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Evaluation of Land Use Changes of Ilia's Prefecture Using Geographical Information and Contemporary Satellite Techniques

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Abstract: This thesis has as main objective, first to describe the changes in land use in the prefecture of Ilia (located in the western part of the Peloponnese-Southern Greece) during the period 1987-2014, and second to study the impact of mega fires on the environment through the use of advanced remote sensing techniques and satellite data. Particularly, three Landstat satellite images of the years 1987, 2004 and 2014 were used for the analysis, which was performed using 5.2 ENVI and ArcGIS 10.1 remote sensing software's. All data have been radiometrically and atmospherically corrected and subjected to analysis. Exported raster data were further classified using high resolution oobject based image analysis. The application was done using supervised and non-supervised classification techniques. Classifications results were used for visual and qualitative comparison of changes in land cover over the survey area. Moreover, in order to assess the classification results, field work was also carried out, in which site specific data were obtained, and classification classes were redefined. Classification results, for the three reference years, were mapped accordingly to create land cover maps for each case. Eventually six land cover change maps were made; two for any combination of two reference years. On the basis of the results obtained, it is shown that land covered by the provisions of the Forestry Law (Aleppo pine forests and scrubland) slightly exceeds 50% and shows a slight upward trend. The areas covered by evergreen bushes — broadleaf exhibit during 2007-2014 a significant increase due to the great fire of 2007. Finally, several changes occurred in the land use and associated with the expansion of agricultural land.

Key words: remote sensing, GIS, landstat, timeless use/land cover changes, object classification

1. Introduction

The use of remote sensing technique in the detection and the monitoring of changes in land use in the prefecture categories, with major significance in the environmental protection, focuses on the spectral and spatial properties of vegetation and the surrounding environment. The changes observed in these characteristics are measurable over time and there is the possibility to attribute the time dynamics of the changes that occur, contributing to their understanding. In order to be measured the changes in vegetation and in other soil characteristics over time, it is necessary to first determine the relevant groups or species of vegetation observed at a given time (reference time) and how these then evolve due to anthropogenic or non-causes. Mapping and control researchers use statistical, computational, and cartographic methods to incorporate, analyze, and map telescopic data, as well as other spatial information.

Long-term studies concern a wide range of applications in Geosciences. Examples of such applications are the recording of changes in forest areas,

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the monitoring of coastal changes, the recording of floods, forest fires, deforestation, etc.

In this context, the aim of the present study is to demonstrate the change over time - change of land uses in the Prefecture of Ilia from the earliest years until today and mainly the change after large fires (fire of 2007). Sub-objectives are to highlight the changes and the degree of change of land uses in forest areas, rural areas and urban areas with the use of GIS and modern telescopic techniques.

1.1 Literature Review

The exploration of land use changes detection began several years ago. In 1977, Angelici et.al. developed the first techniques for detecting land use changes using Landsat images, leading to the revelation of the nature of the change and also to numerical results of land use areas. In general, the detection of changes involves the use of longitudinal data, in order to separate land cover areas, which change between the dates the images were taken [1]. In Forest Science, numerous studies have used satellite data over time, especially data provided by the Landsat TM recorder, to identify and to record land uses [2-5]. From a forestry perspective, perhaps the most important application of satellite data is the distinction and the mapping of forests and forest areas, as well as the calculation of the area occupied with precision determined by the spatial resolution of the available images.

2. Material and Methods

2.1 Geographical Location

The research took place in the wider area of the Prefecture of Ilia (Fig. 1). The prefecture of Ilia is located in the North-West part of the Peloponnese and has an area of 2,618 km². It is bordered on the north by the Prefecture of Achaia, on the east by the Prefecture of Arcadia, on the south by the Prefecture of Messinia and on the west by the Ionian Sea. The surface of Ilia is basically lowland. Of 2,618 km², 609 km² are mountainous, located in the northeastern part (border with Achaia), in the eastern (border with Arcadia) and in the southern (border with Messinia). In the rest of the prefecture, west and north of these mountainous parts, lies the plain of Ilia, which is the largest in the Peloponnese area.

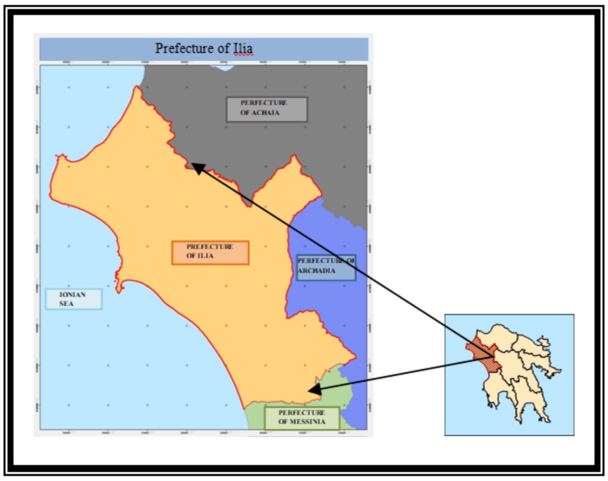

Fig. 1 Study area.

2.2 Methodology and Work Stages

The stages of work of the methodology followed by the present paper in order to achieve its objectives are the following:

(a) The first and most important step concerned the selection of the study area and the search and the collection of data

(b) The second stage involved the use of a Geographic Information System for the proper preparation and creation of the necessary thematic maps and the corresponding databases. The information provided by the above thematic maps formed the basis on which the next steps were based.

(c) The third stage included all steps for editing three Landsat 5TM and Landsat 7 ETM + satellite imagery, from different shooting dates in 1987, 2007 and 2014, with the aim of recording land use/coverage, using the supervised classification method. Then, the changes that took place during the periods 1987-2007 and 2007-2014 were determined by the method of comparing the sorted images. At the same time, a description was made on the design and the execution of the outdoor data, the spectral confusion problems which were observed during the classification of the image, and the assessment of the accuracy of all produced thematic maps of land use / coverage and the detected changes.

(d) Finally, in addition to the technical part of this research, great attention was given to the investigation of the causes that create or favored these changes.

In addition, the aerial photographs were processed at this stage, from the years of 1945, 1960, 1986, 1997 and 2008. The analysis was based on the distinctions of forest vegetation from forest legislation in combination with the distinction of land uses given by the Corine Land Cover program.

The conceptual model of this paper is presented in Fig. 2.

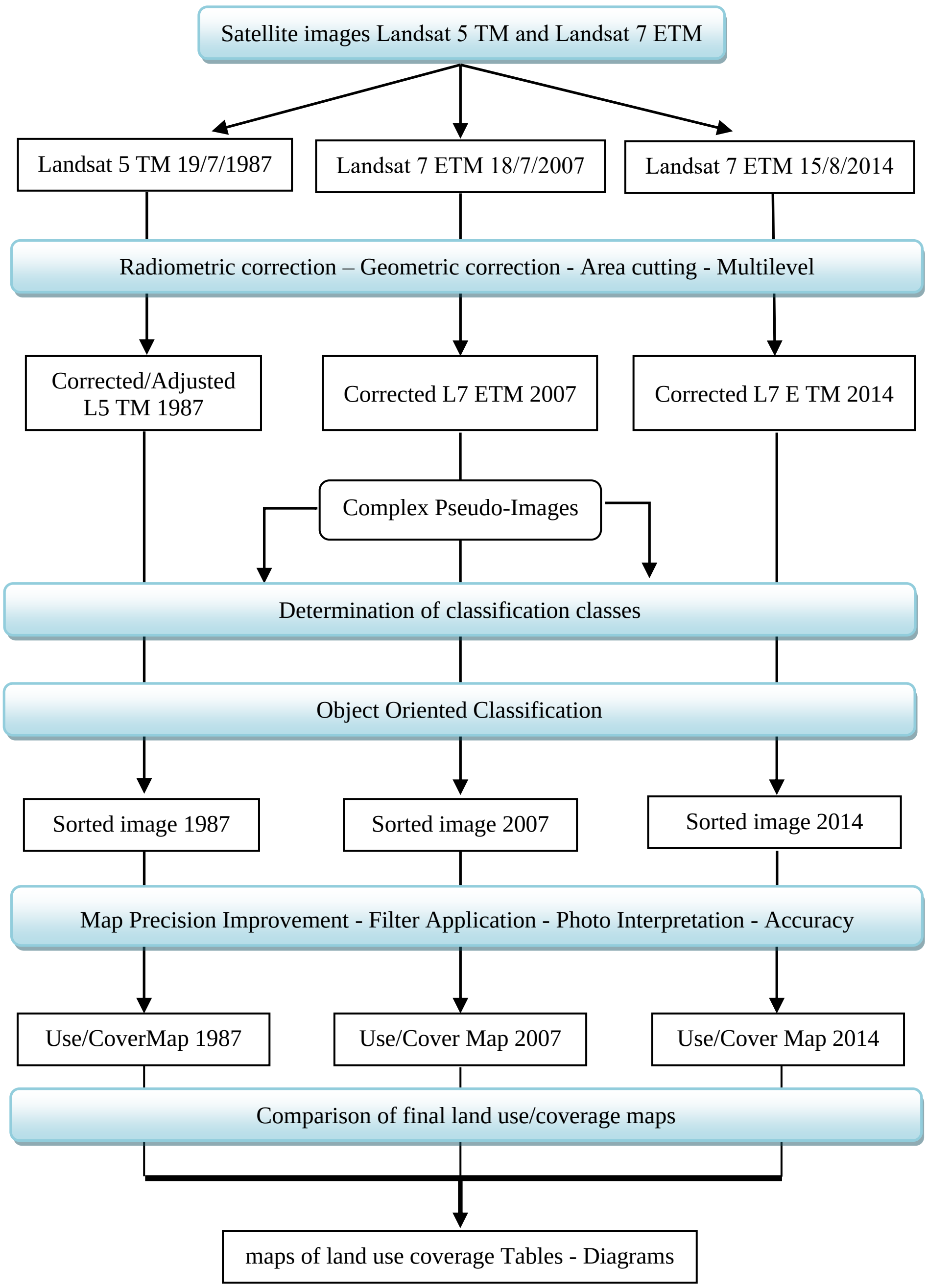

Fig. 2 Conceptual model.

2.3 Processing Software and Data

In order to achieve the goal of this paper and the execution of the above model, the ENVI 5.2 satellite image processing software of EXELIS and the GSP software were used. ArcGIS 10.1 of ESRI.

The following data were collected for the application of the method:

- LandsatTM satellite imagery with download dates in July 1987, 2007 and 2014 [6].
- The digital altimeter model (D.E.M.) (Source: YPEKA - Ministry of Environment & Energy).
- Satellite images of Google Earth dated at 28-7-2007 and 28-7-2014.
- The orthophoto maps of the Ministry of Agriculture for the year 1996 (Source: YPEKA).
- The orthophoto maps of the Greek National Land Registry of the year 2007 (Source: EKHA)
- The aerial photographs of the Prefecture of Ilia dated in 1945 and 2008 of the Directorate of Forests of the Prefecture of Ilia (Source: Directorate of Forests of Ilia)
- Data from the European Corine Land Cover program for the year 2000.
- Field data. An on-site autopsy was performed for visual observation and recording of land use /coverage areas, similar to the defined classes. The autopsy in the area was performed in the presence of experienced rangers, confirming the over time or the unstable land cover of these areas.
- The boundaries of the Prefecture of Ilia in a vector file (shp) from the website of the ministry [7].

With the aid of ENVI software, satellite imagery (LANDSAT) was corrected radiofrequently and then atmospherically using the FLAASH method. Finally, the images were adjusted to the limits of the study area.

2.4 Selection of Object-Oriented Classification Method

In the present study, the object-oriented image classification was selected, in order to investigate its usefulness regarding the classification of land use/coverage in the study area, including the specific characteristics that distinguish it (large area, heterogeneity of land use/coverage, intense morphology change, small and fragmented agricultural holding, etc.).

The object-oriented approach has the advantage of introducing spatial proximity properties between objects in the classification process [8]. These properties of objects can compensate for the technical weaknesses of the classifiers in issues regarding the distinguishing between classes, and produce a more realistic representation of the types of the ground surface, if compared with methods based on pixels [9]. The combination of spatial information and spectral characteristics of objects has generally greatly improved the accuracy rates of classifications [10-13]. The application of classification algorithms (supervised or not) to objects offers advantages over methods based on pixels. In the object-oriented image analysis, conceptual, spectral, scale, texture information is introduced, which are integrated in the feature space of the supervised classification, and in the hierarchical structure of its rule set. This kind of information creates new possibilities for increasing the quality of classifications [14]. Particularly, LandsatTM's data classification for mapping land cover types using the object-oriented image analysis method has been found to improve mapping accuracy by 90.67%, compared to 81.67% of the supervised classification method which is based on the analysis of pixels [15].

The object-oriented image analysis is closer to the human eye than the per-pixel analysis. Studies dealing with classification methods have shown that object-oriented analysis achieves greater accuracy in classification, as well as more detailed class distinction [16, 17].

The techniques of object-oriented classification better represent reality by introducing concepts of relationships between the objects of the image. In this way, a hierarchical network of its objects is created, determining clearly the relationship of each object with its neighbors, the sub-objects that form it, as well as the super-objects that surround it (Fig. 3).

Taking into account the above, the classes defined in this study were a total of eight (Table 1).

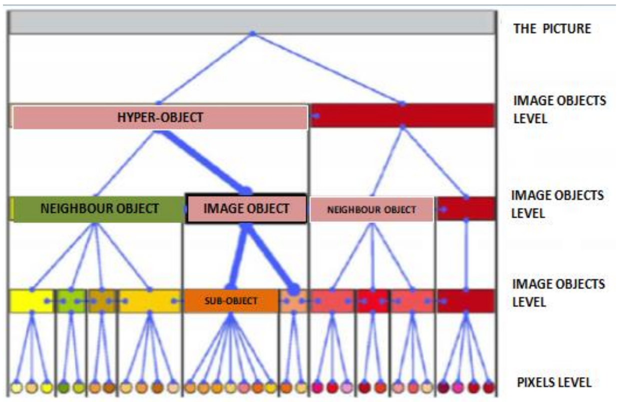

Fig. 3 Hierarchical network of image objects.

Table 1 The classification of the study.

	Description	Uses
1	Coniferous	Areas covered by conifers higher than 2 m with sparse or dense coverage.
2	Broadleaved	Areas covered by broadleafs larger than 2 m with sparse or dense coverage.
3	Sclerophyllous vegetation/transition forest areas	Areas covered by high shrubs of evergreen broadleaves/areas located on forest boundaries
4	Shrubs	Areas covered by shrubs
5	Sparsely vegatated areas	Surfaces covered by low vegatation with relatively sparse density.
6	Agricultural areas	Plowshares, tree-grown arable lands
7	Other coverages	Settlements, industrial areas, rocky outcrops, quarries, areas covered with snow, etc.
8	Waterbodies	River lakes etc.

2.5 Application of Object Classification

Before the development of the model, auxiliary data were created which were introduced in the program as additional processing levels. Areas with agricultural crops have been exported as a vector archive from the CORINE 2000, in order for the classification to be limited to the rest of the classes. This was deemed necessary due to the spectral similarity of rural areas with other classes (e.g., irrigated fields — broadleaf vegetation, non-irrigated fields — bare areas). The resulting polygonal vector level functioned as a thematic level for the definition of the primary domain analysis. In addition, the Normalized Difference Vegetation Index (NDVI) was calculated in order to be introduced as a thematic level. Its introduction was considered necessary due to its ability to distinguish vegetation from other categories. Finally, after multiple "trial and error" method procedures, a customized indicator was calculated in identifying differentiating characteristics, which was called "SUM" and was used because it was found to be able to separate the vegetation classes from each other. NDVI and SUM were calculated from the following types.

The categories of changes as coded for this study are:

- Agricultural lands that have changed. This change mainly shows the pressures of abandoning the marginal lands or the urbanization of the agricultural land. In combination with the next change, the image of the rapid rearrangement of the agricultural space during the study period is formed.
- Areas converted to agricultural. The expansion of agricultural land as one of the key changes to the
- detriment of natural vegetation and land coverage is analyzed.

- Forests that have changed. Here, all the changes that have taken place to the detriment of the country's forests
- are captured and analyzed, regardless of whether they relate to conversion to agricultural cover or to other categories of natural vegetation. These individual changes are analyzed in the previous and the next category, respectively.
- Forests that have been turned into low and bushy vegetation areas. This change is a subcategory of the previous one and is extremely useful as in most cases it indicates the effect of forest fires.
- Areas of low and shrubby vegetation that have been turned into forests. Correspondingly, this reverse trend is significant as it indicates either the recovery of forests burned before 1987, or the reconstruction of forests due to the reduction of pressures in the primary sector.

With the help of the interoperability between the software of ENVI 5.2 and ArcGIS 10, the raster files created in ENVI were transferred to the desktop of ArcGIS, and then for each period of the study, the thematic land cover maps and also thematic maps of land cover change categories, depicting the spatial distribution of these changes, were created.

3. Results and Discussion

3.1 Time Period 1987-2007

During the period 1987-2007, 123,473.00 acres of agricultural land were converted into other coverages (Fig. 4). This change is more striking in the mountains and is mainly related to the installation of low vegetation and shrubs (47% and 31% on earth respectively).

While during the same study period 80,850.00 acres of distinctions were converted into other available caps (Fig. 5). This size corresponds to 33.39% of the total exposure required to cover the forests in 1987. The largest percentage of forests converted to other types of

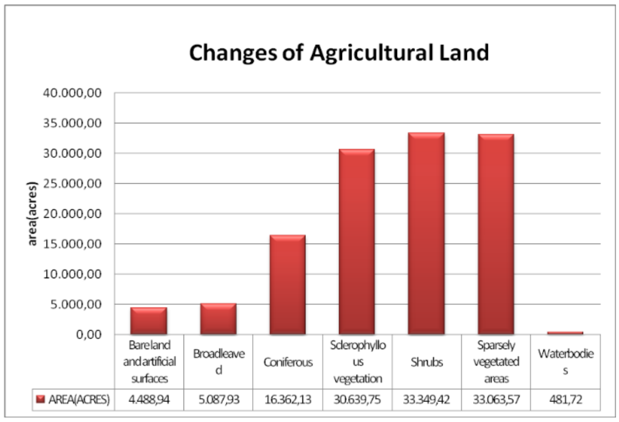

Fig. 4 Change of agricultural land.

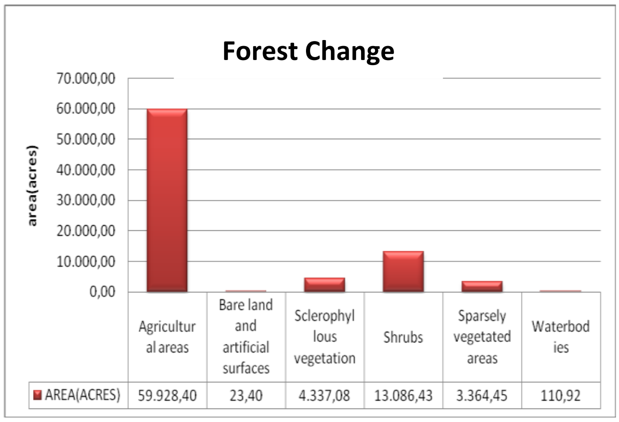

Fig. 5 Forest change.

coverage gave way to agricultural lands (more than 70% of this change).

3.2 Time Period 2007-2014

During the period 2007-2014, 529,659.61 acres of agricultural land were converted into other coverages. This change is more pronounced in the mountains and is mainly related to the installation of low vegetation and shrublands (47% and 31% on the land respectively). It is remarkable however the change of agricultural land to artificial surfaces of about 70,000 acres and the change of agricultural land to shrubs of evergreen broadleaf (Fig. 6).

For the same study period, approximately 121,893 acres of forest were converted to other types of cover. This size corresponds to 64.06% of the total area covered by forests in 2007. The largest percentage of forests converted to other types of cover gave way to

Shrubs of Clover Leaves (more than 60% of this change) (Fig. 7).

The results of the classification for all three time dates are shown in Table 2 and Fig. 8.

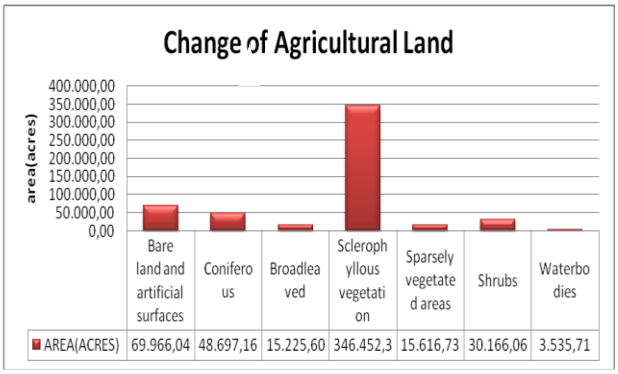

Fig. 6 Change of agricultural land

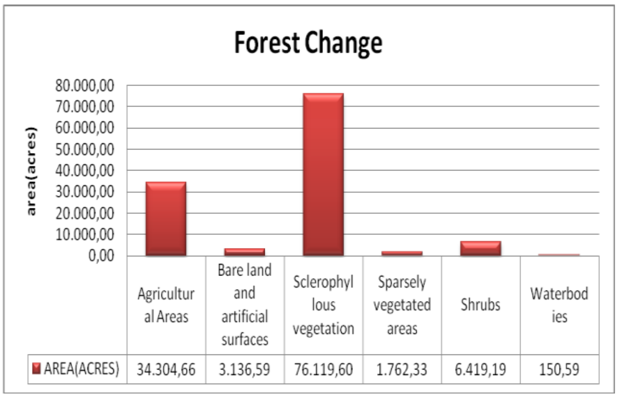

Fig. 7 Forest change.

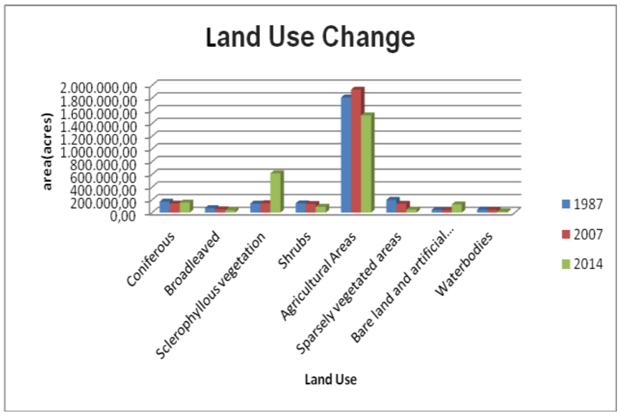

Fig. 8 Land use change for the years 1987-2007-2014.

4. Conclusion

4.1 Time Period 1987-2007

The general trends presented in the study area are the increase of cultivated areas (approximately 124,200.00 acres) and of areas with evergreen broadleaves, (approximately 5,140.00 acres) and the reduction of natural forest vegetation and pastures (low vegetation areas + Shrubs).

The main reasons for the changes in the distribution of land use/coverage were the intense urbanization, the increase of the population in the lowland areas and the modernization of the road network, which has as a direct consequence the intense urban expansion and the improvement of transport. Furthermore, forest ecosystems are under more pressure in areas with strong tourist traffic and in areas with high economic value (coastal areas).

Table 2 The results of the classification for the three -under investigation- snapshots.

		1987		2007		2014	
No.	Type of land use/coverage	Area (ACRES)	Percentage (%)	Area (ACRES)	Percentage (%)	Area (ACRES)	Percentage (%)
1	Coniferous	172,434.22	6.57	140,878.52	5.37	157,323.60	6
2	Broadleaved	69,737.21	2.66	50,765.33	1.93	36,684.90	1.4
3	Sclerophyllous vegetation	141,074.81	5.38	146,214.10	5.57	616,806.90	23.51
4	Shrubs	145,189.31	5.3	134,911.20	5.14	92,084.40	3.51
5	Agricultural areas	1,808,433.80	68.92	1,932,623.00	73.65	1,528,893.90	58.27
6	Sparsely vegetated areas	199,073.59	7.59	137,962.08	5.26	46,751.40	1.78
7	Bare land and artificial surfaces	42,297.35	1.61	37,713.09	1.44	128,546.10	4.9
8	Waterbodies	45,683.50	1.74	42,856.46	1.63	17,648.10	0.67

4.2 Time Period 2007-2014

Based on the results recorded in the table, the following observations emerge:

a) Coniferous forests show an increase of 0.6% compared to 2007 (16,450 acres), and this is mainly due to the development of natural regeneration, while broadleaf forests show a slight decrease of 0.54%. (14080 acres). In total, a small increase in forests by 2360 acres is observed. The main changes made for other use/coverage are to artificial surfaces by 3,140 acres (2.57%) and 34,305 acres (28.14%) to crops. The biggest change, however, is the forests to bushes of evergreen — broadleaf with 76,120 acres (62.45%). This change is mainly due to the fires, with the most important being the large fire that broke out in the summer of 2007, as well as the impact of the human factor, with the extensive deforestation and logging that took place in the area.

b) the crops show a significant reduction in their area by 404,000 acres (15.40%). This significant reduction in cultivated land is due to many reasons. The main reason is the reduction of subsidies for certain crops, as well as the disconnection of production from the subsidy in some of them. The main reasons for the changes in the distribution of land use/coverage were the intense urbanization, the increase of the population in the lowland areas and the modernization of the road network, which has as a direct consequence the intense urban expansion and the improvement of transport. Moreover, the European agricultural policy of subsidies for specific crops has led to the replacement of many non-profitable crops, especially in the last decade, with other more profitable crops or to a state of state of fallow farming and cultivation. Also, while in the period from 1987 to 2007 there is a small increase in cultivated areas, mainly to the detriment of natural vegetation, in the period 2007-2014 there is a decrease. This is due to the intensification of crops recorded in recent decades that has slowly begun to lead to the creation of barren lands. These soils can either no longer be cultivated or yield very low yields, resulting in being abandoned and turned into barren lands or pastures.

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