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ABSTRACT	<p>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. In Greece only during the summer of 2007-2009, 71 people died and about 200,000 ha of forest and many houses were burned, mainly in the wider area of Ancient Olympia. The aim of the paper was the better organization of firefighting means in order to avoid of a new disaster. The method which was followed:</p> <ol style="list-style-type: none">1. It was estimated the rate of spread of fire in predominantly forest species of the Kronion hill and the surrounding area i.e. Broadleaves evergreen and Aleppo (Calabrian pine) pine.2. It was designed the firefighting system is separated in the design of prevention and suppression.3. The forest protection zones were mapped. <p>Fires in Mediterranean shrublands (MSL) are the most dangerous of control and treatment side as they combine high speed and very high thermal stress. Addressing fires MSL terrestrial means is impossible after the very initial stage. In fields (mountainous grasslands), the existence of purified zones can help control the spread of the fire if there are strong winds. Fire lookout stations and independent functioning extinguishing towers are required, as well as the parking of a vehicle in Ancient Olympia during the summer months for early detection and extinguishing.</p>
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KEYWORDS	Mediterranean shrublands; terrestrial means; forest protection zones
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Introduction

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.

In Greece 85% of forest fires occurring at altitudes of below 500 meters (Dimitrakopoulos, 1998) i.e. in semi-mountainous areas [Altitude 300-650 (700) m] and lowlands. 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 houses were burned, mainly in the wider area of Ancient Olympia.

In the historic forest of Ancient Olympia, this as we know is of great archaeological value (Figure 1), the fire reached by the stadium and the museum and fire extinguishing a few meters before reaching the buildings and ancient ruins. The pine forest in the surrounding area (Aleppo pine) was destroyed along with the famous Kronion hill that dominates the stadium. Pine forests have been planted at the feet of these hills to deter the erosion of the soil.



Figure 1. Historic Forest of Ancient Olympia before the fires of 2007

The current situation is:

- Rehabilitation of burnt vegetation shows improved aesthetic (Figure 2), with removal of burnt pine (Figure 3) and planting shrubs as oleander, lentisk (Schinos), Myrtle.



Figure 2. Aesthetic improvement of the burnt area with shrubs.



Figure 3. Removal of burnt pine in front of the Archaeological Museum

- The evolution over time of Kronion hill is shown in figure 4. Despite enduring disasters produce new shoots and evolution. The ancient oak forest of Olympia was succeeded by the Aleppo pine with understory of evergreen broadleaved. The understory has already been restored, but not the arboreal vegetation except from a few cypresses. We hope in the second stage to have and arboreal vegetation of broadleaved evergreen and Aleppo pine for better protection.

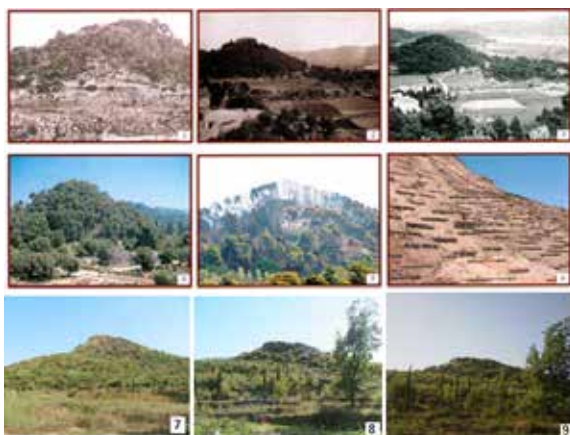


Figure 4. Diachronic evolution of vegetation of Kronion hill (1: 1900, 2: about 1910, 3: 1930, 4: 2004, 5: 2/9/2007, 6: 10/23/2007, 7: 12/07/2011, 8: 08/11/2012, 9: 07/27/2014).

- The anticorrosion measures by logs bars at Kronion hill were successful (Figure 5b), except a small area required reinforced retaining (Figure 5a).



Figure 5. Unsuccessful (a) and successful (b) retaining measures

The aim of the paper was the better organization of firefighting means in order to avoid of a new disaster.

Materials and Methods

The research area of Ancient Olympia in the Peloponnese area occupies 98 hectares around the Kronion hill and the archaeological site (Figure 6).



Figure 6. The major forest fires in the research area of Ancient Olympia (see: arrow) and more widely during the summer of 2007.

The method which was followed:

1. It was estimated the rate of spread of fire in predominantly forest species of the Kronion hill and the surrounding area i.e. Broadleaved evergreen and Aleppo (Calabrian pine) pine.

2. It was designed the firefighting system is separated in the design of prevention and suppression.

This research is focused on the prevention and also with the first intervention, because after their failure the control of the fire is difficult and costly, because the support from aircrafts is required and the losses are uncontrollable. Prevention of suppression in the first 15 minutes is the most important stage of protection, because the suppression leads to uncontrollable situations.

Direct fire suppression requires access on forest roads in the outbreak of the fire and adequately equipment of fire trucks with special hoses.

Figure 7 is shown the protection zone when used specifically linked hoses in length of 300 meters uphill and 500 meters downhill. The difference in the uphill and downhill measures is due to the greater need for a water pressure uphill.

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 common fire trucks (Tsakalidis and Gitas, 2008), which may be up to 100 %. E.g. fire pump ROSENBAUER NH20 on vehicle ELBO (Figure 8) has a pump flow at low pressure: 1750 l·min⁻¹ at 10bar and at high pressure: 400 l·min⁻¹ at 40 bar.

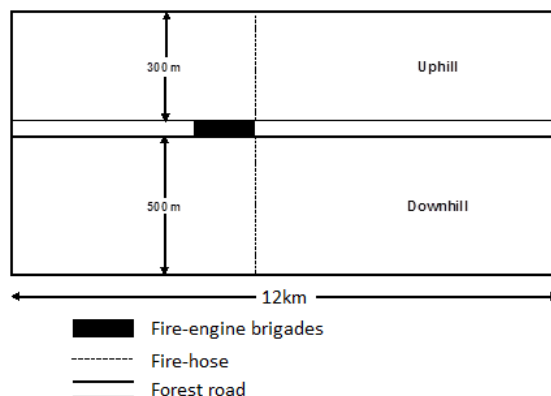


Figure 7. The protection zone, when special linked hoses are used in a length of 300 meters uphill and 500 meters downhill.



Figure 8. Typical Forest firefighting vehicle (UNIMOG of ELBO)

Table 1 is shown the number and total length of hoses according to available fire brigade vehicles type.

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) X(4)
UNIMOG 2,5	25 and 45	15 and 6	25and 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

3. The forest protection zones were mapped. The main sources of collection of mapping data of zones were aerial photos, digital orthophotomaps and satellite images with high geometric resolution (1 m). Additionally digital terrain models in Raster format using GIS (Arc Info 9.2) were produced and are based on photogrammetric measurement and digitization of analogue topographic maps at a scale of 1: 5000. The necessary control points for the photogrammetric procedure of aerial photographs measured by geodetic GPS. The forest road network of the study area was mapped in Vector format (polygonal lines).

Results

A. Fire extension rate

In figure 9 (Directorate of Forests, 2008) is shown the estimation of the fire spread rate based on a typical scenario of meteorological conditions of summer season for the type of fuel that is represented by the semi-mountainous rural - grasslands, evergreen broadleaves and Calabrian (Aleppo) pine.

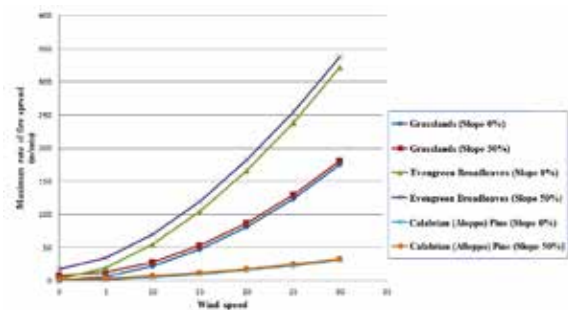


Figure 9. Estimation of the fire rate spread

We observe that:

- a. The rate of fire spread in Mediterranean shrub lands (MSL) is very high (up to 340 m / min) and their spread particularly favored by the winds, as seen from the above table on. Winds stronger than 5 km / h make the speed of the fire to exceed the limits of the suppression capabilities by terrestrial means. The slope affects the speed of the spread of the fire in MSL only in case of no wind.
- b. The fields - grasslands are a biomass fuel component that is found in many places in forest complexes, spatially connecting other types of forest fuels so often in a decisive way for the spread of the fire. In general the behavior of fire in the fuel is mainly controlled by the intensity of the wind and can reach up to 180 m / min.
- c. The spreading speed in the trachea (Aleppo) pine, as is shown by the relative spread rate of the above chart is fast with maximum bit less than 33 m / min. The wind severely affected by the spread of the fire in this fuel. The slope affects to a lesser extent the spread of speed, but in small wind

intensity contributes significantly to accelerate the roll. When the stands, which usually amount to 15-20m height and have 80% ground cover, have positions in understory with evergreen broadleaves or grass, then we have crown fires, the mixture leads to uncontrollable situations.

B. Forest protection rate calculation and determination of protected and unprotected from fire areas.

From the cartographic processing and placement of zones can immediately extinguish by terrestrial means arose the map of figure 10and forest protection percentages of figure 11.

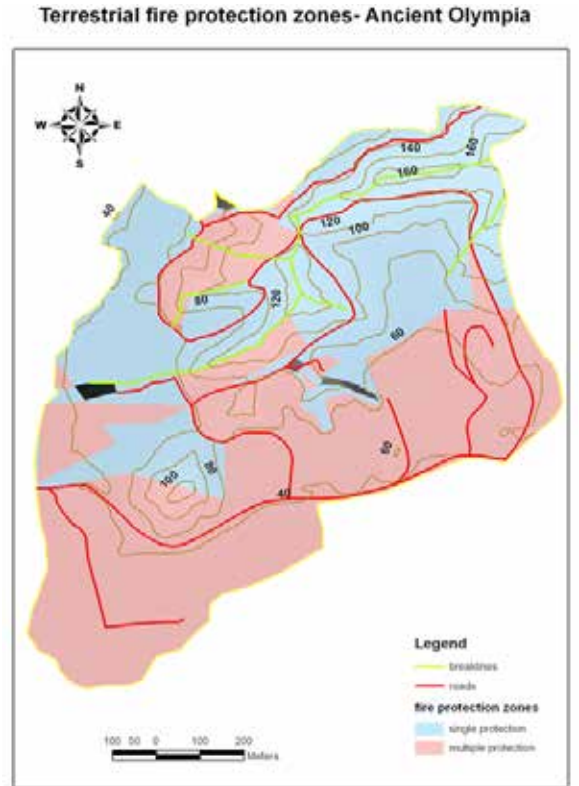


Figure 10. Protection Zone Map in Olympia on the model of 300-500 meters.

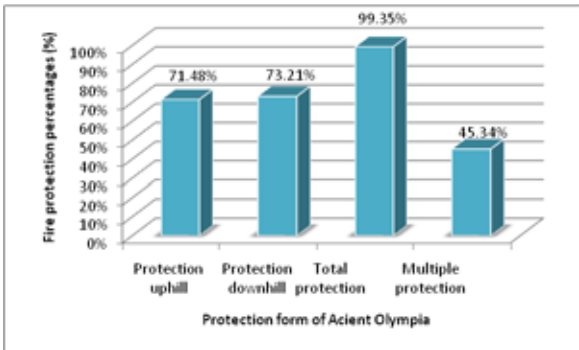


Figure 11.Percentages of fire protection in the area of research on model of 300-500 meters.

We observe that in Ancient Olympia (Figure 10) percentages of simple protection amounted to 99.35% and 45.34% the multiple one (Figure 11).

Conclusions

- Fires in Mediterranean shrublands (MSL) are the most dangerous of control and treatment side as they combine high speed and very high thermal stress. Addressing fires MSL terrestrial means is impossible after the very initial stage.

- In fields (mountainous grasslands), the existence of purified zones can help control the spread of the fire if there are strong winds.

- Fires in fuel pine are generally rapid and with high heat load. In places where there is understory of evergreen broadleaved or carpet of needles, the speed and intensity of the fire will have more speed and heat intensity. Where there tiered fuel structures is very likely that the fire to be crown fire and move uncontrollably, depending on the intensity and stability of steering winds will blow during of spreading. Conifers have thick skin with large heat capacity which can ensure the survival of individuals at higher intensities.

- The rate of spreading of fire of evergreen broadleaves is very high and when they are understory adversely affects the fire in high forest. A reception forestry measures without creating high forest understory is necessary.

- The protection of roads is sufficient if the hose length is sufficient (model 300-500 meters) and appropriate space allocation of forest roads.

- Fire lookout stations and independent functioning extinguishing towers are required, as well as the parking of a vehicle in Ancient Olympia during the summer months for early detection and extinguishing.

- Organization of firefighting and the region to prevent introduction of the fire from outside of Olympia areas that are not organized to deal with fires.

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