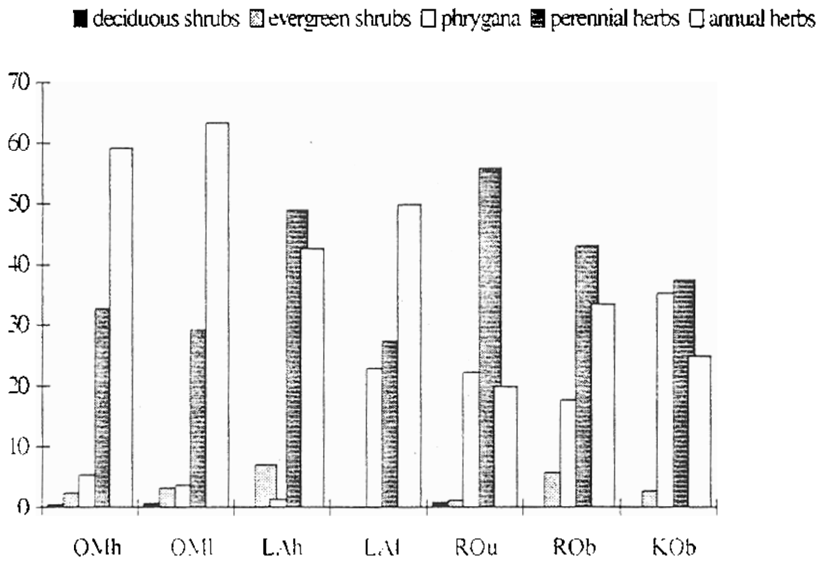

Figure 1. Index of plant linear density

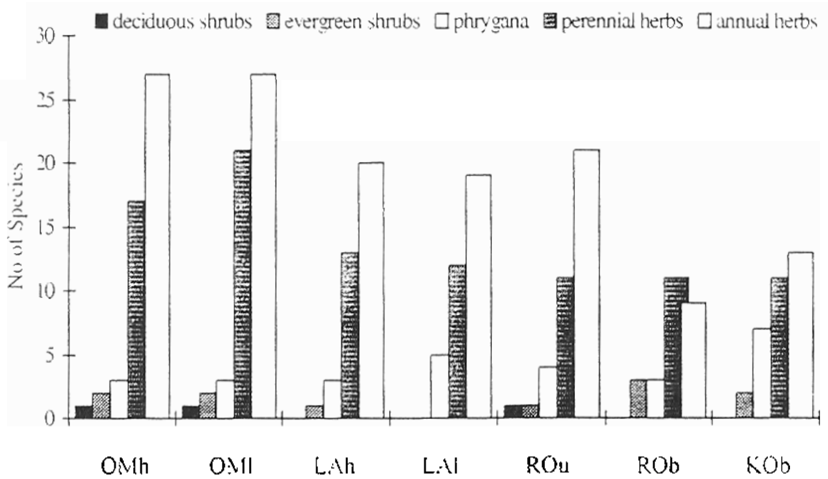

Figure 2. Plant species richness

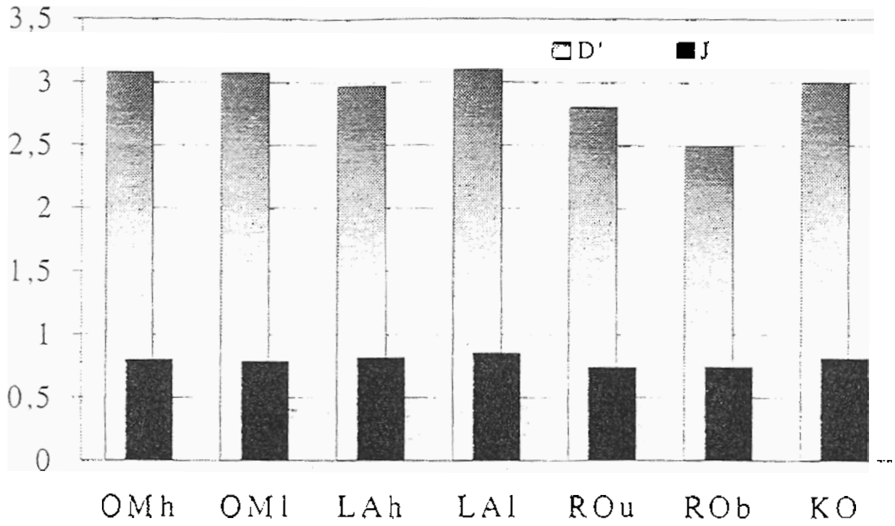

Figure 3. Plant community diversity and equitability indices

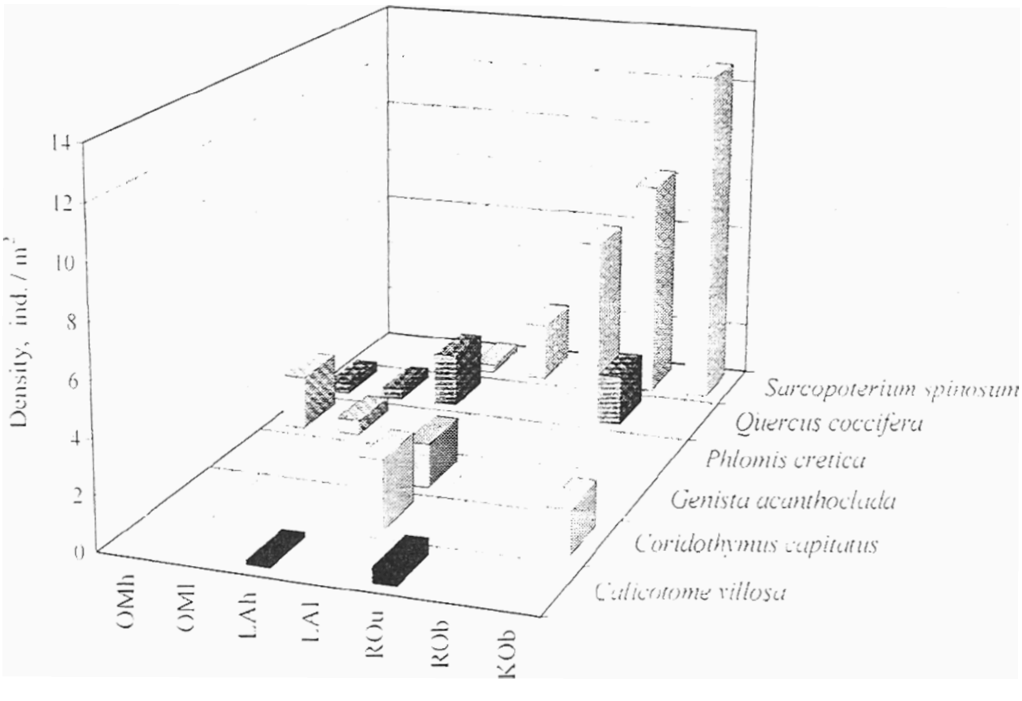

Figure 4. Plant species density

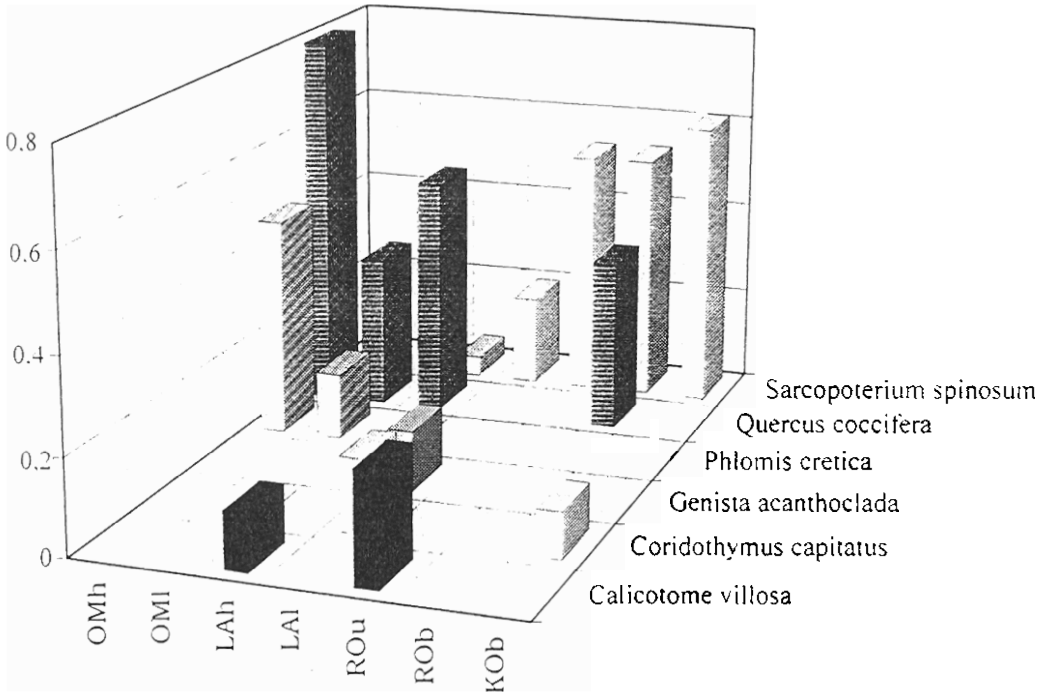

Figure 5. Leaf area index

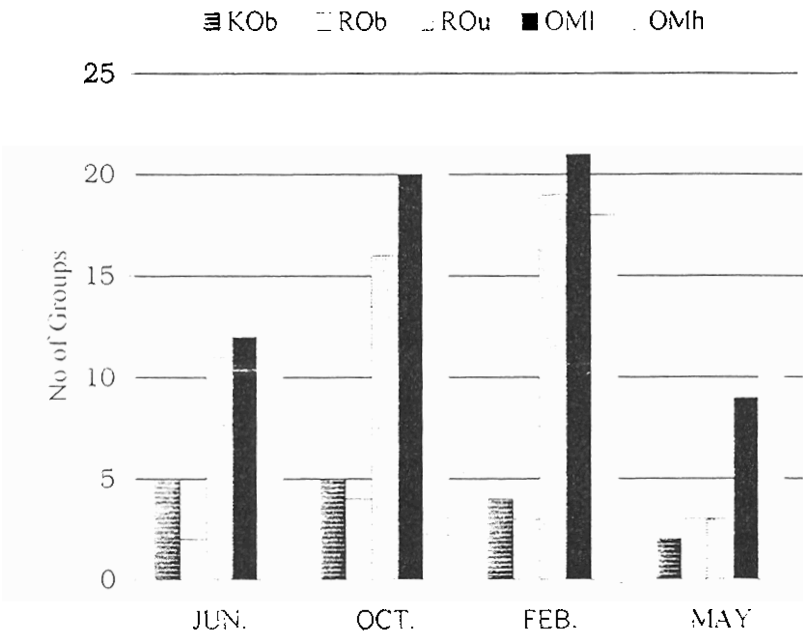

Figure 6. Number of soil arthropod groups

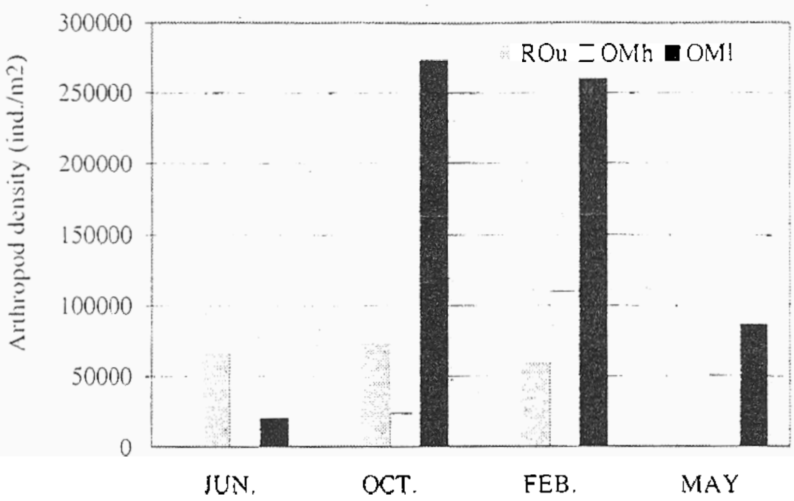

Figure 7. Total density of soil arthropods

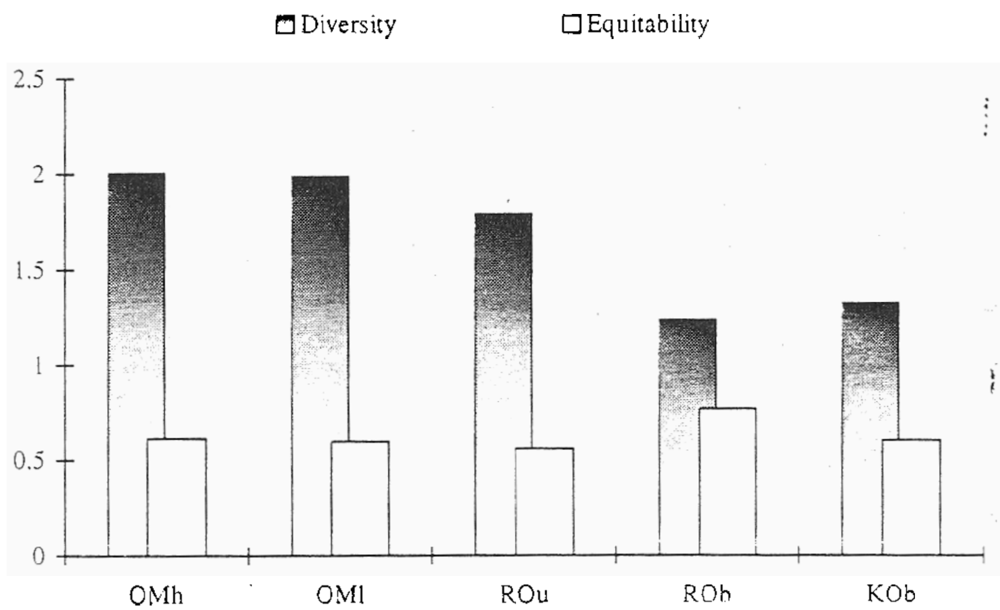

Figure 8. Soil arthropod community diversity and equitability indices

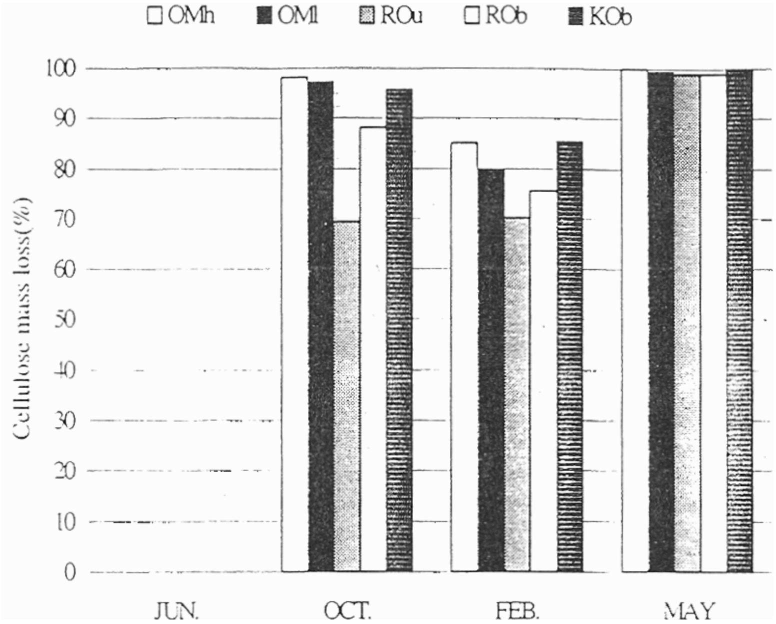

Figure 9. Soil biological activity

From these, the main concluding remarks that can be drawn are:

1. Plants species were grouped in functional types, according to their life habit. Plant species richness decreases as the altitude diminishes. In all cases, but for ROb, annual herbs were showing the richest flora. Concerning the woody taxa, the number of phryganic species versus that of the other shrubs increase from the high elevation to the lower. This ordination seems to be indifferent from the stocking rate of the sites, which goes from RO to OM, LA and KO, with a decreasing value. In general, the literature on the relationship between plant diversity factors such as climate and disturbance regime is rather contradictory, particularly for Mediterranean ecosystems (Denslow, 1980; Basanta et al., 1989). The overall trend gives a positive relation between species richness and precipitation (O'Brien, 1993) similar to our results.
2. Data on woody species productivity as they are deduced from the estimation of LAI should be explained by two factors: a) the number of individuals of the species in question, and b) its relative leaf size. The only species appearing throughout the gradient is *Sarcopoterium spinosum*, the high LAI values of which are due to its very high density at the lower altitudes. The LAI values of the species at the study sites are forming two major groups: one is that of LA and the other is of the remaining sites according to the relevant altitude of the sites. Within the second group another sub-group is formed and it corresponds to the burned sites.
3. Soil arthropod communities are grouped in accordance to the physical, characteristics of the organic horizon (thickness, quantity of accumulated organic matter, compression, etc.), something, which is in accordance to previous, reports (Castri & Vitali - di Castri, 1981). Fire (a recent event) is affecting the horizon through the burning of the litter, while grazing is indirectly affecting its characteristics through the consumption of vegetative tissues (and therefore the elimination of litter production and accumulation) and through the soil and litter trampling and compression.

4. Soil biological activity shows a similar pattern in all sites, indicating that at least at the microbial population level no major differences can be detected.

Overall, we could say that the biological indicators selected tend to reflect more clearly the influence of the prevailing climatic conditions rather than the grazing impact per se.

Acknowledgement

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