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AN OPENING UP AND HARVESTING SYSTEM TO PREVENT AND FIGHT FOREST FIRES

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Abstract: *Climatic changes may cause temperature rise and thus increase the risk of forest fire. Because of the forest fire, in Greece only during the summer of 2007-2009, 71 people died and about 200,000 ha of forest and many homes burned. In Greece, the forests with the greatest exposure to fire risk are usually those located near the residential and touristic areas where there are major pressures on land use changes. In these areas, the deliberate actions causing forest fires exceed a percentage of 50%. Terrestrial fire protection zones have been set, based on the technical capabilities of the Greek fire-fighting brigades for the study area. Special plastic fire-hoses are used, adapted to the fire-fighting brigades; they are connected in pieces of 30-50 meters up to a total length of 300 meters uphill and 500 meters downhill. The protection coverage was calculated and the study area was divided into not protected, protected and multiple protected areas. For the mechanization of the harvesting system in Greece the ecological and social issues are taken into account. The proposed opening up model for the research area is given. The proposed model is compatible with the environment and its importance is even greater when we operate in burned areas where the erosion hazards are increased and the preservation of forest soils is the most critical factor for the future reforestation.*

Key words: *load, draught, cable crane, salvage logging, clear cut.*

1. Introduction

Anthropogenic changes in climate are postulated. Climatic changes cause temperature rise and thus increase the risk of forest fires.

In Greece, only during the summer of 2007-2009, 71 people died and about 200,000 ha of forest and many homes burned.

Apart from drought due to climate change, social and political conditions have increased dramatically the number of fires [2].

The fight against forest fires is managed in two actions, prevention and repression. The prevention level is the most important [6], more effective and less costly.

The action of prevention includes silvicultural measures (cleaning the fuel of understory), observations (patrols, aircraft, and satellites), the construction of forest roads and water supply networks.

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In Greece, the forests with the greatest exposure to fire risk are usually those located near the residential and touristic areas where there are major pressures on land use changes, while there are no currently guaranteed cadastral maps and defined title deeds because of the lack of National and Forest Cadastre. In these areas the deliberate actions causing forest fires exceed a percentage of 50% [6].

In Greece, only 15% of the forest fires are occurring at altitudes of over 500 meters [3], mainly due to some oak forests and black pine plantations.

The forest opening up system (harvesting and transportation) is important in order to prevent and fight against the forest fire and its effects.

In Greece, the firewood extraction is done mainly by using animals that carry the wood in a downhill direction on a distance of more than 500 m [4] as well as the draught animals to extract other wood assortments. The optimum road density in non-productive mountainous Greek forests depending on the skidding means ranges from 10 to 15 m / ha corresponding to mean road extraction distance 10000 / 12.5 = 800 meters [5].

These extraction systems are disadvantageous for many reasons:

- Firewood can be extracted efficiently at a mean skidding distance of 100 m (up to 200m) and 250m (up to 500m) by using animals that carry the wood in an uphill and downhill direction, respectively. So animals must be used at distances less than the existing ones.
- Because of the selective silvicultural system may involve the use of highly mechanized harvesting systems.
- The slopes of the mountainous forests in Greece are greater than 30%.
- Because of the lack of forest workers in such difficult works like the traditional harvesting it is necessary in the future to introduce full mechanization even if the extraction is for firewood.

Greek forest ecosystems provide multiple non-timber forest products and services which are crucial for the socio-economic development of the forest, rural and urban areas of Greece.

The socio-economic changes of the last decades, triggered by the urbanization of Greek society and better living standards, have led to an increase in the demand of the social and environmental functions of Greek forests, such as fight against desertification, microclimate management, control of water resources, etc.

From the above the economic importance of certain non-timber forest products is highlighted. All these are important primary resources for the survival of local economies, and the key for the sustainable development of these communities.

In the above context the forest fire-fighting acquires new dimensions that require new technical structured approaches in order to plan how to manage the burned wood and better address the complexity and multi-functionality of the Greek or Mediterranean forests.

Furthermore, in Greece, the indirect ecological benefits of forest help the heavy industry, the tourism and they are more significant than the direct benefits of wood harvesting. Unlike in Europe, the wood harvest is a key economic factor. Cheap timber supplies can be provided by the EU countries with plentiful forest wealth to the poorest ones.

Therefore, the reasons for preventing the forest fires are rather ecological than economic in Greek forestry.

Following a forest fire, clear cuts are implemented resulting in production of logs that are used either for the construction of barriers or for sale. Then, the constructed barriers have functions in soil erosion control.

In Greece post-fire management is organized in two phases. The first step is carried out in order to control the erosion, floods and other catastrophic phenomena. The second phase involves the assessment of requirements for long-term rehabilitation of the forest; this phase is based on a detailed assessment of the biological, economic and social impacts of the fire. Despite the widespread acceptance of this approach, there are many cases in which the remedial actions are implemented without an integrated design, while a number of issues related to post-fire management, including the extraction of burned logs (salvage logging) are the subject of discussion and contrasts between scientists and managers.

The aim of this paper was to answer the following questions:

A. What is the maximum acceptable extraction distance in order to prevent the fire risk and harvesting?

B. How the forest fire effects can be controlled by logging?

C. What would be the optimal (mechanized) harvesting system for the Greek conditions?

2. Material and methods

2.1. Research area

The present study has been carried out in the forest complex of Lailias (Figure 1). The Lailia forest, is located 25 km from the Greek city of Serres, and has a unique natural beauty. It is a high, productive mixed forest of beech and pine (*Fagus moesiaca, Pinus Silvestris* and *Pinus Nigra*) with an area of 3,300 ha. This is a mountainous massif with the highest peak having an altitude of 1850 meters, 83% of forest cover and a road network length of 110 km.

The bio-climate of the region has a temperate character without dry and warm periods belonging to the Central European climate.

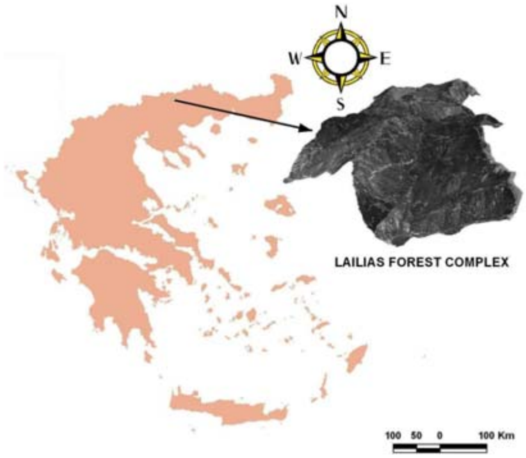

Fig. 1. *Forest complex of Lailias*

2.2. Methodology

In order to prevent the fire risk and to protect the forest, we had to estimate the maximum acceptable distance from the road within the forest. This distance depends on the pipe lengths available on the fire trucks, as well as on the available water pressure, resulting in a shorter width of the protection zone uphill, because of a greater pressure needed for water.

The GIS command REGIONBUFFER was used in order to carry out a buffer analysis with different sides, surrounding the existing forest roads in order to calculate the protected percentage and to define the protected and unprotected areas. In this procedure we took into consideration the local topography and we used breaklines to represent streams and ridge lines. The next step in our analysis involved the classification of the study area in four different types of opening up conditions: not opened, single, double and triple opened for each skidding direction. Finally the opening up and protection percentage were estimated.

For the mechanization of the harvesting system in Greece the ecological and social issues are taken into account.

3. Results and Discussion

3.1. Road distance

According to the pipe lengths (Table 1), we estimated the maximum acceptable road distance as shown in Figure 2.

Sections of tubes and total lengths of action of forest fire fighting vehicles Table 1

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

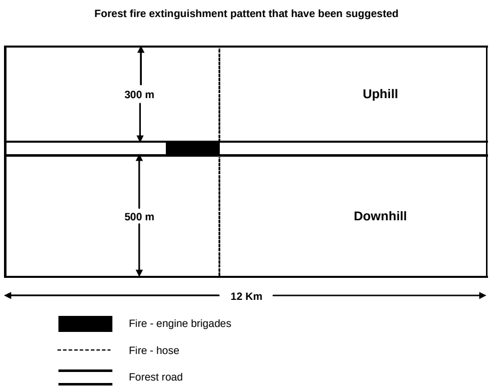

Fig. 2. *The protection zone when used specifically connected pipes in length of 300 meters uphill and 500 meters downhill*

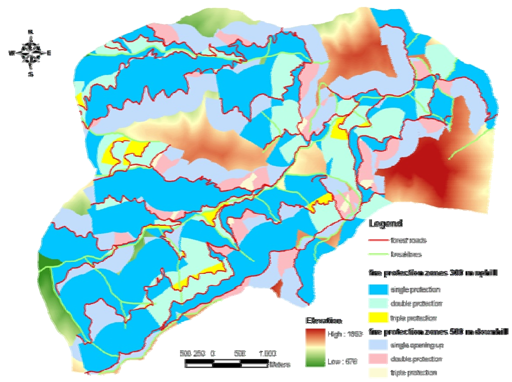

Fig. 3. *Map of terrestrial fire protection zones 300-500 meters in Lailias forest complex*

The protection percentage against fire in the forest of Lailia (Figures 3 and 4) accounted for a share of 79.49% in case of the total protection (out of which 50.40 % of the protected area was uphill and 53.90% of the protected area was downhill) and a share of 24.81% for the multiple protected areas.

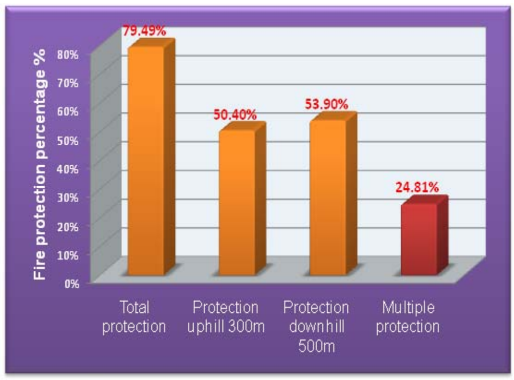

Fig. 4. *Percentages of fire protection in the research area on model 300-500 meters*

3.2. Fight the effects of the forest fires

As described before, there are implemented clear cuts after the forest fires. Depending on the used extraction equipment, the current optimum road density in productive mountainous Greek forests, such as the Lailias forest complex, must be in range of 20-25 m/ha corresponding to a mean road extraction distance of 10000/20 = 400-500 meters.

In figure 5 animals for skidding the logs downhill are used, in order to transit from the semi mechanization to fully mechanize era. Uphill extraction is carried out using cable yarders, draught animals or small winches mounted on tractors. The latter ones are used in order to extract the wood along the rope line. The skidding direction is horizontal, in order to protect the soil against the erosion. This way the cable yarder is mounted less often, a fact that contributes to the efficiency increment and to the soil protection.

The proposed opening up model as well as the opening up percentages for the forest complex of Lailias is presented in Figures 6 and 7.

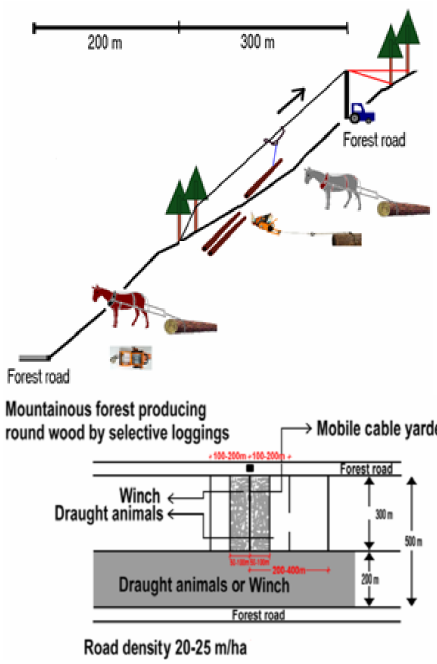

Fig. 5. *Horizontal Plan and Cross section of the proposed opening up*

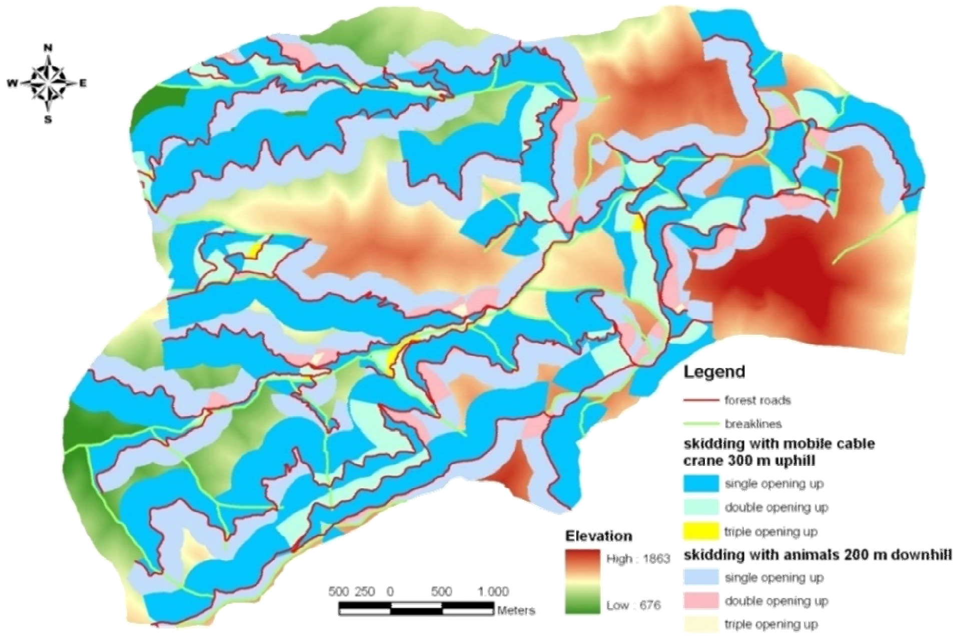

Fig. 6. *Opening up zones in the proposed model of Lailias forest complex*

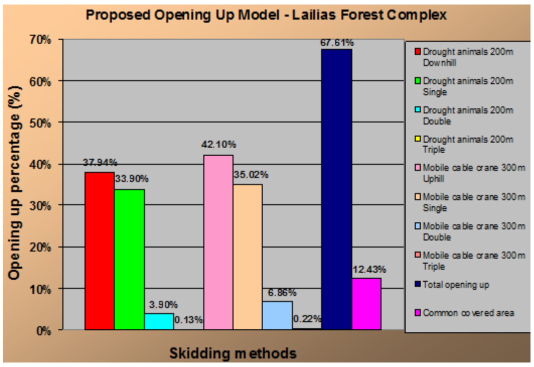

Fig. 7. *Opening up percentage for the proposed model*

The total opening up percentage was of 67.61%; 37.94% of this percent was covered by draught animals, 42.1% by cable yarder and 12.43% represented the common covered area. According to Backmund's classification [1] this percentage was satisfactory.

3.3. What is the optimal method of mechanization in the future?

The lack of forest workers in difficult operations such as the traditional harvesting with animals and the use of clear cut silvicultural system following forest fires is likely to introduce in the future fully mechanized harvesting systems.

This depends on the forest species, the curvature of trees, the afforestation system, the ground slope, the need to build log erosion barriers and the distance between the machines' passes.

According to the forest species the following situations may occur:

- *Conifers species.* The crawler harvester option is indicated on slopes greater than 30% (50-55%) and coniferous trees (black pine, fir), where damage to the roots are of no concern (artificial afforestation); however has little effects to the ground. Even soil compaction is less. The stem straightness of the trees is not an obstacle to the selection of the harvester's head.
- *Broadleaves species.* The wheel harvester is appropriate for slopes up to 30%, because it protects the roots of stumps needed for revegetation. But because of the twisted stems require special heads for the harvester. One such type is the CTL 40 HW.

According to the distance between the machines' passes the design of the harvest should be as presented in Figure 8. The distance between two consecutive passes is larger than that in Germany. Since draught animals work efficiently to 100 meters and they are ideal for use in the full-tree harvesting method [7], the suggested distance between two harvester passes would be of 200-230 meters (Mean skidding distance 100m). Trees that cannot be reached by the harvester (> 15 meters), should be felled using a chainsaw and extracted by animals or tractors near the operational range of the harvester for further processing. The skidding tractors must be used only in horizontal terrains. The logs can be taken from the passes by tractors equipped with skidding cable.

When using a Bagger machine (Figure 9) the distance between passes can be increased to 70 + 70 + 2 × 200 = 540 meters. Then, the extraction of logs to the forest road is performed by a forwarder. The routes of the side passes should be straight. When they are interrupted by the horizontal passes, in order to reduce the risk of erosion, they should be redesigned to a parallel location.

4. Conclusions

From the above concluded:

- The proposed minimum road distance can protect the forests from fires, if the forest roads are spatially distributed evenly in the forest area.

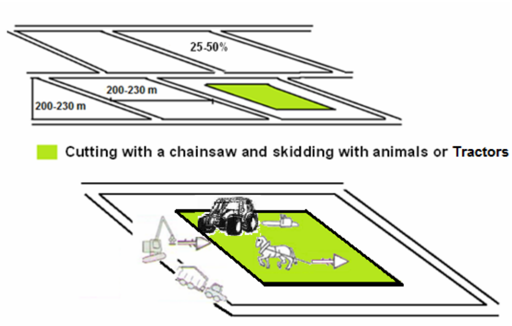

Fig. 8. *Passes of harvest*

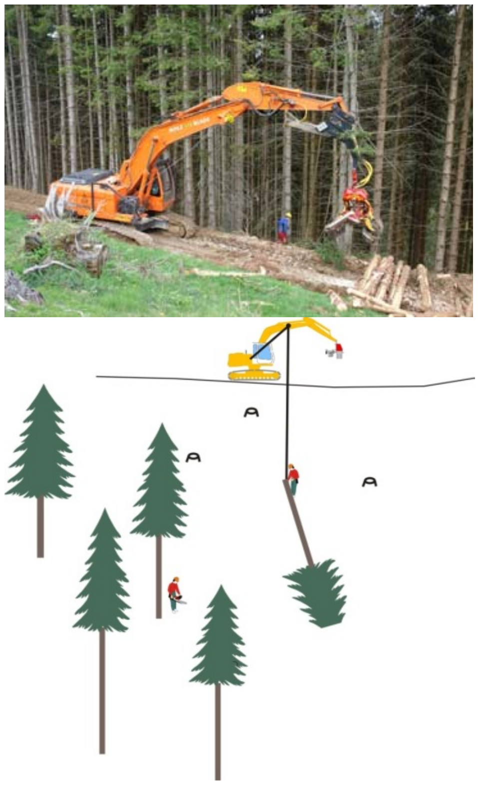

Fig. 9. *Combination of Bagger with Processor and cable crane for a distance of 70 m (Klade) [Photo: Stampfer K]*

- The proposed opening up model for the transitional phase from the semi mechanization to fully mechanization is compatible with the environment which is causing less damage during skidding to forest ecosystems. The opening up percentage of this model satisfies both harvesting and protection from the fires.

- Designing the appropriate prevention and extinction works of forest fires with innovative environmentally compatible methods (environmentally sound construction of forest roads, allocation of fire fighting vehicles, fire lookout stations, types of fire fighting vehicles, the required number of vehicles and personnel), the fire spread can be limited.

- Projects to recover the area after fire (original methods of harvesting timber, erosion wooden barriers, etc.).

- The proposed opening up model is more compatible with the environment when it is operated in burned areas where the erosion hazards are multiplied and the preservation of forest soils is the most critical factor for the future reforestation, and that's why its importance is greater.

We suggested:

- The fully mechanized method for clear cuts is necessary in the future. At least, a limited number of machines should be installed in 2-3 stations all over Greece from where they could be transported to wherever it is necessary.

- In a network the researchers and service representatives whose object is fire ecology and forest management, have to work all together in order to develop and disseminate decision criteria for post-fire management into the forest landscape.

- The creation of forest maps and the control of illegal buildings are prevention measures of forest fires and land use maps are a developmental measure of forest areas.

- In these cases there should be proposed both the rehabilitation actions based on a detailed assessment of the effects of fires and the clear approach to the organization of rehabilitation which is separated in two categories: the one of direct interventions to address short-term risk and the other of the mid-term risk.

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