# OBSERVATION OF THE CHANGES AND THE DEGRADATION OF THE FORESTS AFTER THE FIRE WITH THE USE OF REMOTE SENSING AND GIS: STUDY OF THE SUBURBAN FOREST OF SEICH-SOU, THESSALONIKI, GREECE

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## ABSTRACT

The issue of forest fires is an important environmental matter of the Mediterranean countries. During the summer months, with the high temperatures and the strong winds, fires are often caused with negative effects both for the environment and the human activities. Thus, information is demanded, on the position and the extent of the burnt areas, but also on the state of the vegetation after the fire. Remote sensing data are used successfully for the observation of the forest fire. They also allow the display of the results, helping that way the procedure of deciding and organizing the actions that must be done after the conflagration. The contemporary satellite systems of high spatial and spectral analysis allow on one hand the raising of useful geometrical information and on the other hand the determination of the burnt areas with high precision, exploiting techniques of classification. Furthermore, the use of GIS facilitates the cartographical presentation of the Remote sensing data and they allow the quantification of the effects of the fire. In the current study, the suburban forest of Seich-Sou of Thessaloniki (Greece) and the changes that resulted in it, due to the major conflagration of 1997 (the 55% of the total area was burnt) is examined. More specifically, satellites from three different time periods were processed. For the state of the forest before the fire, a panchromatic image from the satellite system was used. For the period after the fire, images from the satellite system SPOT – 4 were used, whilst for the valuation of the present situation images from the satellite system WV-2 were utilized. In those images a temporal classification of the coverage of the earth was performed. The results of the classification and the satellite images were entered in GIS, in order to locate the changes that occurred, not only by the fire, but also by the human activities. The changes were examined according to the current institutional situation, and the control of the legitimate or not, activity that was detected, relatively to the building structures, the agricultural cultivations and the other usages in the reforested area was attempted.

**Keywords:** Remote Sensing, IRS, SPOT-4, WV-2, GIS, Forest Fire, Forest Degradation, Classification, Change Detection

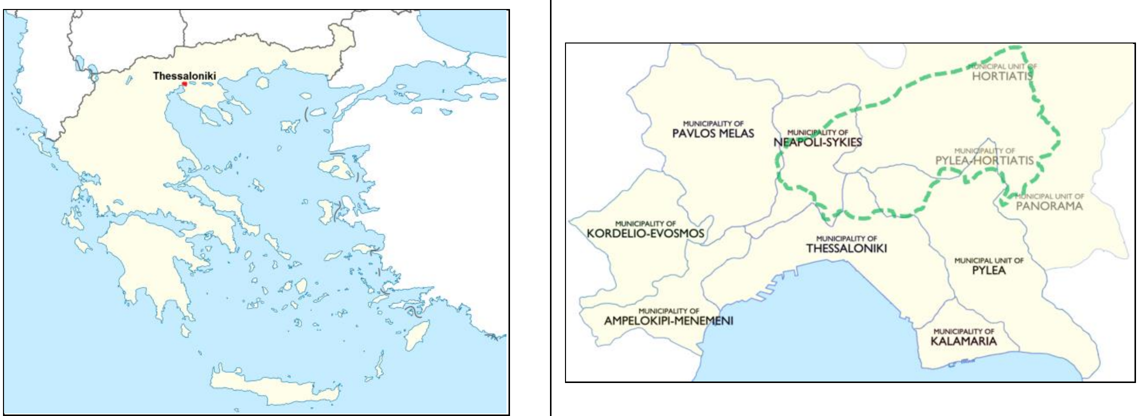
## 1. INTRODUCTION

Forests, as part of natural ecosystems of the planet, have great value to human being and to the environmental balance in general. However the damage that has been caused by humans such as the fairs that break out in them, the uncontrolled logging etc., puts forests in risk. Especially in the Mediterranean area where the situation is deteriorated, the risk of fire is high due to the type of vegetation and the climatic conditions that occur especially during the summer months (Vila et al., 2001). According to studies, during the period 2000-2006, only in Southern Europe, an average of 450.000 hectares of forest

area was burned annually (IEEP, 2008), which caused serious problems to both the environment and human activities. Thus, there is a need for prevention and monitoring of the phenomenon of forest fire such as data acquisition in order to tackle the problem and collection of data and information, so as to be taken and managed decisions (Popescu et al., 2012).
The remote Sensing and Geographic Information System (GIS) represents science fields of Geomatics, which are indicated for the management/ analysis/ monitoring of the environment (Chuvieco et al., 2005). On the one hand, Remote Sensing can contribute in this direction by receiving and processing satellite images. This procedure can give adequate data about the former state (Mitri and Gitas, 2010). The contemporary satellite systems, with their advanced features and high spatial resolution, allow the collection of up to date data (Calle et al., 2011). While the technical classification of satellite imagery is successfully used for accurate mapping of burnt areas (Kartalis and Feidas, 2006). On the other hand, the use of GIS, in this kind of studies, is the basis for developing a tool management and organization of forest areas, fire predictions, mapping and quantifying the effects of fires.
In this paper the authors attempt to identify the changes that occur in the suburban forest of Seich-Sou in Thessaloniki (N. Greece, Figure.1a), due to the huge fair that broke out in 1997, using satellite images from different periods before and after the event and also using GIS. Moreover, is attempted to control the legality of the anthropogenic interventions, which were carried out in the forest area, according to the framework of the protection of the urban forest.

## 2. THE AREA OF STUDY

The suburban forest of Seich-Sou is located in the north of the urban complex of the city of Thessaloniki (N. Greece, Figure 1b) and adjoins with it. The area can be described as hilly and the terrain is described as smooth. The altitude is fluctuated between 80 to 563 meters. In the majority of the areas the slopes vary between 20 to 50 per cent. This forest is artificial and its creation began in 1912. In 1973 the reforested area of 2.979 hectares is delimited, which exists until today. The forest of Seich Sou is protected by DG 2193/1973 (Government Gazette, Gazette, 1322V '/ 1973), decision of the Prefect of Thessaloniki, the strength of which reinstated by DG 1157/1990 (Government Gazette, Gazette, 240D; / 1990) similarly prefect decision, which analyzed the ownership of 2.979 hectares that were declared as reforested and its limits.




a) b)

**Figure 1. a)** Greece and the city of Thessaloniki, **b)** Thessaloniki and the suburban forest of Seich-Sou (Doted area)

## 3. MATERIALS AND METHODS

### 3.1 DATA

In order to collect information about the situation of the suburban forest before, immediately after the fire of 1997 and the current situation, timeless images from satellite system IRS-1C, SPOT-4 and WorldView-2 were used (Table 1). For the geometric correction of images were used orthorectified images of 2006, spatial analysis 0,50 m and the Digital Terrain Model (DTM) of the study area. To determine the limits of reforestation area and find the ownerships that exist within the forest area, topographic maps were used DG 2193/1973 (Government Gazette, Gazette, 1322V '/ 1973). That map defines the boundaries of the reforestation area, the areas excluded from this, as well as the ownership.

**Table 1.** Characteristics of satellite images

| Satellite | Type of image | Date | Spatial Resolution |
|---|---|---|---|
| IRS-1C | Panchromatic | 29/6/1996 | 5,8 m |
| SPOT-4 | Panchromatic | 25/8/1998 | 10 m |
| SPOT-4 | Multispectral | 25/8/1998 | 20 m |
| WorldView-2 | Panchromatic | 16/6/2010 | 0,5 m |
| WorldView-2 | Multispectral | 16/6/2010 | 1,6 m |

### 3.2 METHODS

#### 3.2.1 REMOTE SENSING

The satellite images were corrected geometrically (methods of image registration and resampling) (Richards, 2013), selecting control points between the image and the existing orthorectified images of 2006 in Greek Geodetic Reference System of 1987 (EGSA-87) and using the DTM of the area. The data processing made using the software ERDAS IMAGINE 2011.
For the panchromatic image IRS, 70 Ground Control Points (GCPs) were identified, that adequately allocated in the area. The average accuracy that obtained was 1,0341 pixel or 5,99 meters.
As for the satellite images from SPOT-4, a compile of multispectral and panchromatic image was made, in order a new image to be created, which will obtain the spectral information of the multispectral and the high spatial resolution of the panchromatic (Levin, 1999). The complex satellite image, that revealed, has spatial resolution of 20 meters. For the composite satellite image, 50 Ground Control Points (GCPs) were detected, while the mean accuracy that obtained was 1,0249 pixel or 20,50 meters.
As for the satellite images from WorldView-2, composition of multispectral and panchromatic image was held so as a new image was created, which has a better spatial resolution. The synthetic image that occurred has spatial resolution of 0,5 meters. For this image, 70 Ground Control Points (GCPs) were identified, that well distributed a comparison with the entire area. The average accuracy that obtained was 1,6180 pixel or 0,81 meters.
For the determination of individual land cover and the connection of spectral characteristics of the image in a substantial category of information, a supervised classification of satellite imagery was made (Weber and Dunno, 2001). In this way, the spectral characteristics of the image were matched with groups of common elements, the classes, so to achieve the evaluation of landscape and the quantification of various land cover. During the image classification SPOT-4, 8 classes were identified, (Table 2), while

the overall accuracy of classification was calculated 80,2%. The classification's result is shown in Figure 2.

**Table 2.** Classification of satellite image SPOT-4

| **Classes** | |
|---|---|
| Paved road | Vegetation 2 |
| Burnt area | Forest road 1 |
| Buildings | Forest road 2 |
| Vegetation 1 | Forest road 3 |

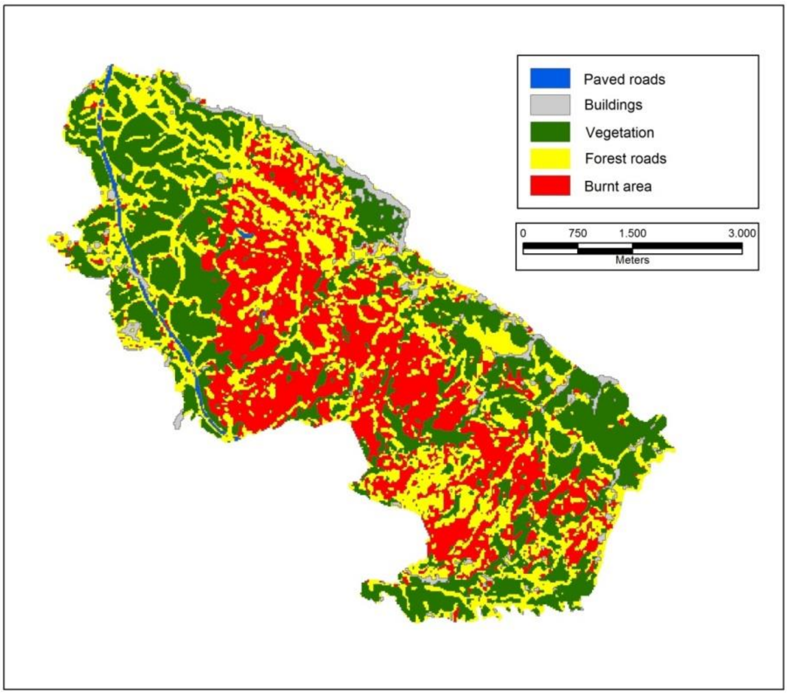



**Figure 2:** Classified image SPOT-4 after the fire

For the classification of synthetic satellite image WorldView-2, 13 different classes were identified (Table 3). For each of the above classes several training areas throughout the study area were selected, in order to achieve the best result (Figure 3). The accuracy of classification of WorldView-2 image was estimated 90,8%.

**Table 3.** Classification of satellite image WorldView-2

| **Classes** | |
|---|---|
| Paved road 1 | Ground 1 |
| Paved road 2 | Ground 2 |
| Vegetation 1 | Forest road 1 |
| Vegetation 2 | Forest road 2 |
| Vegetation 3 | Forest road 3 |
| Agricultural cultivation | Tile surfaces |
| Buildings | |

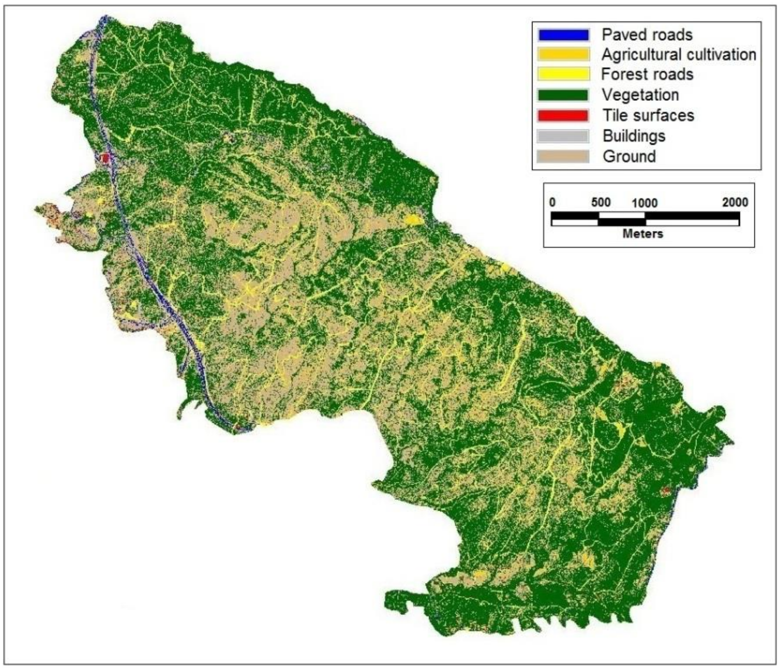



**Figure 3:** Recent classified image, WorldView-2.

### 3.2.2 GIS

For further procession of data Geographic Information System has been used, which allows the quantification and the cartographic presentation of data. In this paper the software ArcGIS-ArcMap 10 was used. Initially, classes of similar covering materials were grouped, while afterwards an attempt was made in order to improve the presentation of the classified image SPOT-4. For this reason, road network was digitized from the satellite image before the fire (IRS) and added to the raster image of the classified SPOT-4 (Figure 4).

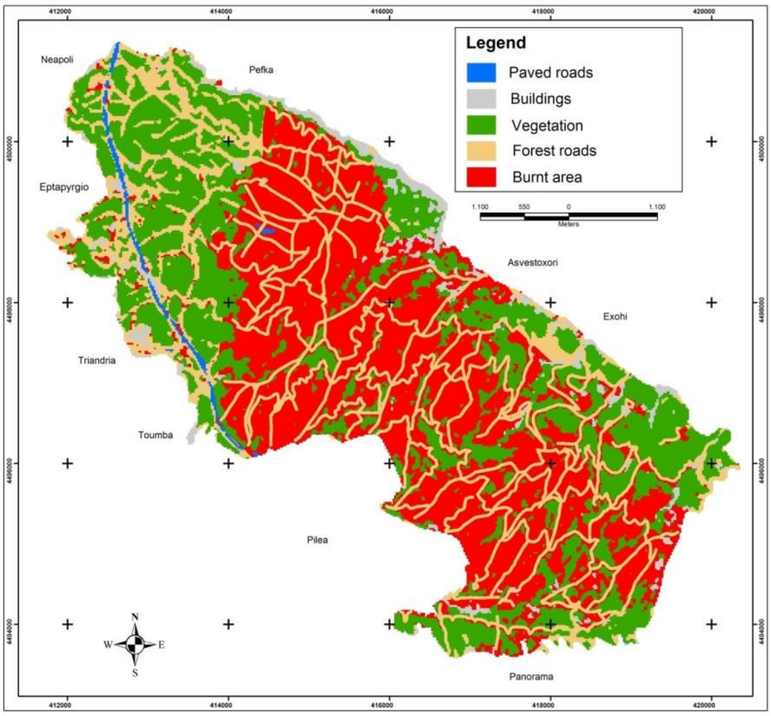



**Figure 4:** Classified image (SPOT-4), after the process in GIS

The areas that calculated from the two classified images after the fire and now are presented in tables 4 and 5.

**Table 4:** Land cover 1998, after the conflagration

| **Classified image SPOT-4** | |
|---|---|
| **Land cover** | **Area (ha)** |
| Paved roads | 22,97 |
| Buildings | 96,87 |
| Burnt area | 1.107,86 |
| Vegetation | 986,22 |
| Forest roads | 671,21 |
| **Total** | **2.885,12** |

**Table 5:** Land cover 2010

| **Classified image WorldView-2** | |
|---|---|
| **Land cover** | **Area (ha)** |
| Paved roads | 30,43 |
| Buildings | 45,13 |
| Tile surfaces | 22,00 |
| Vegetation | 1.560,63 |
| Forest roads | 174,94 |
| Γεωργική γη | 3,25 |
| Έδαφος | 1.048,69 |
| **Total** | **2.885,08** |

## 4. Results

In the suburban forest of Seich Sou, before the fire, lush vegetation was located in the whole area, while there was a dense forest road. The burned areas were detected in the central and south-east of the urban forest, while the north-west areas were not affected (Figure 4). In the newest satellite image, changes were detected in all different areas of forest. In the burned area particularly, vegetation is noticed, due to the reforestations and the natural regenerations. Furthermore, changes occur in the forest roads, where there is more density in North-west (Figure 5). In some areas, agricultural cultivation is recorded.
The quantitative evaluation of the results of the two classifications shows that, for the period after the fire, the burned areas and the forest roads – classes that have similar spectral signature and was not possible to separate them completely- represent the 60% in total, while vegetation remaining represents only the 34% (Table 4). In the recent state of the forest, the vegetation is 54%, which is the higher percentage comparison with the state after the fire, the forest roads is 6% and the surfaces that have no coverage, while the destruction that caused by the fire represent the 36% of the total area. Considerable area is occupied by paved roads and building structures (Table 5).
As for the changes that occurred from the comparison of the modern classified image of 2010 with the orthorectified satellite image IRS of 1997, there are interventions, such as new forest roads, buildings and agricultural cultivations in locations where previously fallow areas existed (Figure 5). The set of changes that are made between 1997- 2010 are grouped into five categories - forest roads, paved roads, agricultural cultivations, buildings and other uses. For these changes, a search of legal framework and restrictions

within the forest was made, in order to demonstrate the need or not for further investigation.

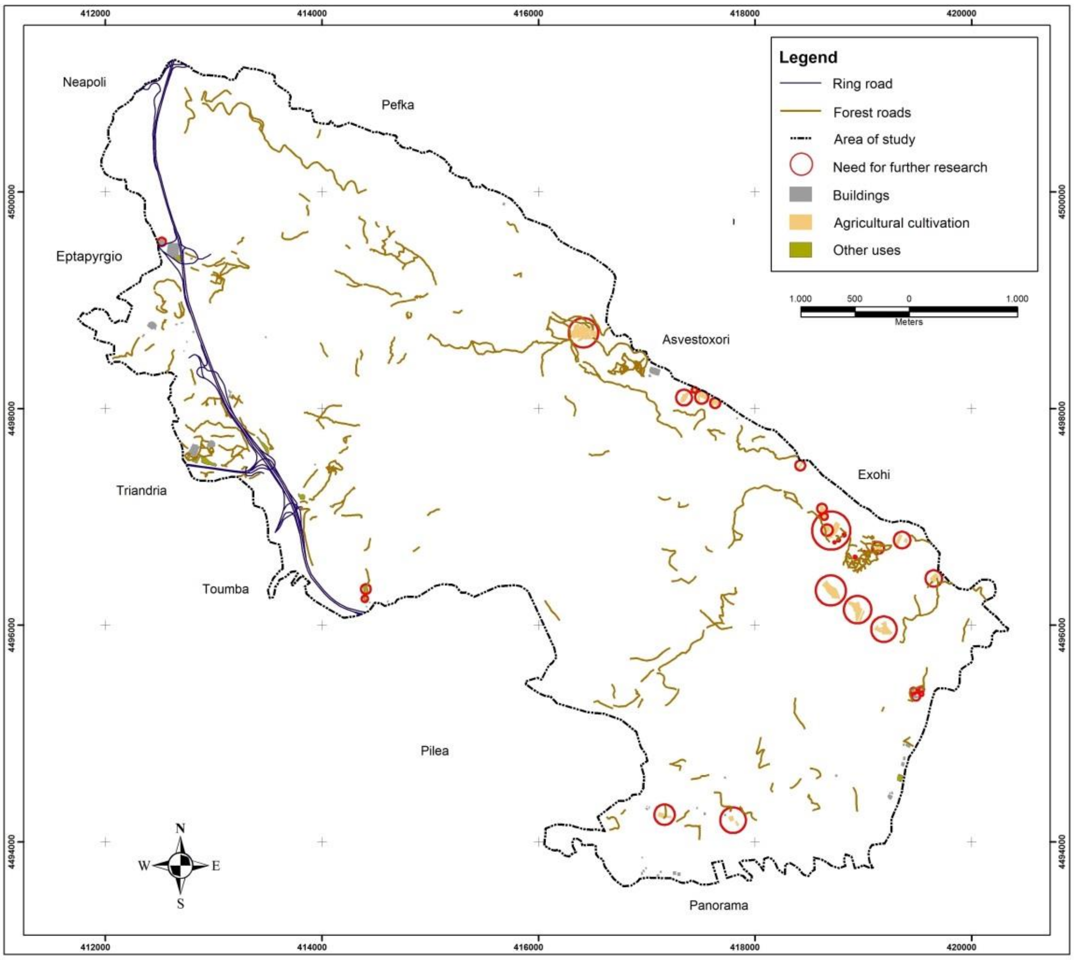



**Figure 5:** Change detection 1997-2010, from the compare of satellite images

## 5. CONCLUSIONS

From the processing of the temporal satellite images, the use of GIS and the study of the available data a lot of interesting elements arise. Regarding the study area, the burned location was illustrated with accuracy, as well as the damage which was made in the vegetation due to the fire in 1997. The new forest roads in the suburban forest were recorded for better access and strengthen of fire protection zones in case of emergency.
Through the comparison of the quantitative data, which were occurred from the results of the two classifications, an increase in vegetation by 58% was noticed, as a result of the reforestations and the natural regeneration of the forest. In addition the paved roads increased by 32.5%, due to the construction of the ring road. As a result of the fire, 36,4% of the area still remains without any coverage. Moreover, new agricultural cultivations (0,11%) was located; something that is illegal according to the legal framework about the protection of reforestation area and therefore a further investigation is required.
As for the constructions/buildings that detected (0,76%), there are two types of interventions that needs to be considered, depending on the type and their purpose. Thus, the interventions that were designed to preserve the forest area such as for better fire protection and for the public benefit are lawful and they cannot be challenged. In contrast, the construction, which was located in illegal locations, requires further investigation and exploration.

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