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Determining Fire Protection Zones In The University Forest Of Taxiarchis – Vrastama In Greece

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Abstract

Climatic changes cause temperature rise and thus increase the risk of forest fires. In Greece the forests with the greatest risk to fire are usually located near residential and tourist areas where there are major pressures on land use changes. Considering the fact that environmental conditions had become even worse (increased temperature, drought and vegetation), the problem of forest fires in Greece, is expected to become more intense. This work focuses on developing an optimization model for the opening up of the forest mountain areas by taking into account the prevention and suppression of forest fires. The research area is the university forest of Taxiarchis – Vrastama of Chalkidiki Prefecture in Northern Greece. The percentage of forest protection area that can be reached by fire hose is examined whether the total hose length corresponds to the actual operational capacity to reach a fire source. A case study was conducted to determine the forest area being protected by fire extinguishing vehicles. This case study corresponds to a fire suppression bandwidth (buffer zone) with a radius of 300 m uphill and 500 m downhill from the origin point where the fire extinguishing vehicle stands. The most important forest technical infrastructures to prevent and suppress fire are roads network (opening up) and their spatial distribution. Patrols of small and agile 4×4 pickups appropriately equipped (hose length of 500 meters with uphill pressure up to 300 meters) for the initial action against the fire during summer coupled with early warning of fire lookout stations adequately ensures the forest protection of University Forest of Taxiarchis – Vrastama. However, spatial allocation of the already existing forest roads needed improvements, for both forest protection purposes and for better management of skidding.

Key words: forest fires, GIS, opening up, firefighting hoses.

Introduction

In Greece, only 15 % of forest fires occur at altitudes over 500 m altitude (Dimitrakopoulos 1998), mainly in oak and black pine plantations. The arrival time of initial extinguishing fire crew to the highlands is very slow and takes about 60 minutes (Dimitrakopoulos 2001).

According to researchers the growth rate in infrastructure costs should be accompanied by a corresponding reduction in costs and damages (Figure 1). In Greece however, the damages caused by fire (suppression costs and loss of forest) are independent of the infrastructure costs to strengthen fire fighting forces and efforts.

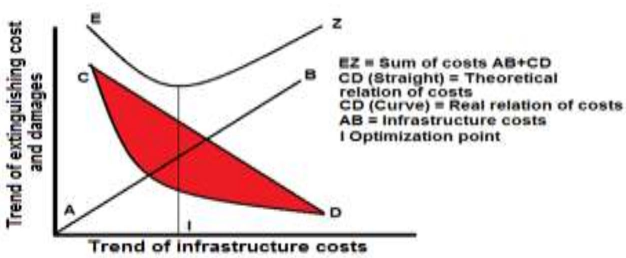

Fig. 1. Correlation between infrastructure expenditure and expenditure for extinguishing and damages.

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The rate of reduction of costs is not directly (DC) proportional to suppression costs and damages, but is associated with DC curve and the right branch of the curve EZ has smoother slope on the left side (Dimitrakopoulos and Skourtos 1991). This is due to poor organization, the misplaced breakdown of costs and the overall institutional framework.

Therefore, new firefighting model is required to optimize the efficiency, independent of the excessive cost of expenditure. This is also result of the socio-economic conditions prevailing in the country that is expected to worsen the situation.

This study aims to focus on developing an optimization model for the opening up of the University Forest of Taxiarchis – Vrastama by taking the prevention and suppression of forest fires into account.

Materials and Methods

Research area

The Taxiarchis – Vrastama University Forest is located in the center of the Chalkidiki prefecture, specifically in the south and southwest slopes of Mt. Holomon in latitude 40°23´ to 40°28´ N and longitude of 23°28´ to 23°34´ E and in an altitude range from 320 m to 1165 m. The forest belongs to the Polygiros municipality of the Chalkidiki prefecture, region of Central Macedonia.From a geological perspective, the area belongs to the Rodopi zone, in particular the Forest appears as part of the Serb-Macedonian mass, in particular of the Vertiskos range. The rock formations include silicate materials and silicate sandstones, marbles, calcareous schists, micaceous gneiss, granites, and various sedimentary rocks in small areas. The soil of the area belongs to the category of acid forest soils.The climate of the area is considered as Mediterranean with short hot and dry summers and mild winters. The vegetation of the area is dominated by deciduous forests and is comprised of vegetation zones depending on the floral composition, the rock layer and soil conditions, the aspect and slope of a particular area, the ambient temperature and the precipitation. Hence, three zones are distinguished: *Quercetalia ilicis*, *Quercetalia pubescentis* and *Fagetalia*.

Methodology

The most important forest technical infrastructures to prevent and suppress wildfire events are:

a) Forest road network (opening up)

b) Buffer Zones.

Direct fire suppression requires access on forest roads during the outbreak of fire and appropriate fire equipment vehicles with special hoses (Akay et. al. 2012, Oguz et. al. 2012).

Figure 2 shows the protection zone covered by fire nozzle from the forest road or conventional short hoses (Figures 3 and 4). We mention that the ability for successful extinguishment is limited.

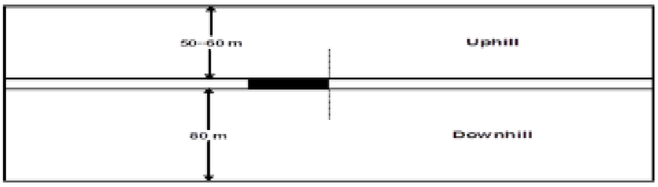

Fig. 2. Protection (Buffer) zone with conventional short length hoses.

Fig. 3. Extinguishment from forest road with truck mounted brass fire nozzle.

Fig. 4. Extinguishment from the road with short length hoses.

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Figure 5 and Table 1 shows the protection zone when using specifically connected hoses in length of 300 m uphill and 500 m downhill (Psilovikos et al., 2011). The difference in the uphill and downhill measures is due to the greater need for a water pressure uphill.

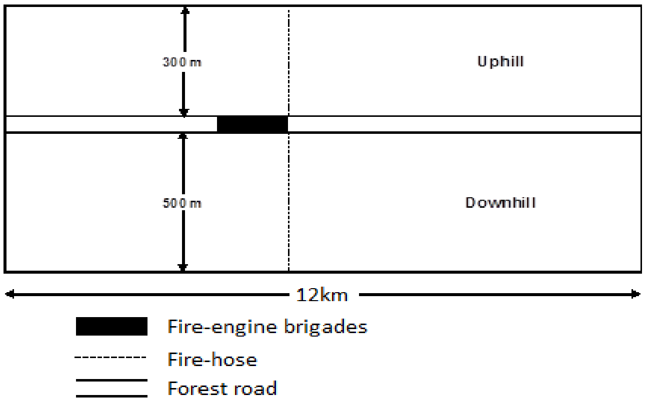

Fig. 5. The protection zone (800m) in the sides of the road, when used specifically connected hoses length 300 m uphill and 500 m downhill.

Table 1. Characteristics and total length of hoses on available fire brigade vehicles.

Vehicle Type	Cross sections of tubes, mm	Number of pieces per section	Length per section, m	Total length, m
1	2	3	4	5 = 3×4
Unimog 2,5	25 and 45	15 and 6	25 and 15	465
Man 1,5	25 and 45	15 and 6	25 and 15	465
Iveco 2,5	25 and 45	15 and 6	25 and 15	465
Man 5	25 and 45 and 62	15 and 6 and 6	25 and 15 and 15	555
Mercedes 10	45 and 62	15 and 8	15	345

source: Psilovikos et. al., 2011

The distance of 300 m uphill depends on the pump pressure of vehicles, but it is sufficient for an average slope of 30 % for the usual fire trucks (Tsakalidis and Gitas 2008), which may be applicable to 100 %, e.g. fire pump Rosenbauer NH20 in vehicle ELBO (Figure 6) has a pump flow at low pressure: 1750 lit/min at 10 bar and at high pressure: 400 lit/min at 40 bar.

Figure 7 indicates the real and the ideal protection coverage.

Fig. 6. Typical firefighting vehicle (Unimog of Elbo) and tank on 4×4 pickup.

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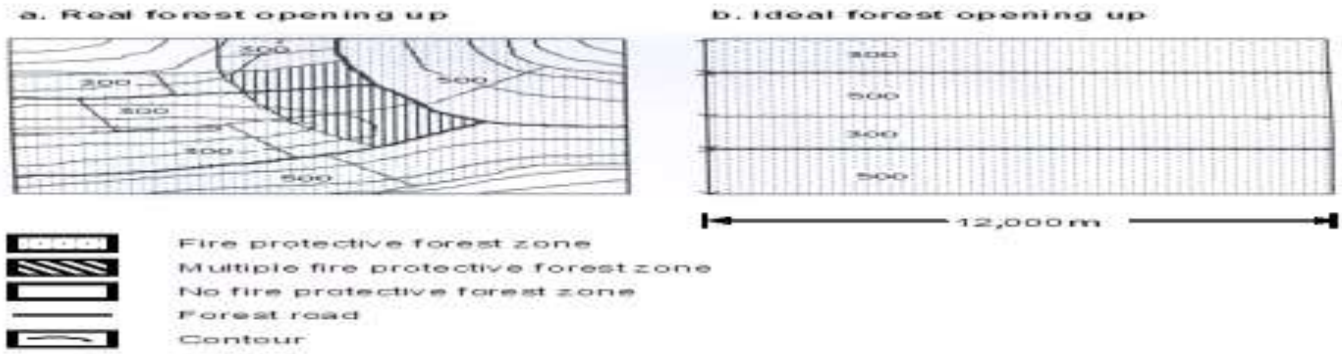

Fig. 7. The real and the ideal protection coverage, according to the forest opening up.

It is evident that at intersections the forest protection is doubled or tripled in the actual design of the road network, so we choose the route of the hose with the shortest distance and altitude difference uphill. In narrow streams, wind conditions created by the fire can cause differentiation of fire behavior by changing the propagation direction and speed towards uphill on the opposite slope, resulting in entrapment of fighting personnel. Therefore the actual design should connecting roads between parallels in order to allow escaping in the case of entrapment.

In mountainous productive forests for wood transport, escaping of fire fighting vehicles is ensured by adequate road density (typically 25 m/ha, much higher from the broadleaf evergreen forest that is less than 10 m/ha) and the lower speed of fire spreading (max 14.8 km/h and evergreen understory 25 km/h). These speeds are less than the average speed of trucks in the forest, which is an average of 25 km/h (Doucas 1987).

Results

Fuel of Taxiarchis-Vrastama

The forest vegetation types in the University Forest of Taxiarchis – Vrastama are presented on figure 8, while the corresponding wildfire rate of spread and fire hazard are shown on Figure 9. The risk due to the speed of the fire appears with a decreasing trend at Farmlands-grasslands of max 181.5 m/min, in mixed deciduous Oak-Beech max 24.5 m/min, in Fir Plantations max 14.8 m/min, in Coniferous-Broadleaved max 7.6 m/min, in Beech max 6.5 m/min and in Black Pine-Fir max 6 m/min. The variation in fire behavior is influenced by the topography (slope, streams with narrow sectional, reclining relief) density of fuel, and weather conditions (Figure 9).

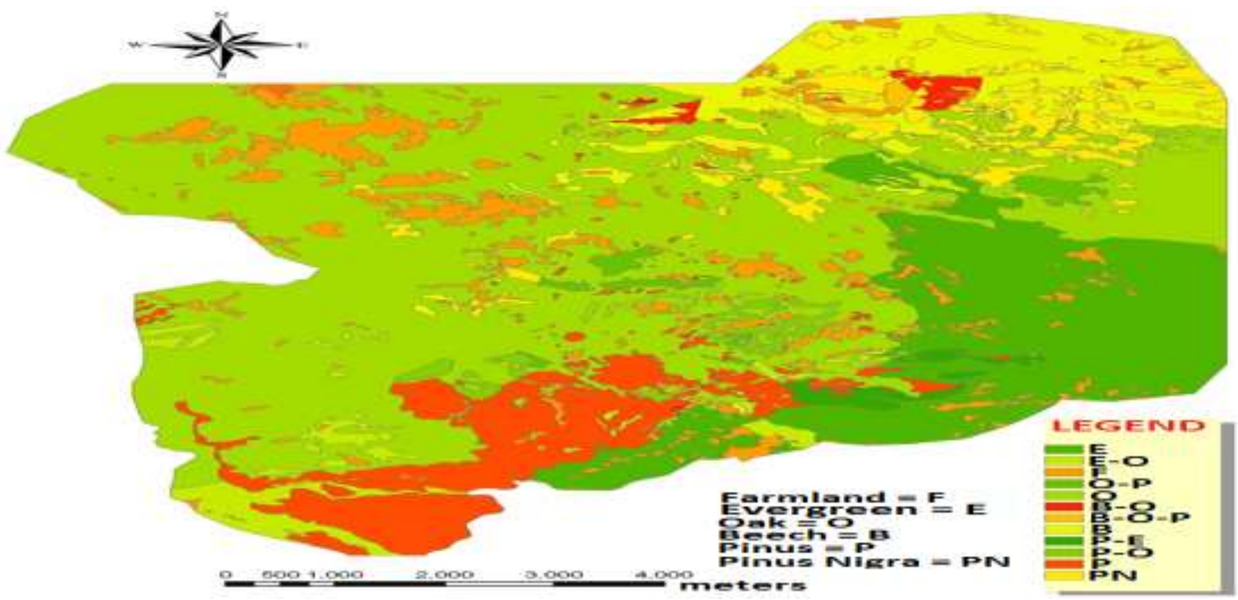

Fig. 8. Forest vegetation types in the University Forest of Taxiarchis-Vrastama (mainly Oak-Beech-farmlands-*Pinus Nigra*).

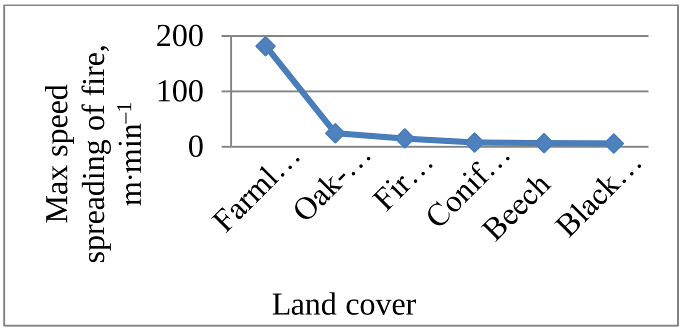

Fig. 9. Maximum speed of fire.

Fire protection of Taxiarchis-VrastamaFire protection zones (buffers) were placed according to the existing road network when using specifically connected hoses in length of 300 m uphill and 500 m downhill. The appropriate GIS command which was implemented was REGIONBUFFER, in order to carry out a spatial analysis with different sides, surrounding the existing roads network (Figures 10 and 11).

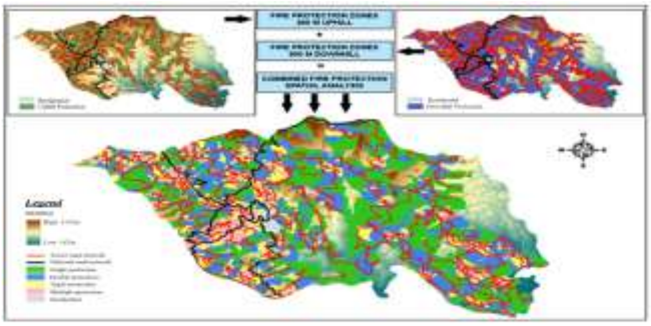

Fig. 10. Map of fire protection in University Forest of Taxiarchis – Vrastama based on the proposed model.

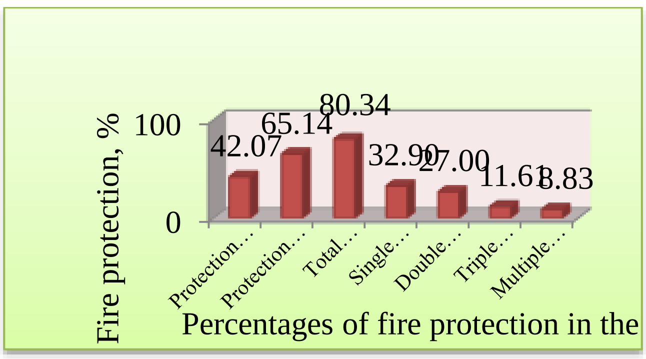

Fig. 11. Terrestrial Fire Protection Analysis.

According to the model of Figure 5, the result was satisfactory because road density exceeded the limit of 12.5 m·ha^{-1} and road distance was less than 800 m.

Regarding in space allocation of road network:

- With optimum road distance of 800 m (300 m uphill and 500 m downhill) estimated forest protection percentage was 80.34 %.- With tube hoses length of 500 m (in case of road distance 800 m), with the appropriate road space allocation and considering the existing road density thepercentage of forest protection was satisfactory i.more than 70 %. The double cover fire protective zones (27.00 %) were excessive compared with single ones (32.90 %). This was also due to the rural roads in order to serve the fir farmlands. Improving in space allocation of the existing forest roads and new roads are needed in the eastern part of the University Forest of Taxiarchis – Vrastama.

Conclusions

Patrols with small 4×4 pickups (Figure 7) appropriately equipped (pipe length of 500 m and pressure on uphill to 300 m) for the first action against fire during summer period coupled with early warning of fire lookout stations adequately cover the forest fire protection of University Forest of Taxiarchis - Vrastama. Nevertheless, road space allocation of the existing forest roads need improvements for both forest fire protection and for better management (skidding) of wood capital.

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