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The combined use of remote sensing and GIS for the study of a Special Protected Area in Greece

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Abstract

A biotope in the central part of Greece has been studied for its importance as a Special Protected Area (SPA) for wild fauna as part of the project LIFE–Nature.

The area of the biotope is 82,635 ha and belongs to the Mediterranean zone; it has a poor economic development record, and human activities in the past have caused a decline in the wild fauna to a very dangerous level. At this time 163 wild bird species have been recorded, and 120 of them have their nests in the area. The most important is the appearance of one of the four existing colonies in Greece of *Milvus migran* and the appearance of *Neophron percnopterus*, which is threatened as well as endangered.

The data for the biotope were obtained through the technologies of remote sensing and GIS, for the location and monitoring of ecological parameters critical for the area. The combined knowledge of foresters and ornithologists succeeded in identifying the habitats that are very important for the protection and maintenance of the wild fauna and where no human activities should no longer take place. Many constructions have been undertaken in the area, the most important of which were an animal feeding tray and an observatory for the wild fauna.

The final results of this study proved the usefulness of the technologies of remote sensing and GIS for the acquisition of the necessary knowledge (know-how) for the management of the protected biotope.

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1 Introduction

Environmental awareness has been increasing in all areas of the EU countries for the past two decades. Natural resources are now recognized to be scarce and fragile and environmental protection remains an important societal concern. The significance of biodiversity and ecosystems information for helping to understand, manage and protect natural resources and the environment is experiencing growing acceptance. Protecting the natural environment means organizing the management of species of wild flora and fauna. In the context of the Community Programme LIFE-Nature, a special project titled "Conservation and Management Actions in Greece" has been approved to be applied in seven biotopes proposed by the Greek authorities and are included in the Special Protection Areas (SPA) of the EU. This project was implemented for the period January 1998–March 2001.

The main purpose of this project is to reinforce the protection and to improve the management conditions of the seven SPAs. This has been done in the following ways: (1) through the elaboration of special decisions for "safeguard measures" for the protection of the areas, to be issued and applied by the respective Public Services; (2) by conducting management plans for the integrated management of each area, also to be approved and promoted by the respective services; (3) through the execution of specific priority measures and actions for the protection of biotopes. Within this project, media work to improve public awareness and dissemination of the results has been undertaken, and the establishment and application of a scheme for permanently "monitoring" the biotopes and the effectiveness of the management actions has also been envisaged.

The conclusion of all the actions led to the development of a Decree-law, which will be applied in the biotopes for the next five years.

2 The study area

One of the seven SPAs is the biotope of "Mountain Antichasia – Meteora" found in the middle part of Greece (Fig. 1).

The biotope is situated in the NE part of Trikala prefecture, its area is 82,635 ha and it belongs to the Mediterranean zone. Antichasia are low-altitude mountains ranging between 1000 and 1500m and are crossed by small mountain rivers. The climate is continental, with cold winters and hot summers. The annual precipitation ranges between 197 and 955mm. The SPA includes a mosaic of different vegetation types. The biodiversity of the vegetation is influenced by altitude, main rock and soil, climatic conditions, human activities and it is characterized by the presence of well-developed ecotypes, which appear as a mosaic of high trees, maquis and brushlands (Meliadis [1]). In its bigger part (lower elevations) the area is covered by vegetation of the Mediterranean zone of *Quercetalia pubescentis* and only a small part of the higher altitudes is covered by vegetation of the beech zone (*Fagetalia*). The dominant forest species is *Quercus frainetto*, mixed in most of the cases with *Q. cerris* and *Q. pubescens*.

Figure 1: Orientation of the study area.

The area has a poor economic development: the people deal with agriculture, animal husbandry and forestry.

The biotope of "Mountain Antichasia – Meteora" is considered important for the wild fauna, as 46 species and subspecies of Annex I of the Directive 79/409 and 59 SPEC species have been recorded there (Hellenic Ornithological Society [2]).

The biotope is host to one of the four colonies of black kite (*Milus nigrans*) found in the whole country. This species is a threatened one in Greece and is vulnerable in Europe. At the same time, the area is most important for the Egyptian vulture (*Neophorn percnopterus*), a threatened species in Europe. As the area satisfies many other criteria and occupies the central part of Greece, it is considered very important for the coherence of the Special Protection Network.

From the seven SPA biotopes of the LIFE-Nature project the biotope of "Mountain Antichasia – Meteora" has been chosen for the implementation of the technologies of remote sensing and GIS as a pilot application. If successful, the new technologies could be applied in the near future for the continuation of the project.

3 Methodologies

Remote sensing and Geographical Information provide a geospatial database that plays an important role in the processing of environmental information, which is characterized by huge volumes of data and complex spatial relationships between the data. Much research has been done in the application of these technologies on national, regional and local levels all over the world (Goward [3]). However, in Greece, the operational application of remote sensing and, to a lesser extent, GIS is at a very preliminary stage.

The digital data layers used in the GIS for this project consisted of a LANDSAT TM7 image and subsequent vegetation maps; digital elevation models (DEMs) were used to produce other derived layers. To produce the vegetation cover type map a LANDSAT Thematic Mapper (TM) image, acquired 28/7/1999, was used (30 and 10m pixel resolution). The study biotope was clipped out of the full digital scene and remote sensing techniques were used for the development of the digital map. Aerial photographs (B/W at a scale 1:35.000 from the 1980s) and orthophotomaps (at a scale 1:20.000) were used as ancillary data. Analogue maps, such as soil maps, base series Forest Service maps, archeological maps, a topographic map, of the Hellenic Military Geographical Service (at a scale 1:20.000), a Land Resource Map (surficial geology/aspects/ slopes) of the area (at a scale 1:20.000) and ownership maps were converted into digital form.

The field work was conducted by special ornithologists who defined the critical areas for the wild fauna and measured important factors for their ecology, such as numbers of birds, nest sites, birth rate, food habits, etc.

Finally, data were pooled for the large construction projects in the area, such as the construction of a dam in the east, the railway reconstruction in the south, the construction of a National Road in the west, all elements that could influence the protection of the biotope (e.g. reduction of the ground water level, increase of vehicle's movement, pollution, decline of aquatic organisms).

All the data were integrated into the digital data bank of the biotope and the image and GIS processing was conducted at the Forest Research Institute of Thessaloniki, in the Lab of Remote Sensing and GIS, on an IBM workstation running IDRISI, ARC/INFO and ARCVIEW software.

4 Results

Numerous variables need to be considered when selecting the areas under protection to ensure that the maximum benefit is achieved. These variables could be distinguished into two major categories: the physiographic (slopes, elevations, aspects, distance to roads, existing water reservoirs, vegetation coverage, etc.) and the man-made variables (land use, infrastructures, recreation areas, monasteries, etc.). The most serious variables that could not be quantitatively measured, or at least predicted, were the social-economical, which influence the behavior and the acceptance of the local citizens (almost 25.000 people in nine municipalities).

The land-cover type map derived from the LANDSAT TM image gave an overall accuracy 81.5% for the desired types, based on the use of the maximum likelihood algorithm. The ten desired cover type categories (Table 1) were the most predominant species (second level of classification).

The biotope was grouped into four major land use categories: forests and forested areas (59.2% of the biotope), agricultural lands (25.27%), rangelands (13.12%), and urban areas (2.58%). The classification underestimates the category of rangelands (mainly sparse brushlands), because an important part of the forests and forested land has been (over-) grazed despite the existing Forest Service regulations.

The spatial overlay of the raster classified image and the soil map produced a new thematic level, representing the distribution of the different cover types on the soil parent material. The statistical evaluation of this data showed 48 different categories. The maximum distributions of each vegetation cover category on the different soil material were as follows: 24.48% of the oak forests are found on tertiary deposits, 68.25% of the evergreen deciduous trees on hard limestones, 60.94% of the brushlands on schists, 68.43% of the agricultural lands on riverbeds, 12.56% of the black pines on gneiss, 59.84% of the spartial forested oaks on laying down cones, 4.56% of the sparse brushland on riverbeds and 13.64% of sycamore clusters on riverbeds.

Table 1. Area of land cover types in the study area, according to the classified raster image.

Land cover type	Area	% of the total area
Beech forests	9,019	1.09
Oak forests	163,651	19.81
Evergreen deciduous trees	244,201	29.55
Brushlands	83,149	10.06
Agricultural lands	208,845	25.27
Black pine forests	269	0.03
Spartial forested oaks	68,492	8.29
Sparse brushlands	25,267	3.05
Sycamore clusters	1,967	0.25
Urban areas	21,357	2.58
Unclassified	140,0	0.02
Total Sum	826,357	100.00

The vegetation cover categories were grouped into nine ecotype categories, according to the encoding of Nature 2000. The derived map gave information about the vegetation and wildlife habitat distribution according to parent material in the biotope. From the above, two new important layers were derived: the present land cover and the potential land cover/use layer. These two layers proved the environmental dynamics and the potentialities of the biotope. Many management actions have to follow these dynamics for the benefit of the wild fauna.

The combination of the information derived by the DEMs (aspect, slopes, elevations), the land cover types, the soil parent material, the (present) land use, the ownership categories, the road and the hydrographic runoff network, and the present sites where the wild fauna is appearing to shrink to, lead to mapping out of the critical habitats. From the field works the ornithologist found that the major factors influencing the appearance of the wild fauna were the vegetation habitat (for food search), the appearance of mature trees (for nesting and shelter), the south, south-east and south-west facing slopes, the existing rough rocky hills (for nesting), the appearance of water (for some species, such as great blue heron), human infrastructures (for the derangement of their environment) and of course the illegal hunting. Other factors that had an influence, with no direct affect, were overgrazing, the use of baits for the extinction of wolves, cutting of mature trees, reforestation with imported forest species, temporary dumps in the streambeds, water pollution of small industries, forest roads near the nests of the wild fauna.

Based on these findings, areas in the biotope that have the appropriate habitat characteristics and shelter (derived from the vegetation cover map), on rough rocky hills, facing south, SE and SW away from human major infrastructures, near water resources (river run-offs, swamps) were the critical places for the wild fauna. The human interventions by hunting were based on the local Forest Service information and the areas where hunting is prohibited (derived from the land use map) were delineated as "barriers". Buffering these areas by 300m produced a polygon coverage of the wild fauna habitats and these were the critical zones for the wild fauna.

Even though the processing of the above data gave ten critical areas, the final result consisted of seven areas, because three of them had no major importance for the wild fauna and also caused local social problems. These areas determined the habitats that must be protected for the maintenance of the wild fauna. With the use of the spatial analysis of all factors that exist in these areas (aspects, elevations, slops, roughness, vegetation types, distance from water reservoirs and roads, etc.), new scenarios and new models were derived, leading to a more flexible management plan. One of the most important scenarios was the identification of areas where the wild fauna could exist in the near future, applying the appropriate management plan.

Eventually, the biotope is characterized as an area of eco-development and is divided into two zones for the application of the management actions (Map 1):

(1) the main area of the eco-development;

(2) the area for the protection of nature.

In the first area the management actions were lighter, and many traditional cultivation methods, grazing methods, woodcutting, and the building of new infrastructures are allowed, but always according to the existing regulations. In the second area, which composed the critical areas for the wild fauna, the management actions are very severe. Many traditional cultivation methods and methods of grazing have to be changed, and from now on have to be based on scientific methods. Also, the preservation of mature trees and clusters uncut have to be one of the scopes of the Forest Management Plans. In these areas only research actions are allowed for the protection of the wild fauna. Special works, such as anti-burning strips, and cutting forest roads should be done very carefully and with the minimum of annoyance to the wild fauna.

The construction of the animal feeding tray and observatory in the study area, as a pilot application, was based on the spatial analysis of data derived from field work, previous experience of the ornithologists and the digital map layers. The major problem with these works was that the animal feeding tray cannot be constructed near cities and human infrastructures (due to the smell of the dead animals), but it must be quite near the road network because the observatory has to be reached by visitors (the distance between the two works cannot be more than 500–700m). The land cover layer, derived from the classified digital image, was used to mask the urban areas in the processing of the rejection areas for the works, the road network for the approximation to the observatory, the land use layer for the avoidance of trouble to citizens, and the DEM used for the sight from the observatory. Buffer zones have been developed around archeological sites, monasteries, small industries, recreation areas, and the road network and these are then combined with the mask land cover layer in order to reject the inappropriate areas. The instructions from the ornithologist, from their field works (Hatzilakou [4]), experience (Hallmann [5]) and the existing literature (Thomson [6], Gaines[7]) lead to the isolation of three different areas. By using more acceptable criteria (social and economical) for these three areas, it was possible to define the final pivot area (Map 1) and using the recent results of the ornithologist this is probably the most acceptable area for the wild fauna. The area of the animal feeding tray is closed to any visitor using road bars. Only a special guard, responsible for the feeding of the wild fauna can reach the area. This man is measuring the wild fauna's behavior. These records are very essential for the continuation of the operation of the animal feeding tray.

Finally, one action that has to be undertaken is to inform the citizens of the benefits from the application of the management plan, before the application of the Decree-law. This was achieved with informative lectures in schools, town halls, and municipalities. A community center has been built inside the biotope, and this provides educational booklets and posters of the wild fauna in the biotope to enable better information to be given for visitors and citizens.

5 Conclusions

The results of this project give resource specialists, such as foresters, ornithologist and ecologists, the baseline from which they can manage an SPA in Greece. Having the appropriate, accurate and mainly scientifically based information, they can further monitor potential areas and propose new management actions through the application and continuation of the project in the future years. The goal of this pilot project in the biotope of Mountain Antichasia – Meteora is the implementation of a long-term, low cost and high-quality monitoring program to identify trends in the environment and provide data for updating regional services that are responsible for the biotope. Environmental changes can be recorded through a monitoring program using multitemporal satellite images and the existing digital data bank and field works.

The final Decree-law, which will protect the environment for future years, is based on the results of different scenarios and on scientific knowledge, and the processing of the environmental data is an accurate, flexible way of taking into account social and economical parameters, which in many cases were quite serious.

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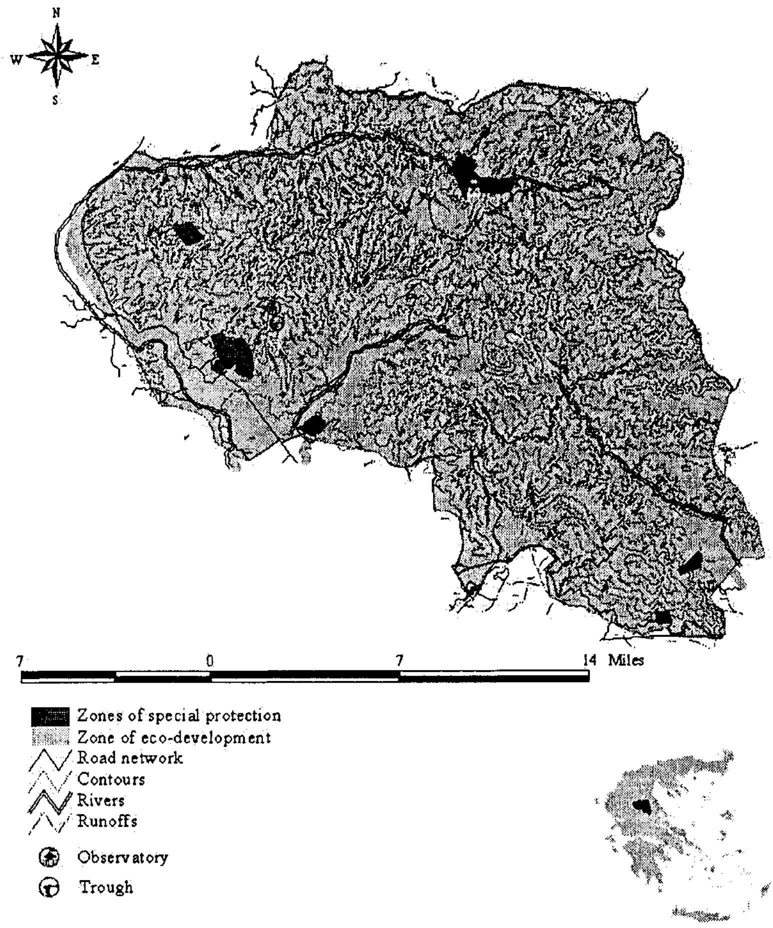
Map 1. The Special Protected Area of Mountain Antichasia - Meteora



This pilot effort using the current technologies must be applied to the other SPAs in Greece, because the whole methodology combines knowledge, experience and technology in a more appropriate way for the protection of the environment.

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