

## Environmental planning directions in peri-urban residential areas and scattered settlements vulnerable to forest fires

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### Introduction

Forest fires are a phenomenon with an important natural role in the Mediterranean forest ecosystems but for a number of reasons related to human needs and activities, for several decades, it has become a major problem for modern states, especially in the Mediterranean and in our country too. The ecological disasters caused by the increased frequency of fires observed today, due to human activities, is much greater than that caused by natural frequency fires. In our country, the abandonment of the countryside “removed” from the forests their natural protectors, of the populations that lived and exercised in them, and accumulated large quantities of combustible forest fuels. This over-accumulation exacerbates the problem of fires, creating favorable conditions for their onset and increasing their intensity if they occur.

In our country, as in other Mediterranean countries, there have been settlements near and in forests for a long time. However, the fires that reached them did not cause any damage as the perimeter of the settlements had limited fuel due to its continuous use by the inhabitants, the surrounding area usually had agricultural crops and functioned as a pastureland and the inhabitants actively participated in the suppression of any fires. Internal migration from the countryside to large cities has led to a sharp decline in forest populations and the gradual abandonment of traditional rural activities resulting in biomass accumulation and increased vulnerability to forest fires.

Almost at the same time, these socio-economic developments and the gradual degradation and scarcity of space in large urban centers, direct the residential pressures mainly to the peri-urban and coastal forests as well as the tourist areas, gradually transforming huge areas into a constantly changing mosaic of settlements and fragmented forests (mainly to the detriment of forests and agriculture), which are absolutely vulnerable to forest fires.

Fires in wildland-urban interface (forest-settlement mixing zones) are a relatively new problem that has gradually emerged since the 1980s as a separate problem of great importance in our country. In both cases (settlements near and in forests and in peri-urban and coastal forests), the conditions created greatly increase the risk of fire starting from anthropogenic activities that are very difficult to deal with by the firefighting forces, can cause loss of life and can lead to destruction, in addition to the forest, property and infrastructure. Typical examples in our country are the fires of 2007, during which many residents of settlements lost their lives, mainly in the Peloponnese and Evia, the fire in 2018 in Mati, Attica, during which 103 people lost their lives and the big fire of 2021 in North Evia which burned almost all the forests around the settlements, cases that highlighted the problem of security of settlements against forest fires.

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This paper examines issues of fire protection planning of these areas in the light of a complex of forest-settlements as a whole, and discusses measures that can be planned to protect this complex.

### Materials and methods

#### 1. Peri-urban residential areas in forests, the case of Mati, Attica

Cottage or holiday homes settlements, often built without a plan in or in contact with forests, are distinguished by low to medium quality housing construction with several flammable materials and many weaknesses in relatively small plots. The vegetation is often in contact with the houses and the road network is usually insufficient (narrow roads, large slopes, dead ends, inability to turn, etc.). In addition, residents, who in many cases have become permanent in these areas, have little awareness of the risk of fire and lack of knowledge to prevent and respond to a fire.

The case of the settlement of Mati, in Attica is representative of the creation of settlements in the peri-urban space of cities and especially of the spread of holiday settlements in areas where mainly *pyrophilic* (or fire-resistant) species of forest vegetation are spread. This development, as shown in figure 1, expanded the perimeter of residential areas and the contact zone of settlements with forests (wildland-urban interface). In the fire of 7/23/2019, 103 people lost their lives, mainly in the settlement of Mati, and a total of 1,275.9 ha were burned in the settlements of N. Voutzas and Mati, of which 693.40 ha of settlements (over than 1400 homes) and 582.50 ha forest lands (figure 2).



Figure 1. Typical image of settlements in the forests (before the fire)

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figure 2. Map showing the burned area because of the fire of 23/7/2018 in the region of Voutzas, Rafina and Mati, Attica (NKUA, 2018)

### *2. Settlements scattered in forests, the case of Northern Evia.*

The socio-economic developments mentioned above, among others, created a problem of security in these settlements against forest fires. In the region of Northern Evia, most settlements are scattered in forests, mainly in the coastal, hilly and sub-mountainous zone, where the vegetation belongs to the thermo-Mediterranean formations of the Eastern Mediterranean which are typically flammable. In addition, the forests that dominate the area are typically characterized by fragmented management, due to which fuel accumulates, and insufficient fire protection infrastructure.

During the catastrophic fire of 3-11 / 8/2021, the total area burned was 51,203.15 ha (figure 3) of which 32,218.90 ha are located in the Municipality of Limni - Mantoudi - Agia Anna (percentage 63% ) and the 18,984.26 ha in the Municipality of Istiaia Edipsos (percentage 37%). In the Municipality of Limni - Mantoudi - Agia Anna, 18 Local Communities have been affected by the fire, of which 77.11% (on average) of their total area has been burned, and in the Municipality of Istiaia - Edipsos, also 18 Local Communities, of which burns 62.31% (on average) of their total area.

It is noteworthy that in several Local Communities the percentage of their area that has been burned exceeds 80% and reaches up to 100% (YLI, 2021).

Typical examples are the settlements of Achladi and Gouves (figure 4) that are surrounded exclusively by Aleppo pine forests with the exception of some small agricultural crops (vineyards, fruit trees and a few vegetable gardens). Most of the land that used to be rural and created some intermediate gaps in the forest, after the long abandonment of their owners, became forested area. The data of the burned areas are presented in the following table (table 1):

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A/A	Settlement	Total area (ha)	Burned area (ha)	Percentage burned on total area (%)
1	ACHLADI	1.913,60	1.877,28	98,10%
2	GOUVES	1.465,95	1.269,86	86,62%

table 1. total and burned area / settlement

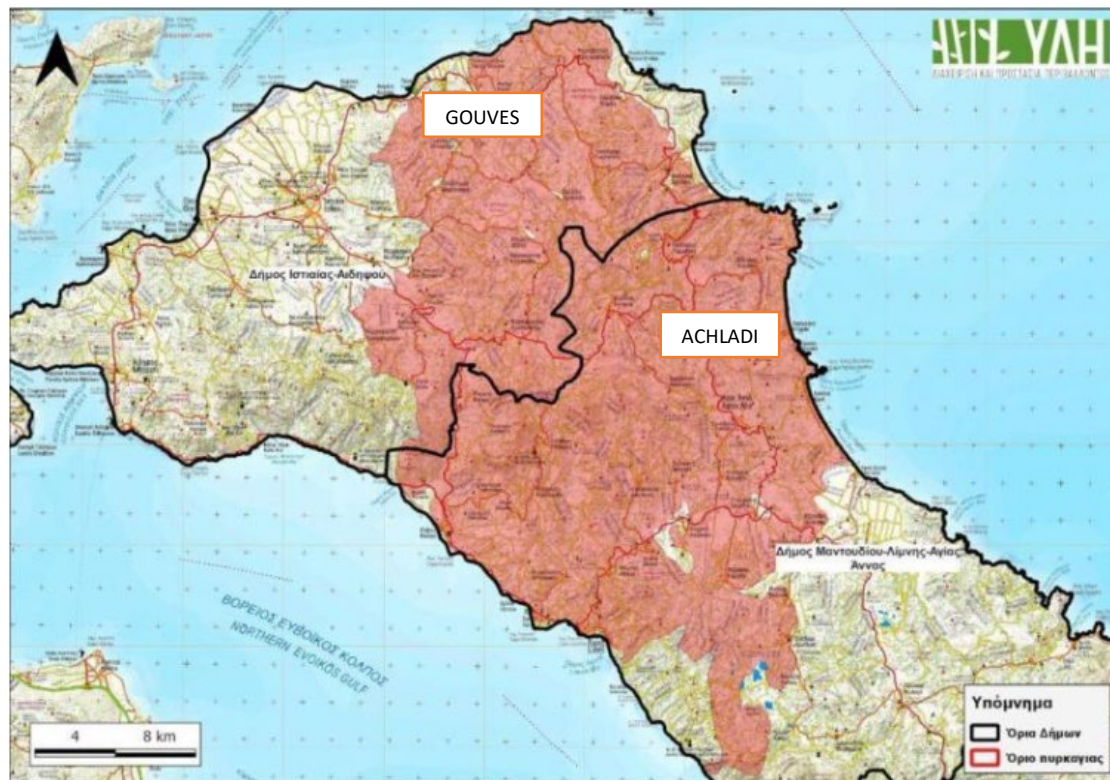


figure 3. map showing in red the extend of fire of 3-11/8/2021 in North Euboea (Evia) and the location of the settlements (YLI, 2021)

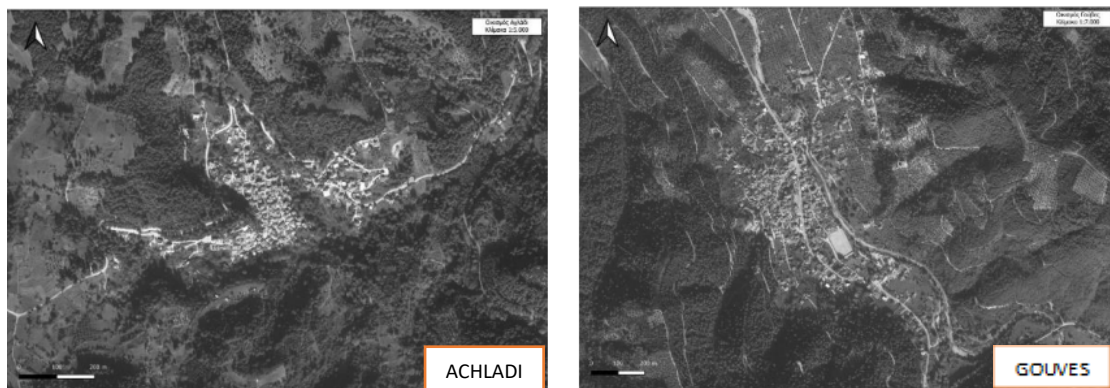


figure 4. Aerial view of settlements and the surrounding forests, before the fire

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The specific areas are characterized by a mixture of forest-settlements in a Mediterranean environment and the main thing is the safe and quality living of the inhabitants, the vacationers and the visitors. In these areas the exposure especially to the risk of forest fires is constant. Especially under the "extreme" conditions that often prevail during the summer in our country, the occurrence of fires can cause great damage because the fire suppression, even for a well-organized mechanism, is very difficult in such areas.

From this point of view, environmental spatial planning should take full account of this risk in order to try to solve significant problems and incompatibilities to reduce or even eliminate it. All kinds of interventions should focus on prevention and relate to a set of actions that must be taken before starting a fire, in order to: a) reduce (or eliminate) the possibility of fire, b) reduce the probability of spread of any fire, and c) organize a mechanism capable of efficient monitoring of any new fire, sending and organizing the forces required for its immediate suppression.

Reducing the risk should be achieved either by creating forest fuel-free zones, or by reducing forest fuels (removing dead forest biomass), or by increasing its fire resistance. Dealing with the forest-settlement complex as a unit will help to draw up firefighting plans effectively, for such mixed areas, in order to adapt the doctrine of fire suppression in the new context of an upgraded prevention. In this context, of course, emphasis should be placed on the proper management of the forest that will be reestablished and will "surround" the settlements, treated as ecosystem but at the same time to reduce the vulnerability of the residential area. This concerns both the houses and the other facilities (depending on their characteristics and the vegetation in their immediate vicinity) as well as the traffic organization of the settlements.

Finally, it should be noted that the view of dealing with the forest-settlement complex as a unit is not new and in fact very recently described in the Report of the Independent Committee of Experts to Investigate the Causes of Fires under Prime Ministerial Decision Y60 / 2018 (known as "Goldammer committee"): *"The increased risk in structured forest areas is due to the existence of human activities near forest ecosystems (recreation, work, etc.) combined with insufficient infrastructure (road network, fire hydrants, etc.) and lack of knowledge of the people of the city on the dangers and how to react in case of fire. Given the above, it is obvious that the existence of forest-settlement mixing zones must be seriously taken into account when preparing firefighting planning for a wider area, so that special attention is paid there both during the prevention phase, with special planning and measures to reduce of danger, as well as in case of fire with special measures for the protection of homes. The removal of vegetation from the construction elements and the creation of safety zones (zones cleared of vegetation) around each house is an important measure to protect settlements and individual houses from the threat of forest and rural fires"*.

## Results

As mentioned above, the protection of settlements from fire became a major issue after the fires of 2007, when huge forest areas were burned and many human lives were lost, mainly in the Peloponnese and Evia. Recently, in the year 2018, we had the 103 dead people in Mati, while in 2021, the fire in Northern Evia again highlighted the problem of the safety of settlements, against forest fires.

The reduction of the risk is sought, either by creating a zone without vegetation, or by reducing the fuel, or by increasing its resistance to fire. The main purpose of fire suppression, especially in high forests, is to convert the tree canopy fire into a ground fire, so that ground-based firefighting forces can intervene.

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The second way to intervene in the firefighting, is the active extinguishing, with the operation of water rotor head sprinklers, in case of danger, from an early warning system or with a human command. The combination of creating a fire zone, with the simultaneous operation of an active fire extinguishing system, is the best combination in reducing, or eliminating the risk. It is a preventive measure, which combined with the rational organization of fire protection, becomes a positive factor of forest firefighting.

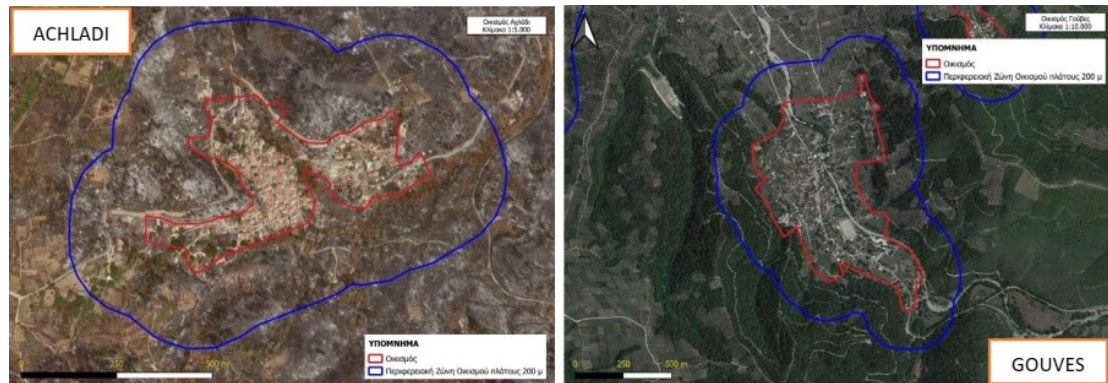


Figure 5. peripheral clear or vegetation treatment buffer zones in scattered settlements in forests

In the case of scattered settlements in forests, fire zones are absolutely necessary. The creation around the settlements of fire zones (figure 5.) in combination with the active forest firefighting, incurs an economic cost that concerns the cleaning of the fire zone and / or its planting with the appropriate vegetation, the construction of water depots, pressure systems for the water rotor head sprinklers, construction of automations for the operation of active forest firefighting, etc.

In the case of peri-urban residential areas, such as in the Mati area of Attica, after catastrophic fires, efforts are made for urban management and replanning of areas which will continue to be at significant risk due to the high probability of various catastrophes (earthquakes, forest fires, floods, etc.). In these areas, the combination of vegetation that will be installed in a natural or designed way, of the natural ground vegetation around and inside the residential area and the given urban planning situation, can create difficult fire conditions at any time. In the example of the Mati area of Attica, this situation concerns the entire settlement and does not differ spatially to the extent that individual units can be distinguished and demarcated. The whole area is therefore considered to be a high risk area for fire. In addition, since the largest percentage of fires is due to human negligence, special emphasis should be placed on informing the public about the risk of fire caused by negligence and on their mobilization and readiness to deal with any incident.

In the general context of prevention, a network of fire protection and defense zones can be organized that can be at the same time escape routes for evacuation of the area in case of fire or transport of residents to safe places.

In the initial stage of urban planning, attempts are made to formulate basic principles and directions of a "standard" civil protection planning for the residential area, focusing on the risk of forest fire. For this purpose, the consideration of the urban fabric as "integrated building blocks" is methodologically preferred, in which it will be possible to take into account a) the location of the houses in relation to the nearby and the neighboring vegetation (cover, height, plantings around houses, vegetation within a radius > 30m.), b) the construction materials of the houses and other infrastructures and

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facilities and c) any special interventions along the streams in a zone (desirable) width 100m. This approach is harmonized with the basic direction of forming an "environmental network" that will run through the intervention area from north to south and from west to east with a multiple role, both to upgrade the environment and the landscape, as well as the lines of defense against fire risk (as underlined in the framework of the research project "Research and scientific support of the TEE during the process of preparation of the E.P.S. for the fire-affected area of Mati, Attica" / NTUA / SPE, 2020).

### **Discussion**

In the case of scattered settlements in forests, as mentioned above, fire zones are absolutely necessary. Their creation around the settlements requires the commitment of the areas of the zone and their continuous maintenance. An alternative is the possibility of creating zones with agricultural crops (e.g. olives, vines) that can delay the development of a fire and provide income to residents.

In the case of peri-urban residential areas, the interventions can be structured a) at the level of plot and house (location of the house in relation to the nearby and neighboring vegetation, e.g. within a radius of 30 m., coverage, height, construction materials), b) at the level of integrated building blocks and c) in any special interventions e.g. along the streams in a zone (desired) width 100m. Especially this intervention can be, as far as possible, the scope of the solution of creating zones with agricultural crops (e.g. olives, vines) that will act as fire retardants zones / defense zones, between settlements or even within them. The combination of appropriate vegetation of the riparian zones with the obligatory planting of non (low)-flammable species in the neighboring plots, can give good results.

For plots and houses should be done at the responsibility of the owners assessment of the risk of destruction from a possible fire, by assessing the surrounding vegetation (quantity, density, proximity) and the condition of the homes in terms of fire resistance of structural elements (wood, metal, concrete, plastic, etc.). A valuable guide in this process is the IMDO guidelines for "Housing Security from Forest Fires" prepared in the framework of the project "Contribution to the prevention of forest fires with the INCA methodology" (Xanthopoulos & Roussos, 2014). The necessary modifications and adjustments should be made based on the evaluation. In addition, informing residents about the potential risk to their homes as well as the measures they can take on their own to mitigate this risk should be an integral part of firefighting planning. In addition, the precautionary information of the residents about the actions they should take in case of fire, the roads that should be used in case of evacuation of the area as well as important points of the area are considered as the most important elements of precautionary preparation before any high risk fire period.

A similar assessment of the risk of destruction from a possible fire should be made for the integrated building blocks with the condition of the common green. A similar assessment should be made for the network (density, quality, width of roads, slopes, escape routes). Traffic issues and organizational issues for dealing with emergencies are interrelated and crucial, however, and the presence of vegetation affects the safety of the settlement.

Finally, the suitable shelters of the population, necessary for the possible evacuation of the area and the shelter or pre-concentration and removal, must be distributed in such a way that they have an appropriate size and position that corresponds to the specified service radius specified by the relevant emergency plans. These areas, as they can accommodate vegetation, should not be vulnerable to fire.

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For the possible planting and / or handling of the vegetation, a basic criterion should be the use of non-flammable plant species, the careful grading based on the height and the planned keeping of safe distances from houses and infrastructures. A similar emphasis should be given to plantings across the roads in the light of achieving a relative "discontinuity" in the vegetation with that of plots and gardens and by selecting suitable mainly non (low)-flammable species. Finally, it is crucial to ensure access for firefighting vehicles, etc. around the squares, which should be accompanied by the restriction or absence of plantings at certain distances in the peripheral plots.

### **Concluding Remarks**

The management of scattered settlements and peri-urban residential areas in forests, in terms of fire risk, requires "preventive" planning in the light of the nature of the forest-settlement complex. This view is crucial and so far there are no relevant specifications for an integrated approach that should briefly include: a) formulation of forest fire scenarios from which to implement feasible suppression plans, b) creation of fire protection or "defense" zones, c) creation of places of safe shelter of the population in case of fire, d) the obligatory planting of non-flammable plant species in private gardens, e) the completion of a "non-flammable" green network with planting of suitable plant species in public areas.

Fire Protection Plans should be prepared for an entire area of increased vulnerability such as forest-settlement mixed areas. In the context of these plans, it is obligatory:

A) To study the history of forest fires in this area by recording data such as the starting point, the cause, the course of the front, the current climatic conditions, the damage caused, the outline of the fire etc.

B) Fire scenarios should be formulated using the most appropriate computer software, from which to derive feasible plans. Plans should be adopted by the services involved so that there is always readiness.

C) The high risk areas should be defined in order to propose and gradually implement (based on a specific schedule) critical interventions such as:

i) creation of fire protection or "defense" zones (at the outer borders of individual units of each area) by clearing them of flammable vegetation and planting non-flammable items,

ii) creation of safe places in case of fire with the possible utilization of existing plots or the formation of new ones, possibly in compulsorily expropriated areas,

(iii) the mandatory planting of non-flammable plant species in private gardens to create a zone that could be used to restraint a potential fire;

iv) the completion of the "non-flammable" green network with planting of suitable plant species in public areas (tree lines, squares, etc.),

(v) the creation of zones with agricultural crops (e.g. olives, vines), along axes, or settlement boundaries, with the aim of creating a flame-retardant or unburned zone to fight or slow down the movement of fire.

D) The solution of "active" fire protection that can complement the fire safety zones should be considered, in areas where it is not possible to provide large areas for special operations and of course to operate in parallel and in combination where possible. This solution concerns the installation of water rotor head sprinklers, which will provide "defense zones". Depending on the characteristics of a fire, they will aim to reduce its intensity, or to stop its front.

E) Other solutions should be considered such as e.g. the installation of metal fire fences where this is deemed appropriate from a technical and economic point of view.



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### Definitions

- "Forest fire risk" is defined as the combined effect of the influence of fixed (e.g. climate, terrain, forest fuels) and variable factors (e.g. meteorological parameters, forest fuel humidity), which determine the onset, spread, difficulty controlling fire and the losses it causes (NWCG, 2008). The human factor is related to all phases of fires, from ignition, spread to fighting. The human factor varies between regions, depending on the socio-economic conditions, uses and practices applied. The various risk factors operate individually and in combination with each other and determine the level of risk of starting a fire at any given time.

- Among the constant risk factors as "forest fuel" is considered vegetation when examined from the perspective of forest fires and is characterized by all living or dead organic material present either in the soil (foliage, needles, branches, trunks, grasses, shrubs, seedlings and trees) or on trees (branches, foliage), of any size or shape, that cause or ignite and burn. Based on their vertical distribution, forest fuels are classified into three layers, terrestrial, surface and aerial fuels. In the special case of forest-settlement mixing areas, the "fuels" are not limited to vegetation but also concern the construction materials of the houses (particle boards, wood, plastics, tar paper, etc.) which transmit the fire and enhance its energy.

- Among the variable factors, the main "meteorological parameters" related to the risk of fire are air temperature and humidity, rain and wind intensity, as they mainly affect the state of forest fuels. The amount of heat required to raise the temperature of the fuels to the point of ignition depends on their initial temperature and the temperature of the air around them. The humidity of the fuel is affected either by atmospheric precipitation or by water vapor which condenses on their surface and is absorbed by them. There is a constant exchange of water vapor between the atmosphere and the dead

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fuel, a process which depends on the temperature and humidity of the fuel and the atmosphere. Dry fuels absorb moisture from a humid atmosphere and release their moisture into a dry atmosphere. During very dry periods, low atmospheric humidity has an effect even on green fuels. The speed of the wind affects the flammability of forest fuels and dries them as it accelerates the process of evaporation. However, irrigated green can mitigate the risk of onset and affect the speed at which a fire spreads.

- "Flammability" is considered the relative ease with which a substance ignites and maintains combustion and in relation to vegetation its flammability is determined by its content of extracts and moisture, by its continuity and density. Flammability, which is also taken into account when assessing the risk, is difficult to determine scientifically. Concepts include ignitability, combustibility, sustainability and consumability, i.e. the degree to which fuel is consumed by fire (consumability).

- "Prevention" of forest fires means all projects and all actions taken before the start of a fire, with the aim of a) reducing or eliminating the possibility of fires, b) reducing the probability of any fire spreading and c) reducing the damage that can result from a fire. In addition "prevention" means all the projects and actions that support the suppression of fires. These projects result from the firefighting planning and their purpose is to purposefully serve the needs of the repression mechanism.

- "Scenarios" with the use of appropriate computer software, can give a hypothetical but relatively realistic picture of a possible fire and document decisions about reaction times (propagation, speed), safety and protection needs (thermal intensity) and possible ways to evacuate the area. The creation of scenarios mainly includes the identification of possible starting points of fire, the determination of the possible period of the time of the event and the definition of meteorological scenarios. The scenarios are presented with various graphic illustrations of the spread of the fire at different time intervals.

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