LAND COVER CLASSIFICATION OF OLIVE TREES

IN THE GREEK ISLANDS USING LANDSAT-TM IMAGES

John N. Hatzopoulos
Christina Giourga
Sotiris Koukoulas
Nikolaos Margaris
UNIVERSITY OF THE AEGEAN
Department of Environmental Studies
17 Karadoni Street
Mytilene T.K. 81100
GREECE

ABSTRACT

The process for land cover classification of olive trees for management purposes and environmental concern over the Greek islands is described. Data from the Greek island of Lesvos are presented and analyzed while data from other Greek islands such as Skopelos and Zakynthos are in processing stage. The use of different Landsat TM bands together with the vegetation index, to obtain better results, is also presented.

INTRODUCTION

The mechanization of agriculture which, starts in Greece with the beginning of 50's, has affected the agricultural production though the use of heavy machinery is limited to the flat areas. The reduced production cost which was obtained in the flat areas had negative effect on the cultivation of mountainous areas and areas of the Greek islands (cultivation was performed on terraces) which was based on manual work. This situation became worse in the less favoured areas with the introduction of improved species, the use of fertilizers and pesticides which are applied to yield higher production under certain environmental conditions, the substitution of natural proteins with zoic proteins, the substitution of olive oil with seed oil and the increased use of products of machine controlled agriculture (Margaris 1987, Giourga 1991).

The impact in the Greek islands was more intense due to less favoured environmental conditions such as less rainfall and cultivation on terraces which resulted in the abandonment of the agricultural fields (Margaris 1988, Turril 1929).

The problem of such abandonment and in particular for the olive trees which utilize soils meeting marginal condition requirements and which are exposed to the competition of the seed oils, has guided the research team of the Laboratory of Ecosystem Management of the University of the Aegean, to the study of the olive trees in the Greek islands starting with the island of Lesvos. The change in land use due to the abandonment of such agricultural areas has an impact to the local economy and to the environment. In the areas where agriculture is abandoned and in the case that no other alternative resources are developed, the result is population shrinkage (Giourga 1991). In such cases it is necessary to take certain actions to preserve the existing environmental conditions which if they loose the people who naturally maintain them, there is the danger of degradation because of the change in land use from agriculture to pasture which usually happens in the Greek islands (Margaris 1987, Giourga 1991). This study of the olive trees in

the Greek islands is performed in cooperation with the Laboratory of Remote Sensing at the University of the Aegean and using Landsat TM imagery.

CLASS CATEGORIES

The precise estimate of spectral signatures to determine the land cover encounters many difficulties due to the nature of the agroecosystems which are developed in the island. Some of the difficulties are: the very small size of land parcels, the cultivation of a great variety of vegetation species which include annual plants and wooded types of a mosaic shape, the abandonment of variable sized areas cultivated with olive trees in different locations, the difference in the types of natural vegetation which grows up in the abandoned olive tree areas (phrygana or maki) etc. It is also important to note that the entire island of Lesvos is not covered by areas of uniform type of vegetation species but by a mixture of species which are difficult to be determined. Exception to that are areas covered by phrygana, pine trees and olive trees which compose groups according to selected features.

In order to maintain homogeneity for selected land cover types with meaningful environmental information curried on different signatures of the Landsat-TM spectral bands (Davis F. & Dozier J, 1990, Lillesand & Kiefer 1987, Peng Gong & Howarth 1990, Swain & Davis 1978, Zhenkui Ma & Olson 1989) the olive tree land cover was divided into five class categories as follows:

Class-1:
Olive trees of high crop production. The trees in this category have about a uniform and symmetric shape. The density of the trees is such that the reflectance recorded in the imagery is entirely attributed to the trees and there is no reflectance from the terrain.

Class-2:
Olive trees of moderate crop production. They are not enough dense to completely cover the terrain and their development is not symmetrical. The area covered by the canopy of the tree is larger than the area of the uncovered ground.

Class-3:
Olive trees irregularly shaped and having parts destroyed from frost, disease or drought. The area of the ground covered by the canopy of the tree is smaller than the area from uncovered ground.

Class-4:
Olive trees abandoned in recent years (about 10-years). The canopy covers a limited area and the ground is covered with self grown vegetation composed of grass and bushes.

Class-5:
Olive trees abandoned for many years. The live parts of the existing olive trees tend to disappear giving their place to self grown vegetation which is of a shrub and brush type and exceeds in high the remains of the olive trees.

The remaining classes were composed of uniform groups such as: (6) sea water, (7) bamboo or calm, (8) pine trees, (9) Phrygana or garig, (10) urban areas, rock & bare soil, (11) maki-like olive trees, (12) a group of wooded type of vegetation composed of a large number of different species called maki, (13) the remaining grass type of vegetation.

GROUND SAMPLES

It was given an effort to take ground samples from different areas of the island involving all class categories. The following Table 1 gives the magnitude of the samples:

TABLE 1. Representative samples of all categories from different parts of the island.

No.	CLASS CATEGORY [symbols on the map Fig. 2]	x1000 m² Area	Pixels
1	Olive trees of high crop production [e1]	235	261
2	Olive trees of moderate crop production [e2]	120	134
3	Olive trees suffering from frost, disease or drought [e5]	9	10
4	Olive trees abandoned in recent years [e11_g7]	12	13
5	Olive trees abandoned for many years [e11_t3]	22	24
6	sea water [sea]	10000	1111
7	Hydrobiotopes [kalm]	90	100
8	Pine trees [p]	75	83
9	Phrygana [garig12]	113	126
10	Bare soil, rocks, urban areas [urban_soil]	300	333
11	Olive trees abandoned for many years (Maki-like) [e_m]	38	43
10	Maki vegetation [maki_1]	52	58
13	Other type of vegetation [veg]	150	166

The magnitude of those samples was chosen to be sufficient according to the size of the corresponding areas of land cover (Lillesand & Kiefer 1987, Mather 1987, Swain & Davis 1978). Some of the ground samples were also used for quality control. The location of the ground samples was estimated from 1:50000 scale maps.

PROCESSING OF THE LANDSAT-TM IMAGERY

The image processing was performed in the Laboratory of Remote Sensing at the University of the Aegean using the PC-ERDAS package. Fig. 1 shows the processing steps. The original Landsat-TM imagery was obtained on June 20 1992. The first step as shown in Fig. 1 was to perform radiometric enhancement (histogram equalization), Geometric

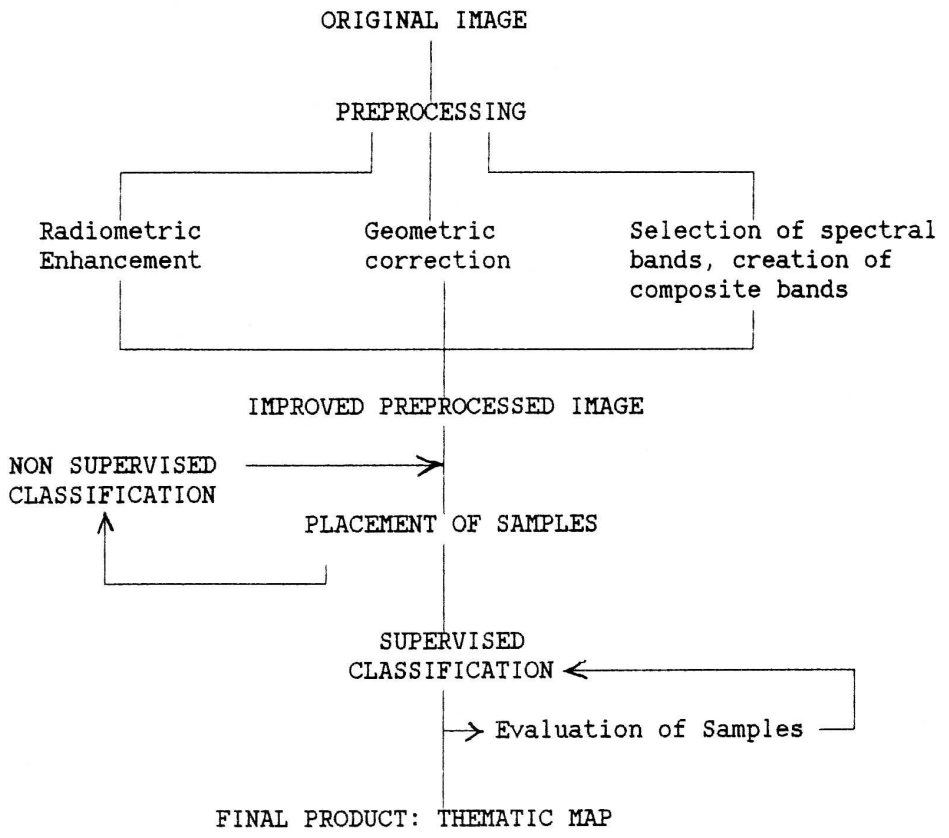

Figure 1. Processing steps.

correction to resample the image on a UTM reference grid (Richards 1986) and to select the TM spectral bands for the classification. The selected spectral bands were 1, 2, 3, and 4 from the Landsat TM imagery plus a composite band No. 5 based on the NDVI and defined as follows:

$$\left[\frac{TM4 - TM3}{TM4 + TM3} + 1 \right] * 127$$

Those bands were selected for the classification taking into consideration work done by: Mausel et al 1991, Peng Gong & Howarth 1990, Zhenkui & Olson 1989 and by running several experiments to make sure that the selected bands provide the required accuracy for this project.

In the second step the sampling area polygones are defined in the image and an unsupervised classification is performed to assure separation clusters for the known categories and check for mistakes and errors (Richards 1986).

In the final step, half of the sample areas were used to perform supervised classification for the given classes and the remaining half of the sample areas were used for check. This process was applied iteratively to insure consistency of the data in the sample areas. Finally supervised maximum likelihood classification was applied to the image using all samples thus obtaining the final results.

The signatures of all categories of land cover are shown in table 2:

TABLE 2. Signatures of olive tree categories

No.	Band 1		Band 2		Band 3		Band 4		Comp-b-5	
	min μ	max σ	min μ	max σ	min μ	max σ	min μ	max σ	min μ	max σ
1	18	23	16	18	23	27	63	75	179	192
	20	1.5	17	0.6	25	1.4	67	3.6	184	5.2
2	24	41	21	31	32	48	67	87	160	178
	32	4.2	26	2.9	40	4.6	79	5.0	168	4.3
3	21	29	18	21	26	28	57	65	172	177
	24	2.6	19	1.2	27	0.5	60	3.0	175	1.8
4	21	28	19	21	28	31	53	57	164	170
	25	2.6	20	0.8	29	1.2	56	1.6	167	2.0
5	30	34	23	29	38	48	64	70	150	161
	32	1.7	26	1.5	42	2.8	67	2.4	156	3.5
6	8	21	3	10	2	10	3	8	84	169
	13	1.7	6	0.9	6	1.0	5	0.7	117	10.3
7	14	24	16	23	16	28	102	129	199	225
	19	2.1	19	1.5	20	2.7	114	6.5	215	5.7
8	10	25	11	20	14	28	40	59	170	196
	15	3.0	14	1.7	19	2.8	50	4.0	185	5.4
9	42	61	30	44	48	73	58	82	134	142
	50	5.2	37	3.6	59	6.3	71	6.5	138	1.8
10	48	99	34	75	50	107	58	109	128	155
	66	9.8	47	6.5	68	8.6	81	7.3	138	5.2
11	12	21	14	18	18	26	48	53	168	184
	18	2.3	16	1.3	22	2.6	51	1.7	176	4.7
12	8	14	10	15	11	18	55	77	196	219
	10	1.8	12	1.0	14	1.8	66	5.3	208	6.2
13	21	35	18	30	25	48	56	73	152	182
	30	3.5	24	3.0	37	5.7	67	4.6	164	6.4

CLASSIFICATION RESULTS

A portion of the classification results (Mytilene area) are shown in Fig. 2. The final results, shown in Table 3, were compared with data obtained from the Hellenic National Statistical Service which keeps records for the total area covered by olive trees which was 449326 x1000 m². The difference of this value and the total area shown in Table 3 is about 17% which is considered acceptable for this project.

TABLE 3. Results of olive tree classification (Lesvos)

CLASS CATEGORY	x1000 m²	%
Olive trees of high crop production	66860	18
Olive trees of moderate crop production	141560	38
Olive trees suffering from frost, disease or drought	70850	19
Olive trees abandoned in recent years	63426	17
Olive trees abandoned for many years	29790	8
TOTAL	372489	100

CONCLUSIONS

The use of remote sensing for environmental applications such as the desertification of the Greek islands provided valuable information in an easy reliable and low cost manner. The results exceeded the expectations for this project and in many cases classified land cover information was tested and found to be more reliable than information from existing maps of the same area.

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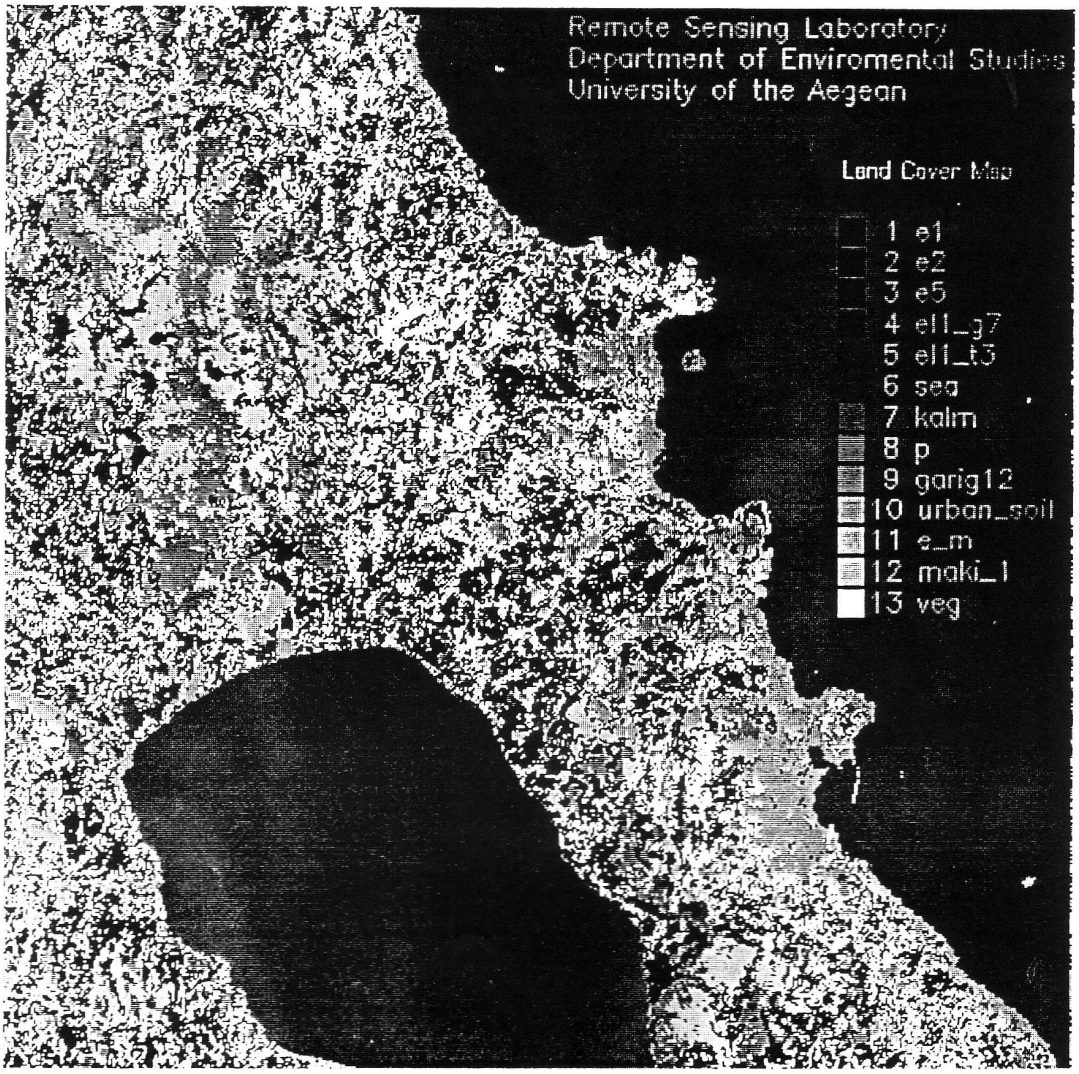

Figure 2. Classification results in raster presentation.