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Abstract. Geographical Information Systems (GIS) were used for mapping and monitoring the vegetation changes in the region of Argithea, western part of the Prefecture of Karditsa. GIS technology was used for the creation of a data bank, which will constitute a permanent source of elements for the proper management of this region. The study area was distinguished in various categories of ground cover and the basic categories of land use. In the present study, the vegetation types of the Argithea region are presented, with special focus on the grazed ecosystems. The results showed that the rangelands cover 67.6% of the total area and most of these are of very poor range condition. The grazing capacity is almost equal to grazing pressure, which is probably a result of the interannual reduction of the number of grazing animals in the region (i.e. 5% reduction from 2001 to 2006). As a result of the heavy grazing in the past, changes in species composition and lack of natural regeneration of tree species were observed. The use of GIS gave the opportunity for a detailed inventory of the area which leads to a more rational grazing management scheme.

Keywords. Geographic Information System (GIS) – Ground cover – Land use – Grazing capacity – Range management.

Contrôle et analyse de la végétation naturelle dans la zone d'Argithea de la Grèce Centrale

Résumé. *Les systèmes d'information géographique (GIS) ont été utilisés pour la cartographie et le suivi des changements de la végétation dans la zone d'Argithea, partie ouest de la préfecture de Karditsa. La technologie GIS a été utilisée pour la création d'une banque de données, qui constituera une source permanente d'éléments permettant une gestion appropriée de cette région. La zone d'étude a été caractérisée par différentes catégories de recouvrement et modes d'exploitation. Dans cette étude, les types de végétation dans la région d'Argithea sont présentés, en se concentrant sur les écosystèmes exploités. Les résultats montrent que les parcours couvrent 67,6% de la superficie totale et la majorité sont des parcours pauvres. La capacité de pâturage est pratiquement égale à la pression de pâturage, qui est probablement le résultat de la réduction interannuelle du nombre d'animaux en pâturage dans la région (5% de réduction de 2001 jusqu'à 2006). En conséquence du pâturage intense pratiqué dans le passé, les changements de la composition floristique et le manque de régénération naturelle des espèces arbustives ont été constatés. L'utilisation du GIS offre une opportunité pour établir un inventaire détaillé de la zone ce qui permet de développer une stratégie de gestion de pâturage plus rationnelle.*

Mots-clés. *GIS – Couverture du sol – Utilisation de la terre – Capacité de pâturage – Gestion des parcours.*

I – Introduction

Rangelands occupy about 47% of the world's land surface, constituting the largest terrestrial land use of earth (Williams *et al.*, 1968). They provide a variety of products and services, which contribute to human health and welfare. Their primary function is to provide forage for domestic and wild animals. In order to effectively manage range ecosystems, it is essential: (i) to evaluate and

classify them according to their species composition, soil quality, range condition and productivity; and (ii) to monitor and continuously verify their status. Management strategies should always be based upon firm data and they must be modified according to changes in vegetation characteristics through time.

Geographic Information Systems (GIS) is a modern technology which has been recently used for mapping and monitoring vegetation changes in range ecosystems and thus it is a useful tool for evaluating and improving management practices (Platis *et al.*, 1997, 1999). Using GIS technology we are able to delineate environmental sensitive regions and to monitor their dynamic evolution. Detecting vegetation characteristics modifications through time due to natural and anthropogenic factors gives us the opportunity to propose management actions which will better suit to the specific changing conditions in each study area.

The aim of this study was: (i) to classify and evaluate the rangelands of Argithea region, central Greece; (ii) to create a data bank which will allow detection and monitoring of future vegetation changes; and (iii) to give guidelines for rational range and livestock management.

II – Material and methods

The study area is the Argithea region (15,299.4 ha), located in the western part of the Prefecture of Karditsa, central Greece. It is a mountainous area expanding from low altitudes to the alpine zone (600-2200 m) dominated by medium to high slopes and occasionally very steep (>66%). The climate is continental, with cold and wet winters, heavy snowfalls and hot dry summers.

The study area was classified in various categories of ground cover and the basic categories of land use. For this purpose, the orthophotomaps were digitized and all the relative information was recorded in a data base (Stone *et al.*, 1994). Using these data several thematic maps were reproduced, making use of GIS (Cowen *et al.*, 1995). The vegetation types of Argithea region are presented. Special attention was given on the grazed ecosystems. We distinguished the following land cover categories:

(i) Agricultural land.

(ii) Abandoned farms (>5 years).

(iii) Grazing lands (main category).

- Grasslands with <10% woody species.
- Shrublands (<5 m high).
- Partially forested areas with <40% cover and timber stock <100 m^3/ha.

(iv) Forests.

(v) Barren land.

Rangelands were classified as good, fair and poor condition following the criteria in Table 1 (Papanastasis, 1989).

Table 1. Criteria for range condition classes

Class	Desirable plants	Vegetation cover	Erosion
Good	≥70%	≥2/3	No evidence of erosion
Fair	40%-70%	1/3-2/3	No evidence of accelerated erosion
Poor	<40%	<1/3	Signs of accelerated erosion

The classification criterion of grazing lands was the dominant plant species (Whittaker, 1962) and the basic classification unit was the "range". For more information about the inventory and the classification system see Papanastasis *et al.* (1986) and Papanastasis (1989).

The main livestock species grazed in the study area were sheep and goats, whereas cattle were a minor constituent of livestock industry in this area. Grazing was performed following a traditional continuous grazing system for five months per year. Average stocking rates in the study area were estimated as the number of small ruminants per ha. One cattle was assumed equal to five small ruminants (Holechek *et al.*, 1989). Grazing capacity was estimated according to the productivity of the rangelands, the total rangeland area and the forage needs of domestic animals (Cook and Stubbendieck, 1986).

III – Results and discussion

Shrublands and grasslands were the dominant vegetation types in the study area (32.4 and 29%, respectively). Shrublands in low altitudes (less than 800 m) were dominated by *Quercus coccifera* and in high altitudes (more than 800 m) by species of the genus *Juniperus*. Grasslands were extended mainly in high altitudes, especially beyond treeline and they were dominated by perennial grasses, such as *Festuca valesiaca*, *Poa bulbosa*, *Trisetum flavescens*, *Phleum alpinum* and others. Abandoned farms and partially forested areas, i.e. the remaining two vegetation types where livestock grazing was also performed, covered 3.9% and 2.3% of the total area respectively. That means the total grazing land constituted 67.6% of the total study area, which delineate the importance of rangeland resources in Argithea region. Forests (dominant tree species were *Pinus nigra*, *Abies borissi regis* and *Quercus conferta*) occupied a substantial area (23.1%), while arable land was relatively small (7.8%). Finally, barren land slightly exceeded the 1% of the total study area (Table 2).

Table 2. Land use of Argithea region

Land use	Area	
	ha	%
Agricultural land	1,195.8	7.8
Abandoned farms	595.8	3.9
Grazing lands	9,748.9	63.7
Grasslands	4,440.0	29.0
Shrublands	4,963.1	32.4
Partially forested areas	345.8	2.3
Forests	3,538.1	23.1
Barren land	220.8	1.4
Total	15,299.4	100.0

The majority of rangelands in the study area were in poor condition (56%), with signs of accelerated erosion only in sites in high altitudes and steep slopes (Table 3). The vegetation in poor condition rangelands was dominated by undesirable perennial plant species such as *Juniperus* spp., *Pteridium aquilinum*, *Helleborus cyclophullus*, *Galium* spp., etc. A great part of the total rangeland area was in fair condition (39%). In fair condition rangelands, some desirable plant species for livestock (especially legumes) existed, but generally these species were sparse. Only 5% of the total rangeland area was in good condition. Good condition rangelands were mainly in medium elevated sites with minimum slopes (usually less than 15%). Several legume species (*Trifolium* spp., *Medicago* spp., *Lotus corniculatus* and others) were common in these sites, while no erosion signs were observed at all.

Table 3. Range condition classes of Argithea region

Range class	Area	
	ha	%
Good	517.2	5.0
Fair	4,034.4	39.0
Poor	5,793.0	56.0
Total	10,344.7	100.0

The 60% of the grazed area in Argithea region belonged to the three (III) site class (Table 4), as a result of the shallow soils (less than 15 cm) and the medium to high slopes which was the usual case in our study area, especially in high altitudes. On the contrary, only 10% was classified in I site class (with soil depth more than 30 cm), whereas the rest grazing area (30%) belonged to the II site class.

Table 4. Site classes of Argithea region

Site class†	Area	
	ha	%
I	1,034.5	10.0
II	3,103.4	30.0
III	6,206.8	60.0
Total	10,344.7	100.0

†I: soil depth > 30 cm, slope (usual) < 15%;
II: soil depth 15-30 cm, slope 15-30%;
III: soil depth < 15 cm, slope > 30%.

Grazing capacity of the total grazing land was estimated as 1.1 Animal Unit Months per hectare. Stocking rates did not exceed grazing capacity for the year 2006 (1.1 Animal Unit Months/ha) but did so during the previous five years. Grazing pressure was not uniform in the whole study area. The most accessible sites, especially near livestock sheds, were grazed more heavily than the distant ones. Hence, it is an urgent need to follow a more appropriate range management plan based upon the productivity and the condition of each rangeland in the study area, in order to equalize grazing pressure and to maximize range productivity (Nastis and Tsiouvaras, 1991). Stocking rates in the study area were decreased about 5% during the last six years (2001-2006) and this is expected to have positive consequences on the condition of rangelands, the biodiversity and the ecosystem stability. For example, a slow increase of the participation of desirable plant species in the vegetation composition is expected in the next years, at expense of the undesirable ones. Wildlife concerns should also be taken under consideration, as well as the needs of local people, especially the development of livestock husbandry which is the vital element of rural economy in the study area. Grazing land improvement should also be accompanied both with livestock market development and efforts for improving the education level of the human community. Under an appropriate grazing management scheme, grazing by small ruminants can be a useful tool for the improvement of the current status of grazed lands in Argithea region. Moderate grazing intensities by small ruminants usually rejuvenates plant growth, prolongs growth season, improves forage quality, increases plant diversity and is beneficial to wildlife (Rhodes and Sharrow, 1990). Conversely, overgrazing hinders plant succession, diminishes stand density, reduces forage

availability and quality and creates unfavourable habitats for many wildlife species (except of those preferring earlier stages of succession such as some rodent and lagomorph species) (Davidson, 1993). Thus, for a sustainable range and animal management in a specific area, stocking rates should not exceed the threshold of grazing capacity. However, grazing capacity is of dynamic nature and their temporal fluctuations depend on many factors (animal species, vegetation composition, forage availability, climatic conditions, etc.) (Holechek *et al.*, 1989). Since there is a potential for radical fluctuations of grazing capacity through time, stocking rates and generally the grazing management strategy should be appropriately modified according to its temporal changes.

IV – Conclusions

Rangelands constituted the major land use types in Argithea region, mainly shrublands and grasslands. Grazed areas were almost up to the 2/3 of the total area indicating their significance in local economy and development.

The majority of the grazed area was in poor and fair condition, especially in high altitudes and this was attributed mainly to the specific ecological conditions, as well as to the heavy grazing pressure during the past years.

The interannual reduction of stocking rates from 2001 to 2006 resulted in the equalization of the grazing pressure and the grazing capacity at the year 2006, which it is expected to have positive consequences in range condition and productivity in the future.

An appropriate management plan should be designed and strictly followed to ensure the quick improvement and restoration of rangelands in Argithea region. This plan should be based upon current scientific range management principles, taking into account the needs of local people, as well as the wildlife and also the other components of these ecosystems. To achieve this, continuous monitoring is needed to detect changes in range conditions and vegetation characteristics, which will be used for evaluating and improving management strategies.

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