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Protection Degree from Forest Fires at the Mountainous Forests of Greece

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Abstract — ***Forest fires are an ancient phenomenon. Appear, however, with devastating frequency and intensity over the last 30 years. In our country, the climatic conditions in combination with the intense relief, favor their rapid spread. Considering the fact that environmental conditions provided for decades even worse (increased temperature, drought and vegetation), then the problem of forest fires in our country, is expected to become more intense. This paper aims to focus on developing an optimization model for the opening up of the forest mountainous areas taking into account the prevention and suppression of forest fires. Research areas are the mountainous forest complex of W. Nestos of Drama Prefecture, the university forest of Taxiarchis – Vrastama of Chalkidiki Prefecture and the forest complex of Lailias of Serres Prefecture. The percentage of forest protection area can be reached by fire hose is examined under the light whether the total hose length corresponds to the actual operational capacity to reach a fire source. The most important forest technical infrastructures to prevent fire are road networks (opening up) for fire protection and buffer zones. Patrols of small and agile van 4×4 appropriately equipped (hose length of 500 meters and putting pressure on uphill to 300 meters) for the first attack of the fire in the summer months coupled with early warning of fire lookout stations adequately cover the forest protection of the mountainous forest areas.***

Index Terms— GIS, opening up, protection, wild fires.

I. INTRODUCTION

In Greece, only 15 % of forest fires occur at altitudes of over 500 meters [4], mainly in oak and black pine plantations. The arrival of initial extinguishing fire crew to the highlands is very slow and takes about 60 minutes [2].

In table I are observed that while the risk in four months November - February are low in March and April shows relative increase before decrease in May. This increase occurs mainly in Northern Greece in the Prefectures of the Central and Western Macedonia, particularly at border prefectures of Florina, Drama etc.

Possible explanations are:

- The state of the herbaceous vegetation in April in conjunction with the practice of the shepherds for graze after fire.

- The movement of large numbers of illegal immigrants in the mountainous areas in order to cover heating needs during the night ([7] et al. 1999).

The risk is due to the speed of fire spread and with decreasing trend from agro-pasture lands max 181.5 m / min, mixed deciduous oak-beech 24.5 max, Fir Plantations max 14.8 m / min, Coniferous-Broadleaved max 7.6 m / min, Beech max 6.5 m / min, Black Pine-Fir max 6 m / min. The variation in fire behavior is influenced by the topography (slope, streams with narrow section, reclining relief) density of fuel, meteorological conditions.

Fig. 1 is shown, according to foreigner researchers that the growth rate in infrastructure costs should be accompanied by a corresponding reduction in fighting costs and damages.

The rate of reduction of the costs is not directly (DG) proportional to suppression costs and damages, but is associated with DG curve and the right branch of the curve EZ has less slope from the left [3]. 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 paper aims to focus on developing an optimization model for the opening up of the forest mountainous areas taking into account the prevention and suppression of forest fires.

Table I. Fire risk in Greece during the year ([7] et al. 1999)

Month	Fires / 1000 Ha / 10 year
January	0.020
February	0.035
March	0.048
April	0.041
May	0.028
June	0.071
July	0.173
August	0.276
September	0.256
October	0.140
November	0.021
December	0.007

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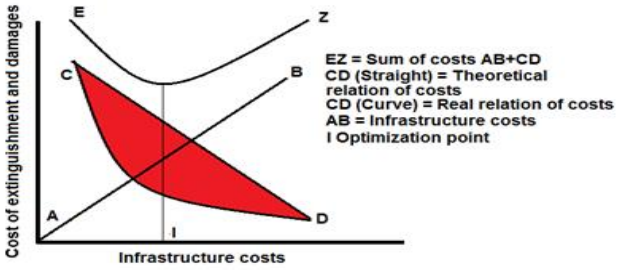

Fig. 1, Optimization of the firefighting expenses for minimizing costs and damages.

II. Materials and Methods

A. Research areas

a. University Forest of Taxiarchis - Vrastama

University Forest of Taxiarchis - Vrastama is located in the center of the Chalkidiki prefecture, specifically in the south and southwest slopes of Mt. Holomon in latitude 40°23′ -40°28′ and longitude 23°28′ -23°34′ and in an altitude of 320-1,165 m. The forest belongs to the Polygiros municipality of the Chalkidiki Prefecture, region of Central Macedonia (Fig. 2).

From a geological perspective, the area belongs to the Rodopi zone, in particular to the Forest appears a part of the Serb-Macedonian mass, in particular of the Vertiskos range. The rock formations that are found 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.

b. Lailias forest complex of Serres

The study area of Lailias is covered with a productive mixed forest (Fagus sylvatica Fagus orientalis and Pinus Sylvestris) and Acer Pseudoplatanus and Platanoides located in Northern Greece and occupies 3243.94 ha. Lailias is a Ski centre in Serres in the Macedonia Region of Greece (Fig. 2). Lailias is at an altitude of 1,847 meters. Locations near Lailias include the Mountain of Vrontous Mountains and the Village of Karydochori. Lailias mountain refuge is 24 km from Serres Creece at 1,500 meters altitude near the Ski Center Lailias. Is covered by forest at a rate of 83% and the road network has 110 km length.

c. Forest complex of W. Nestos (Kara-Dere)

The prefecture of Drama is the richest prefecture in forest of the country. In the mountainous region of Elatia there are the unique spruce and birch forests in Greece. The region extends along the Greek-Bulgarian border. There are rich pastoral ecosystems, the use of fire to improve them was and is a bushfire or forest fire risk. Forest complex of W. Nestos are Spruce (Elatia) 8% -3% - Birch (Elatia) – Beech 14 - Oak% 46% - Pinus Sylvestris 20%.

Geographically, the area of forests in the Western Complex of W. Nestos is located at the western part of the Rhodope Mountains, north of Drama, the Greek-Bulgarian border and extends from longitude 24° 25' west to 24° 3' and the latitude 41° 34' to the south 41°19', in the spheroid International 1909 (Hayford). Also it is 55-130 km road distance from Drama (Fig. 2).

The area belongs to the Forest Office of D. Nevrokopiou amounts to 18,579 Ha, while the rest of the Forest Office of Drama.

Predominately aspects on the horizon are S-SE-SW, and the N-NE-NW aspects occupy a limited extent.

The district occupies an area generally between 300m elevation curves and 1,500 with a minimum altitude of 140 meters and a maximum of 1,815 m. The prevailing slopes are strong (50% of the area around) and very strong (75%).

The climate of the wider region is characteristic to the transition between the Mediterranean and central European, with continental tone type Csb in the classification of Koppen, which justifies the presence of boreal species Forest pine, birch and spruce.

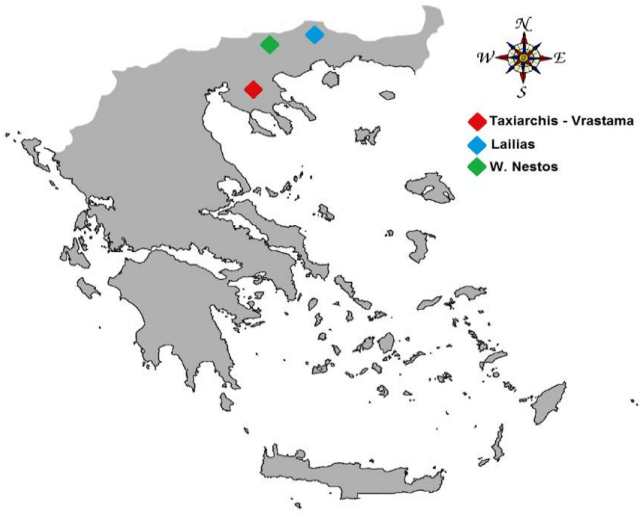

Fig. 2, Research areas

B. Methodology

The most important forest technical infrastructures to prevent fire are:

a) Forest roads network (opening up) for fire protection;

b) Buffer Zones.

Direct fire suppression requires access on forest roads in the outbreak of fire and appropriate fire equipment vehicles with special hoses [1], [5].

Fig. 3 shows the protection zone with fire nozzle from the forest road or conventional short hoses (Fig. 4 and 5). We mention that the possibility of extinguishment is limited. Fig. 6 and table 2 shows the protection zone when using specifically linked hoses in length of 300 meters uphill and 500 downhill. The difference in the uphill and downhill measures is due to the greater need for a water pressure uphill.

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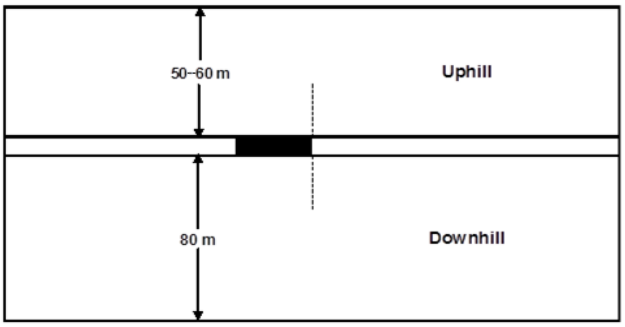

Fig. 3, Protection (Buffer) zone with conventional short length hoses

Fig. 4, Extinguishment from forest road with truck mounted brass fire nozzle

Fig. 5, Extinguishment from the road with short length hoses

The distance of 300 meters uphill depends on the pump pressure of vehicles, but it is sufficient for an average slope of 30 % in the normal fire [6], which may be up to 100 %. E.g. fire pump ROSENBAUER NH20 in vehicle ELBO (Fig. 7) has a pump flow at low pressure: 1750 l·min–1 at 10bar and at high pressure: 400 l·min–1 at 40 bar. Fig. 8 indicates the real and the ideal protection coverage.

It is evident that in the actual design of the road network is double and triple coverage forest protection at intersections, so we choose the route of the hose with the shortest distance and altitude difference uphill. In narrow streams cross wind conditions created by the fire itself can create differentiation of behavior by changing the propagation direction and speed of propagation uphill of the opposite slope resulting in entrapment of staff fighting. Therefore the actual design should be provided and connecting roads between parallels to escape vehicles in the case of entrapment.

Table II. Fire risk in Greece during the year ([7] et al. 1999)

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

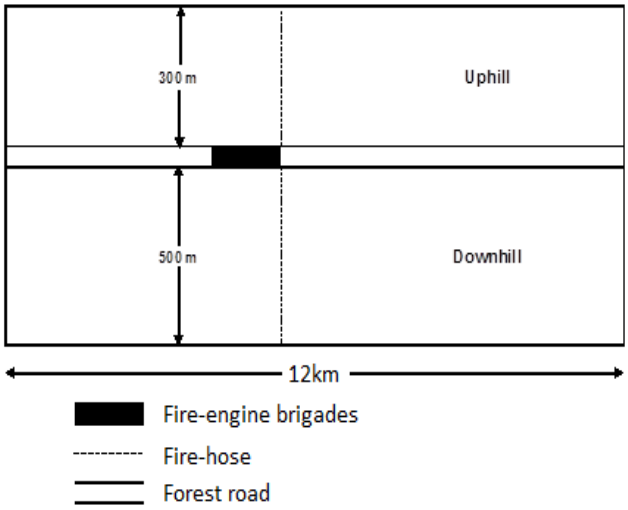

Fig. 6, The protection zone when used specifically linked hoses length 300 meters uphill and 500 meters downhill

Fig. 7, Typical firefighting vehicle (UNIMOG of ELBO) and tank in agile van 4×4

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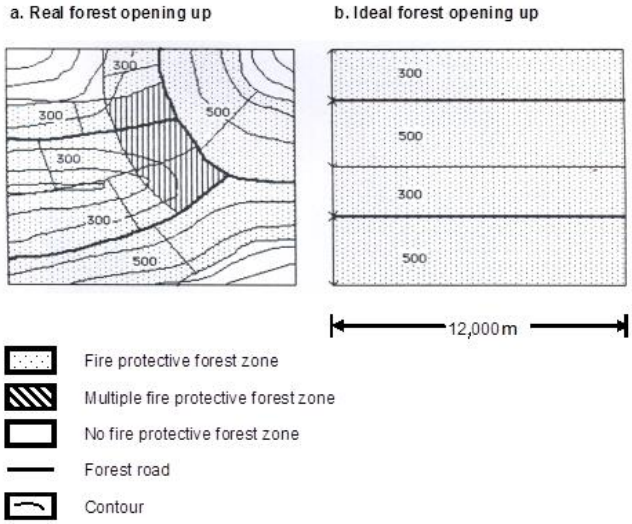

Fig. 8, The real and the ideal protection coverage

III. RESULTS - DISCUSSION

A. University Forest of Taxiarchis - Vrastama

Fire protection zones (buffers) were placed according to the existing road network when using specifically linked 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 (Fig. 9). According to the model of fig. 6, the result was satisfactory because road density exceeded the limit of 12.5 m·ha–1 and road distance was less than 800 m. With optimum road distance of 800 m (300 m uphill and 500 m downhill), estimated forest protection percentage was 80.34 %. 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 already existing forest roads and new roads are need in the eastern part of the University Forest of Taxiarchis – Vrastama.

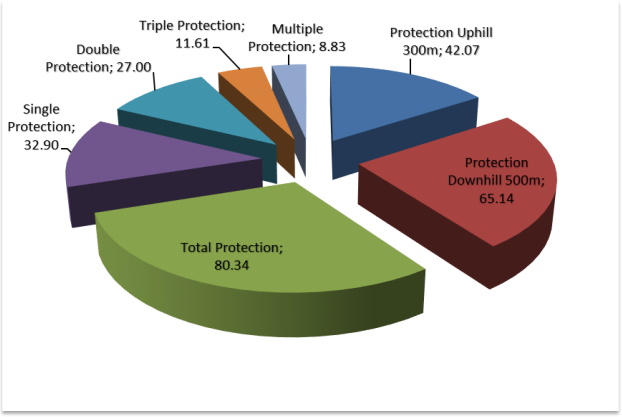

Fig. 9, Terrestrial Fire Protection Analysis

B. Lailias forest complex of Serres

The percentage of protection against fire from the ground, in the forest of Lailia (Fig.s 10, 11) amounts to 79.49% for the total protection, that it's divided in 50.40 % protection uphill and 53.90% protection downhill, and 24.81% for the multiple protected areas.

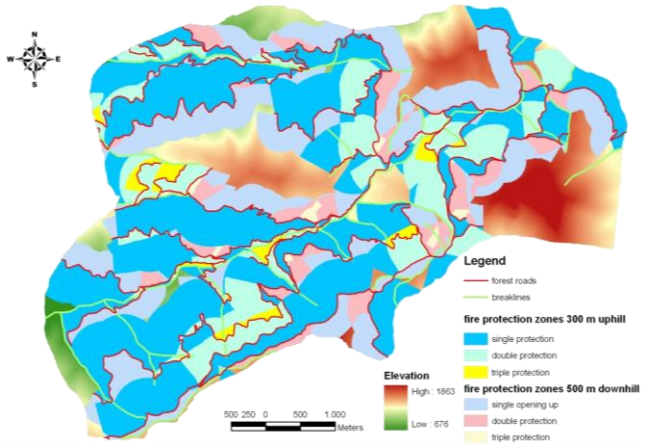

Fig. 10, Map of terrestrial fire protection zones 300-500 meters in Lailias forest complex

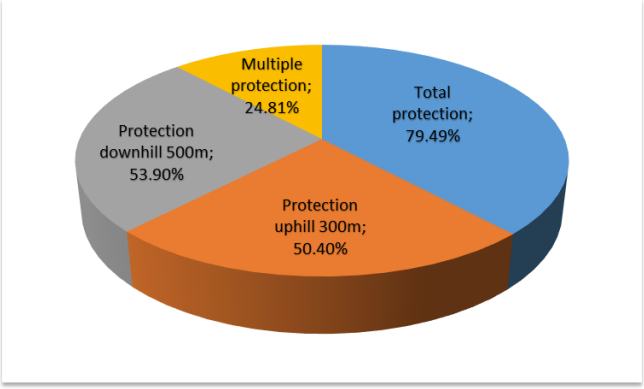

Fig. 11, Percentages of fire protection in the research area on model 300-500 meters

C. Forest complex of W. Nestos (Kara-Dere)

The existing road density of forest complex of W. Nestos (Forest Office of Drama and Forest Office of D. Nevrokopiou), is 15.09 m·ha–1 and the road distance in 10000 / 15.09 = 663 m. According to the model of fig. 6 is satisfactory because the road density exceeds the threshold of 12.5 m·ha–1 and road distance is less than 800 m. Given that the productive mountainous forests the optimum road density for mechanization of skidding works, should reach the optimum economic that the complex of W. Nestos amounts to 21.90 m·ha–1 corresponding to 457 meters road distance this will be even more satisfying.

Regarding the space allocation of roads to the existing network:

- Optimum road distance 457 m (hence timely firefighting in 150 m uphill and 250 m downhill) was calculated forest protection percentage 45.62% (Forest office of Drama Dex = 16.64 m·ha–1) and 38.60% (Forest Office of D. Nevrokopiou with Dex = 11.03 m·ha–1) (Fig.s 10, 11).
- Optimum road distance 663 m (200 uphill and 400 downhill) estimated forest protection percentage 57% (Forest Office of Drama) and 50.7% (Forest Office of D. Nevrokopiou).

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- Optimum road density 800 m (300 uphill and 500 downhill) estimated forest protection percentage 63.7% (Forest Office of Drama) and 57.6% (Forest Office of D. Nevrokopiou) (Fig. 12).

So with tube length 500 m (by road distance 800 meters), and with the proper space allocation of roads parallel with the increase of road density until Dec expected more adequate fire protection percentage > 70%. Improving space allocation of roads need the Eastern part of the Forest Office of Drama and the West part of the Forest Office of D. Nevrokopiou until the optimum road density of 21.90 m·ha–1.

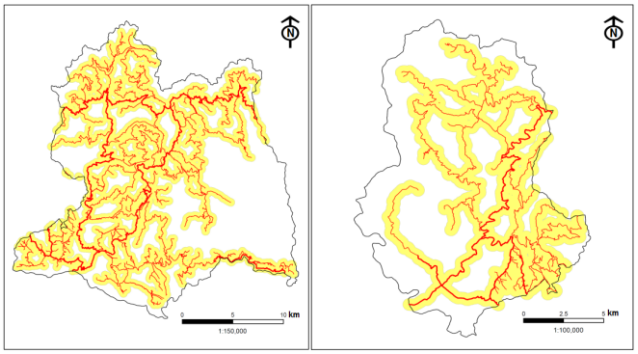

Fig. 12, Forest protection percentage 63.7 % of the West Nestos complex managed by the Forest Office of Drama (left) and 57.6 % by the Forest Office of D. Nevrokopiou (right) with road distance 800 meters (fire extinguishing distance 300 m uphill and 500 m downhill)

IV. CONCLUSIONS-SUGGESTIONS

These results conclude and suggest that:

In mountainous productive forests for wood transport, escaping of fire fighting vehicles is ensured by adequate road density (typically 25 m·ha–1, much higher from the broadleaf evergreen forest that is less than 10 m·ha–1) and the lower speed of spread of the fire (max 14.8 km·h–1 and evergreen understory 25 km·h–1). These speeds are less than the average speed of trucks in the forest, which is an average of 25 km·h–1.

Patrols of small and agile van 4×4 (Fig. 7) appropriately equipped (pipe length of 500 m and putting pressure on uphill to 300 m) for the first attack of the fire in the summer months coupled with early warning of fire lookout stations adequately cover the forest fire protection of University Forest of Taxiarchis – Vrastama, and W. Nestos forest complex. But in space allocation of the already existing forest roads needed improvements for both forest fire protection and for better management (skidding) of woody capital. As for the forest complex of Lailias with a percentage of protection against fire from the ground amounts to 79.49% for the total protection it is more than satisfactory for the Greek and Mediterranean standards.

V. ACKNOWLEDGMENT

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AUTHOR PROFILE

Dr. Vasileios C. Drosos, Associate Professor I was given birth in Katerini - Pieria Prefecture in Central Macedonia of Greece. I graduated from the Department of Forestry and Natural Environment of Aristotle University of Thessaloniki in 1990. I am holder of doctoral title with degree "Excellent" from 2000. I elected as Lecturer in the Department of Forestry and Management of the Environment and Natural Resources of Democritus University of Thrace in Orestiada in the cognitive object of Forest Cadastre on 2000. On December of 2005 I elected as Assistant professor in the same Department. I elected as Associate professor on December of 2012 in the cognitive object of Forest Cadastre, Forest Constructions and Forest Opening up. During these years the following courses: Geotechnical Drawing, Technical Mechanics, Topography, Elements of Technical Legislation, Applications of Photogrammetry, Topographic Instruments and Surveying of Forest Regions, Technical Works and Environmental Impact Assessments, Building and Structural Materials, Forest Road Construction, Forest Aerial Photography, Forest Cadastre, Opening up of Forest - Skidding and Transport of Forest Products, Technology of Structural Materials, Science of Engineer, Remote Sensing of Natural Resources, Implementations of Machineries in Forest Technical Works, Forest Constructions, Mapping of Natural Resources and Agricultural Engineering were taught. My research interests are Forest Cadastre, Land Planning, Environmental Impact, Technical Design, Technical Engineering, Surveying, Photogrammetry, Forest Opening Up and Forest Constructions. I am member of FORMEC network. I have above 140 publications in Greek and foreigner magazines and congresses.

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