REMOTE SENSING AND RASTER GEOGRAPHIC INFORMATION SYSTEM TECHNIQUES, DETECTING THE RELATION BETWEEN NATURAL VEGETATION AND LITHOLOGY-MORPHOLOGY

PARCHARIDIS[1] IS., PSOMIADIS[2] EM., TSINTZOURAS[2] ST.

ABSTRACT

Geomorphic factors, such as slope and aspect and the lithology presented in the area are the main parameters, with the clime, influencing the distribution and increasing of the natural vegetation. The development of a raster GIS, which uses as inputs remotely sensing images and DEM-derived spatial models, gives us the opportunity to correlate the above parameters in a economical, faster and multidisciplinary way, and the possibility to elaborate a high amount of inputs from various sources. The selected area is located in Fokidos Prefecture along the coast in the Corinthian gulf where the limestones and flysch constitute the main lithological components.

Keywords: GIS, Remote Sensing, Geobotany, NDVI, DEM-derived spatial models, terrain analysis.

KEY WORDS: Remote Sensing, GIS, LandsatTM, NDVI, DEM, spatial models, Cross maps, vegetation-lithology-morphology, South-Central Greece.

1. INTRODUCTION

The type and density of vegetation largely depend on the lithologic type which determines the soil type, according to climate, altitude and slope conditions. Very often the presence of vegetation, the type of the density variations, can be used as keys to understand the lithology of the bedrock. Alignments of different vegetation types or presence of vegetation vs bare soil, can be interpreted as indicators of fractures or of permeable lithology alternated with impermeable. Geologic materials and processes can directly influence the character and amount of nutrients available for land growth. Weathering of rocks and minerals influences the abundance and nature of clay minerals present in the soil cover, there be influencing soil fertility and land growth. Vegetation is also influenced by the distribution of moisture and can therefore indicate areas of shallow water table, where density and growth are higher. The presence of vegetation, retaining rain-water and reducing surface runoff, favors the infiltration of water in the soil and the recharge of whatever aquifers may be present in the substratum. Subdivisions of vegetation cover may take into account the deferent types, for example forest, shrubs, pasturlands, as well as the composition and the density (Mouat, 1983). Variations in the density, vigor, and kinds of plants may be recorded in remote sensing images (Dainelli 1989, Campbell 1987)

State of the art results in the geobotanical remote sensing is extremely dynamic. Much work is been done to establish vegetation-substrate relationships and to understand those physiological, anatomical and morphological responses to metal stress and substrate condition which influence the spectral characteristics of stress vegetation.

The lithology and the climate conditions of an area determines the topography, morphology, weathering, drainage network and the land cover.

[1] Earthquake Planning and Protection Organization, Xanthou 32, 154 51 N. Psychiko, Athens-GREECE, eppogeo@hol.gr.

[2] Lab.of Mineralogy-Geology, Agricultural Univ.of Athens, Iera Odos 75, GR-11855 Athens-GREECE.

The distribution of natural vegetation over an area and the relationships with the local lithology and the morphology using remote sensing data and spatial models in a GIS system is the main task of the present study.

2. PHYSICAL BACKGROUND OF THE AREA

i. Location of the area.

The area under study is located in Central Greece along the northern coast of Corinthian Gulf, with coordinates UL 22°24΄ ,38°30΄ and LR 22°24΄44΄΄, 38°18΄11΄΄, topographic sheets "Amygdalea", "Itea", edition of HMGS scale 1:50.000 (1988).

ii. Clime

Along the coast the clime is mild and in the island more "rough" with denseand frequency precipitations.

iii. Geological settings

The lithological units of which this area is composed are autochthona carbonate sediments (limestones, dolomitic limestones and dolomites)of upper

Triassic to Upper Cretacian of Parnassos and Pindos zone, which belongs to the outer Hellenides zones geotectonically. The older carbonate formations belong to Upper Triassic, they are composed of limestones, dolomitic limestones and dolomits as well as the Jurassic occupied the central part. The eastern part of the studied area is occupied mostly of cretacian medium- to fine- bedded microcrystallined limestones and are developed over the southern part of the area.

The formation of flysch follows in sequence the paleogenic to paleotertiary formations which are developed mostly over the central and western part of the studied area. The flysch is composed of limestone schists, sandstones, and conglomerate. Its thickness is even 400m (Mastoris, 1968).

The neogenic conglomerate formations of Saint-Euthimia demonstrate a big surface expansion, their thickness reaching 40-50 m. They are composed mostly of carbonate pebbles of big diameter with an increscement of the marls material northwards.

The more recent sediments in the studied area are the quaternary deposits which fill the Amfissa-Itea valley, the talus slope, and the detrital cones and the deposits in Mornos basin.

The tectonic structure of the area results from a geodynamic regime which acted in three different periods as show by the three bauxite horizons that appear in karstic depression of the carbonate components of the upper Triassic and Upper Cretacian. The karstic surfaces demonstrate the creation of old corrosion surfaces which result from the affection of meso-alpine orogenetic movements.

The presence of NNW/SSE and E/W anticline and syncline in the eastern and western part of the studied area reveal the action of Triacic orogenetic movements. The noticed overthrusts and fractures are components of the orogenetic movements that took place during the phase of extremely intense action. (Mastoris 1968, Celet 1962, Katsikatsos 1992, Jacobshagen 1986).

iv. Vegetation

Gentle slopes, hilltops, and valleys are cultivated, while steeper slopes facing the drainage system are in forest cover. The beds are too thin for differences in vegetation preference to be easily observed. Especially in the eastern part of the area, where the karstic limestones appear, is not favorable for the establishment of agriculture or vegetative growth. So, shrubby vegetation is observed in the valleys.

v. Human geography

The area is characterized by a medium level of human activities and infrastructures. The main urban centers are located along the coast most populated of which are Galaxidi, Eratini and Marathias. In the inner part Amygdalea, Agia Euthimia and Tolofon are located. The main roads follow the coast line and in the inner part the major valleys.

3. METHODOLOGY

The followed methodology is described in the flow chart (table 1).

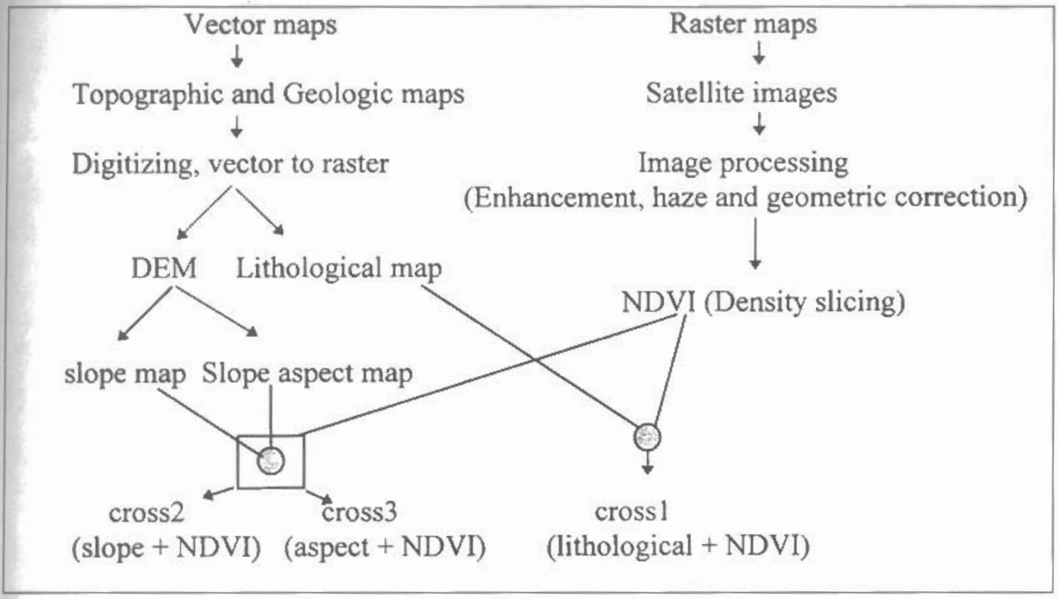

Table 1: Methodology's flow chart of the study

4. VECTOR AND RASTER DATA CAPTURE AND PROCESSING

i. Satellite data, creation of Normalized Difference Vegetation Index (NDVI) image

To detect the distribution of the natural vegetation and its density in the area we analyzed the digital LANDSAT TM subscene part of the full scene 184/033, 7 bands, dating 4/10/1986, cloud cover 0%. From the available TM subscene data, the 3 and 4 bands were selected which have been enhanced and geometrically corrected, taken in account 23 GCPs along the coast line and in the inner part and using to warp the nearest neighbor method and as projection system the EGSA '87. These two bands are used to create a NDVI image using the method of dividing the pixel brightness of the two bands to produce a new image, method known as rationing.

Vegetation indices in remote sensing are combinations of reflectance of two or more bands usually in the visible and near infrared band. The vegetation index used in this study is the Normalized Difference Vegetation Index (NDVI), (Avery and Berlin 1992, Richards 1994):

NDVI = (NIR band - VIS band)/(VIS band + NIR band)

(VIS= Visible band=band 3, NIR=Near infrared band=band 4)

The new one is a black and white image where vegetated areas will generally yield high values because of the relatively high near-infrared reflectance and low reflectance in the visible band. In contrast water has larger visible reflectance than near infrared reflectance and corresponds to the very low pixel values. Rock and bare soil areas have similar reflectance's in the two bands and result in vegetation index in low gray values. In order to be more familiar for interpretation the density slicing technique was applied on the NDVI image (fig. 1).

ii. Lithological map

A digital geological map of the area has been created. The area yielded in the geological sheets "Amygdalea" (1977) and "Itea" (1962). The formations referred in the two maps have been unificated (according to their lithologic … een created (fig. 2).

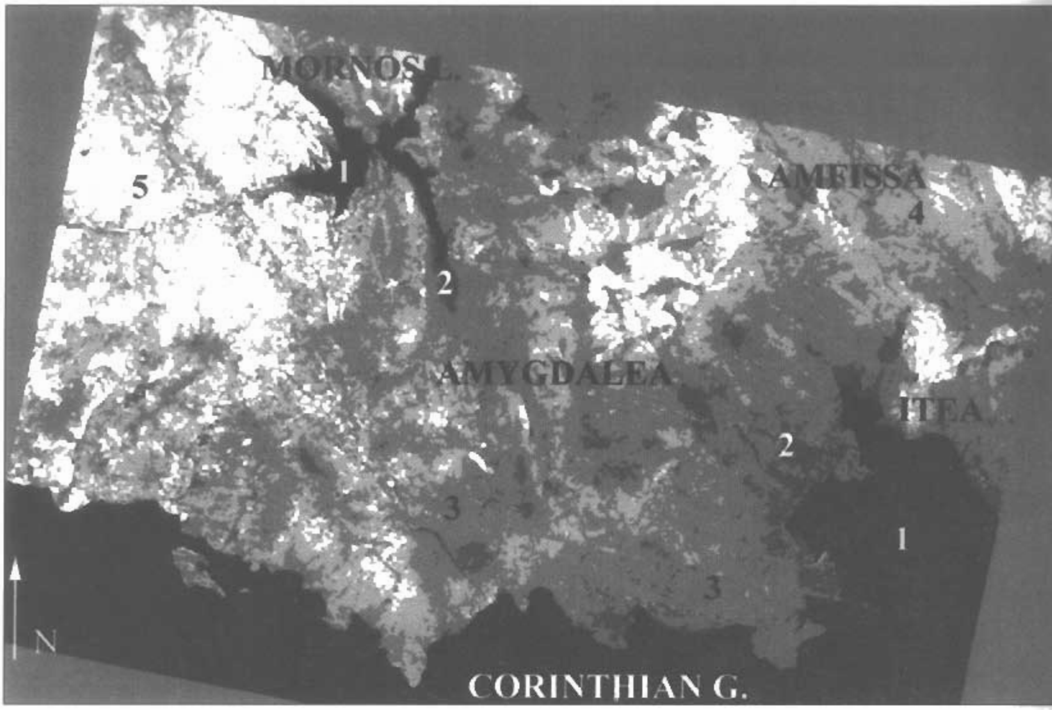

Fig. 1: Classified NDVI image: 1: Water, 2: Outcrops and bare soils, 3: Shrubs, 4: Open forest, 5: Dense forest.

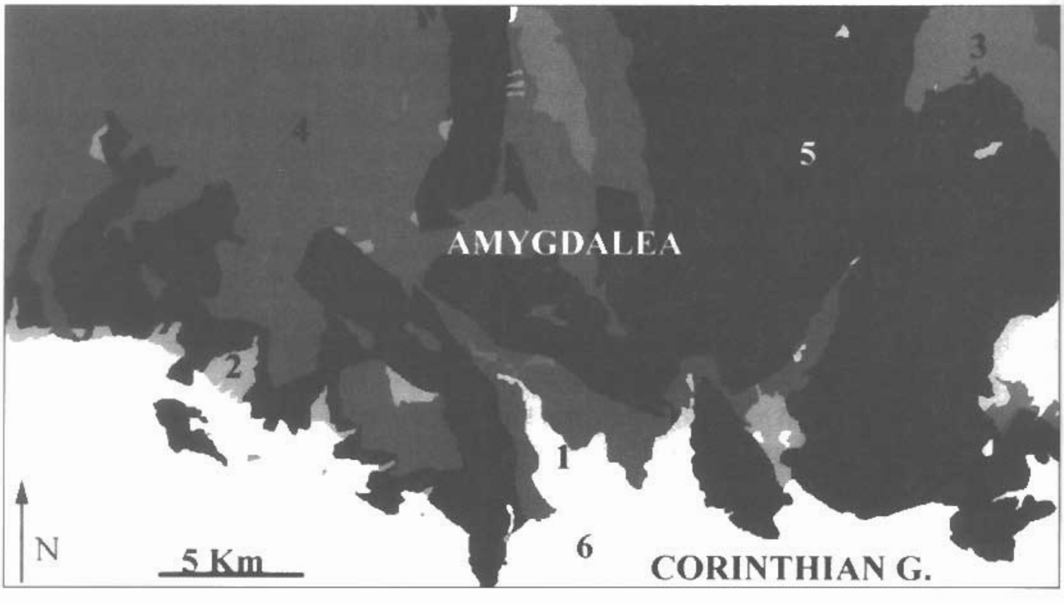

Fig. 2: Lithological map of the area after unification of the original units (from geological maps "Itea" and "Amygdalea" publ. by IGME): 1: Alluvium, 2: Slope fan debris, 3: Conglomerates, 4: Flysch, 5: Carbonates, 6: Sea.

iii. DEM derived spatial models creation.

The Digital Elevation Model (DEM) and the DEM-derived spatial models (relief image, slope and aspect) are the digital representation of terrain relief, describing the earth' s surface. The information offered by those is important in geology by delineation of geomorphologic units, ridge and drainage lines, basins, change of slope, relief shading etc.

The DEM derived spatial models were obtained through the following steps:

- digitizing the contour lines from the topographic maps
- rasterizing the generated vector maps (pixel size=45m)
- interpolating the isolines to obtain the Digital Elevation Model
- filtering the DEM in order to create slope and aspect map
- classifying pixel values in the two maps according to their DNs table (fig. 3 and 4).

5. GIS DEVELOPMENT AND MANIPULATION OF THE DATA

The work was conducted using a raster GIS for the operations. Generally raster GIS are easier to implement than vector GIS, they are also faster to use for many operations, specially where spatial precision is less important and data sampling is fairly uniform (Edwards, 1991).

The data were manipulated combining the NDVI image with one of the other thematic maps each time. The Cross operation performs an overlay of two raster maps. Pixels on the same positions in both maps are compared; the occurring combinations of class name intentifiers or values of pixels in the first input map. And those of pixels in the second input map are stored. These combinations give an output cross map and a cross table. The cross table also includes the number of pixels that occur for each combinations. From the pixel size of the maps and the number of pixels encountered as a combination, the areas of the combination are calculated. The main restrictions in order to apply these techniques is that both input maps should have the same georeference and the output map uses the same georeference of the input maps. Three Cross images were created with the respectively tables. According to the values for the different units of the maps the results are as following:

i. Cross1 (NDVI vs lithology, fig. 5): The dense and medium vegetation covers the 55% of the flysch (scrubs=43%, bare=2%),in the carbonates the 32% (scrubs=59%, bare=9%), while in the conglomerates 16% (scrubs=71%, bare=13%),in the alluvium 23% (scrubs-crops=62%, bare-soil cover=15%) and in the cones 45% (srcubs=49%, bare=6%).

ii. Cross2 (NDVI vs slope, fig. 6):The dense and medium vegetation cover 22% of the flat-almost flat area (scrubs-crops=64%, bare-soil=14%), 31% on undulate slopes (scrubs=60%, bare=9%), 45% on the moderate steeps (scrubs=51%, bare=4%), 54% in the high steeps (scrubs=43%, bare=3%).

iii. Cross3 (NDVI vs aspect, fig. 7): In the NE facing slopes the dense and medium vegetation cover 41% (scrubs=52%, bare=7%), 39% in the SE facing slopes (scrubs=54%, bare=7%)the same values correspond for the SW facing slopes and 45% for the NW facing slopes(scrubs=49%, bare=6%).

6. CONCLUSION - DISCUSSION

Geomorphic factors influencing ecosystems are essential. They include such elements as slope steepness, slope aspect and relief. Slope steepness acts indirectly by influencing the rate at which precipitations is drained from the surface. Slope aspect has a direct influence on plants by increasing or decreasing the exposure to sun light and prevailing winds. Slopes facing the sun have a warmer, drier environment than slopes that face away from the sun.

On the other hand, soils which determines the quantity and quality of the vegetation is directly related with the nature of the lithology presented.

The most obvious observations on the data produced are the rich vegetation over the flysch instead of the poor one on carbonates. As we know the flysch generate a thick soil cover that favor the increasing of the vegetation, in contrast the carbonates rocks are bare or almost bare due to the intensive karstic corrosion presenting in the area.

It is very interesting the presence of the vegetation in the moderate and high steep slopes. This is valid for flysch formation because usually generates a rich autochthonous soil cover mainly in sloping areas. Finally the northern aspects of the slopes (NE and NW) represent the higher percentage of medium and dense vegetation because of the microclimate conditions and/or other parameters.

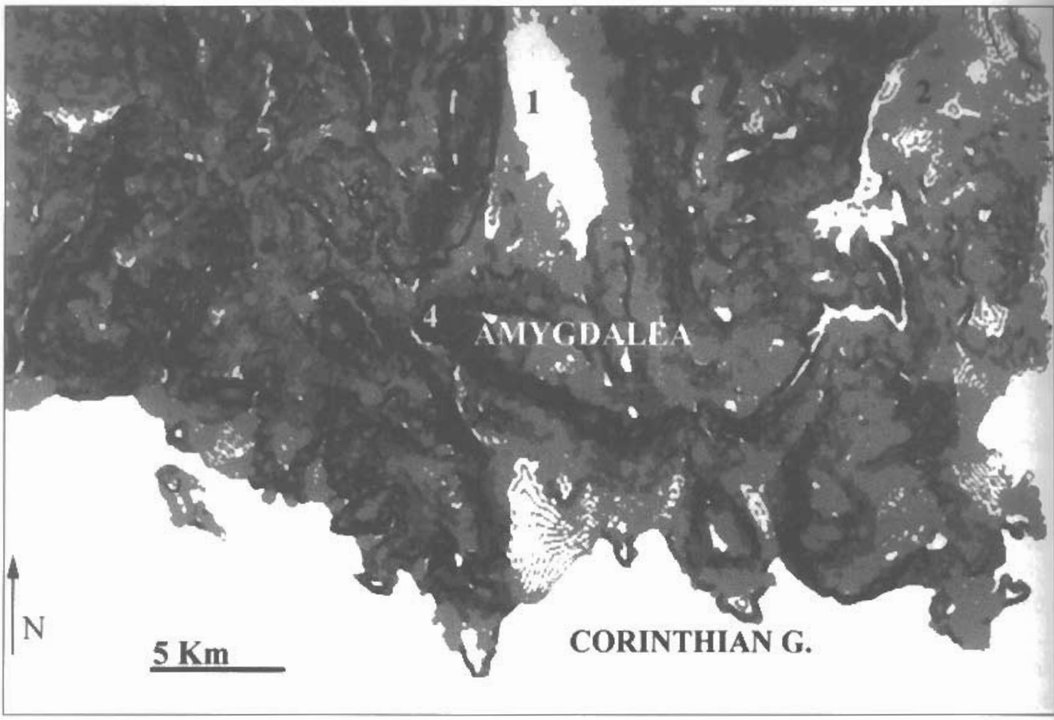

Fig. 3: Slope map of the area: 1: flat-almost flat, 2: ondulate, 3: moderate steep, 4: high steep.

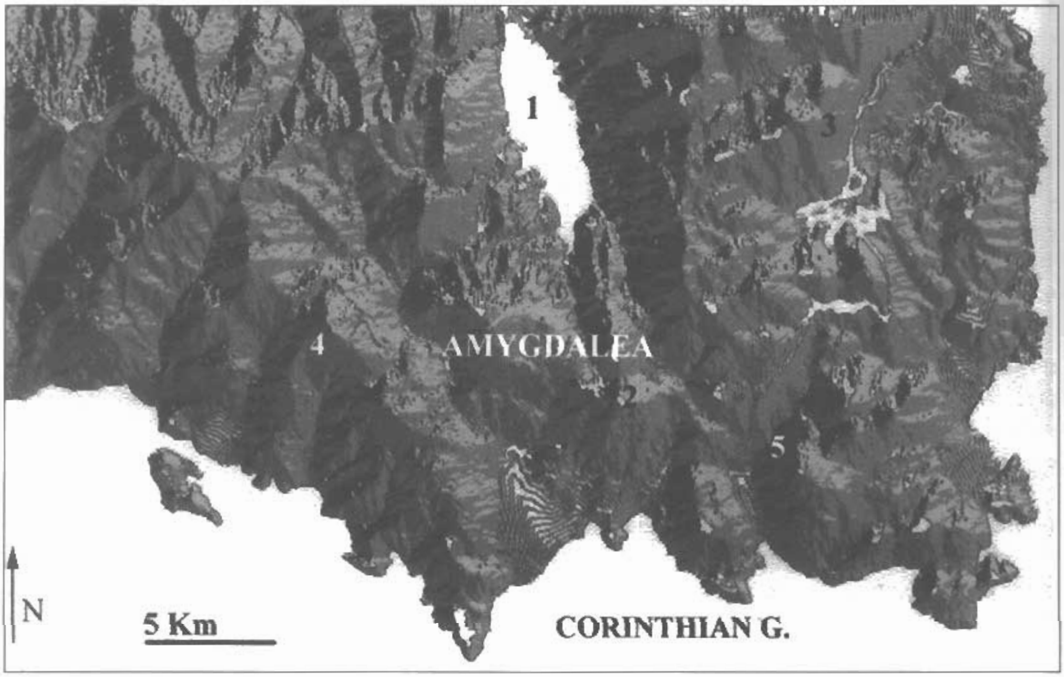

Fig. 4: Slope aspect map of the area: 1: Flat, 2: NE facing slopes, 3: SE facing slopes, 4: SW facing slopes, 5: NW facing slopes.

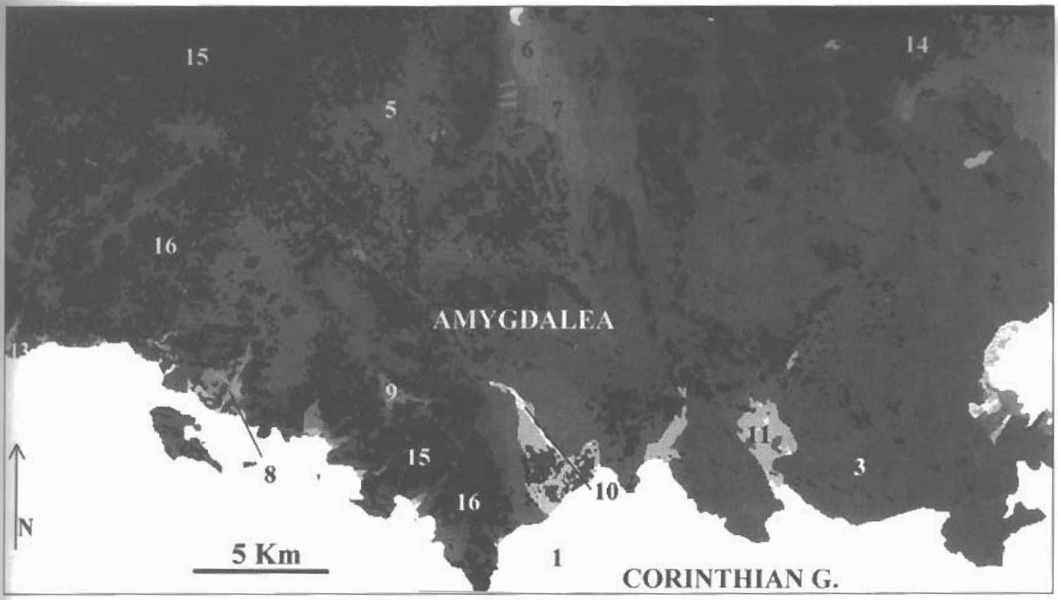

Fig. 5: Cross1 (NDVI + Lithological map): 1: Water, 2: Carbonates* outcrops and bare soils, 3: Carbonates*shrubs, 4: Flysch*outcrops and bare soils, 5: Flysch*shrubs, 6: Conglomerates*outcrops and bare soils, 7: Conglomerates*shrubs, 8: Cones*outcrops and bare soils, 9: Cones*shrubs, 10: Alluvium*outcrops and bare soils, 11: Alluvium*shrubs, 12: Alluvium*medium+dense vegetation, 13: Cones*medium+dense vegetation, 14: Conglomerates*medium+dense vegetation, 15: Flysch*medium+dense vegetation, 16: Carbonates*medium+dense vegetation.

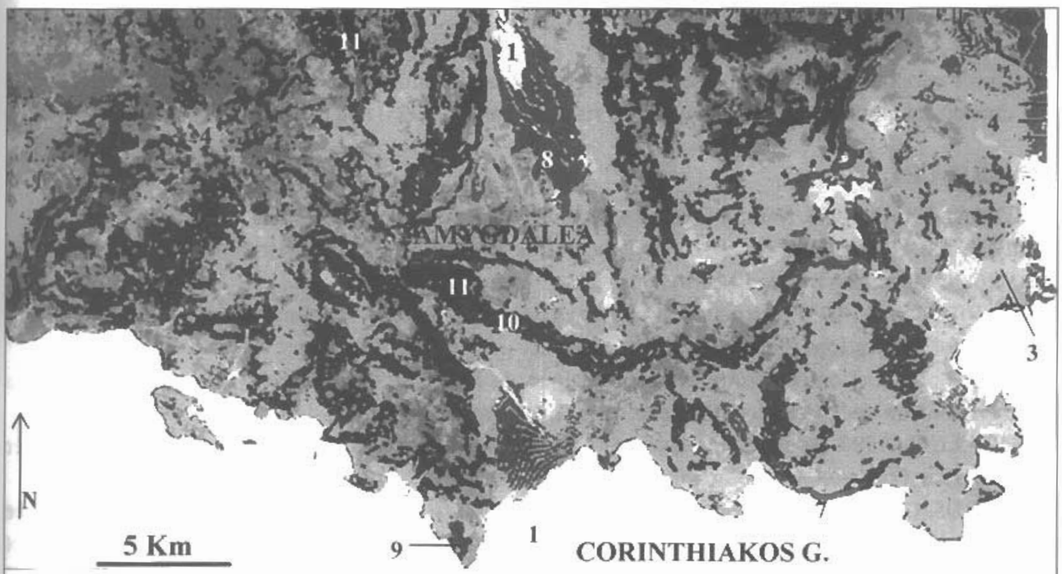

Fig. 6: Cross3 (NDVI + Slope map): *1*: Water-*flat* areas, 2: *Outcrops and bare soils*flat*-*nearly* flat, 3: Outcrops and bare soils*moderate steep+undulate, 4: Shrubs*moderatesteep+undulate, 5: medium vegetation*moderate steep+ undulate, 6: Dense vegetation*undulate+moderate steep, 7: outcrops and bare soils*high steep, 8: Shrubs*flat-nearly flat, 9: Dense+medium vegetation*flat-nearly flat, 10: Shrubs*high steep, 11: Dense+medium vegetation*high steep.

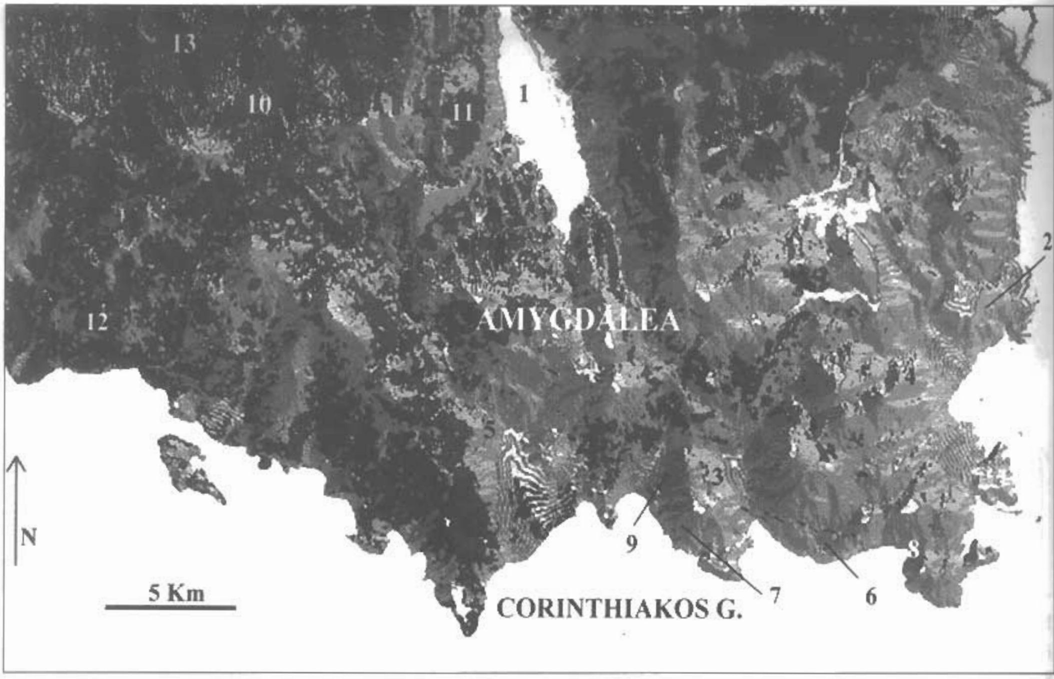

Fig. 7: Cross2 (NDVI + Slope aspect map): 1: Flat (no aspect), 2: NE*Outcrops and bare soils, 3: NE, 4: SE* Outcrops and bare soils, 5: SE*shrubs, 6: SW* Outcrops and bare soils, 7: SW*shrubs, 8: NW*Outcrops and bare soils, 9: NW*shrubs, 10: NE*medium+dense vegetation, 11: SE*medium+dense vegetation, 12: SW*medium+dense vegetation, 13: NW*medium+dense vegetation.

The development of a GIS as described in this work contributes to the study of the landslide risk, to the soil erosion susceptibility, flood and wildfires risk (Alexander, 1993) and finally in the land evaluation.

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