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LAND - USE CHANGES IN AN AREA HEAVILY AFFECTED BY FIRE:
THE CASE OF MT. PENTELI

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ABSTRACT

Wildfire is a natural hazard frequently occurring in the Mediterranean environment. Mediterranean ecosystems having been evolved under the recurrent occurrence of wildfire, they are considered as being adapted to it. This adaptation is expressed through specific regeneration mechanisms shown by the individual organisms forming the Mediterranean biological communities. In this context, Mediterranean Aleppo pine forests can be burned and subsequently regenerate without being degraded under certain conditions. It is critical that the regenerating forest is left to unroll its auto-successional processes without being disturbed either by another fire or any other human interference, e.g. grazing, reforestation.

The objective of this contribution is to describe the changes in land use and the landscape characteristics during the last 50 years in Mt. Penteli area, as they are related to the fire history of the area.

Mt. Penteli is located in the North-East part of Attika and it is an area which has been repeatedly affected by a significant number of large and small fires during the last 50 years; it is also an area that suffers from an increasing pressure of human activity.

The envisaged area is a wildland - urban interface. A series of land-use maps from different time periods, covering the past 55 years, was created through photo-interpretation and classification of satellite images. Based on these maps landscape characteristics and their changes over the years are evaluated with the use of various analyses of geographic data such as fragmentation and cross-tabulation. These characteristics are also correlated with historical fire records available for the area.

It is expected that the output of this study could be used by the authorities and the urban planners for a rational development of such areas and the improvement of infrastructure related to protection from wildfire.

INTRODUCTION

Penteli Mountain is located at the north-east of Athens city and is one of the most important forests of the Attika Region. The vegetation is typical Mediterranean consisted by Pines, shrubs (maquis) and herbaceous vegetation. The envisaged area is state owned covers 12000 ha approximately and is managed by the forest office of Penteli. It is included in a square defined by the coordinates $23^{\circ} 52'$, $23^{\circ} 58'$ East and $38^{\circ} 00'$, $38^{\circ} 52'$ North.

The study area has clear characteristics of wildland - urban intermix and suffered dramatic changes in land use during the last decades.

The dry climate, the flammable vegetation as well as the pressure for increased human activities facilitated the occurrence of a large number of fires in the wider area of Penteli, which occasionally become also important in size, threatening human lives and properties. In this paper, a methodology for studying the formation of the wildland-urban interface in Penteli area is proposed. In addition, the results obtained by applying this methodology to the particular study area are presented. The proposed methodology could be eventually used for studying other areas with similar characteristics in order to provide valuable information about urbanization process and interaction between different land use and disturbance.

MATERIAL USED

The aim of the work was to study the land-use changes in the area for a long period of time and to combine them with the fire history of the area.

In order to achieve this objective, land - use maps were created for different time steps in the past. In addition, collection and analysis of fire data from historical records was organized.

The land-use changes in the area of interest were studied for a 50 years period, from 1945 until 1995.

It was considered that the land-use reconstruction for three time intervals would provide the necessary and important information for the purposes of the particular investigation. Thus the landscape was reconstructed for the years 1945, 1971 and 1995. The respective land use maps were then created.

The main material used for the landscape reconstruction were aerial photos (Scale 1:30000, 1:15000) and fire management orthophotomaps of the Ministry of Agriculture (Scale 1:20000). Existing thematic maps were also used in order to provide auxiliary information.

Three land-use maps, one for each of the above mentioned years were produced, using the following six broad land-use categories: dense pine forest, sparse pine forest, shrublands, cultivated areas, settlements, other.

The three maps were digitized and appropriately transformed in digital-raster maps for further analysis with ARC-INFO GIS.

Concerning fire history of the area, data from past fire events were recorded and stored in a digital database. Further processing was made for the creation of a map layer with the ignition location of these fires (see figure 2). One hundred twenty fires reported for the period 1954 - 1995 were registered for this purpose.

METHODOLOGY

The objective of the work was to study in detail the land use changes, not only quantitatively but also qualitatively, by means of their spatial distribution. Thus the size and the exact location of these changes was examined.

In order to do this, a series of information layers was created from the basic land-use maps, using specific GIS spatial analyses.

The analyses in the current study were concentrated mainly on the changes that occurred between forests and non-forested areas, such as cultivation areas and settlements.

The three land-use maps were combined using conditional spatial analysis functions of the GIS, for the calculation of several layers each of them representing areas which suffered a particular combination of land-use changes during the 50 years period.

The different combinations of changes were defined by the three land-use main categories namely forested areas, cultivation areas and settlements. Consequently and through this procedure, twenty seven map layers were created in total. (e.g. map layer showing the areas which were forested in 1945 became cultivation in 1971 and settlements in 1995 or map layer showing the areas which were forested in 1945 and 1971 and became settlements in 1995 etc.).

A map of the areas which didn't change in terms of the three main categories of land-use is shown in Figure 1.

Knowledge of the size and spatial distribution of specific changes in land-use was feasible in this way, which was also combined with the fire history of the area, for the study of land-use change process in relation to forest fire occurrence.

RESULTS OBTAINED

The most important conclusions and results obtained for the area of interest are presented here below:

- Dramatic change of land use occurred in a significant proportion -about one third, of the study area. Changes observed mostly near the boundaries of large forested and agricultural areas where the great number of the fire ignitions occurred.

In Figure 2, a synthetic map, derived from the overlay of the most important map layers of land-use changes combinations, is shown. On this map the ignition locations of the fires are also indicated.

- As it can be observed in the map of Figure 2, Kalitechnoupoli, Rapentosa, Ntaou-Penteli and Palea Penteli are the locations where most of the fires occurred. Thus an important part of these areas were often burned either by large or by small fires.

In these areas great changes of the land use ended with the urbanization of the region.

- A three-step urbanization process was observed in the region of Nea Makri where forested areas in 1945 became agricultural until 1971 and finally settlements until 1995.
- It was observed that abandoned agricultural land that has been forested was partially burned by the large fires occurred during the envisaged period but no ignitions started from such areas.
- The region of Anthousa and Ntrafi was forested until 1971. Several patches of settlements appeared in the forested areas since then but cultivated areas do not exist in this region. There were several fires present in this region during the last forty years period.
- Rapentosa region is kept forested during the whole time period with some agricultural patches included in it. A number of agricultural patches appear in the region during the period 1945-1971 which were reforested again until 1995. Fires in this area are recorded in the period 1956-1978. After 1978 (and since 1995) no ignitions of forest fires are recorded in this area.
- Kalitechnoupoli and Ntaou Penteli areas suffered great changes of land use since 1971 when significant urbanization started. A lot of fires occur in the area, which was repeatedly burned mainly in the period between 1971 and 1987.

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Figure 1 (left): map of areas where no land-use change occurred. Dark colored areas are forested, light colored areas are cultivated.

F-C-C	C-F-C
F-F-C	C-F-F
C-F-S	F-S-S
C-S-S	F-C-S
C-C-S	F-C-F
C-C-F	F-F-S



Figure 2 (right): synthetic map of several layers showing combination of land use changes during the 50 years period. F code is used for forested areas, C for cultivation. S for settlements.

Land - use map : year 1995



[White box]	no data
[Dark grey box]	dense pine forest
[Light grey box]	sparse pine forest
[Dotted box]	shrubland
[Diagonal lines box]	cultivated areas
[Cross-hatched box]	settlements
[Horizontal lines box]	other



Figure 3: Land-use map of the year 1995