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STAVROS SAKELLARIOU
Department of Planning and Regional Development, University of Thessaly, Greece

FANI SAMARA
Department of Planning and Regional Development, University of Thessaly, Greece

STERGIOS TAMPEKIS
Department of Planning and Regional Development, University of Thessaly, Greece

OLGA CHRISTOPOULOU
Department of Planning and Regional Development, University of Thessaly, Greece

ATHANASIOS SFOUGARIS
School of Agricultural Sciences, Department of Agriculture Crop Production and Rural Envinonment, Greece

ESTIMATION OF FIRE RISK IN A GREEK ISLAND FOR THE PREVENTION OF FOREST FIRES

Abstract:

The comprehensive prevention of forest fires is an issue of vital importance for the protection and sustainable development of forests which constitute irreplaceable natural resource for any society. Nowadays, it is operated an integrated recording, processing and analysis of local characteristics of any given area, supported by the state-of-the-art technological capabilities, so that we may explore the fire risk possibilities across any territory. The aim of the paper is the determination of fire risk in a Greek island, which is called Thasos. Specifically, the paper explores the determination of fire risk levels across the entire study area, based on the local characteristics of the island, namely, the influence of the fuels structure, slope, aspect, as well as the influence of the road and human settlements network. The collective contribution of all these factors to the ignition and propagation of forest fires highlighted specific areas which are characterized highly sensitive. Hence, essential preventative measures must be established, especially across these critical areas. Such measures could include: the optimal (spatial) allocation of watchtowers as well as the spatial optimization of the mobile firefighting vehicles; the forest fuels treatment in the areas where are characterized of extremely high fire risk; the restriction of accessibility in the aforementioned areas when extreme meteorological conditions are predicted to happen and other similar measures that could prevent the forest fires before they take huge dimensions. Therefore, this analytic process could be quite valuable in any given area, so that the fire agency staff to be properly prepared and act immediately, when a fire incident takes place. In addition, it should be emphasized the fact that the fire agency will have the flexibility of allocating its staff at the most sensitive areas and decrease the forces in areas of relatively low fire risk.

Keywords:

Forest Fires, Fire Risk, G.I.S., Thasos island

Introduction

The comprehensive prevention of forest fires is an issue of vital importance for the protection and sustainable development of forests which constitute irreplaceable natural resource for any society. Naturally, the prevention of forest fires preserves both the ecological and environmental wealth of any country (endemic flora and fauna; retention of carbon dioxide and oxygen release; anticorrosive properties and protection of adjacent urban areas from flooding; special places for leisure purposes etc.) and saves valuable financial resources (for the restoration of damages etc.), while, at the same time it promotes the social development and prosperity for any country.

For all these reasons, nowadays, it is operated a comprehensive recording, processing and analysis of local characteristics of any given area, supported by the state-of-the-art technological capabilities. Primary objective of these operations-studies is the exploration of individual as well as collective influence of these characteristics to the estimation of fire risk in the study area. The literature has focused on several methods for estimating the fire risk (Chen et al., 2003; Chen et al., 2004; Dong et al., 2006; Iliadis et al., 2002; Iliadis, 2005; Jaiswal et al., 2002; Kaloudis et al., 2005; Lapucci et al., 2005; Power, 2006; Sharma et al., 2012; Temiz and Tecim, 2009; Vadrevu et al., 2010), studying at the same time not only the natural but also the anthropogenic causes of fire ignitions. It should be stressed that the contribution of both natural and anthropogenic causes for fire ignition is differentiated according to the (local) meteorological, topographic and cultural peculiarities.

Therefore, the aim of this paper is the determination of fire risk in a Greek island, which is called Thasos, relying on the local characteristics of the study area. After we have estimated the fire risk in the entire area, we will be capable to establish the essential preventative measures in the most vulnerable areas.

Materials and Methods

The pillar of our methodology lies in the fact that the unique fire risk map will be created based on the local characteristics, such as slope, aspect, fuel, distance from the road network and distance from the human settlements. Initially, the individual influence of each and every factor (either natural or anthropogenic) to the fire risk will be computed. Afterwards, the aforementioned inputs will be integrated into a unique map which will indicate the total fire risk, taking into account the contribution of all dimensions. Definitely, different weights will be assigned to each factor relying on its magnitude to the fire ignition, intensity and propagation. The procedure which took place has been supported by the analytic capabilities of GIS.

The table 1 summarizes the assignment of the classes for every factor to the corresponding fire risk level.

Table 1: Classification of local factors based on their influence on fire ignition and propagation

Slope levels (degrees)	Aspect	Fuel type – Possible manifestation of fire	Distance from road network (m)	Distance from human settlements (m)	Fire Risk Level
0 – 5	Ground level	Restricted or no fuels	500	Not applicable	Very Low – 1
5 – 10	North - Northeast	Little fuels – Surface fire	400	4.000	Low – 2
10 – 20	East - Northwest	Surface fire and torching	300	3.000	Moderate – 3
20 – 30	West – Southwest - Southeast	Combination of surface fire and crown fire	200	2.000	High – 4
> 30	South	Full crown fire	100	1.000	Very high – 5

Source: Own processing

The development of fire risk levels is based on some certain criteria. More specifically, the fire incidents tend to be more aggressive in steep slopes. So, when the slope level is increasing, the respective fire risk level is growing. As regards aspect factor, generally, in Mediterranean areas, South aspects are considered to be more dangerous for fire ignition and intensity (http://geology.isu.edu, 2014). Concerning the fuel types, an alternative approach has been adopted. This approach is directly related to fuels type and density. Several fuel types present some certain characteristics, which in turn, greatly affect the fire behavior and propagation. Hence, according to the specific characteristics of the fuel stand, the possible manifestation of fire has been determined. That is, no fire or very little fire may happen in arid lands as well as in urban and agricultural areas. When there is little fuel (e.g. grass), we can characterize the incident as a surface fire. On the other hand, when there is a mixture of specific fuels, we can have either surface fire and torching or a combination of surface fire and crown fire. In the most extreme conditions, when certain fuels exist in some areas, we can observe incidents of full crown fire of high intensity.

Regarding the anthropogenic factors, two of them are considered to be the most influential to fire risk level. The first one, is the distance from the road network, while most incidents of fire ignitions are located in proximity with the road network; these incidents caused either by accidents (e.g. from cigarettes or infrastructure networks) or arsons (Ager et al. 2014; Syphard et al. 2008). For this reason, the methodology contains the creation of distinct spatial units (buffers) in relation to the segments of road network and

more specifically, the zoning (both sides) of the roads with multiple 100 meters rings. It is obvious that the most dangerous zone is the first ring (width of 100 m.) which is in immediate contact with the roads. Consequently, the fire risk level tends to be decreasing until the last zone (500 meters away from the roads), where the general accessibility is complicated in relation to the distance from roads.

Finally, the last factor which affects the fire risk level is the distance from human settlements and structures, while many fire incidents ignite at specific areas, known as Wildland Urban Interface (Syphard et al. 2008). Adopting the same reasoning with the road network, we create multiple spatial units (buffers of 1.000 meters) around all settlements. Here, we chose the distance to be greater than the road network due to the fact that the accessibility near the towns is quite easier (agriculture activities take place there etc.).

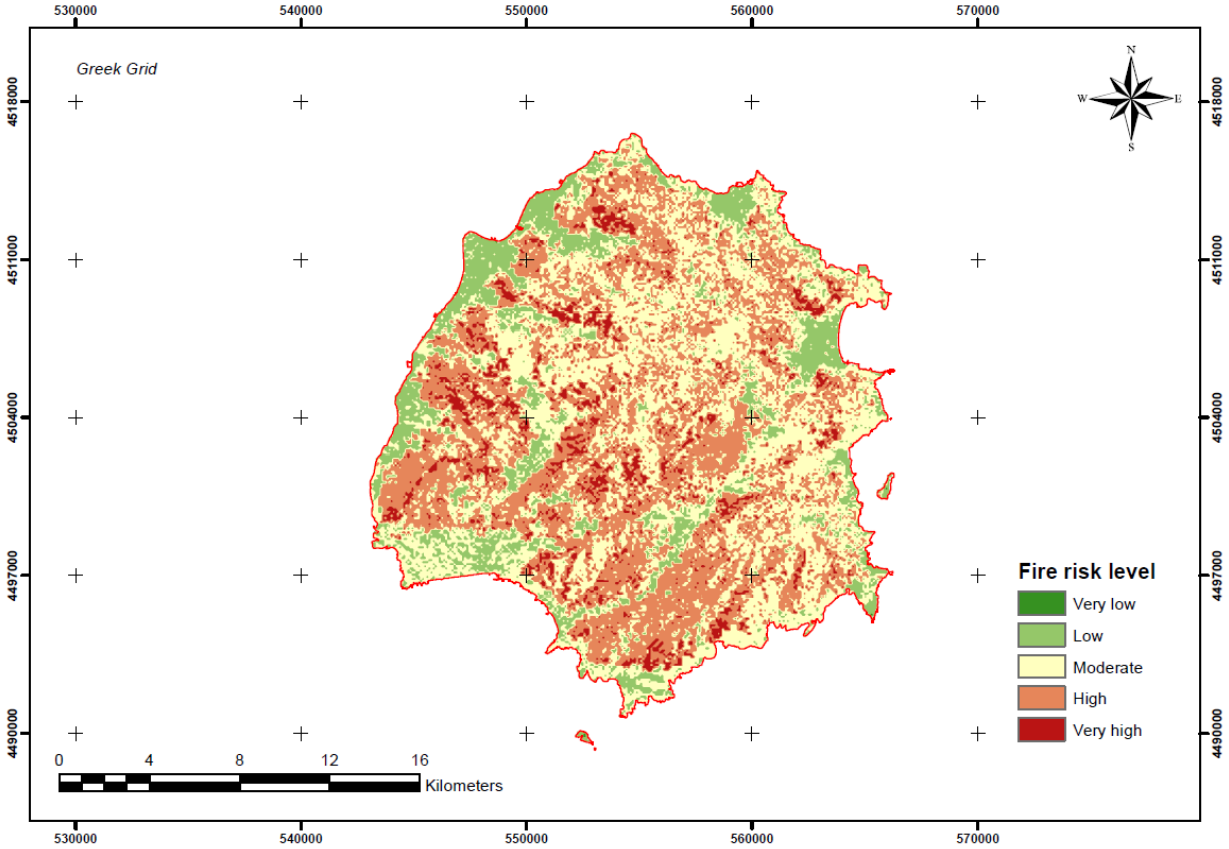
Results and Discussion

Before the creation of the unique fire risk map, we should weight all the involved factors which are conducive to the overall fire risk, while the influence of each and every factor is variable.

The most fundamental element, without which a fire cannot even ignite and evolve, consists of the fuel. That is why, among the five factors under study, we weight the fuel with an influential percentage of about 50% (to be more precise, the final adopted percentage is 45%), since this factor is considered to be the most contributing factor to the ignition of forest fires. Concerning the geomorphology of the study area which plays a critical role to the fire propagation and behavior, we assign an influential weight of 15% for both the factors slope and aspect. Finally, regarding the anthropogenic dimensions, we adopt a weight of 15% for the zone that is adjacent of road network (buffers), which is really dense and covers the entire area. In addition, we assigned a special weight of 10% for the zone around human settlements (buffers), due to the fact that the most incidents take place in this area which is well known as Wildand Urban Interface. It should be noted that this percentage is relatively smaller than the others because the fire incidents in this area can be easily perceptible by the local population and the passing vehicles (Massada et al. 2009).

The following map depicts the final unique fire risk map after the integration (overlapping) of the five distinct analytic-thematic maps, as described above. As we can conclude from this map, we should emphasize the fact that areas of low fire risk is about 15% of the total area; areas of moderate fire risk is about 42% of the total area, while areas of high and very high fire risk is about 43% of the total area. Hence, we observe that about half area of the island faces many possibilities of igniting a fire due to the interplay of natural and anthropogenic factors. That is, the most vulnerable areas are located on the south and west part of the island. Hence, we should intensify our preventative measures primarily on these areas, as resulted from the above analysis.

Map 1: Fire risk levels in the island of Thasos, Greece



Source: Own processing

Conclusions

The paper presents the preliminary results of a broader research programme regarding the efficient management of forest fires at the Greek insular areas. Specifically, the paper explores the determination of fire risk levels across the entire study area, based on the local characteristics of the island, namely, the influence of the fuels structure, slope, aspect, as well as the influence of the road and human settlements network. The collective contribution of all these factors to the ignition and propagation of forest fires highlighted specific areas which are characterized highly sensitive. These areas are mainly located in the interior of the island, where plenty of vulnerable fuels (forests) and abnormal ground take place, characteristics which certainly increase the possibilities of extreme incidents of forest fires. That is why, essential preventative measures must be established, especially across these critical areas. Such measures could include: the optimal (spatial) allocation of watchtowers as well as the spatial optimization of the mobile firefighting vehicles; the forest fuels treatment in the areas where are characterized of extremely high fire risk; the restriction of accessibility in the aforementioned areas when extreme meteorological conditions are predicted to happen and other similar measures that could prevent the forest fires before they take huge dimensions. Therefore, this analytic process could be quite valuable in any given area, so that the fire agency staff to be properly prepared and act immediately, when a fire incident takes place. In addition, it

should be emphasized the fact that the fire agency will have the flexibility of allocating its staff at the most sensitive areas and decrease the forces in areas of relatively low fire risk.

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