Forest Fires

Risk Assessment and Case Studies in Bulgaria, Greece, Italy and Spain

European Civil Protection

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Table of Contents

1 Hazard description

1.1 General aspects

A wildfire is simply an uncontrolled fire that is wiping out large fields and areas of land. It is typically fires that started out of a lightning strike, or people carelessly starting it, or accidentally, or even arson, that went un-noticed and got out of hand. These fires sometimes burn for days and weeks. They can wipe out an entire forest and destroy almost every organic matter in it.

Wild fires can also be termed *forest fires, grass fires, peat fires and bush fires* depending on type of vegetation being burnt. Note that these fires tend to thrive in very warm and dry climates, rather than the thick, moist rainforest types.

The destructive nature of a wildfire in a forest is phenomenal. A forest is an entire ecosystem consisting of biotic factors like animals, insects, birds, bacteria, plants and trees. It also consists of abiotic factors like water, rocks and climate in that forest area. If a wildfire strikes such an ecosystem, all life forms will be lost. The air and water will be heavily polluted. The soils will be badly degraded and other abiotic elements will be affected including water catchment areas. Different wildfires burn differently.

Some factors combine to provide a complex web of ingredients that help wildfires to burn more and quicker. Here are a few:

- Wind:
  Winds direct or change direction of fire to new areas with new fuels. Additionally, they provide fresh supply of oxygen, a key ingredient of fire, to the situation.

- Slope:
  Wild fires usually move faster uphill than downhill. The steeper the slope, the faster they burn. This is because steeper slopes tend to have many fuels in close proximity and the wind action if much more aggressive uphill.

- Temperature:
  Conditions with higher temperature tend to absorb moisture from fuels and make them conducive to catch fire. This is why areas with lots of sun and higher temperatures tend to be dry and has more fire events.

- Humidity:
  Fuels in locations with high humidity and rainfall tend to be damp and moist. Humidity is the amount of water vapor in the air. The higher it is, the higher the moisture in the fuels there and the less likely they are to catch fire.

- Times and seasons:

In many places, the seasons tell a story. In the US, the summer stretch registers lots of fires. That is because the summer heat makes fuels drier and provides richer oxygen than the winter seasons. In many places in West Africa, the onset of the dry Harmattan Winds from the Sahara desert in the dry seasons make fires burn more.

- Fuels:
  The ease at which wildfires spread also depends on the fuel composition. Trees and vegetation with lots of moisture tend to slow down fires than dry vegetation such as dry grass, dead leaves, tree needles, brush and small trees. Additionally, some vegetation with high oils and resins aid combustion and makes fires burn with more ease.

- Space between fuels:
  Wildfires burn more and spread faster if there are more fuels in close proximity. If fuels are sparsely distributed or are patchy, the fires tend to slow down. This is why a common method of ending a fire is to create a ring of space around it.

1.2 Types

- Ground fires: fires that burn organic material in the soil are called. This is a slower burning fire, usually under litter or under vegetation. They burn by glowing combustion.

- Surface fires: some fires burn on the surface of the ground. They burn dry leaves, broken twigs, branches, and other materials on the ground. These fires spread quickly.
- Crown fires: burn with huge flames and has intense heat and power. They burn from treetop to treetop and spread very quickly with the wind and heat. It is even worse if they are exposed to steep slopes.

- Spotting is yet another interesting fire type. Sometimes winds blow 'firebrands' away from crown fires onto new areas. Firebrands are like fireball that fly from burning treetops to other new places, resulting in new fires and keeps the fires spreading.

- Conflagration: This is a large fire with a character of aggravation, usually enhanced with wind action and firebrands.

1.3 Causes

- Campfires:
  In many places, camping is a big thing. People, both young and old spend time in the woods to enjoy the great outdoors. Sometimes fires are needed for various things during camping and they can start wildfires if not put out properly.

- Smoking:
  Some people smoke whiles driving, biking or walking. Sometimes the buds are not properly extinguished thrown away. You never know where that bud will end up and start a fire.

- Lightening:
  A good number of wildfires were started by lightning. It is a bit hard to imagine, but investigators confirm this as very common. When lightning strikes, it can produce a spark. It can strike trees, power cables, rocks and many other things and just set them off.

- Burning debris: Refuse, junk and yard waste are common items that are permitted to burn in many places. People are therefore very quick to set anything ablaze as a way of disposing off them. But that can get out of hand and start a fire.

- Accidents or equipment failure: Car crashes, gas balloons, lawn mowers and many other equipment have been known to start fires when they go wrong. These are accidental but if not detected quickly, can cause massive problems. This is why fire fighters always move to an accident scene in anticipation of a fire break.

- Fireworks:
  Fireworks are banned in many places because of their explosive nature and high potential to start a fire. If fireworks are not blasted at the right places, they can end up as fires elsewhere.

- Arson:
  This is the act of setting fire to a property, piece of land or anything with the intention of causing damage. A person who does this is called and arsonist. Arson specialists believe that many fires are started by arsonists, and may account for about 30% of all wildfire cases

1.4 Parameters and measurement of phenomenon

Forest firefighting is commonly based on estimations made by firefighting experts from visual observations. These estimations are subject to a great number of errors due to smoke occluding the flames, human inaccuracy in the visual estimation and errors in the localization of the fire. Recently, new technologies have been applied to fire fighting.
However, many of these technologies still have different practical problems for their use in operational conditions, such as low reliability, high costs and others.

It should be noted that artificial perception systems suffer from all the fires perception problems present in field (sudden and uncontrollable changes in lighting, calibration inaccuracies), and other related to the particular characteristics of fires such as the presence of smoke and fire nature (non-rigid object with rapid and difficult to predict) behavior.

There is fully dynamic parameters, which are constantly changing (speed and wind direction), others change frequently (fuel moisture, which vary with the day-night cycles and climate of the place) and others that change slowly as the fuel. These features make often do not have the exact values of the parameters at the time of the fire, or that are difficult or impossible to obtain.

The accuracy in the input parameters affecting the outcome of the simulation because these parameters determine the stage where fire develops. Thus, the spread calculated by the simulator would according to the scenario described by the parameter values then have described the scenario incorrectly, it will result in a spread that is inconsistent with reality (but if it will do with the scenario that mischaracterizes the parameters)

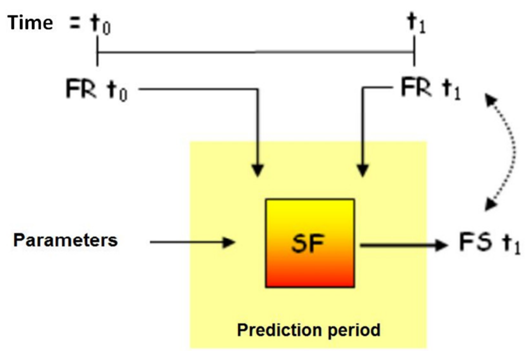


Figure: Traditional prediction

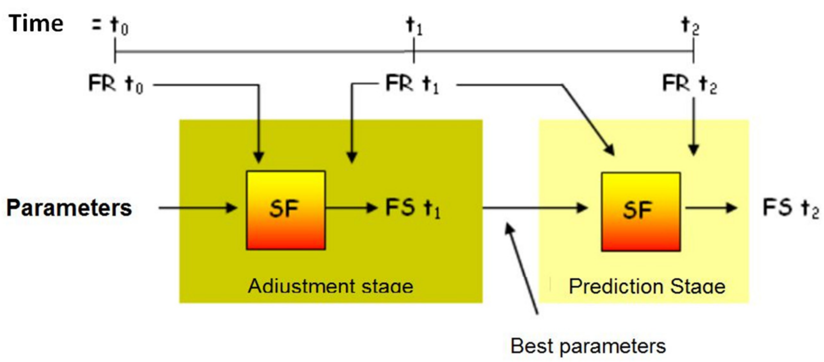
Class tors receive as inputs the initial state of the fire (in Figure 1, real fire FRt0) and the input parameters that describe the surrounding fire. The simulator returns the status of the fire front to a later time (simulated fire FSt1en Figure 1).

When the simulation result FS1y actual progress of fire (FR1) is compared, typically simulated real fire would spread. The simulation results do not match the actual progress of the fire occurred. However, this method consumes few computing resources and little time (depends on the complexity of the internal models simulator).

At this point you can appreciate the improvements you can achieve a software tool that, assuming this uncertainty on the accuracy of the input parameters, try to work with them and tune them up to correct values. This type of interaction between computer science, experimental science (data processing available to improve the final performance of the system) and theoretical science (such as physics, chemistry, etc. in the development of the equations of fire behavior models) it is what allows you to place this work in the field of computer science.

The classic method consists of a single step: predicting step. In data-driven prediction, a stage of adjustment before predicting step is introduced. This new stage corresponds to putting a method based on the use of computationally intensive in order to obtain the set of parameters that best predict the fire behavior. Said set of parameters it will be used as input in the phase prediction for a subsequent time instant.
In this method it is to use and obtain the benefits of using computer tools and methods that have resulted from years of study and work: high performance computing, data mining, etc., to improve prediction using the same system simulation that in the traditional method but wrapping resource to provide us with Computer Science for better performance.

Add this new stage increases the cost in time of the process therefore will require distributed computing and parallel to reduce the time of final count. Figure 2 outlines the data-driven prediction.



Forest fire simulators use various input parameters to describe the topography, climate and vegetation of the environment where the fire develops. As expected, each of these parameters is a domain-specific value. In firefighters work 8 parameters are used, 6 of which vary and 2 do not (it is assumed that their values are available at the time of the simulation). Given the number of parameters and their ranges, the number of combinations is very large values. Working with this many combinations in our method becomes the biggest problem to solve: make an effective search in this large search space.

Genetic Algorithm

Then one goal is to make an optimized search in a search space large enough to make impossible an exhaustive search if you consider that the prediction must be obtained in a short time so that it is useful. In this work a genetic algorithm is used to search a limited and effectively. This method is widely used in many domains, and although its good performance depends on the type of problem, its widespread use in many application domains demonstrates its effectiveness.

This type of algorithm simulates the natural genetic evolution. It is based on a population of individuals evolve iteratively and individuals survive this evolution better adapted to the environment. Individuals who survive are those with the best features in the population and they are used to generate new individuals who will form the next population. Therefore, new individuals inherit the good characteristics of the parents.
Take this to a programming environment involves defining what is an individual (at least how it is formed), defining a population of individuals and define a function that determines how an individual is adapted to their environment.

FIRE monitoring tool:

The Fire Monitoring Tool calculates in real time parameters fire sequences using the visual images from cameras and processing infrared and GPS and telemetry data. The system uses these parameters to generate and represent a 3D model of the fire.

The tool receives two types of inputs. First receives image sequences visual and infrared taken from different viewpoints, allowing capture a number undetermined synchronized images. The other inputs is field information, including topographic maps of the terrain (digital terrain model) and number information cameras used, their position and orientation.

The main block of the tool is the Block Image Processing. In this Calibration Measurement Processing and Estimation: block two tasks are mainly performed. Calibration allows to establish relations between the coordinates of the images and the "world real "and is used to convert pixel meters measures taken over the images. The processing task scans all the images that are captured. The algorithms used in each case depend largely on the type of image (infrared or visual) and sight from which it is taken.

Estimation of measures combining the results of all processing images with calibration data and heuristic information to calculate estimates fire parameters such as propagation speed, flame height, width and front angle flames. Filtering is performed to eliminate noise and reduce spurious effects errors and inaccuracies.

Once you have calculated all the parameters of the fire, the display block used to generate a 3D model of the fire, which is then represented from various points of view. The 3D model not only includes fire geometric data such as height flames front position but also contains information such as temporal evolution propagation velocity. The tool has functions for exchanging information among all the blocks described.

The scheme includes cameras and fixed cameras installed in vehicles such as helicopters positions. Fixed cameras can be arranged in a high number of combinations such as front view cameras (the camera axis is perpendicular to the flame front) and side view camera (the camera axis is parallel to the flame front). The front view cameras allow estimation of the position of the front and can provide propagation velocity. These cameras also allow measuring the height of the flames. The side view cameras are useful for measuring the height and length of the flames and the width of the front. The aerial images allow obtain estimates of the position of the flame front, including the propagation velocity and the burned area. They can also provide information of the most active fronts of the fire.

1.5 Effects

With a simple glance, we can identify a fire-affected area because the landscape deteriorates: the distinct shapes and colors of vegetation disappear and everything becomes a sort of greyish desert. People who live nearby lose the landscape of their childhood. However, the effects of a forest fire go much further.

Forests, i.e. nature, are a source of life, health and wealth. It is the place where a large, and diverse, number of living beings coexist: animals, plants, micro-organisms … All the living organisms that inhabit forests interact and play an important role for each other as well as for human beings (for instance, they produce clean air and water, as well as many other necessary things such as wood, wild mushrooms, honey, grass for livestock…).
In a forest # re not only do plants burn, but also animals are also affected: they either die or have to move to other places because they lose their nourishment and shelter.

In addition, the soil is greatly damaged because of the high temperatures reached during a fire: the creatures that live underground, and break down organic matter to allow plants to grow, also die. On top of this, the land loses the protection of plants, thus following rain water detaches soil and ashes dirtying rivers, reservoirs and, sometimes, even cities and towns (floods).

Air becomes polluted as well because of the smoke and because vegetation stops absorbing CO2 from the atmosphere. During a fire, many resources used by humans are destroyed, especially in rural areas.

Many people lose their livelihood (cottages, farm schools, campsites…) or part of their income (crops, pastures, hunting, honey, wood, cork, pine nuts, houses…). Occasionally, people die; people who live in the area, but also people who put out the fire.

Soils and organic matter: but there is more to that. Take forest soils for example. Forest soils are rich in decaying debris and nutrients, and are composed of many natural features that support a myriad of life forms and organic activities. Wildfires raise the temperatures of these soils to over 900°C and this potentially wipes away almost all the organic value of the soil.

Watershed: the effect on watershed is also key. Burned organic matter in the soil (volatized organic compounds) also affect the natural layering of the soils. This negatively affects infiltration and percolation, making the soil surfaces water repellent. Water therefore is unable to drain into water tables and the run-offs on the surfaces cause erosion.

1.6 Secondary effects

Economic cost:

If you have ever seen firefighters battling a wildfire and the images they show on TV, it will give you an idea of the immediate damage it can do to wildlife and vegetation. Fires also destroy houses and almost anything in its' way. Additionally, the city spends millions of money to fight them with chemicals, logistics, aircrafts and trucks, time and personnel. The economic loss can be huge.

Researchers believe that forest fires are not very bad, as they have some benefits too. In fact, they believe that even though young animals and birds may die, many animals are able to escape or move away from fires. Birds fly away; dear and other reptiles find their own escape routes and so on.

Many plants easily grow back and there is usually good recovery after a fire. Some plants have their seeds opened up and exposed to ash-enriched soils. Examples include serotinus cones, from a tree species such as jack pine. Species like white pine and yellow birch also benefit from forest fires in a similar way.

2. Risk Assessment - National Maps of Hazard in Greece, Bulgaria, Italy and Spain

2.1 Greek Risk Assessment and Hazard Map

Risk assessment is a very important element in the management of any natural hazard. In the field of forest fires, risk assessment forms the basis for planning, budgeting and preparedness. All fire prone countries have some form of risk assessment, often more than one (e.g. various indices), as it is a concept that can take different forms and can have different meanings, according to the objectives for which the assessment is to be made and used.

The initial idea of understanding and predicting the danger that forest fires represent is reflected in the efforts to build a National Fire Danger Rating System (NFDRS) in the USA. Fire danger was defined as “The resultant descriptor of the combination of both constant and variable factors which affect the initiation, spread and difficulty of control of wildfires on an area” (Deeming et al. 1972). The fire danger rating of an area gives the manager a tool to assist in the day-to-day “fire business” decisions. The structure of the 1978 NFDRS system is shown in Figure 1 (Bradshaw et al. 1984). In it, risk is associated with the assessment of the existence of heat sources that can cause ignitions in the rating area. These can either be due to thunderstorm and lightning activity (lightning risk) or due to man (man-caused risk). The existence of a heat source does not necessarily lead to ignition. The condition of fine dead fuels (e.g. grasses, needles, leaves), in regard to their moisture content and their temperature, also plays a role in the probability of ignition (Bradshaw et al. 1984).

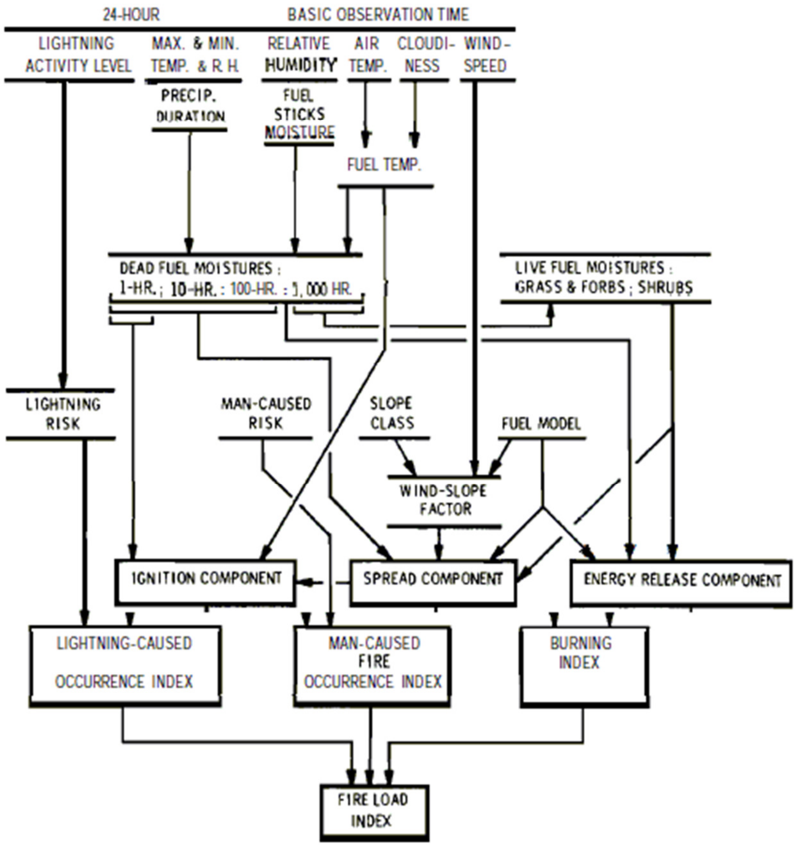


Figure 1. Structure of the 1978 National Fire Danger Rating System of the USA

In short, fire risk is defined as the chance that a fire might start, as affected by the nature and incidence of causative agents.

Another fire danger rating system with a long history of development is the Canadian Forest Fire Danger Rating System (CFFDRS), the national system for rating fire danger in Canada. Its structure is shown in Figure 2 (Lawson and Armitage, 2008).

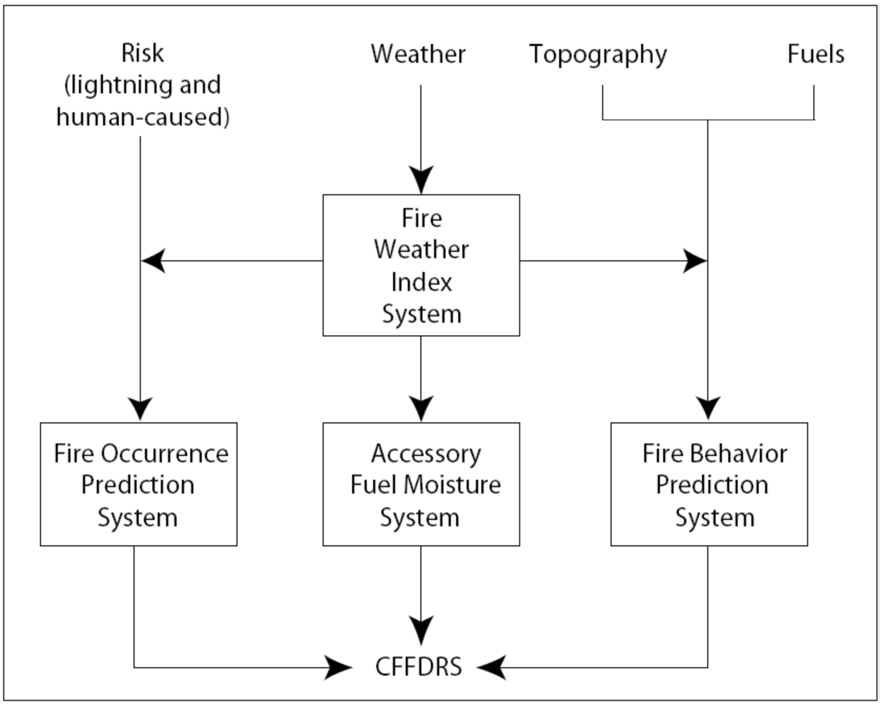


Figure 2. Structure of the Canadian Forest Fire Danger Rating System (CFFDRS)

As in the NFDRS, the lightning and human caused risk are clearly identified but the Canadian Forest Fire Occurrence Prediction (FOP) System which is envisioned as a national framework of both lightning- and human-caused fire components is still under development ((Lawson and Armitage, 2008). The subsystem of the CFFDRS that has found wide use around the world is the Canadian Fire Weather Index (FWI). The purpose of the FWI System is to account for the effects of weather on forest fuels and forest fires. Other factors affecting fire danger (i.e., fuels, topography) are dealt with elsewhere in the CFFDRS .

The FWI System is comprised of six components (Figure 3) which provide numerical ratings of relative wildland fire potential. The first three components are fuel moisture codes that follow daily changes in the moisture contents of three classes of forest fuel with different drying rates. For each, there are two phases — one for wetting by rain and one for drying — arranged so that the higher values represent lower moisture contents and hence greater flammability. The final three components are fire behavior indexes, representing rate of spread, amount of available fuel, and fire intensity; their values increase as fire weather severity worsens. The six components are described below.

- Fine Fuel Moisture Code (FFMC): A numerical rating of the moisture content of litter and other cured fine fuels. This code is an indicator of the relative ease of ignition and flammability of fine fuel.

- Duff Moisture Code (DMC): A numerical rating of the average moisture content of loosely compacted organic layers of moderate depth. This code gives an indication of fuel consumption in moderate duff layers and medium-size woody material.
- Drought Code (DC): A numerical rating of the average moisture content of deep, compact, organic layers. This code is a useful indicator of seasonal drought effects on forest fuels, and amount of smouldering in deep duff layers and large logs.
- Initial Spread Index (ISI): A numerical rating of the expected rate of fire spread. It combines the effects of wind and FFMC on rate of spread without the influence of variable quantities of fuel.
- Buildup Index (BUI): A numerical rating of the total amount of fuel available for combustion that combines DMC and DC.
- Fire Weather Index (FWI): A numerical rating of fire intensity that combines ISI and BUI. It is suitable as a general index of fire danger throughout the forested areas of Canada.

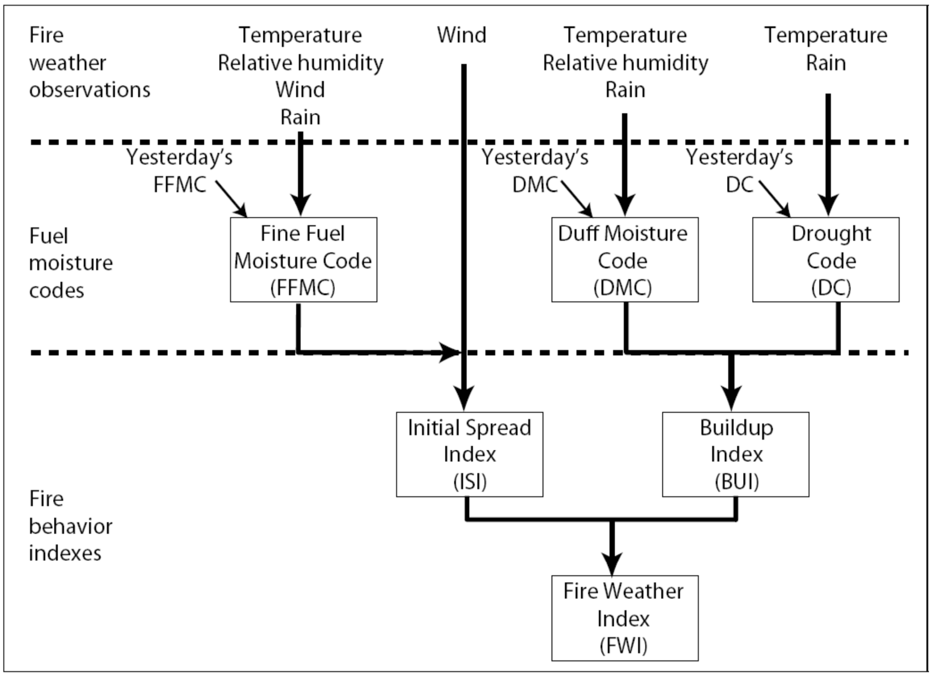


Figure 3. Structure of the Canadian Forest Fire Weather Index System (Lawson and Armitage, 2008).

The interpretation of the meaning of FWI values into in fire danger levels for Nova Scotia, Canada is shown in Figure 4. This interpretation may be quite different for other countries.

Category	FFMC	DMC	DC	ISI	BUI	FWI
Low	0-81.9	0-13.9	0-144.9	0-1.9	0-19.9	0-3.9
Moderate	82-86.9	14-24.9	145-254.9	2-4.9	20-36.9	4-9.9
High	87-88.9	25-36.9	255-334.9	5-8.9	37-52.9	10-16.9
Very High	89-90.9	37-54.9	335-429.9	9-17.9	53-75.9	17-22.9
Extreme	>=91	>=55	>=430	>=18	>=76	>=23

Figure 4. Interpretation of the FWI values in fire danger levels for Nova Scotia, Canada (http://novascotia.ca/natr/forestprotection/wildfire/forecasts.asp)

The FWI has received significant testing and comparison with other indices. In one of the most rigorous studies Viegas et al (1999) compared six meteorological indices and found that the FWI had a superior performance in summer conditions. This was one of the reasons that led to its wide international adoption (e.g. Europe, Australia, New Zealand, etc.).

In Europe, the European Commission services, that had to deal with a multitude of forest fire danger approaches in its various member states (Figure 5) which did not allow comparison of support needs between those states, decided to take action for improving the situation. The European Forest Fire Information System (EFFIS) of the Joint Research Centre (JRC) of the European Commission became the center-point for providing reliable and up-to-date information on forest fires in Europe using state-of-the-art tools. In regard to fire danger, it chose the FWI as the index for mapping predicted fire danger (Figure 6).

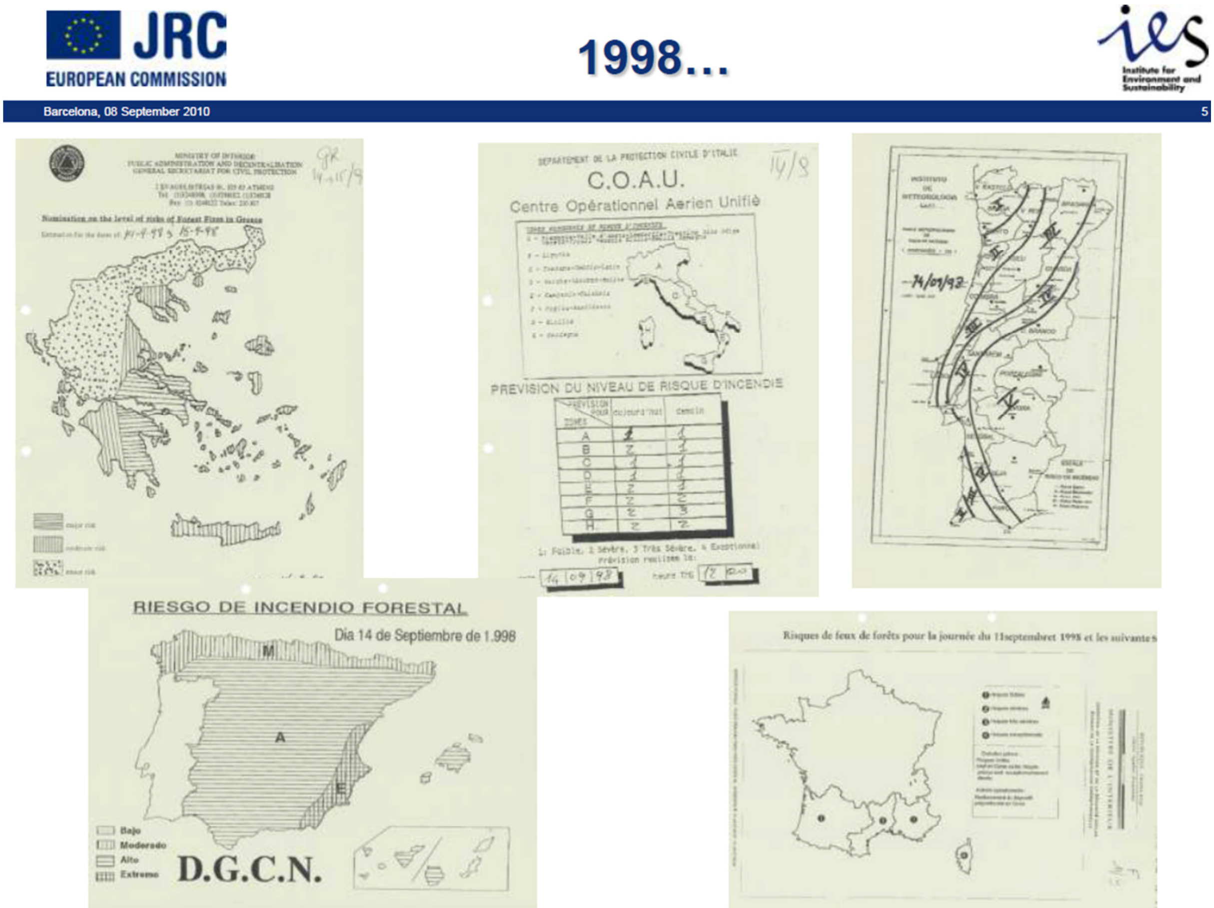


Figure 5. Fire danger maps produced in certain Mediterranean EU member states in 1998.

As mentioned above, the FWI is an index based on meteorological information. This offers the advantage that current fire danger can be calculated based on meteorological measurements, and future fire danger can be estimated based on weather forecasts, as done in EFFIS. On the other hand, as fire risk (lightning and human-caused), topography, and especially fuels have a wide spatial variation, the member states as a rule take the EFFIS fire danger maps into consideration but have developed their own system, and produce a daily fire danger map covering their needs.

In Greece, a daily fire danger prediction map is prepared by the General Secretariat of Civil Protection. It is produced by a team of forest fire and meteorology expects, is published online every day around 13:00 (http://civilprotection.gr/el) and is valid for the next day (Figure 7).

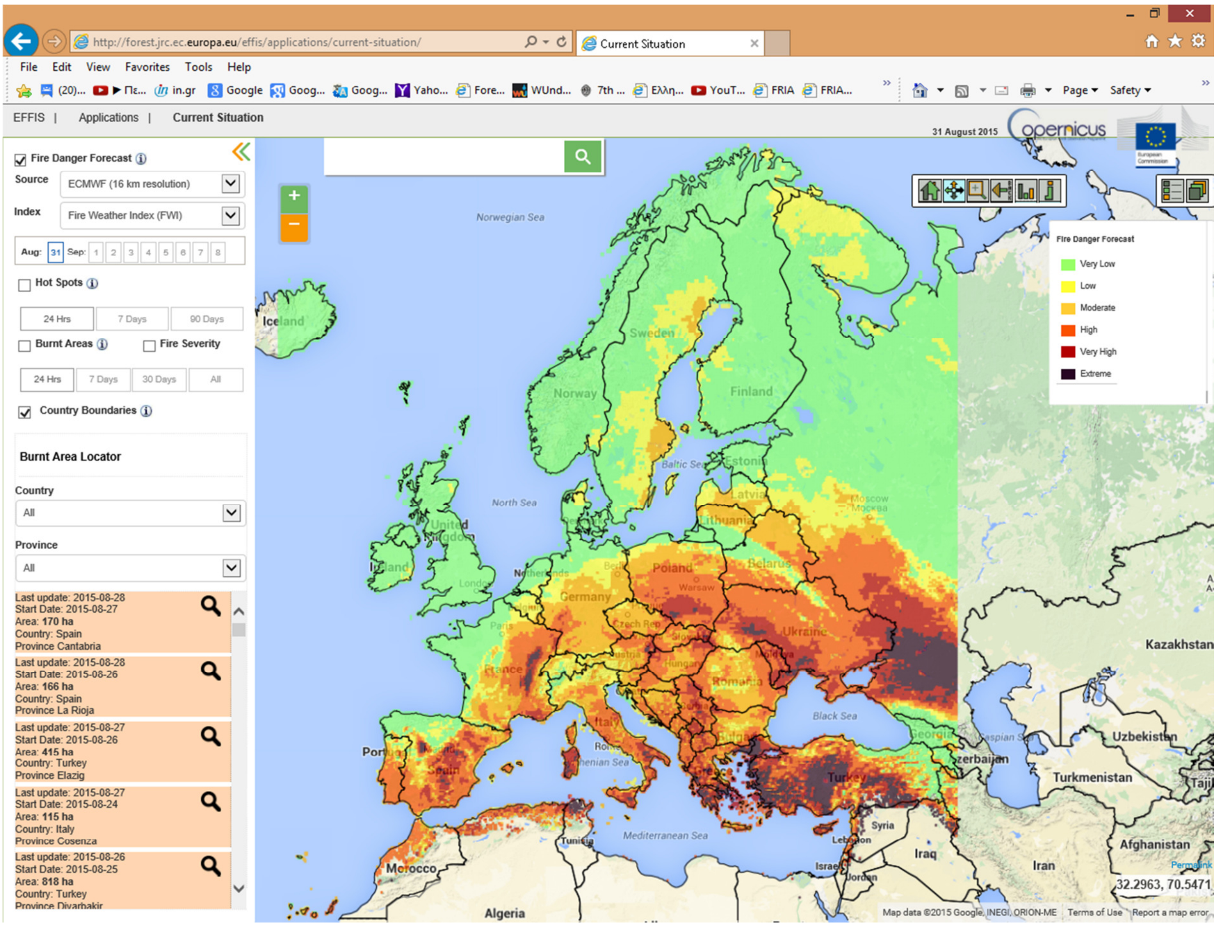


Figure 6. The FWI based map of the "current situation" of fire danger for August 31, 2015, made available on-line by the EFFIS (http://forest.jrc.ec.europa.eu/effis/applications/current-situation/)

Fire risk tailoring to fire management needs

From the presentation above it is evident that the initial approach of fire risk, as conceptualized in the NFDRS and relating only to the eruption of fires, has been superseded by the need for a more complete fire danger index that also includes the potential for active fire spread. It is clear that the causes of fires differ significantly between parts of the world (for example in southern Europe about 95% of the fires are human caused while in Canada approximately 80% of the fires are lighting caused) but fire managers also want to know the difficulty they will face in controlling these fires.

As weather is the most dynamic factor affecting fire risk, the indices mentioned above and the corresponding fire danger maps that are based on them, are dynamic in nature. As a result they facilitate forest management decisions for day to day operations. Examples include:

- Adjusting alert levels of the fire suppression resources according to the fire danger class (low to extreme), usually following protocols that have been foreseen in presuppression plans. For example, in Greece, the local authorities are usually mobilized when fire danger is predicted to be very high or extreme.
- Relocating firefighting resources such as helicopters where high fire danger is predicted.
- Alerting the population with an emphasis on prevention. This is done through the Mass Media (e.g. publicizing the fire danger map followed by comments and warnings), and through other means such as special signs by the roads (Figure 8).

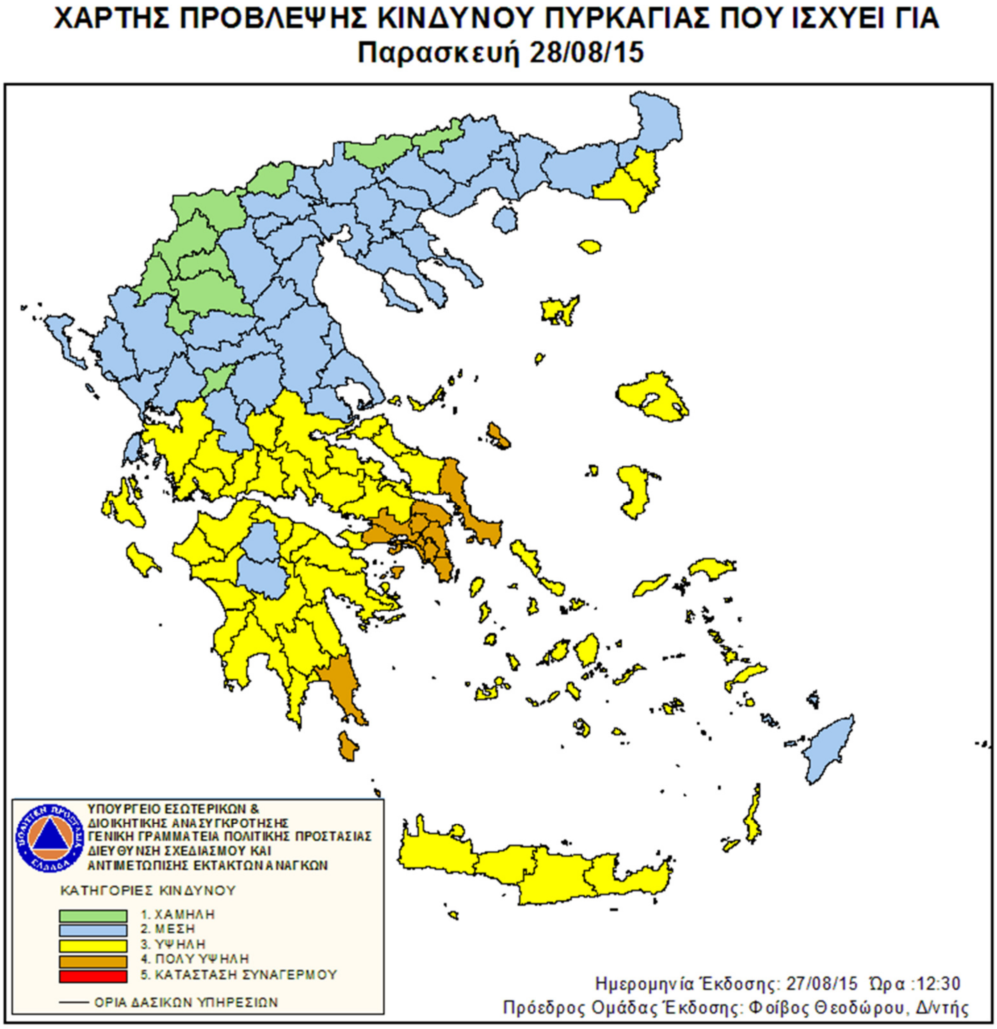


Figure 7. The fire danger prediction map for Greece for August 28, 2015.

Figure 8. A sign informing citizens about fire danger on Mount Hymettus near Athens, Greece. It is combined with road closure on a day of very high fire danger.

In addition to the dynamic, short-term fire danger rating, fire management also requires a long-term (static) risk assessment. Such assessment usually looks at the spatial distribution of risk but may also look into the temporal evolution of risk through the year. An early concept by the EFFIS development group, presents a good distinction between the variables that affect the two types of risk (Figure 9)

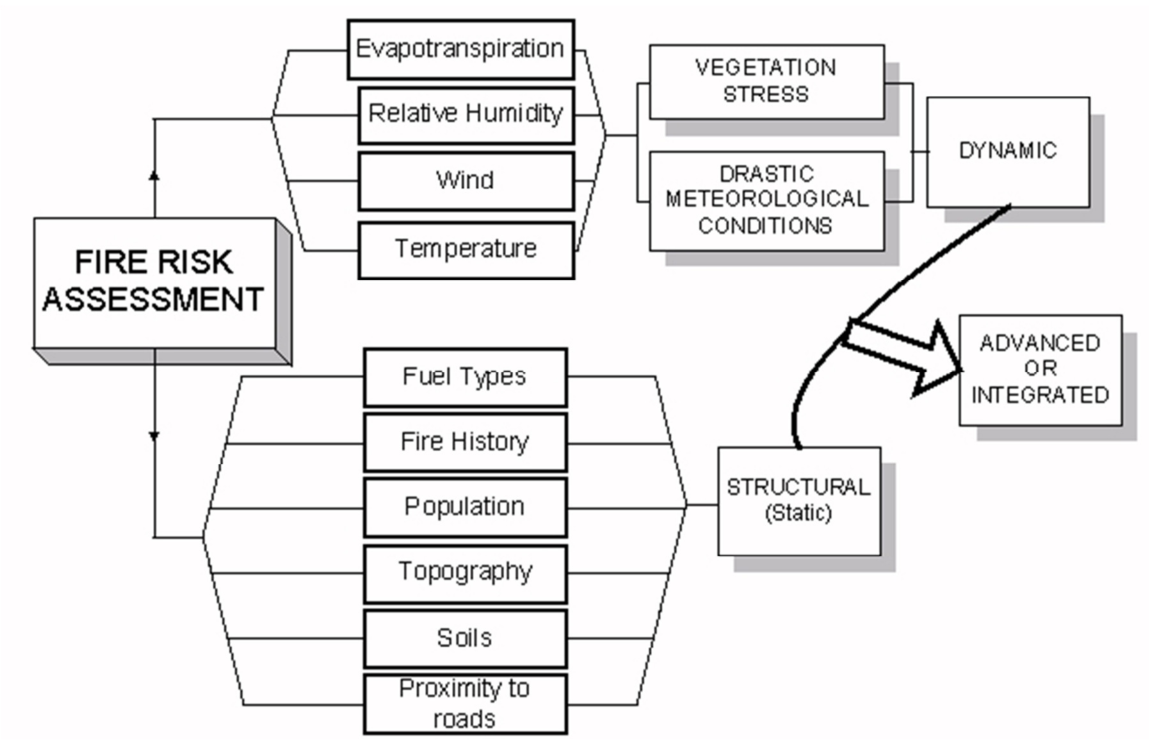


Figure 9. An early approach for dynamic and static fire risk assessment by the EFFIS team of experts.

Risk zoning is one of the uses of a static map. For example, in Greece, the Forest Service offices (dasarheia) in the country have been categorized in three classes of fire risk based mainly on the fire history (number of fires and burned area) for more than 30 years. Fuels are also implicitly taken into consideration.

In regard to fuels, it should be said they are directly associated with the concept of fire hazard which is defined as “a measure of that part of the fire danger contributed by the fuels available for burning” (FAO 2006). An association of the forest types with the fire hazard they represent as fuels may allow a first rough static fire risk map based on existing vegetation maps (Xanthopoulos et al. 2012). These can then be modified taking the other parameters shown in Figure 9 into consideration.

Static forest fire risks are very valuable for determining and distributing budgets to administration units and to determine distribution of firefighting resources. When they have a temporal component they can help to reorganize resources throughout the year and even to differentiate the start and end of the fire season by geographical area.

Finally, it should be said that in the context of technical risk assessments, the term ‘‘risk’’ considers not only the probability of an event, but also includes values and expected losses (Hardy, 2005). This approach has entered the field of forest fires gradually through the 1990s and reflects the perception and influence of economics and the insurance industries on the concept of risk. The approach helps in building a valid and valuable threat analysis that can form the basis for solid prevention and pre-suppression planning. A good example of how this concept can be applied is the New Zealand Wildfire Threat Analysis framework (WTA) (Figure 10).

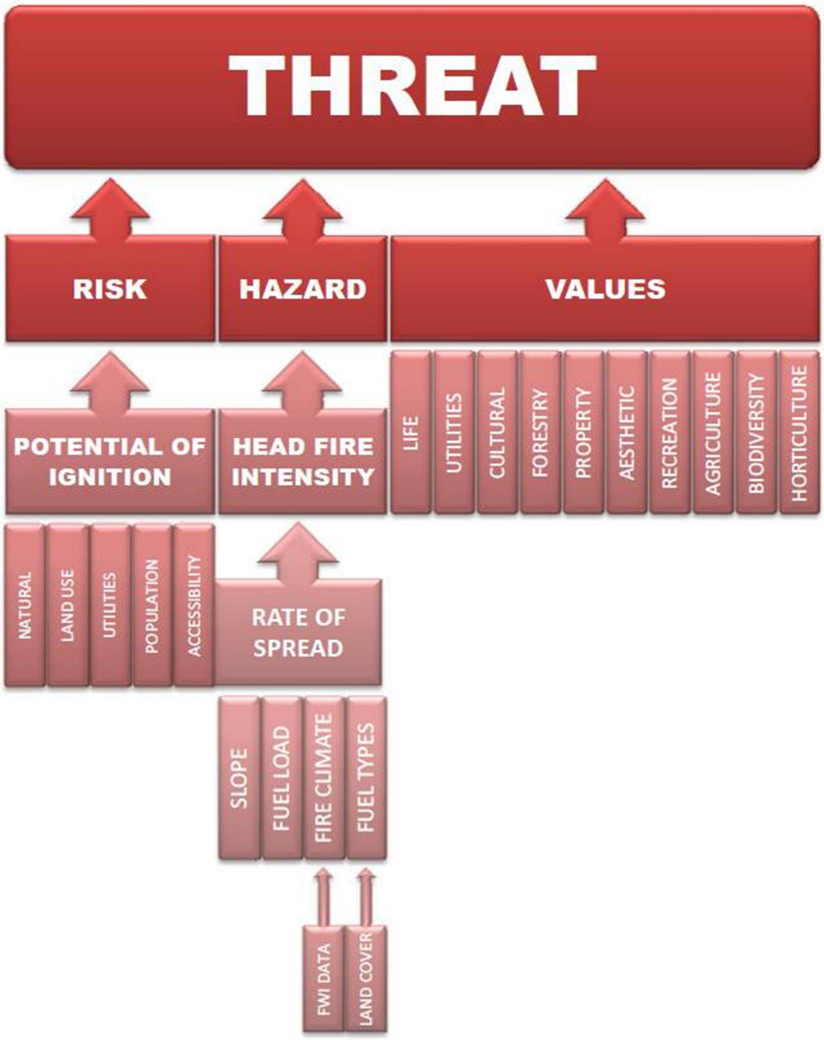


Figure 10. Wildfire Threat Analysis Structure (Majorhazi, 2002)

The procedure for producing a forest fire threat analysis map is based on the formula:

Threat = Risk X Hazard X Values

and lends itself to the use of a Geographic Information System as illustrated in Figure 11.

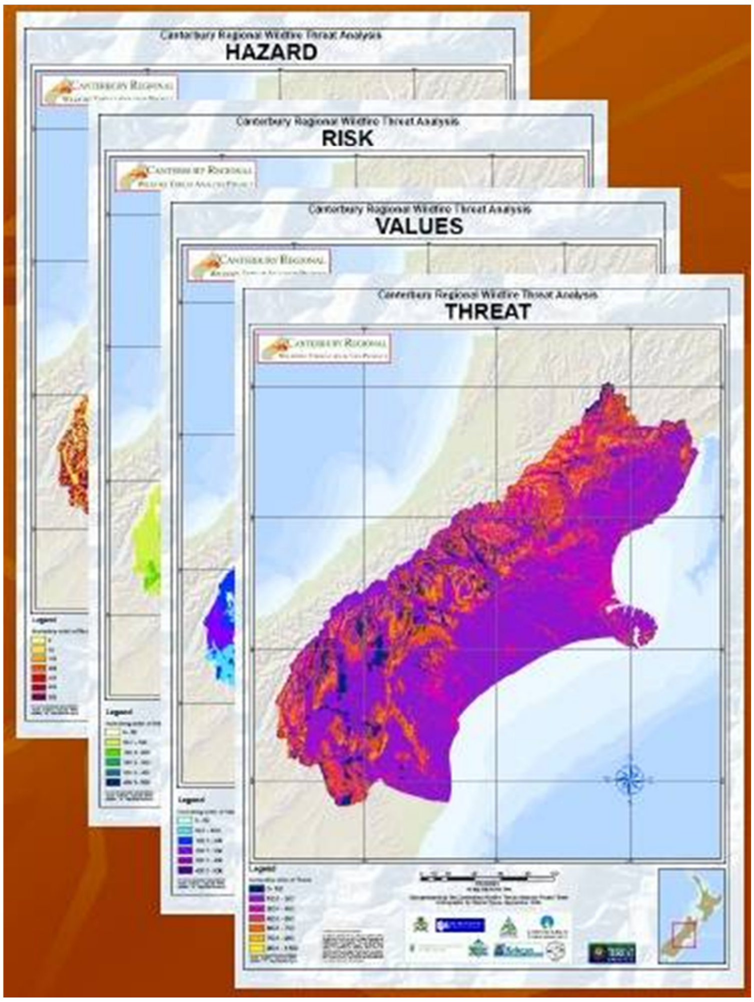


Figure 11. Illustration of the procedure for developing a forest fire threat analysis map with the help of a GIS.

Wild Fire Risk Assessment in Greece

1. Introduction

Wild Fire Risk in Greece is dependent on two main factors, the Mediterranean type climate and the seasonal climate variations. Generally, summer in Greece is very hot accompanied by dry atmosphere and in the broader Aegean area also by very strong north winds. The risk of fire depends thus mainly on the daily climate condition that will prevail and applies on forest areas, shrublands or even domestic land.

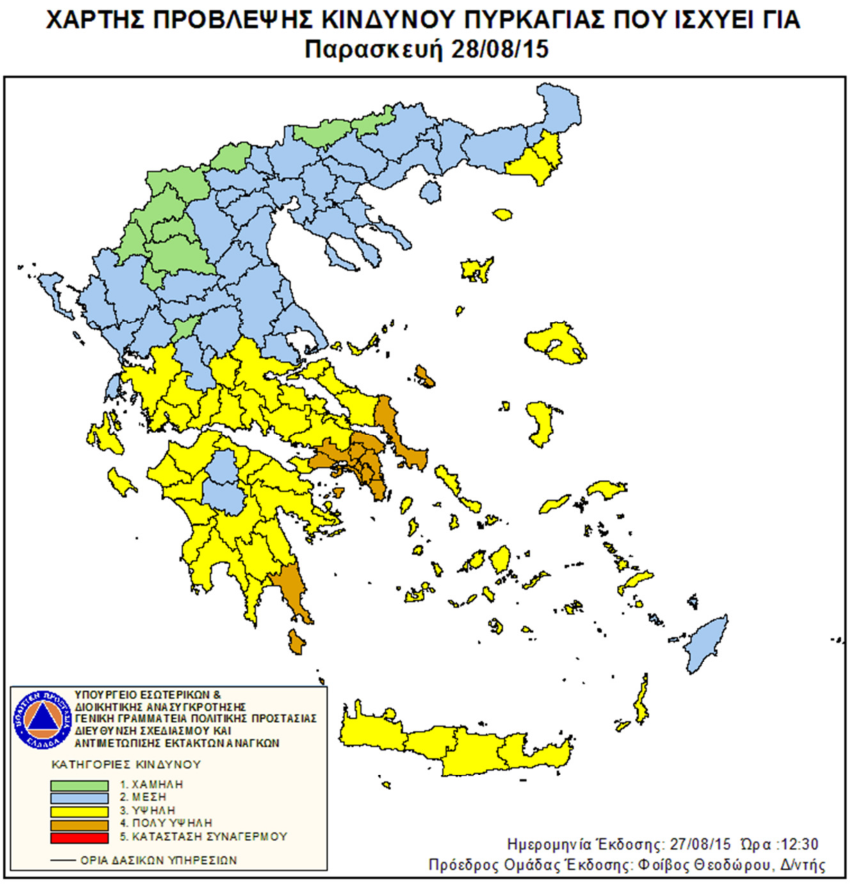
In Europe, the European Commission services, that had to deal with a multitude of forest fire danger approaches in its various member states which did not allow comparison of support needs between those states, decided to take action for improving the situation. The European Forest Fire Information System (EFFIS) of the Joint Research Centre (JRC) of the European Commission became the center-point for providing reliable and up-to-date information on forest fires in Europe using state-of-the-art tools. In regard to fire danger, it chose the FWI (The Canadian Forest Fire Weather Index System (Lawson and Armitage, 2008) as the index for mapping predicted fire danger.

As described in the Wild Fire Risk Assessment chapter, the FWI is an index based on meteorological information. This offers the advantage that current fire danger can be calculated based on meteorological measurements, and future fire danger can be estimated based on weather forecasts, as done in EFFIS. On the other hand, as fire risk (lightning and human-caused), topography, and especially fuels have a wide spatial variation, the member states as a rule take the EFFIS fire danger maps into consideration but have developed their own system, and produce a daily fire danger map covering their needs.

According to the Greek legal framework, the responsibility for the prevention of forest fires belongs to the Forest Service. However, given the scale of forest fire prevention elements, all actors involved in the management of forest fires as well as the citizens have motivation and right to be involved.

The General Secretariat of Civil Protection in Greece, which is responsible for the study; the policy planning; the organization and coordination of the civil protection actions, has made many efforts related to forest fires issues (including the development of the “3rd General Emergency Plan for Forest Fires” within the framework of the General Civil Protection Plan with the code name "Xenokratis”, the issuing of circulars for the “Planning of Civil Protection Actions to Manage the Forest Fires Risks” and the “Civil Protection and Removal due to Evolving or Imminent Forest Fire Disaster” - all available at http://www.civilprotection.gr).

In Greece, a daily fire danger prediction map is prepared by the General Secretariat of Civil Protection. It is produced by a team of forest fire and meteorology expects, is published online every day around 13:00 (http://civilprotection.gr/el) and is valid for the next day.



The fire danger prediction map for Greece for August 28, 2015.Green color refers to low risk, the reddish to the higher

2.2 Bulgarian Risk Assessment and Hazard Map

Forest fire causing events can be divided broadly in two:

a. Natural phenomena, e.g. lightning

b. Human interference, which in turn can be divided into

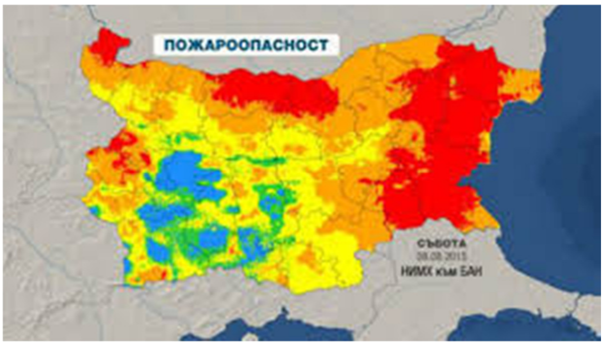
- Intentional – *though the reason may differ, fires are caused by intentional actions*

- Unintentional – due to human negligence - Disposal of matches and cigarette butts; careless handling of fire from workers, pastors, campers, tourists, etc .; technical failure of machinery and vehicles working in forest or agricultural areas; children playing with fire; uncontrolled burning of waste or large patches dry grass near the forest; spontaneous combustion of substances and materials; short circuits and accidents of electrical transmission lines that pass over and near the forest and others.

Forest fires or "wild fires" can practically occur everywhere. Especially dangerous is the summer season, when thousands of tourists make camp out in the wild. All Bulgarian mountains in periods of prolonged drought are potentially at risk. Fires can occur not only in the mountains. Every year the authorities warn farmers to take measures when working outdoors in the heat. Serious risk of fire exists at harvest time in the regions of Dobrudzha, the Danube plane, Thrace, the Sofia plane and elsewhere, where large distances and the lack of sufficient amounts of water impede rapid fire extinction.

Particular attention should be paid to natural parks and wildlife sanctuaries, located throughout the entire country. A fire can destroy natural habitats that nature has needed millennia to create. National legislation prohibits human intervention in those areas, so the potential recovery of the affected areas will be left in the hands of nature alone.

During prolonged droughts in the summer almost the entire country is potentially threatened by fires.

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2.3 Italian Risk Assessment and Hazard Map

In Italy every year thousands of wood hectares burn because of forest fires, defined by the Italian law as fires that are going to spread on wooded areas, eventually with human structures inside, on cultivated or wild areas and on pastures.

The nature of forest fires can be fraudulent or involuntary and in particular they are tied to property speculation, pastoral activities, human negligence and carelessness; in the last 30 years the 12% of the Italian forest heritage have been destroyed.

The year 2007 has been the annus horribilis for italian forests because there were more than 10.000 forest fires. Consequences on natural steady state are heavy, considering both the ecosystem damages (for example animals and vegetation) and the impact on soil stability.

Altereations due to forest fires promote slope instability phenomena, and can be the base for soil loss, soil slip or mass movements in case of rain. Restoration times are very long.

Every region is affected by forest fires, but in different periods of the year and with a different level of seriousness.

Overall italian environmental and climatic conditions promote forest fires development mainly in two periods of the year. In Alpine areas, such as in the highest zones of Apennines, forest fires develop chiefly in winter/spring, when vegetation has been dried out by freezing; on the contrary in summer there are often storms that reduce fire risk.

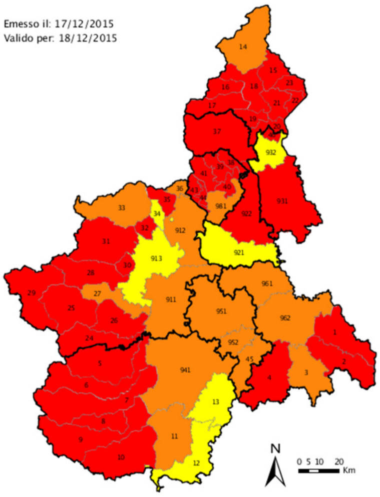
In the rest of Apennine and, in general, in the central and southern part of Italy there is a different situation; here there is a Mediterranean climate and fire can develop more easily in summer, when it’s hot, windy and dry. What is aforementioned is only a general structure because, there are some regions that are affected by forest fires for the whole year and the human hand make everthing less predicable and not framing into schemes.

According to the Italian legal framework there are many Services and Structures that are involved in forest fires management cycle.

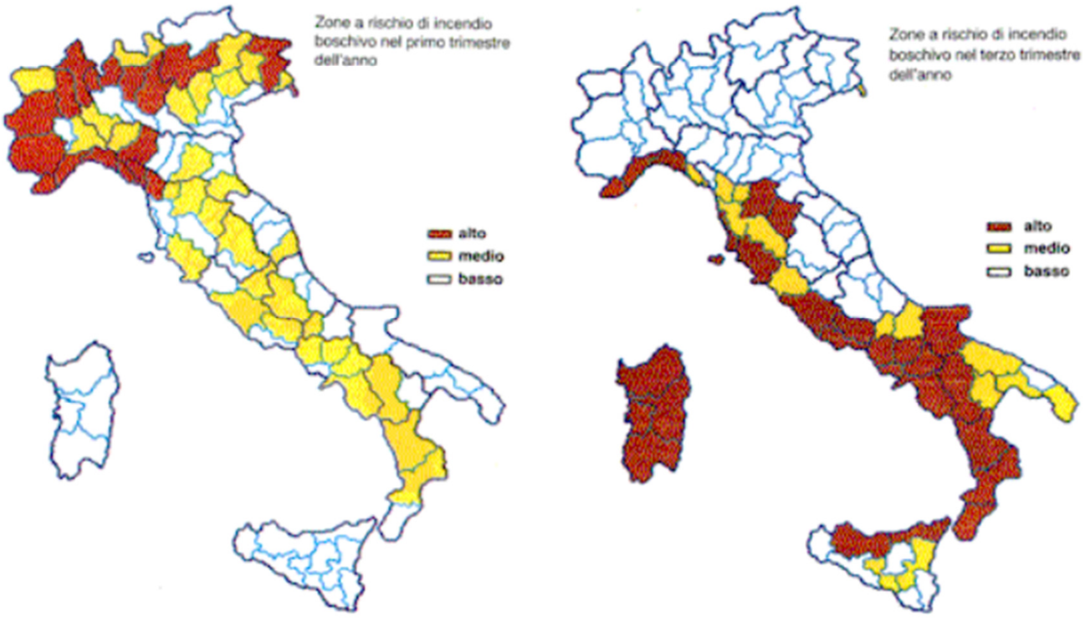
The main role is conducted by Regions, that have to prepare the Regional Plane for prevision, prevention and action to contrast forest fires; in this document you can find the list of direct and indirect actions to do for a correct forest fires management.

The local Regional Agency for Environmental Research and Protection is responsible for the daily emission of the Regional Forest Fires Hazard Bulletin, that communicate the hazard evaluated using different methods (for example the Fire Weather Index - FWI, also called “Canadian Method”).

During the emergency the forest fire is faced by the “Corpo Forestale dello Stato”, Civil Protection, at different levels according to the importance of the occurrence, and Fire Fighters too.



Example of Regional Forest Fire Hazard Bulletin (Piemonte Region – NW part of Italy)



On the left you can see the map of forest fires risk in the first three months of the year; on the right the same map is referred to the third trimester of the year

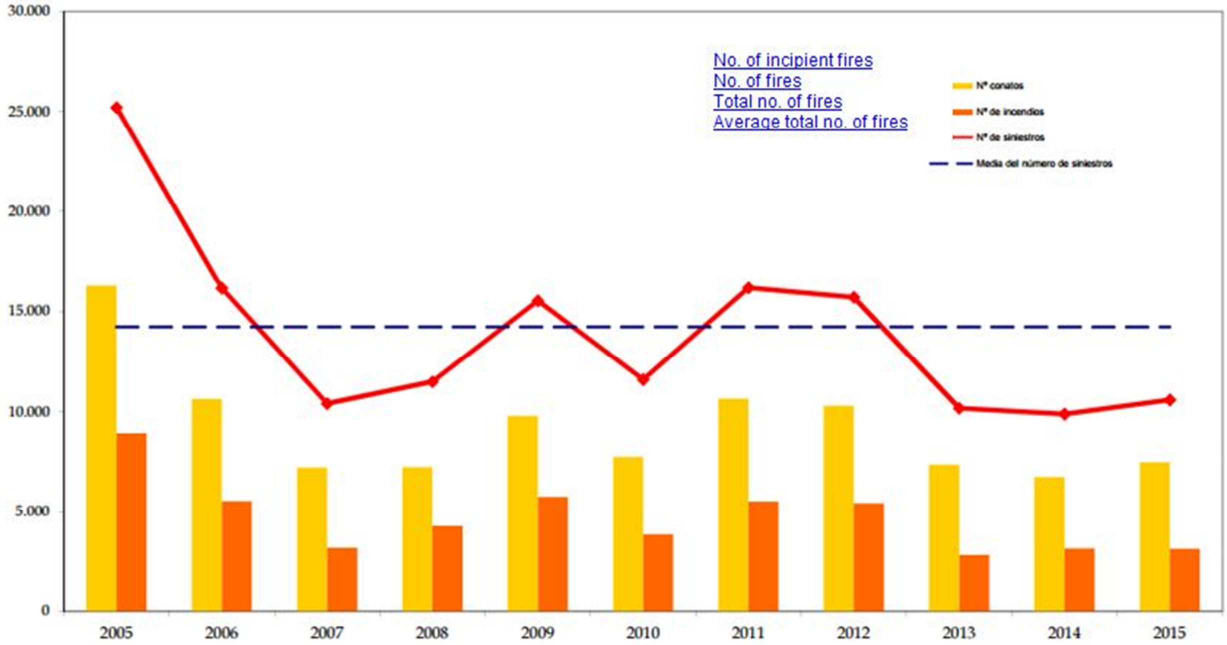
(http://www.comunevitulano.it/avvvpc/pages/antinc_bosc.htm)

2.4 Spanish Risk Assessment and Hazard Map

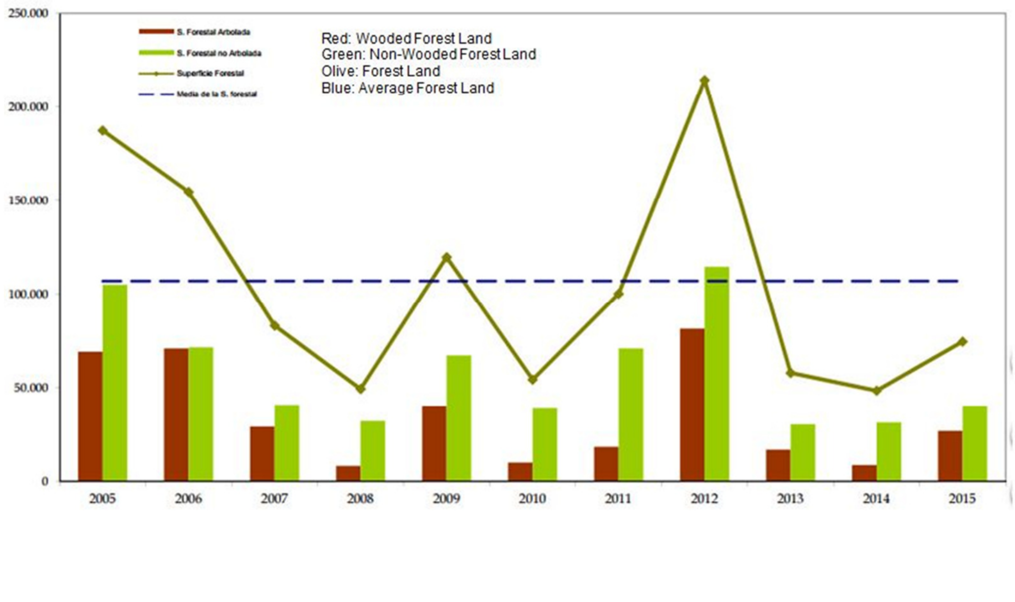
Fires are regular ecological phenomena in forest systems and the dominating factor in their dynamic. Between 1961 and 2004, there were approximately 20,000 forest fires each year in Spain, for an average of 152,000 hectares of burned land.

Although this number has fallen in recent years, there were major peaks of burned land in 2005 and 2012. In 2012, the total number of fires was 7% lower than the average for the previous decade (2001-2010), but the forest area affected was 48% higher than the average for that period. The statistic for the total number of forest fires has improved, but the size of the forest area affected has worsened, making 2012 the year with the largest forest area affected in that decade.

Fire is, without a doubt, a phenomenon that persists year after year, and it is the leading cause of the destruction of Spain's forests.

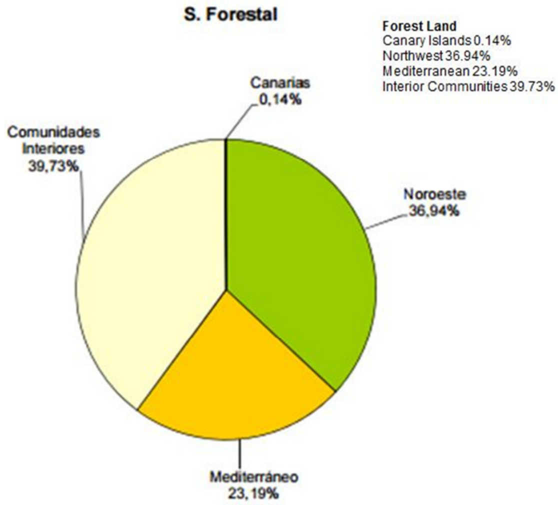


Evolution of incipient fires between 1 January and 30 November 2005-2015.

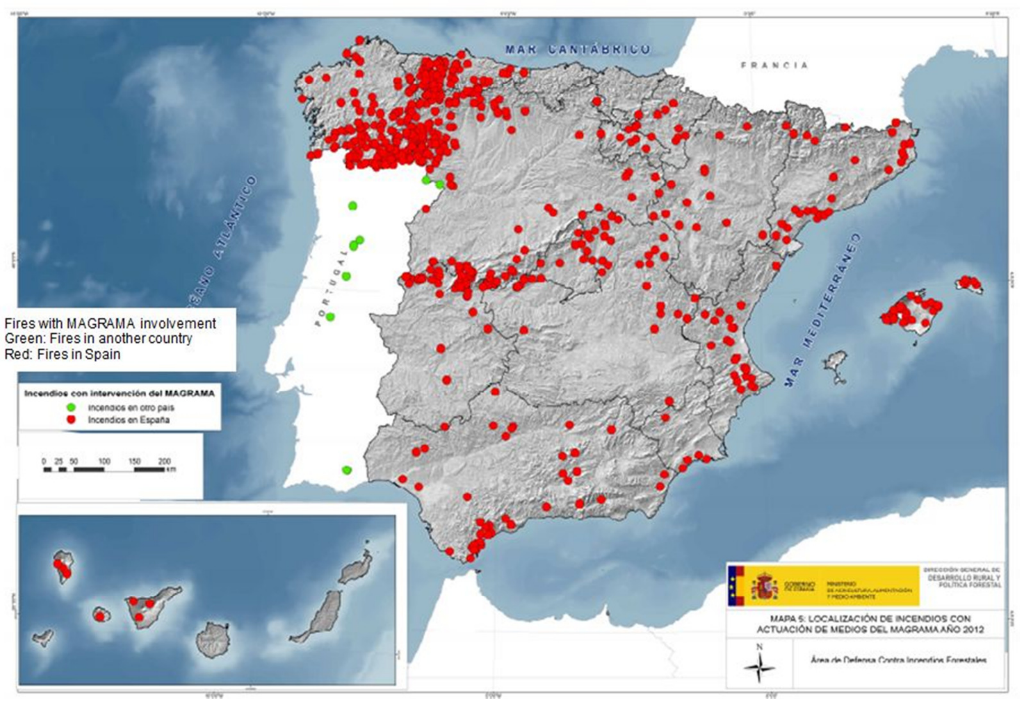


Evolution of forestland between 1 January and 30 November 2005-2015.

In general, for the country as a whole, forest fires break out primarily and in equal proportions in the inland regions and in the northwest area of the peninsula, followed by the Mediterranean region, but to a lesser degree.



Forest fires between 1 January and 30 November 2005-2015.



Sample map of the Ministry's forest fire operations in 2012.

Some of the factors that contribute to fires are the abandonment of agricultural lands (which increases the size of the areas with natural and uncontrolled vegetation) and the elimination of traditional uses of forests by rural communities, who in the past had gathered wood, herbs or resins. Another factor worth noting is the importance of climate and how it affects this last aspect, especially the number of fires. The statistics coincide with years of severe drought and years with heavy rain. In terms of the area (the land burned), this is influenced by the condition of the forest landscape's structure.

It is important to keep in mind that most fires in this day and age are caused by humans.

Risk Analysis

In Spain, many of the responsibilities of the central government are transferred to the autonomous communities, so forest fire prevention (as well as flood prevention) is handled by each region through the Regional Action Plans. The Community of Valencia, for example, has established PATFOR (Plan de Acción Territorial Forestal de la Comunitat Valenciana, the Regional Forest Action Plan of the Community of Valencia).
These documents classify the forest land in each region and then determine the risks, resources and warnings for each emergency level.
As mentioned in a previous document, a forest fire is influenced by the index of the NATURAL PARK'S LOCAL RISK, which among other aspects, is determined by the type of vegetation, uses and activities, environmental conditions or the topography of the land. The VULNERABILITY OF THE NATURAL PARK, due to the exposure of people, goods and resources, is also considered, along with LAND ZONING, which is determined by the risk and vulnerability to establish hazardous areas or risk maps. The necessary resources for prevention and their ideal location are determined, along with the intervention resources for minimizing consequences (Monitoring and Surveillance Plan using the DYSTER system, location of the Fire Station and mobile squads, patrols, etc.).

For example, the Valencian province, and specifically the city of Valencia, contains the Devesa-Albufera Natural Park, which is located in a high-risk area within the Special Plan Against the Risk of Forest Fires in the Community of Valencia.
In this case, the municipality of Valencia is required to prepare a Municipal Action Plan against the risk of forest fires that establishes:

- The aspects related to the organization
- Operating procedures for the resources and corresponding services
- And items that may be assigned to the organisation by other government bodies or other public/private entities.

All of this must be done with the aim of handling pre-emergency and emergency situations caused by forest fires within the regional area of responsibility. This area, which covers 21,120 hectares, is one of the most emblematic and valuable natural spaces in the Community of Valencia and the Mediterranean basin. It covers 13 municipalities, and the municipality of Valencia houses the largest area, which is 5,880 hectares and represents 43.67% of the area that comprises our municipality (13,465 hectares).
The Valencia City Council acquired the Albufera Lake and the Devesa Forest from the State in 1911. In 1983, the Valencia City Council approved the Special Interior Reform and Protection Plan for the Saler Dehesa Forest, which marked the start of this ecosystem's recovery. The Albufera National Park was declared on 8 July 1986, and it included the Devesa of L'Albufera within the Park.

Aside from being declared a National Park of the Community of Valencia, its value has also been recognised on a national and international level:

• Since May 1990, it has been included in the list of Wetlands of International Importance under the Ramsar Convention as well as in the Spanish Wetlands Inventory.

• It has been declared a ZEPA Special Bird Protection Zone.

• It has been declared a LIC Zone (Area of Community Importance) within the Mediterranean biogeographic region.

Technology, Controlling risks

Fires are increasingly linked to the anthropic exploitation of forests through urban development, which leads to more ignition sources of anthropic origin, whether they are accidental or intended. This increases the number of fires in these areas, and as a result, the exposure of the nearby resident population, as occurs in Valencia.

Images of the Devesa-Albufera forest region and its developed area.

Images of the Devesa-Albufera forest region and its use by the population

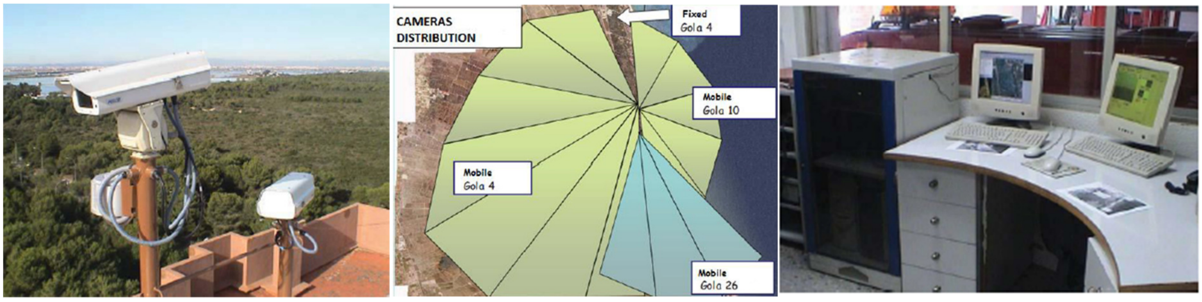
Technology is advancing at an astounding pace and it is becoming increasingly accessible, affordable, and present in our lives. In terms of risk prevention, there are many applications for forest fires and there is proof of the strong success of risk detection and prevention in this field. Devesa National Park has an automatic fire detection system aimed at identifying and locating fires in the early stages.

The system, which was launched in 2002 and operates 24/7, is called DISTER (Fire Detection through the use of Heat Sensors). It was developed by the Polytechnic University of Valencia in collaboration with the Valencia City Council's Fire Brigade Service.

The duties of the observation posts are:

- To obtain and process thermographic images. Since this is the fundamental part of the system, it captures and processes the images, and detects potential fires.
- To exchange information with the monitoring elements of the motors, and to adjust the thermal cameras and the interface with the communication modules.
- To broadcast alarms, and to synchronise and control commands.
- To link with the video images of each remote post, as well as to remotely control the cameras from the central command post.

In this case, there are a total of four thermal imaging cameras and three video cameras that cover nearly the entire marsh and the Devesa.Images are continuously captured by the thermal cameras and then processed, point by point, in order to locate temperature increments in the area. Once a hot spot has been detected, it is analysed electronically to determine whether it is a real alarm, in which case an alarm category is assigned and its coordinates are provided.



Camera on building tower, area covered, system at the fire brigade control post.

There are several risk levels in the Natural Park:

- Low Risk Level: This usually applies to January and May due to the cold (January) and rainy (May) weather of these months, as well as to their lack of holiday periods.
- Moderate Risk Level: This usually applies to October, December, April and July. April is in this category due to the activities that take place in the Devesa during the Holy Week holiday period. The higher volume of visitors in April explains the increased risk level compared to May. On the other hand, July marks the start of extra patrol efforts in the area. These have a dissuasive effect that justifies the fact that July has a moderate risk level, compared to June, which has a high risk level.

- High Risk Level: This risk level applies to August, September and June. June is due to the start of the summer season, combined with a lack of extra patrol efforts during this month. On the other hand, the August and September levels are due to the summer months, when temperatures are high and a significant amount of heat has accumulated in the prior months.
- Extreme Risk Level: As opposed to what may seem intuitive, these levels apply to February and March. This is due to the special impact of the Fallas festival on the area, which raises the risk of fire due to the increased presence of people in the area and the recreational use of pyrotechnic materials that are linked to this fiesta.

There are other variables that affect the probability of fire, and since there is a high probability during certain months, preventive measures are established for high or special (extreme) risk levels.

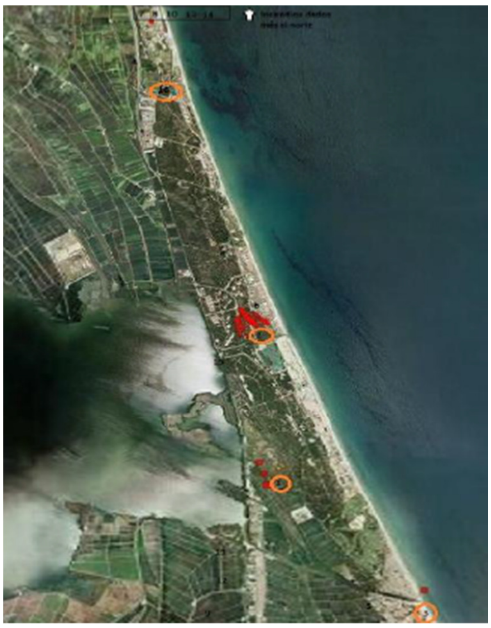
Some examples of preventive measures include: increasing the presence of patrols in order to inform residents and Park visitors, operating at entrances and emergency roads, and dissuading people who intend to cause fires.

Photos of volunteers and fire brigade services.

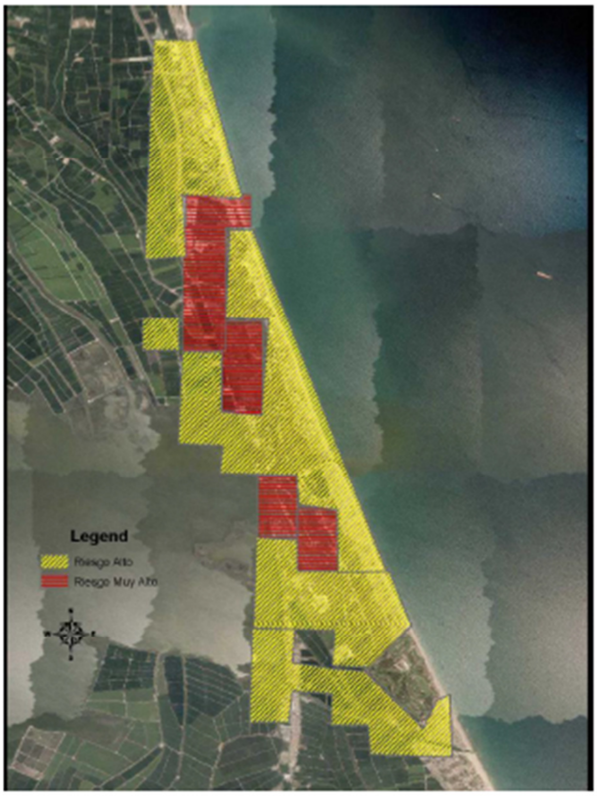
The image shows the location of the 16 fires that took place in the Devesa between November 2007 and January 2010. Only four (25%) were detected by the camera system. One burned an area of more than 10,000 m2, two burned between 100 and 500 m2, and a smaller fire burned between 50 and 100 m2.

Expert studies show that despite the challenges faced by the layout or orography of the land, the system is making progress and getting better, but false positives and the detection of small fires must be improved. Data must be cross-referenced and efforts should be focused on the most hazardous zones.

These high-risk areas (due to their vegetation) are marked in the physical risk map of the Natural Park's Forest Fire Prevention Plan. If the installation of a technological system that monitors the forest is being considered, the areas with the highest risks must be determined so efforts may be focused on them.



Spatial distribution of fires and real alarms detected by the DISTER system



<u>Physical risk map on orthophoto. (CANALES, P. 2015)</u>

3. Prevention-Mitigation

In recent years, the focus of fire prevention has changed. While the end goal of preventing catastrophic loss of life, property, and natural resources has remained the same, the strategies and tactics involved have been modified. Increasing fuel loads have made today's wildland fires harder to control, expensive to suppress, and a threat to the lives of firefighters and civilians. Potential negative wildland fire consequences now involve more than blackened acres and property loss.

When today's wildland fires spread they often burn with intense heat and erratic fire behavior, severely impacting and even altering ecosystems and communities and challenging their ability to recover – and sometimes claiming human lives.
It is important to embrace the fact that, while past suppression tactics have been effective, fire prevention tactics and strategies have changed. No longer can we afford to invest all our resources in fire suppression forces, equipment, and strategies. "Reactive" fire suppression programs must evolve into "proactive" fire management programs that effectively apply fire prevention and hazardous fuels reduction techniques to not only reduce unwanted fire ignitions, but also minimize damages and personnel exposure from wildfires.

As communicators prepare to embark on a fire prevention program, it is critical to keep this in mind: wildland fire is an essential, natural process.
The goal of a fire prevention program is to prevent unwanted human caused fires
While this requires raising awareness of the risks associated with wildland fire, the message must be balanced with the natural role of fire to support the overall mission of land management agencies which sometimes includes using fire as a tool. If we go too far in "scaring" the public, they will not be inclined to support other fire management initiatives. A holistic approach to wildland fire communication is key.

New techniques and strategies for fire prevention education can be used in specific situations to more effectively reduce the damages and risks from unwanted wildfires.
Producing an effective wildfire prevention plan may mean doing old things differently, doing new things, aiming at different targets or getting "out of the rut" and working outside the comfort zone for a while. It will be important to develop efficient prevention programs and deciding when they should be carried out. This may mean doing more adult education. It may mean doing more high visibility patrolling with fire suppression personnel. It may mean giving prevention training to non-fire personnel. It will mean better results for most prevention programs.

The overall strategy of every wildfire prevention plan should focus on the "three E's" of the fire prevention triangle: Engineering, Education and Enforcement. Each of these three activities is an important piece when reaching out to the public and ensuring that there is a strong understanding of the message that is being conveyed. Within each of the three categories, there are several guiding principles to follow. While the general message is that all prevention programs need to use a variety of methods to capture the public interest and therefore understanding, it is important to understand how each of the three activities are crucial to wildfire prevention.

3.1 Emergency planning

Forest fires are a major problem in Spain both owing to their frequency and extension. Apart from the ecological, economic and human cost, their effects on the health of the population are immediate.
According to data published by the Ministry of Agriculture, Food and Environment (MAGRAMA), 10,626 forest fires were recorded in Spain in 2013, which burnt a total of 58,985.02 hectares of land. These figures show a considerable decrease in both parameters over the last decade, and 73.9% less than the total burnt surface area in 2012, which amounted to 226,125.10 hectares. The year 2013 was also the second year with the lowest figure of burnt surface area. The best year was 2008, when 50,322.09 hectares were burnt.

Create an **evacuation plan** must include:

- A designated emergency meeting location outside the fire or hazard area. This is critical to determine who has safely evacuated from the affected area.
- Several different escape routes from your home and community. Practice these often so everyone in your family is familiar in case of emergency.
- Have an evacuation plan for pets and large animals such as horses and other livestock.
- A Family Communication Plan that designates an out-of-area friend or relative as a point of contact to act as a single source of communication among family members in case of separation. (It is easier to call or message one person and let them contact others than to try and call everyone when phone, cell, and internet systems can be overloaded or limited during a disaster.)

Be Prepared:

- Have fire extinguishers on hand and train your family how to use them (check expiration dates regularly).
- Ensure that your family knows where your gas, electric, and water main shut-off controls are located and how to safely shut them down in an emergency.
- Assemble an Emergency Supply Kit for each person,
- Maintain a list of emergency contact numbers posted near your phone and in your emergency supply kit.
- Keep an extra Emergency Supply Kit in your car in case you cannot get to your home because of fire or other emergency.
- Have a portable radio or scanner so you can stay updated on the fire.
- Tell your neighbors about Ready, Set, Go! and your Wildfire Action Plan.

Emergency Supply Kit
Each person should have a readily accessible emergency supply kit. Backpacks work great for storing these items (except food and water) and are quick to grab. Storing food and water in a tub or chest on wheels will make it easier to transport. Keep it light enough to be able to lift it into your car.

Emergency Supply Kit Checklist

- Three-day supply of non-perishable food and three gallons of water per person.
- Map marked with at least two evacuation routes
- Prescriptions or special medications
- Change of clothing
- Extra eyeglasses or contact lenses
- An extra set of car keys, credit cards, cash or traveller’s checks

- First aid kit
- Flashlight
- Battery-powered radio and extra batteries
- Sanitation supplies
- Copies of important documents (birth certificates, passports, etc.)
- Do not forget pet food and water!

Items to take if time allows:

- Easily carried valuables
- Family photos and other irreplaceable items
- Personal computer information on hard drives and disks
- Chargers for cell phones, laptops, etc.

3.2 Raising awareness - training or other educational activities for different target groups

Wildfires have the potential to cause extensive loss of life, property, and resources. As fire conditions approach or worsen, fire prevention, and education is often overlooked, fire prevention education teams can be mobilized in advance of fire starts, when fire danger conditions worsen. This section lists fire prevention activities that have proven to be successful in reducing ignitions and losses from wildland fires, when applied effectively and in the appropriate situations.

Internal Communications

Internal newsletters, information board posting, staff meetings, dispatch morning reports, on-site training programs, and tailgate sessions all provide excellent opportunities to communicate fire prevention messages. Fire prevention information can also be presented at on-site workshops, seminars, and other educational programs.

The Public Information Officer and Wildfire Prevention

The primary responsibility of a Public Information Officer assigned to a wildfire is to keep the public and other incident personnel updated about suppression efforts. However, having the attention of the public and the news media focused on a wildfire presents a unique opportunity to deliver fire prevention messages as well. Public Information Officers are encouraged to deliver fire prevention messages when they are talking to the public and the news media about wildfire suppression.
Sometimes, in the heat of the moment, it is easy to lose sight of this opportunity. Always contact the Incident Public Information Officer(s) assigned to a wildfire in your area and work with them to deliver unified messages to your shared audiences.

Public Awareness and Education

Education of the public on the natural role of fire and the prevention of unwanted wildland fires is becoming increasingly important as communities encroach on wildland areas. Nationally, arson and debris burning are the leading causes of wildfires in the wildland/urban interface. Education and enforcement is key to prevention of these types of fires. It is also key to a better public understanding of the benefits of prescribed and natural fire. Printed materials, including general information handouts, site bulletins, and brochures, should include a fire prevention message. The use of the Smokey Bear icon should be encouraged in order to emphasize the prevention message.

Smokey draws immediate attention and enhances any fire prevention message. Media campaigns can be initiated which include show-me tours, photo opportunities, and demonstrations, and solicit support for public assistance in fire prevention programs. Appropriately, located signs and posters with carefully worded prevention messages are effective.

Wildfire prevention education includes those activities that are aimed at changing people's behavior by increasing their awareness and understanding of the issues. Following are sample tactics for consideration when developing a prevention education plan.

- *Public Awareness and Education*

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- *Community Awareness*

- Provide fire safety videos, CDs, and DVDs to other agencies and organizations.
- Provide homeowner fire safety material.
- Conduct fire safety programs with homeowner's associations.
- Conduct or participate in local town meetings.
- Conduct fire prevention education programs with local service clubs.
- Provide information with local county planning commissions.
- Provide public education training for local fire departments.
- Coordinate community activities, such as “Fire Awareness Time” annual campaign (spring clean-up, weed abatement program).
- Develop guidelines for field use for working with local organizations, governments, and communities.
- Help to implement programs such as Neighborhood Watch, Junior Forest Ranger, and Fire wise programs.
- Public Meetings – Participate with city councils and county commissioners to proclaim “Fire Prevention Week.”

- Develop a system to incorporate roadside signing in selected areas, such as those with a high occurrence of human caused fires.
- Develop a fire prevention page on the Internet.

• *Mass Media – Television*

- Prepare seasonal public service announcements and interviews for local use.
- Coordinate efforts with fire prevention cooperators to develop television public service announcements.
- Monitor and facilitate the national Advertising Council activities with local stations.
- During local fire incidents, stress the importance of increased fire prevention efforts.
- Participate in morning or afternoon local television talk shows.
- Continue presenting rotating fire prevention messages on cable television.
- Work with meteorologists to provide fire danger and prevention messages in their forecast

• *Mass media – Print/radio*

- Provide local radio public service announcements to appropriate stations.
- Provide local written media with timely news releases.
- Develop a schedule of local fire prevention activities and prepare news releases to be used on a scheduled basis.
- Provide local print media with timely news releases.
- Assist local print media to obtain Advertising Council materials.

• *Fire Prevention High Visibility Public Contact*

- Establish engine patrol routes and implement on a needed basis, i.e., holidays, high use periods and weekends.
- Develop a hunter assistance patrol program, which includes fire prevention messages.
- Implement high visibility fire prevention efforts in the following areas:
    . Fire prevention patrol.
    . Visitor center fire prevention.
    . Organizational militia approach to fire prevention.
    . Establish "trap lines" including contacts with key community leaders and forest users at key locations

4. Preparedness

Definitions

In the Merriam-Webster dictionary, preparedness is defined as “the quality or state of being prepared; especially: a state of adequate preparation in case of war”. Focusing on disaster preparedness, the Business Dictionary (http://www.businessdictionary.com/definition/disaster-preparedness.html) describes it as the “process of ensuring that an organization:

- Has complied with the preventive measures
- Is in a state of readiness to contain the effects of a forecasted disastrous event to minimize loss of life, injury, and damage to property
- Can provide rescue, relief, rehabilitation, and other services in the aftermath of the disaster, and
- Has the capability and resources to continue to sustain its essential functions without being overwhelmed by the demand placed on them.

It also states that “preparedness for the first and immediate response is called emergency preparedness”.

In the field of forest fires, preparedness is the result of activities that are planned and implemented prior to fire ignitions. As such, in a broad sense, it constitutes part of fire prevention. In regard to fire management organizations, preparedness is a continuous process that includes developing and maintaining a firefighting infrastructure, predicting fire activity, hiring, training, equipping, and deploying firefighters, evaluating performance, correcting deficiencies, and improving overall operations. Preparedness is a process that takes place throughout the year and includes routine pre-season actions as well as incremental in-season actions conducted in response to increasing fire danger (Bloms 2015).

Whereas forest fire preparedness is an important task for the state, involving all the above mentioned activities, it is also a task for the local authorities, for small communities and even for individual citizens who live permanently or enjoy their vacations in homes that are close to forest vegetation.

4.1 Forest Fire Preparedness Plan

Good planning is the basis for being prepared for wildfires when the fire season arrives. The objective of such planning is the development and application of a **fire preparedness plan**. Depending on the level for which the plan is being prepared, its specific objectives, content, characteristics, and level of detail obviously vary. In its Preparedness Plan a country must assess its operational needs and corresponding budget requirements, to adjust its resources and fire management infrastructure, to plan for fire prevention and suppression, and to set rules for building-up measures, trained personnel and appropriate equipment according to changing fire activity conditions as predicted by a reliable operational fire danger rating system. At the other end, at the level of the individual citizen, a Preparedness Plan is much more specific and detailed, focused mainly on personal and family safety and protection of property. In-between the two, counties, large municipalities, small communities and even individual companies exposed to fire risk, need to have an appropriate fire preparedness plan. The "Forest Fire Prevention and Suppression Guidelines for Industrial Activities" issued by the Government of the Northwest Territories in Canada, are an example of such planning, in which a Fire Preparedness Plan is defined as "a plan outlining the condition or degree of being able and ready to cope with an anticipated fire situation" (Bailey, 2011).

4.2 Forest Fire Preparedness at local level

Communities which are built close to forest and/or agricultural vegetation, especially in areas with Mediterranean climate, are likely, sooner or later, to be exposed to the threat of a wildfire and may suffer significant damages. This is valid both for traditional rural communities and for the usually newer settlements which have been built next to or even within forest vegetation, creating what has been termed "Wildland-Urban Interface (WUI)" areas.

In rural communities the chances of damage are much higher than in the past mainly due to the fact that their population has been decreasing in the last decades and has been getting older. Thus, vegetation clearing around villages and consumption as fuel is also decreasing. Fires easily reach and enter unprepared villages causing serious damages.

In WUI areas, the inhabitants are usually people who try to escape the congested and polluted city centers. They try to move as close (or within) the forest as possible without realizing the risk of becoming affected by a forest fire. Even worse, as a rule, they know very little about the forest environment they live in, the risk of becoming unintentional arsonists due to ignorance or negligence, and how to react in case of fire.

The increasing number of unstoppable large fires (also called megafires) in the last decades, that under adverse conditions reach communities in full force causing serious damages and even fatalities, is a serious concern for fire management agencies around the world. The priority these agencies have for protecting lives and property, reduces their capacity to protect forests and limit fire spread and often exposes firefighters to high risks. Recognizing that without appropriately prepared settlements the problem will only be getting worse, these agencies nowadays provide guidance and assistance for improving the preparedness of these communities. Especially in WUI areas, there is an emphasis on developing Fire Adapted Communities (FAC). A FAC is defined as a community located in a fire-prone area that requires little assistance from firefighters during a wildfire. Residents of these communities accept responsibility for living in a high fire-hazard area. They possess the knowledge and skills to (University of Nevada Cooperative Extension. 2011):

- Prepare their homes and property to survive wildfire.
- Evacuate early, safely and effectively.
- Survive, if trapped by wildfire.

Ideally, a community should develop and apply a "Community Wildfire Protection Plan" (CWPP) which will lead to coordinated actions and will maximize protection effectiveness and efficiency. In many countries, specific legislation has been established to encourage CWPP development. In the USA, the Healthy Forests Restoration Act (HFRA) which was enacted in 2003, offers significant incentives to communities to develop CWPPs, allowing however flexibility to tailor it to their local social and ecological context (Jakes et al. 2011). Furthemore, a handbook provides step-by-step guidance for such planning for WUI Communities (Society of American Foresters 2004).

Community Wildfire Protection Plans may address issues such as wildfire response, hazard mitigation, community preparedness, structure protection—or all of the above. The process of developing a CWPP can help a community clarify and refine its priorities for the protection of life, property, and critical infrastructure in the WUI. Furthermore, as found by researchers who analyzed a series of case studies, the process of developing a CWPP can lead to benefits beyond those associated with direct measures such as fuels reduction, including enhancing social networks, developing learning communities, and building community capacity (Jakes et al. 2007).

4.2.1. Developing a Community Wildfire Protection Plan

The first step for the development of a CWPP is to form a core team made up of representatives from the appropriate local authorities, the local fire authority, and the local forest management agency for staring the process. The team should link to state agencies for guidance and technical support and to make them aware of the process in order to achieve compatibility with their larger scale plans. The support and active involvement of other interested organizations and stakeholders, including active citizens, should be encouraged.

The planning process itself should start with the establishment of a baseline map of the community that defines the community's WUI and displays inhabited areas at risk, forested areas that contain critical human infrastructure, and forest areas at risk for large-scale fire disturbance. With the help of this map and on-site visits a spatial risk assessment should be made next. It should consider fuel hazards, risk of wildfire occurrence, and values at risk (e.g. homes, businesses, essential infrastructure etc.). The characteristics of topography in relation to fuels and property, as well as the road network should also be examined in regard to risk. Finally, the local preparedness capability should also be assessed. The level of risk for each factor should be rated (Low, Medium, High) and incorporated into the base map as appropriate.

The resulting map and risk assessments should form the basis for analysis and discussion in the community that leads to the identification of local priorities for fuel treatment, reducing structural ignitability, and other issues of interest, such as improving fire response capability. The CWPP is not complete until a detailed implementation strategy is developed as well as a monitoring plan that will ensure its long-term success. Furthermore, the CWPP must be communicated to the community, all the local key partners and all other relevant organizations at higher scale (Society of American Foresters 2004).

The same steps outlined above for the development of a CWPP for WUI areas in the USA, can also work and have been recommended for the defence of villages, farms and other rural areas against wildfires in the Balkan region (Goldammer et al. 2013).

4.2.2 Community fire preparedness measures

The measures that can be included in a CWPP are dictated by the identified risks. When fire behavior, expressed in the form of fire intensity or flame length, is predicted to be very high, fuel management is the usually prescribed measure for reducing the level of threat (Xanthopoulos et al. 2006). Fuel reduction and fuel separation are two of the most common methods of fuel management.

One of the most common methods of fuel reduction is understory shrub removal. This is usually done along linear features such as roads or along the border of the community. By removing the shrubs and dead fuels on the ground (logs and branches) and pruning tree branches to a height of 2-3 meters, surface fire behavior is reduced significantly and the tree crowns become unreachable by the surface fire. Furthermore, tree removal so that the tree crown cover becomes less than 50% is usually enough to stop fire spread from crown to crown. This is one form of "Fuel Break" which is defined as a treated buffer where vegetation has been reduced adequately to allow firefighters to stay and fight an advancing fire front.

Complete interruption of the continuity of fuels is usually achieved by a firebreak which is a gap in vegetation down to the mineral soil that acts as a barrier to slow or stop the progress of a forest fire. A firebreak may occur naturally where there is a lack of vegetation such as a river, lake or canyon. A strategically located road can serve as a fire break.

Another important measure in a CWPP, to be created or simply identified and maintained if it already exists, are “safe areas”. They are cleared areas where residents and animals are safe from a fire. Safe areas could be pastures, gravel pits, parks, football fields, or even an airstrip.

The road network is critical for easy access of firefighting trucks to all the parts of the community and for safe evacuation in case of emergency. Each community should have at least two ways into and out of the area and the same should be true for each of the neighborhoods. The roads should be wide enough for fire engines to pass and should have adequately wide turnarounds (about 30 m) allowing large fire engines to change direction without difficulty. They should also have wider sections every 100 m or so (turnouts), allowing vehicles to pass each other. All roads should be clearly identified with signs, and all homes should carry visible signs with street names and house numbers. Bridges with limitations for heavy loads, such as those of fire engines carrying 10 tons of water, should be clearly identified in the maps and with signs on the road.

A functional water network with a large water tank and appropriately located hydrants, capable to deliver the needed water with adequate pressure, is another must for a prepared community. In regard to firefighting, detailed planning is done through a pre-suppression plan which is not limited to a community but definitely needs to take all local CWPPs into consideration (e.g. maximum risk areas, fuels distribution, fuel treatment. Both the pre-suppression plan and the CWPPs need to include a dynamic part for preparedness and mobilization of resources and citizens which is based on the fire danger forecasts that are issued by the responsible authorities.

Finally, an element of maximum importance is training of citizens on how to prepare their homes, what to do in case of fire, and how to evacuate safely and effectively. One of the key elements

4.3 Citizen preparedness for forest fires

The number of WUI areas affected by forest fires and the associated damages and fatalities are on the rise, as fires become more aggressive due to fuel built-up, climate change, etc.. In response to this, the message from fire management agencies to the citizens is that they cannot rely completely on the firefighting resources for protection. For example, if a fire reaches a WUI settlement, it is not possible to guarantee that there will be a sufficient number of fire engines available to protect all structures. Furthermore, the firefighters are more likely to protect homes that have had adequate preparation and have become defensible. Thus, it is clear that citizens living in WUI areas need to learn and be ready to protect themselves and their families. In order to do this they need to:

- Get training about forest fires and fire safety, which will guide them on preparing their own family's preparedness plan and will help them act effectively in case of fire (basic firefighting, first aid, evacuation procedures, etc.)
- Prepare their home and its surroundings in order to mitigate the behavior of a fire that may impact their property and to improve the fire resistance of the structure.
- Prepare and practice a plan of actions to do in case of a forest fire, establishing a strategy (e.g. "stay and defend or leave early"), identifying evacuation routes according to fire approach scenarios, setting criteria for preparedness action, etc.. Doing this before the emergency offers time for discussion and review with experts, neighbors, etc., and for communication of the plan to all family members.
- Prepare for an emergency (build an emergency kit, make arrangements for family communications during the crises, agree on safe meeting points in case of separation of family members, etc.)
- Take all necessary fire prevention measures in the daily routine during the fire season.
- Keep informed about fire danger predictions on a daily basis.
- Make timely decisions and act correctly and decisively in case of fire.

A wealth of information for citizens on how to prepare their property and themselves for a wildfire emergency is available on the internet by various fire and emergency management agencies, such as the Federal Emergency Management Agency (FEMA) in the USA (http://www.fema.gov/media-library-data/14090038593910e8ad1ed42c129f11fbc23d008d1ee85/how_to_prepare_wildfire__033014__508.pdf), FireSmart Canada (https://www.firesmartcanada.ca/resources-library/protecting-your-community-from-wildfire), the Country Fire Authority (CFA) in Australia (http://www.cfa.vic.gov.au/plan-prepare/prepare-and-maintain-your-property/), etc.. It is however interesting to note that the characteristics of WUI areas are different from one place to the other. For example, there is a contrast in regard to the vulnerability of structures and the fire environment between WUI areas in USA, Canada, Australia and Mediterranean Europe. This results in different property preparedness recommendations and may even justify different survival strategies (Xanthopoulos et al. 2012).

5. Response

However strong the effort to prevent forest fires may be, it is not possible to eliminate their ignition completely. Thus, especially in Mediterranean areas, fires are sure to happen and the need for a suppression mechanism capable to respond quickly and extinguish them is absolutely necessary.

In the field of forest fires the term “response” usually refers to the dispatching of personnel and resources to fight a starting vegetation fire, trying to control it as quickly as possible while keeping the burned area to a minimum. As a rule, the affected area is forest or agricultural land. This first dispatching of responses and the first intervention is called initial attack. Usually, most fires are controlled through initial attack, burning only a few hectares. However, in spite of the best of efforts, some fires escape initial attack and run uncontrollable for hours and their control requires what is termed “extended attack”. Then, the complexity of the fire increases exponentially as it spreads in many types of fuels and in varying topography. Thus, the number of resources sent to the fire increases very rapidly and the same is true for the cost of firefighting. At the same time the probability that the fire will reach high value areas and will cause serious damages also increases.

When the fires run actively for many hours or days they usually enter the category of “large” fires. The threshold of what constitutes a large fire is a matter of definition. For example, Dimitrakopoulos et al. (2010) define this threshold at 1000 ha. Aggressive fire behavior is an obvious factor affecting fire growth, but delay of initial attack, inadequate or poorly trained resources, lack of access (poor road network, difficult topography, etc.) are also factors that may allow a seemingly benign fire to grow large. Nearly any fire may become large under certain circumstances (Dimitrakopoulos et al. 2010).

A special case of large fires are the so called “mega-fires”, a term introduced in the last decade (Williams et al. 2011) and used to refer to “those fires that exceed all efforts at control until firefighters get a favorable change in weather or a break in fuels”. The main characteristics that make fighting them practically impossible are very high rate of spread with extreme fire intensity and very heavy spotting. Extreme drought of live vegetation, extremely low relative humidity (<20%) that results in very dry fine dead fuels, and large amounts of fuels within forest stands (often affected by diseases), lead to such fire characteristics. When the above conditions are combined with atmospheric instability, leading to plume dominated fires, then the stage is set for disaster.

Typically, forest fires exhibit very active fire behavior and are difficult to fight under high fire danger conditions. However, such conditions do not necessarily result in large burned areas. A host of factors, often including coincidences, determine if a fire become large. Effective response, however, is critical for reducing this probability.

The key elements for effective response are:

- Existence of a good presuppression plan
- Existence of the required firefighting capacity for the “job at hand”. This means appropriate number and mix of capable firefighting resources, including firefighting personnel, fire engines, firefighting airplanes and helicopters.
- Existence of a well organized system of command and control that foresees the build-up of an on-site organization as the fire is growing and the resources are piling-up. This system makes sure there is a standard chain of command and everyone entering the scene has clearly identified

responsibilities. Disbanding of the organization after completion of the suppression of the fire is also foreseen.

- Operation of a well organized and equipped coordination center, with highly trained personnel.
- Existence of highly qualified and experienced officers to undertake the on-site coordination of the firefighting effort, with the help of a specialized support team.
- Existence of a good support mechanism capable of accurate fire danger prediction, effective fire detection, meteorological support, logistics support, and all types of needed support by the local authorities (e.g. carrying water to the firefighting field using water tenders)

Presuppression plan

A forest fire presuppression plan can be thought as part of fire prevention since it is prepared before the onset of fires. Actually, it is the link between fire prevention and suppression. Its content includes the arrangements made for setting the suppression of an actual fire into operation. It has to be written. It must be flexible enough to cover every possible scenario, from a single fire occurring unexpectedly outside the fire season to the most severe combination of large fires occurring simultaneously at the peak of the fire season (Chandler et al, 1983).

A presuppression plan is not independent of the overall preparedness plan of an area. It shares information and its preparation also needs cooperation of all the players but there is an emphasis on the role of the fire suppression organization. For example, a threat analysis which is useful for all preparedness planning is also extremely valuable for guiding presuppression decisions.

A presuppression plan must include a layout of structure of the firefighting organization with a listing of all employees, full-time and seasonal, with their contact data. The same is true for data on all aerial and ground resources (types, characteristics, positioning, alertness and availability status, responsible officers, contact numbers, etc.). Ideally, a presuppression plan should include data analysis for the potential firefighting work load, and evaluation of the required resources, including trade-offs among various mixes of personnel and equipment, including costs estimates. In reality, the budget is usually a limiting factor and the resources may be fixed by decisions at a higher level. Thus, the plan should strive to make best use of resources in regard both to effectiveness and efficiency, giving for example emphasis on development of a good manning guide, as explained below, and making good use of volunteers, and other resources. Furthermore, the plan should identify potential firefighting work load levels or special fire danger conditions that constitute a threshold beyond which the available resources are unlikely to cope with all the fires. In that case, the plan should foresee a procedure for requesting additional resources (e.g. from other places within the country, or international support) without any delay. If planned properly, justified with data (e.g. fire danger rating predictions, satellite images, burned area estimates, etc.) when the situation occurs and a procedure has been set in advance for the request, it is likely that adequate help will arrive in time while the extreme conditions are still on, and will contribute towards mitigation of the disaster. Without such advance planning, it is likely that outside help will start being mobilized only after the occurrence of major disaster (as it happened in Greece in August of 2007, after the death of 80 people) and will probably arrive when the worst is already over. Another potential option that may be included in the plan is to leave some of the starting fires unattended, except probably for a small scale initial attack effort, when the conditions are such that it is not possible to attend all fires. Such approach is not uncommon in Galicia, Spain where the number of fires can be extremely high so priorities need to be determined (Alonso-Betanzos et al. 2003).

A manning guide is also a necessary part of the plan. It provides instructions on how to increase readiness as the fire season advances and fire danger increases. In the plan this is often tied to the Daily Fire Danger Prediction map. This, for example, is the case in Greece. Depending on the fire danger level (low, medium, high, very high, "red flag alert") the daily deployment of fire engines and patrol cars is different. When predicted fire danger is very high or "red flag alert", personnel and resources of other authorities (e.g. Forest Service, municipalities, volunteer groups, military, etc.) are put on alert and special measures are foreseen (e.g. road closures). Obviously, the plan needs to contain lists with all the necessary contact information with key officers of these authorities for keeping them informed and requesting response. At red alert level the presuppression plan may even foresee flight of firefighting planes for detection and immediate intervention during the critical hours of the day. Also, the spatial distribution of predicted high fire danger areas often leads to relocation of resources in order to carry out better prevention and effective initial attack.

Another key component of the presuppression plan is maps and records which aim to provide information on past fires and firefighting events, information on values and on vulnerabilities across the landscape (e.g. soil erosion potential map, map of special areas such as villages, WUI areas, archaeological sites, recreation areas, industrial areas etc.), Of even more importance are maps that provide important information for fire suppression. Examples include (Chandler et al, 1983):

- Vegetation map, depicting all forest and agricultural vegetation.
- Fuel map, depicting vegetation as fuels, in the form that is more appropriate for predicting potential fire spread through fire behavior modeling. It also depicts the location of areas with naturally reduced vegetation, or where firebreaks and fuelbreaks have been constructed, providing opportunities for effective firefighting.
- Water supply map, distinguishing potable water, water accessible by road for fire engines, water accessible only for portable pumps, water accessible to firefighting helicopters, and water accessible for ampnibian waterbombers.
- Air operations map including landing fields, helispots, and aviation hazards such as powerlines and communications towers.
- Machine-line construction map showing areas where mechanized equipment (e.g. dozers, graders) can be used for fire suppression, considering the performance characteristics of each type of equipment as affected by slope, ground cover and soil type
- Special hazards map. Depending on the country hazards may include radioactive areas (e.g. in Ukraine, Russia, USA, etc.) sites with unexploded ordinance (UXO) and minefields (e.g. in the Balkans and even in Germany), and also site with contaminants (e.g from mining activity, hazardous wastes, etc.) (Goldammer et al. 2010).

The ultimate in presuppression planning is individual preattack fire planning where, based on fire eruption and behavior scenarios, complete firefighting scenarios are created: the tactics to be used are decided in advance, the required resources are specified, and all the necessary information and calculations, including logistics, are prepared in advance (Chandler et al, 1983).

Dispatching procedure

Once a fire is detected and reported, dispatching of the appropriate firefighting resources for suppressing it becomes the most critical element of response. This dispatching is usually done at local level. The fire announcement is recorded, including time, name and method of communication with the reporting person, as well as any other information that he/she can offer. The decision for dispatching of the first fire engines is made immediately to avoid wasting time. Usually the closest engines are sent first. The fire is also announced to the main coordination center of the region or country in order to be aware and to anticipate probable requests for aerial support and even additional ground resources. Then the potential of the fire is assessed as best as possible, combining data and maps from the presuppression plan, fire danger predictions, current weather measurements and predictions for the next hours, as well as new information from location coming from the first report of the firefighters reaching the fire area (e.g. fire size, rough perimeter, convection column characteristics, flame length, etc)). Based on this assessment, within minutes of the initial fire report, all the necessary resources as well as an adequately qualified officer for the size of the job, are on their way to the fire scene.

Correct dispatching needs to send enough resources to minimize the chance that a fire will escape initial attack but at the same time it has to be conservative enough to avoid sending too many resources because this adds unnecessary cost and breaks down the pre-existing optimum deployment of resources on the landscape. Actually, immediately after the dispatch to the fire, the dispatcher should evaluate the resulting situation and should try to fill weak spots caused by the initial dispatch by moving up fire engines from other locations.

The dispatcher should keep current with the evolution of the firefighting effort in order to anticipate potential needs well in advance of actual needs. This may require alerting additional resources and may also need preparing to send other logistics support to the fire area (e.g. fuel, drinking water, food, tools, etc.). Weather updates for the firefighters, when not available at the fire site, should be another concern for the dispatcher.

A highly experienced and qualified dispatcher is key for effective dispatching. He/she should be experienced in firefighting, should have very good knowledge of the area (forest fuels, topography, road network, local weather peculiarities, etc.) and of the presuppression plan. However, as two people are never the same, and as knowledge and experience may vary, it is not unlikely that two dispatchers at different shifts will react quite differently to the same type of situation. This may mean reduced effectiveness of the overall system, increased number of fires escaping initial attack, or unnecessarily high costs. It may also mean reduced credibility of the organization which in turn may lead to external pressures (e.g. political, Mass Media, social, etc.) for modifying dispatcher decisions. A reply to this problem and a true tool for better dispatching is the use of computer based Decision Support Systems (DSS).

An early effort for the development of such a system in Greece in the 1990s was that of Xanthopoulos (2002). It was an MS-DOS system on a PC platform called “DISPATCH”. It was based on practical rules and simple fire behavior & firefighting models without spatial analysis capabilities. Its data requirements were minimal and easily fulfilled and its simplicity and friendly user interface made dispatchers with no previous experience on computer use, able to operate it and obtain results very quickly. The system provided suggestions on dispatching fire engines and Canadair CL-215 amphibian waterbombers in an easy to understand format (Figure 1) and proved very useful when it was used operationally at the central coordinating center in Athens.

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************************* F I R E   D A T A *****************************

LOCATION OF FIRE                                           : MILIES (N. EVIA)
MONTH : 7             DATE : 26                 TIME : 14
VEGETATION TYPE             : PINUS HALEPENSIS FOREST
WIND SPEED                  : 6 BEAUFORT GRADES
TOPOGRAPHIC RELIEF     : HIGH (>50%) HOMOGENEOUS SLOPES
ESTIMATED FIRE SIZE AT REPORT TIME : 0,4 - 2 HECTARES
ROAD NETWORK DENSITY   : LOW
SIZE OF INITIAL ATTACK FORCES ALREADY ON THE WAY : 4 - 5 FIRE TRUCKS
EXPECTED ARRIVAL TIME OF THE FIRST GROUND FORCES : 0 - 10 MINUTES
TIME FOR TAKE-OFF OF THE FIRST CL-215         :  15 MINUTES
FLIGHT DISTANCE FROM THE BASE TO THE FIRE     : 100 KILOMETERS
DISTANCE BETWEEN THE FIRE AND THE SEA         :   8 KILOMETERS

************** F I R E   A N A L Y S I S   R E S U L T S *****************

FIRE SERIOUSNESS (0-100)                                          : 62
----------------------- G R O U N D   F O R C E S -------------------------
PROBABLE EFFECTIVENESS OF GROUND FORCES (0-100)                   :  1
FIRE CONTROL WITH CURRENTLY DISPATCHED FORCES IS NOT PROBABLE EXCEPT IF CONDITIONS
CHANGE. IF THE FIRE ESCAPES INITIAL ATTACK, WITHOUT AERIAL SUPPORT, AT LEAST 19 FIRE
TRUCKS WILL BE REQUIRED.
----------------------- A E R I A L   F O R C E S -------------------------
ESTIMATED ARRIVAL TIME FOR THE FIRST CL-215               :  47 MINUTES
MINIMUM CALCULATED TIME BETWEEN WATER DROPS               :  10 MINUTES
NEED FOR DISPATCHING OF AERIAL SUPPORT (0-100)            : 100
IN CASE OF DISPATCH THE PLANES WILL REACH THE FIRE BEFORE IT IS CONTROLLED BY THE
MOBILIZED GROUND FORCES.
PROBABLE EFFECTIVENESS OF AERIAL FORCES (0-100)                   :  86

---------------- ESTIMATED REQUIRED NUMBER OF WATER BOMBERS -----------------
IF ONLY THE GROUND FORCES MOVING TOWARDS THE FIRE ARE USED,
FIRE CONTROL WITHIN 1 HOUR DOES NOT APPEAR POSSIBLE
FIRE CONTROL WITHIN 2 HOURS REQUIRES DISPATCH OF AT LEAST 12 PLANES

BASED ON THE ABOVE DATA FOR GROUND AND AERIAL FORCES ARRIVAL TIME, FIRE CONTROL WITHIN 2
HOURS CAN BE ACHIEVED BY THE FOLLOWING COMBINATIONS OF FIRE TRUCKS AND WATER BOMBERS:

TRUCKS  |   4   6   8  10  12  14  16  18
--------------------------------------------------------------------------
CL-215  |  12  10   9   8   7   5   4   3
--------------------------------------------------------------------------
```

Figure 1. An example of the fire analysis printout produced by DISPATCH.

In the years that followed computers became much more powerful and inexpensive, Geographic Information Systems advanced impressively and found their place in most organizations, fire spread simulation systems proliferated, digital spatial data availability became commonplace, and all these made it possible to develop highly advanced spatially based DSSs in support of fire management, either at the coordinating center or in the field. Many European Fire Research projects produced such systems but the level of acceptance and adoption by the operational fire management organizations has been variable so far. Some examples of such systems are a) the FOMFIS system for off-line efficiency-driven presuppression probabilistic planning (Figure 2) (Caballero et al 1999), b) the E-FIS system for support of fire officers in the field through communication with their coordination center and carrying out simulations at remote powerful computers where data bases are also kept (Figure 3) (Caballero 2002), c) the AUTOHAZARD PRO system which included an automatic fire detection and an optimal resource dispatching module (Figure 4) (Kalabokidis et al. 2011), and the AEGIS system which in addition to being a highly developed Wildfire Web

Geographic Information System, making use of Cloud computing, also includes the "AEGIS App" for forest fire information management in the field, running on Windows smartphones (Figure 5) (Athanasis et al. 2015).

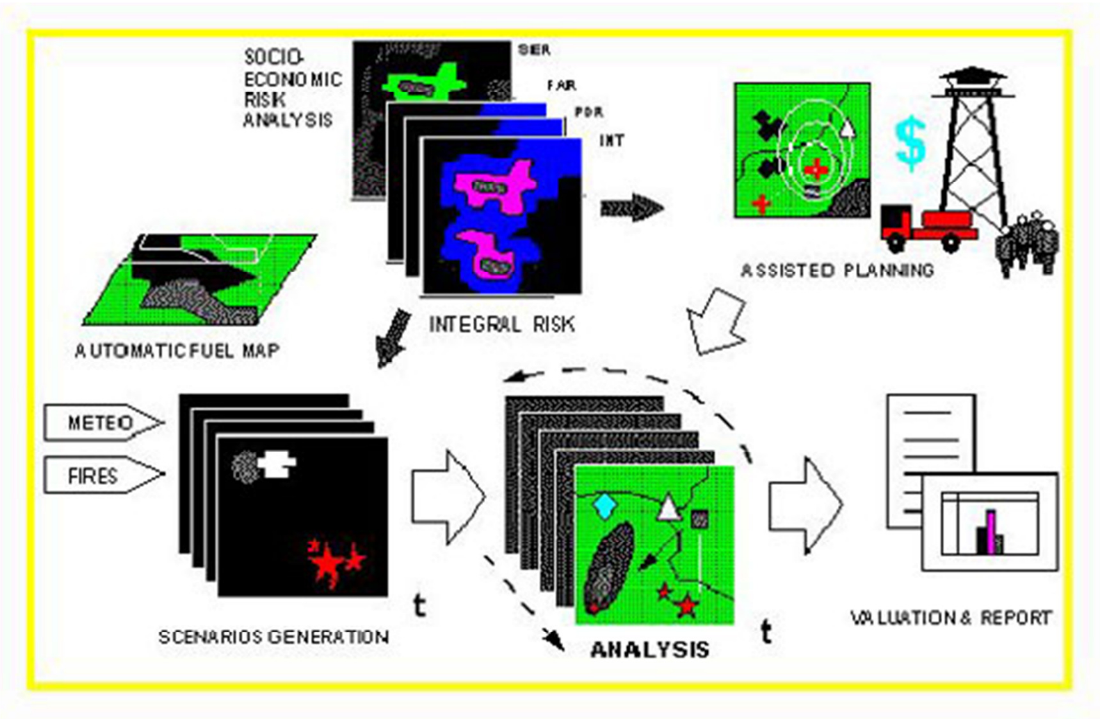

Figure 2. The FOMFIS system architecture

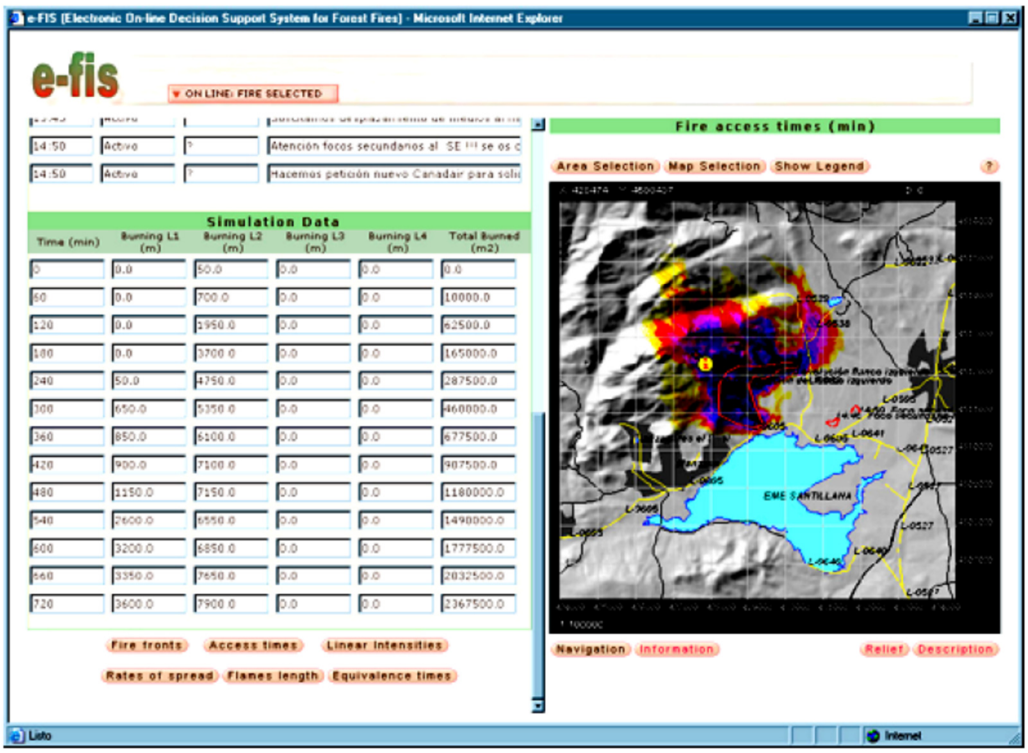

Fig 3. An E-FIS system fire simulation showing the time the fire will reach various points ("fire access times").

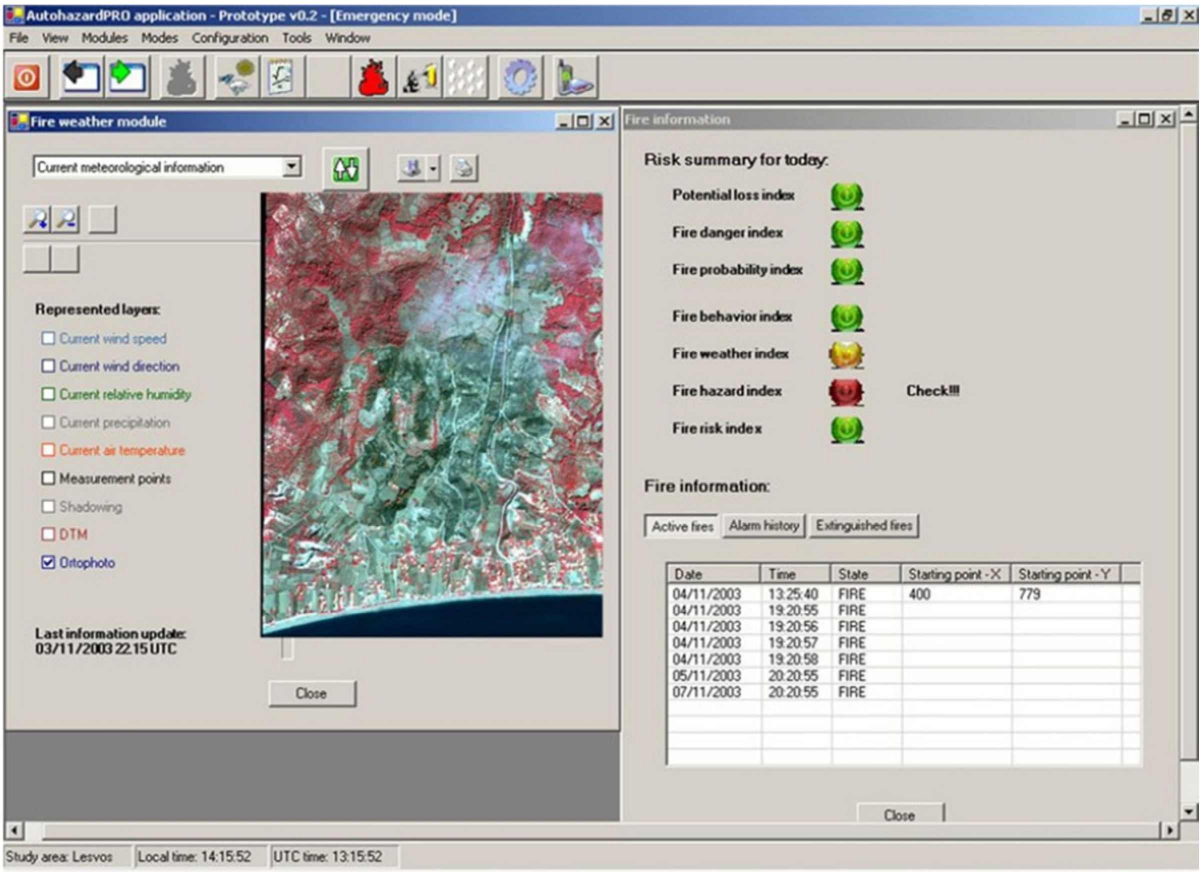

Figure 4. A screen-shot of the fire weather module of the AUTOHAZARD PRO system.

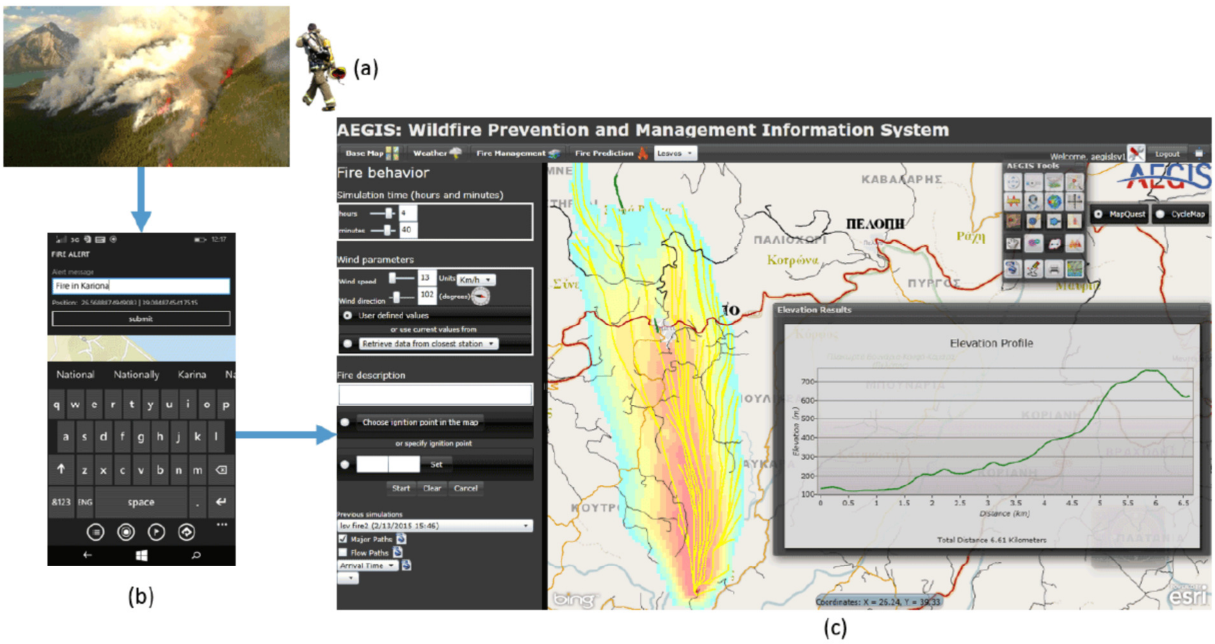

Figure 5. Parallel utilization of the web-based platform and the mobile app of AEGIS.

Firefighting personnel

However good dispatching may be, the firefighting work must be done in the field by ground and aerial resources. Their performance is critical for suppressing a fire quickly. Contrary to the belief of many people, who are impressed by the aerial firefighting resources, a forest fire can only be completely extinguished by the firefighting personnel. This personnel must be physically and mentally fit for the purpose, highly motivated, disciplined, and well trained.

Firefighters can be professionals in permanent jobs in the firefighting organization, seasonal employees hired for the fire season, permanent personnel working for other authorities (e.g. municipalities, military, etc.) or volunteers. In any case, physical fitness is a must, and this is not easy to achieve with permanent personnel. In the USA and in Canada, where most of the firefighting takes place away from roads, using handtools and employing fire suppression methods without use of water, the physical condition of the firefighters is of paramount importance. In the USA, the “Pack Test” is used for testing the Work Capacity of individual wldland firefighters. More specifically it is used to qualify individuals for the three levels of wildland firefighting duty: Arduous, Moderate and Light. It measures aerobic capacity, muscular strength and muscular endurance. All wildland firefighters must meet minimum levels of fitness requirements for the type of duties they are assigned. This emphasis on testing aims at personal safety and health, co-worker safety, and Improved operations. The chart below provides test criteria for arduous, moderate, and light duty performance:

Fitness Requirement	Test	Description
Arduous	Pack Test	3-mile hike with 45-pound pack in 45 min.
Moderate	Field Test	2-mile hike with 25-pound pack in 30 min.
Light	Walk Test	1-mile hike in 16 min.

Similarly in Canada, to be a FireRanger, a candidate must pass the Canadian Physical Performance Exchange Standard for Type 1 Wildland Fire Fighters (WFX-FIT). The test must be passed every year to maintain certification (http://www.wfx-fit.ca/). In Australia, physical testing is done through the Pack Hike Test (PHT) (Philips et al. 2011, 2012), Although the need for good physical condition is also recognized in Europe, fitness standards are not as stringent. One of the reasons is that there is generally preference in firefighting using water from fire engines which is less demanding when compared to working for hours with handtools digging fireline.

Good physical condition is necessary but not adequate for effective and safe firefighting. Excellent training is also a must. Such training has been developed in many of the large fire prone countries (USA, Canada, Australia) which have provided the basis for development of similar courses and training material elsewhere. It should be noted that as weather conditions, fuels, and firefighting approaches differ between countries the content of training must be adapted accordingly. An excellent effort for standardizing training material for firefighters in Europe is the series of handbooks produced by the EUROFIRE Project (http://www.fire.uni-freiburg.de /eurofire/en/EuroFire_Training_EF1_Safety.pdf).

In Mediterranean Europe, in spite of the preference for fire engines that has been mentioned above, it has become evident that ground crews with handtools are necessary for fire suppression. They are extremely useful in firefighting in tall forests, especially at higher elevation, where there is significant amount of dead branches, litter and duff on the ground. In Greece such crews are usually dispatched to fires that grow in size and require a final mop-up effort along the perimeter in order to achieve full control. Another very useful operation of hand crews is immediate dispatching by helicopter close to starting fires, especially those in remote areas. Such helicrews were organized and performed initial attack successfully in Greece in the 1990s but the idea was abandoned later (Figure 6). Helicrews are quite common in the USA and in Canada where fire in roadless wilderness areas are impossible to reach on foot. Also, in the USA and in Russia, there are crews of “smokejumpers” who are highly trained firefighters that parachute near the fires in remote areas for initial attack.

Figure 6. Photos of the training of the first helicrews in Greece.

Figure 7. Smokejumpers parachuting, landing and receiving aerial support (fire retardant drop by a C130 plane equipped with the MAFFS system), and on working on fire control through indirect attack. (Photos from CNN, BBC, and the California smokejumpers internet site)

Firefighting equipment

In the world of forest firefighting there is a number of a number of common equipment which are used in most countries for ground and aerial firefighting. Each country however, chooses the specific types of equipment according to its particular needs and sometimes tries new innovative proposals by various manufacturers who try to improve over the standards.

Figure 8. Photos of various fire engines showing differences in water capacity and maneuverability.

The most basic equipment is the fire engine which carries a varying amount of water and has a powerful pump and hoses that make it possible for the firefighters to bring the water close to the fire perimeter and spray it on the flames. The amount of water carried by the fire engine, the seating capacity for personnel, the capability to move off-road, the performance of the pump, are some of the characteristics that differentiate one fire engine from the other. Some examples of fire engines are shown in Figure 8.

A smaller fire engine with up to 2.5 tons of water is obviously more agile than a large 12-ton fire engine that is often used mainly for fighting city and industrial fires and has limited capacity to move out of asphalt roads. Thus any organization needs to have a mix of fire engines tailored to its needs, and the dispatcher needs to make quick decisions for dispatching the best possible mix based on the available fire engines.

The dispatcher may also have to alert and if needed dispatch other operators and equipment such as bulldozers, graders, portable tanks and pumps, etc. These may offer optimum solutions at certain circumstances but they are often not readily available so good cooperation between the on-site firefighting coordinator and the dispatcher is needed.

Aerial resources

These resources mainly include firefighting fixed-wing airplanes, and helicopters. These also come in various sizes, capacities and characteristics. As they are very costly for a country to purchase and operate or to contract from private companies, decisions on selection, contracting terms and dispatching and engagement rules need to be made very carefully.

Figure 9. Helicopters picking water from swimming pool, river, the sea, and a water tank.

Each of these resources has specific pros and cons. The water refilling capability of helicopters from nearly every open source of water is unparalleled (Figure 9). If such a source is available close to the fire the effectiveness of the helicopters becomes very high. Amphibian airplanes can only scoop water from the sea or large lakes but they can travel faster to a fire (Figure 10)..

Figure 10. Amphibian waterbombers scooping water in sea and lake.

Figure 11. Aerial firefighting resources in action in Greece.

The point to be made here is that the whole issue of choosing one aerial resource over the other is very complex and has to be taken after careful consideration of all aspects of such a decision. Howecer, how these resources are used is even more important (Figure 11). For example, in the first years of use of aerial resources in Greece (1970s-1980s) it was considered a waste to send them to fires before they were large and "worthwhile". Thus ground resources remained without aerial support even when the conditions were obviously very difficult from the first moment. At that time there was no daily fire danger prediction in the country. On the other hand, in the last fifteen years, the dependence on aerial resources for support in initial attack became very strong. As a result the cost of aerial firefighting increased steeply, and the ground crews became relatively complacent expecting that the aerial resources will do the main job. When, in the very difficult fire season of 2007, there were not enough resources available to attack all starting fires, these fires escaped initial attack and burned huge areas (Xanthopoulos 2007).

Command and Control

The final issue to be addressed in regard to the response to a forest fire is the need to have a very good, well trained and experienced officer in charge of the firefighters. Training includes many aspects of fire, including fire weather, fire behavior, firefighting tactics, fire safety, but also acquisition of skills in communication, leadership, etc. Theoretical training must always be followed by gradual built-up of experience. An inexperienced officer, even with the best training credentials, cannot be assigned to lead a very large fire.

An important point to be made is that a good commander may be adequate for coordination of initial attack but when a fire starts growing very large the overall organization must have foreseen a procedure for offering support by building a team of other officers who can undertake some of the tasks. For example, keeping current with the weather, tracking the position of the fire front and making prediction for the next hours, taking care of safety issues, solving logistics problems, etc., are all serious time consuming tasks that cannot be handled correctly by a single person. The build-up of a command and control structure is sometimes done ad-hoc. However, it is best when there is a standard method to be used in order to achieve consistent results. The "Incident Command System" (ICS) that has been developed in the USA and is now also used in Canada, Mexico, Australia, New Zealand and other countries, is a tried and proven method that can help address this issue. In addition to its effectiveness it also facilitates exchange of resources between countries in case of need, as it has happened between the above mentioned countries repeatedly in the last 15 years.

The ICS is a standardized on-scene incident management concept designed specifically to allow responders to adopt an integrated organizational structure equal to the complexity and demands of any single incident or multiple incidents without being hindered by jurisdictional boundaries (https://www.osha.gov/SLTC/etools/ics/what_is_ics.html). It is improtent to note after its development for fire management nowadays it has been adopted for the management of all types of incidents.

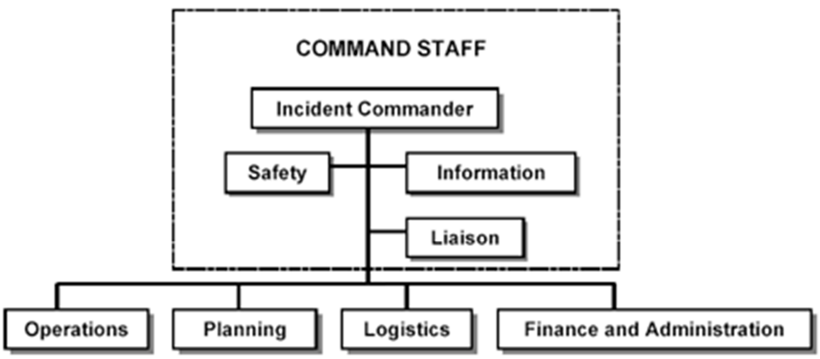

Figure 1 - Incident Command System Structure

6. Recovery

As a forest fire grows it causes damages. These damages can vary from very light to extremely heavy and may include ecological damages, loss of forest values (woody and non-woody forest products, market and non-market values), damage to infrastructures, loss of property and, in the worst case, even loss of life. When the fires become really very large and burn a significant proportion of an area, the economic problems are compounded and serious social problems surface among the people in the area.

Support to the people

Small or medium size fires that affect forest vegetation generally upset the people in the area, especially when the burning forest is of special historic, aesthetic or recreational value. As a rule, the problem is not acute and as the life of people is usually not affected directly, they get used and accept the new landscape, especially as it starts to re-green and recover in the next years. However, the situation is more difficult when extended fires cause extensive damage to agriculture, from wheat fields to olive groves, in addition to burning forest land. This is usually faced by compensating the farmers for the damage. In Europe this is usually done with European Commission funds earmarked for this purpose. The procedure starts by declaration of the affected area as disaster area by the state authorities of the country.

Figure 1. Volunteers and the army distributing food and water to people affected by the fires in Ilia in 2007.

When the disaster is worse, affecting directly villages and other settlements the response needs are much more significant. During the event the people may be advised to evacuate the area. Sometimes they return to find their place devastated and whole families become homeless. Even tourists may be affected. Especially if there is also loss of life, the people suffer a strong shock. Psychological support, clear guidance on what to do and where to go (including distribution of food and water (Figure 1) and settling temporarily in a hotel or an ad-hoc created camp (Figure 2)) and a small economic relief are among the main measures that the state should be prepared to offer to the affected people. For example, immediately after the mega-fires of August 24-27, 2007 in the prefecture of Ilia in Peloponnese, Greece, which burned 44% of the prefecture area (Milliaresis, 2008), the government announced special relief measures on August 27. These measures included payment of an amount of 3000 euro to every affected person for covering immediate needs, a restitution of 10000 euros for those who had their homes damaged (for repairs and replacement of furniture and appliances), postponement of paying taxes for six months, etc. (http://www.minpress.gr/minpress/index/ other_pages-1/information_metra_gia_pligentes.htm).

Figure 2. A ad-hoc camp of prefabricated "container" type homes built for the people of the most affected villages in Ilia.

As the measures and the way they should be carried out had not been clearly foreseen and specified in advance planning, a host of abnormalities occurred when application was attempted. Furthermore, a fund that was established for collecting money through donations from all over the world for reconstruction of the destroyed villages and infrastructures was not utilized effectively in the first 2-3 years when the support was more necessary. As there was no precedent, bureaucratic obstacles and indecisiveness caused serious delays and at the end there were few identifiable results. The effort to prevent an exodus of people towards the large cities and to repair the affected economy failed (Papageorgiou et al. 2013). A notable exception was reconstruction of the two most affected villages of Makistos and Artemida, which suffered many fatalities (Xanthopoulos et al. 2009) in addition to destruction of many homes. Specific donors, such as the Democracy of Cyprus, an intermationally known Greek company and a rich Greek family of entrepreneurs, undertook reconstruction of one of the villages each. They executed the work effectively and in a relatively short time offering real relief to the people (Figure 3).

The difficulties and inefficiencies often manifested when public authorities try to handle post disaster reconstruction and the will of many donor organizations to be directly involved in the reconstruction process in order to achieve optimum results, have been highlighted in recent international conferences that have focused on recovery after major disasters, In the face of rising economic losses from natural disasters. One such example is the World Reconstruction Conference 2 "Resilient Recovery – an imperative for sustainable development", that was organized by the Global Facility for Disaster Reduction and Recovery (GFDRR) and the World Bank, in partnership with the European Union (EU) and the United Nations Development Programme (UNDP) in Washington DC, USA , in September 2014 (Xanthopoulos 2015).

Figure 3. Rebuilding by donors of fire damaged structures in Ilia (January 2008) and a monument recognizing the help of donors (2015).

Post-fire restoration and rehabilitation

Restoration is the “process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed”. This definition is applicable to native forest ecosystems that were degraded or destroyed. Restoration aims to return an ecosystem to its historical condition, although setting this base reference is often difficult in a Mediterranean context where human management has been shaping landscapes for thousands of years. However, in the case of burned area management, our goals may not include restoration at all, in particular if we aim to change the ecosystem type that was burned (e.g. because it had no conservation value, or if we intend to reduce the fuel load in a particular location, independently of the previous land cover). **Rehabilitation** shares with restoration a fundamental focus on historical or pre-existing ecosystems as a reference, but the two activities differ in their goals and strategies. Rehabilitation emphasizes the reparation of ecosystem processes, productivity and services, but not necessarily the re-establishment of the pre-existing biotic integrity in terms of species composition and community structure (Moreira et al. 2012).

Active restoration uses techniques including plantations and direct seeding. These are relatively expensive tools for restoration, as they require site preparation, equipment, man-power, seedlings from nurseries, transport to the area, fertilizers, tree shelters, etc. (e.g. Moreira et al. 2009).

Indirect restoration implies the use of natural regeneration, and it can be either passive or assisted. Passive restoration is based on protecting the area from further disturbances and let ecological succession work (Lamb and Gilmour 2003). In burned areas regeneration may occur mainly from seeds (e.g. Pausas et al. 2004), and from resprouting burned trees and shrubs (Paula et al., 2009). Tree resprouts, in particular, have significant advantages over seedlings or planted trees because they have an established root system which may confer higher probability of survival and better growth (e.g. Moreira et al. 2009).

Mediterranean-type ecosystems are highly resilient to fire when dominated by shrub and tree species that have the ability to resprout or produce seedlings after fire. Thus, these traits should be used in post-fire restoration, mainly through assisting natural regeneration that will likely result in less costly interventions and higher rate of vegetation recovery (Moreira and Vallejo 2009). Artificial regeneration may be preferred when there are reasons such as high visibility of the burned area and strong public pressure (Melissari and Xanthopoulos, 2005), or when there exist other special deadlines, such as the case of the ceremony of lighting the torch for the Olympic Games of Beijing in March 2008, only seven months after the archaeological site of Olympia, Peloponnese, Greece, was destroyed by a wildfire (Lyrintzis et al. 2010).

How do we go about restoration?

In the Mediterranean region, as described above, most often the best thing to do after a forest fire is to do nothing, other than protecting the burned area from land use change and from grazing for a few years (Karetsos et al. 2012). In order to decide if and what intervention is required the manager has to take into consideration the type of the ecosystem and its properties, the severity of the burn and its results (e.g. creation of a hydrophobic layer in the soil), and from these to predict the expected ecosystem responses. According to these, he should decide if intervention is needed and, if yes, what should be the objectives for restoration of the burned area. These objectives may include soil erosion prevention, water regulation, increased forest productivity, biodiversity conservation, carbon storage, enhancing landscape values and reducing wildfire hazard. (Moreira et al. 2012) have proposed the framework for planning post-fire management and restoration in burned areas shown in Figure 4.

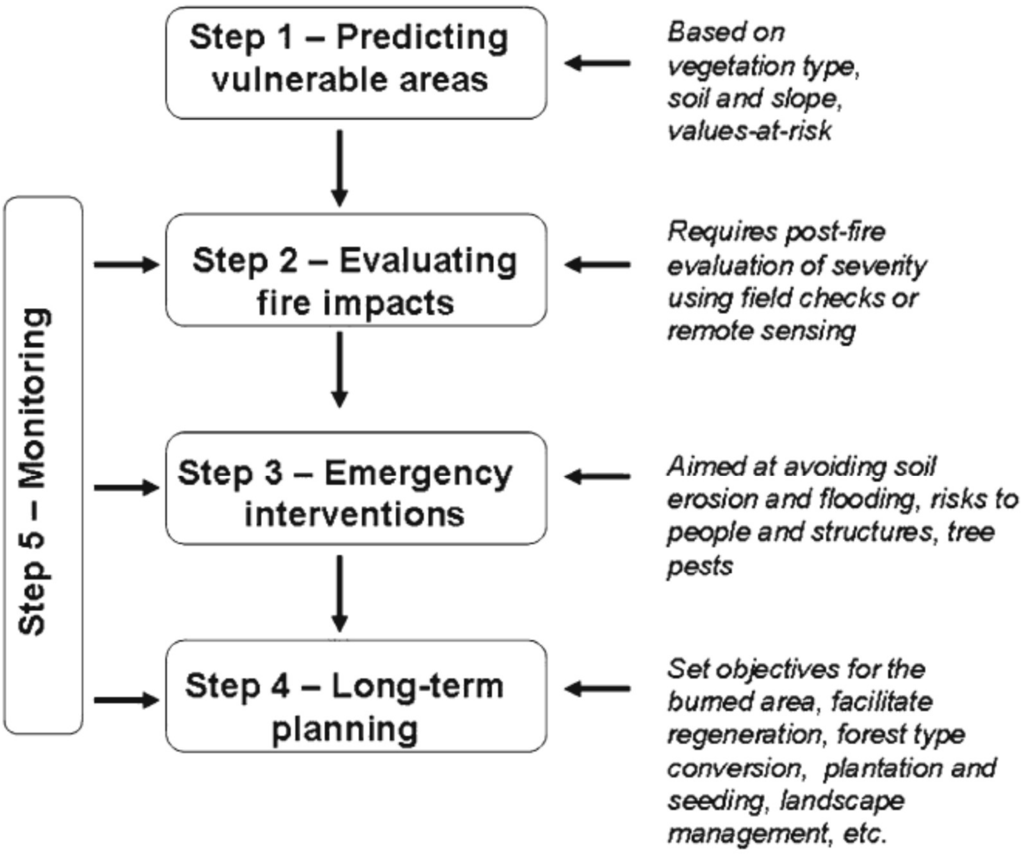

Figure 4. Framework for planning post-fire management and restoration in burned areas.

Emergency Interventions

The most common interventions after significant fires, aim to stabilize the affected area, to prevent degradation processes and to minimize risks for people. They can be considered as “first-aid” rehabilitation (Robichaud et al. 2000) and aim to reduce the potential for soil erosion and to decrease water runoff (Figures 5, 6, 7, 8). Through these, the risk of flooding downhill from the fire can be significantly reduced. They should be undertaken within the first few months after the fire, and, in the Mediterranean region, preferably before the first autumn rains.

Figure 5. Branch piles along the contours and a log-dam in a ravine, built in the forest-park of Thessaloniki, Greece after the fire of July 1997. Photographed here in 2004.

Figure 6. Log-barriers on the slopes along the contours and 2 check-dams, constructed in a ravine after the July 22, 1998 fire on Hymettus mountain, near the suburb of Kareas, Athens, Greece. Kareas is downhill from the burned area. The main restoration objective was soil erosion prevention and flooding protection (Google Earth image, 2001).

Figure 7. Detail of the log-barriers built constructed immediately after the Kareas fire (shown in Figure 6) immediately after their construction.

Figure 8. The area of figures 6 and 7 near Kareas, photographed in April 2005, showing the progress of regeneration. It burned again on July 9, 2005 and on July 17, 2015.

Another risk that also needs to be addressed immediately is the risk from burned trees that remain standing. Having been weakened by the fire they may fall without any warning at any time. Thus, dead trees standing close to roads, trails, and near homes need to be felled as soon as possible using extra care. Special methods exist for predicting if a partially damaged tree will survive or will not make it and needs to be removed (Karetsos et al. 2012). This emergency measure for specific trees is independent of the need to carefully assess the options for the fate of all standing burned timber, where a multitude of criteria must be employed (Xanthopoulos et al. 2007).

An example of all the above, is the 6,200 ha fire that on July 21st, 1995, burned the *Pinus halepensis* forest on Penteli mountain near Athens Greece (Xanthopoulos, 2002). The rehabilitation study that was prepared by the Forest Service, identified a serious flooding risk for the towns of Nea Makri and Rafina which lie downhill from the burned area. The study specified immediate soil stabilization works along the slopes, in the form of log-barriers to be constructed along the topographic contours, utilizing the dead standing timber (Figure 9). Furthermore, reinforced concrete and wooden check-dams were built in the ravines that lead the water in the two towns (Figure 10, 11). Completing these works before the onset of heavy winter rains helped avoid flooding and damages. Opposite to that, an intense wildfire that burned a large part of the Kassandra peninsula, Chalkidiki, Greece, on August 2006, was followed by a strong thunderstorm on August 2006. The result was heavy flooding that caused significant damages (Figure 12).

Figure 9. Log-barriers along the contours, constructed within 3 months of the fire of July 21, 1995, on the slope of Agios Petros, a site uphill from the town of Nea Makri on Penteli mountain, east of Athens.

Figure 10. A check-dam constructed with logs in a ravine on Penteli mountain, within 3 months after the 1995 fire.

Figure 11. A series of concrete check-dams built uphill of the town of Nea Makri a few months after the 1995 fire of Penteli mountain (Google Earth image 2004)

Figure 12. Ashes and mud washed to the sea at Kassandra, Chalkidiki, Greece, when a thunderstorm, on August 28, 2006, hit the area that burned a week earlier (August 21-28) (Kathimerini newspaper).

Some key post-fire rehabilitation principles (Moreira et al. 2012)

- The restoration of a burned area is not just a matter of how to carry out reforestations. The post-fire management approaches and techniques that can be used are quite variable and depend on (1) our capacity to predict how affected ecosystems will react to fi re and (2) the definition of management objectives for the burned area.
- The management objectives for a burned area are mostly local and can be quite variable from place to place, depending on the severity of impacts, the geographic and climate context, and the socio-economic and cultural context. But the main priorities should always be soil and water conservation.
- Ecosystems dominated by shrub and tree species that have the ability to resprout or produce seedlings after fire are usually highly resilient to fire. These traits should be used in post-fire restoration, mainly by assisting natural regeneration that will likely result in less costly interventions and higher rate of vegetation recovery.
- The unbalanced fire management being practiced in Europe, with too much resources being allocated to pre-suppression and suppression actions compared to poor fuel management measures, needs to be changed to a greater focus on fuel management. Adoption of correct post-fi

re management practices is the first step towards adequate fuel management to decrease the damage caused by subsequent fires.

7. Case Study related to Forest Fires

7.1 Greek Case Studies

THE DISASTROUS FIRE SEASON OF 2007 IN GREECE: BREAKING ALL PAST RECORDS

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Greece is a south European country with a Mediterranean climate and vegetation that is typically Mediterranean in all but the high elevation mountains. As one would expect, forest fires in Greece are a problem every summer as in all other countries with Mediterranean climate around the world. The problem has been worsening since the mid 1970s, in spite of strong efforts to strengthen firefighting especially in the last decade. However, in the summer of 2007, the country faced an unparalleled fire disaster that made the news worldwide and left people wondering about the causes and the circumstances that led to it. In this article, an effort will be made to explain what happened and provide some insight, at least to the reader who is familiar with the basic concepts of fire management.

The start of the fire season

Signs about the difficulty of the fire season were evident early on. Snowfall in winter was deficient, making it impossible for many ski areas to operate. Rainfall was also well below normal. In response to the signs, the government increased the firefighting capacity of the country by contracting more heavy lift helicopters (four Erickson Air-Crane, seven MIL MI-26, and five Kamov Ka-32) that were added to the national fleet of 13 Canadair CL-215 and nine CL-415 amphibian waterbombers, and 19 PZL M-18 Dromader single-engine aeroplanes.

In the last ten days of June an early heat wave contributed to an early start of the “main” fire season. Two large fires in middle Greece, the first in the area of Agia on mount Ossa, that claimed two civilian lives, and the second on the extremely beautiful and highly visited mount Pelion in Magnesia, as well as many other smaller fires, were overshadowed, on June 27 and 28, by a 5,600 ha fire that burned 2/3 of the precious Parnis National Park on the mountain that forms the NW part of the basin in which the city of Athens is built. Three worrying signs became evident then:

- Ground firefighting was very ineffective and poorly coordinated (attributed by many to disbanding an excessive number of top ranking Fire Corps officers in March 2007 during evaluation).
- Without effective coordination with ground operations aerial firefighting, when not in unlimited availability (due to multiple fires), was not enough to stop the difficult fires.
- High elevation forests, like the true-fir (Abies cephallonica) forest in the core of Mount Parnis National Park, that normally do not burn aggressively, were already vulnerable this early in the season.

The fires of July and early August

Many fires continued to erupt around the country in the first 16 days of July and were fought with the help of the aerial means, but with an ever increasing difficulty. One of them, near the village of Doxaro in Crete, resulted in the death of three seasonal firefighters who could not escape a quick fire run in a steep canyon.

The most spectacular fire in this time period was a fire on July 16th, near homes, at the base of mount Hymettus that forms the SE border of the basin of Athens. Fanned by a strong wind it moved unchecked for half an hour until the arrival of six Canadair waterbombers, two Erickson and one MI-26 helicopters, which, taking advantage of the short distance (8 km) to the sea controlled the spread of the fire in half an hour. The whole operation was documented live on TV.

A second heat wave hit the country between July 17 and 26, and with it came the second round of disaster. Numerous fires erupted and among them many escaped initial attack and grew to large sizes. A fire that started near and burned through the ancient Acropolis of the city of Corinth (the castle of Acrocorinthos, located on a steep hill) kept burning large tracts of forest and agricultural cultivations for three days, and a second one near the city of Nafpaktos on the north coast of the Corinthian golf, attracted a lot of attention on the 18th and 19th of July. Then a fire that started on the 24th of July at the base of the steep mountains in the area of Aigialia (near the city of Aigio on the north coast of Peloponnese) set the stage for the rest of the fire season. Initial attack from the air was delayed as there were other fires in progress. On the 25th of July, with the help of the slope and a strong wind, it accelerated and burned, practically unobstructed, through the forests, agricultural cultivations and villages on the slopes of the mountains, until it reached the top. Within the next three days it burned about 30,000 ha, destroyed more than 70 homes in nine villages and killed three citizens. It also set a new record for the largest fire in Greece in modern times.

In the last third of July, the fire in Aigialia, a 4,000 ha fire on the island of Kefallinia and a series of large fires in the high elevation forests of northern Greece that kept burning for more than a week, created the feeling that the firefighting mechanism of the country could not cope effectively. The crash of a Canadair CL-415 on July 23, that was operating on a fire near the town of Styra on Evia island killed the two pilots and contributed further to the feeling. Responding to all this, the government requested help from the European Union while in parallel it secured additional aerial means from Russia (a Beriev Be-200 amphibian waterbomber and two Mi-8 helicopters).

On August 5, the northern part of Greece received some much needed rain. Although in the region of Thrace in the north-west end of the country there were strong thunderstorms that caused serious flooding, the rain also extinguished the high elevation fires that had been burning for more than ten days. It also saved that part of the country from what was to follow in southern Greece.

On August 16, it was the turn of Penteli, the mountain forming the NE boundary of the basin of Athens, to experience disaster. The fire started around 10:30 am near a monastery on the slope of the mountain. Initial attack by the ground forces failed. The NE wind, blowing at moderate speed (4 BF, about 25 km/h) moved the fire front towards the Vrilisia and Nea Penteli settlements that can be considered as suburbs of Athens. The fuel was mostly regenerating pine forest after a 1982 fire. The combination of heavy fuel and dry conditions with a medium wind resulted by 11:00 am in the development of strong, nearly vertical, revolving convection column above the fire. The aerial means, which arrived at about 11:00, could not make water drops reporting erratic winds and smoke, so the fire moved unchecked toward the two suburbs. Also, the clockwise rotation of the column resulted in a sideways spread of the fire flank in a west direction towards Kifissia and Ekali two of the richest suburbs of Athens. At about 12:30 the wind became stronger reaching 5 BF (about 35 km/h). The smoke column leaned forward, making it a wind dominated fire (Rothermel 1991), and the aerial means were able to start making drops. By that time, however, the fire had reached all these settlements. By the end of the day the fire was partially controlled, after burning tens of houses and destroying an estimated 800 ha of precious forest. Again, all this was reported live on TV making people wonder publicly about the capacity of the fire suppression mechanism to protect them.

The fires at the end of August

Starting on August 24, 2007 and continuing until August 28, a series of fires that started in the south part of Greece burned as if there was nothing and no-one there to try to control them: Greece faced its worst forest fire disaster ever. This statement is not only about the size of burned area but also about loss of life and property. The damages were beyond any imagination.

Fire danger had been extreme. A heat wave (temperatures above 39 degrees Celsius for three days) was followed by a day of 7-8 Beaufort scale winds (50-70 km/hr) and extremely low relative humidity (8-20%). In addition to all these, the vegetation was severely water stressed.

There had been no rain in southern Greece for the whole summer, and for the first time on record, there had been three heat waves during the summer: the first in late June, the second in July and the third in August, just before the onset of the disaster. The level of water stress of the vegetation is reflected in the following predawn water potential measurements (Table 1) for August, made near Athens in the 2003-2007 period (Xanthopoulos and others 2006). In the summers of 2003, 2004 and 2005 there had been at least one rainfall event. In 2006, the last rainfall fell early in July. The water potential showed a pronounced drop by late August 2006 when two major fires occurred in Kassandra Peninsula (northern Greece) and in the area of Mani in south Peloponnese. In 2007, and although there had been some rain in late May, June and July had been dry.

Table 1. Predawn water potential measurements of three Mediterranean species in Attica, in August of the years 2003-2007.

	Water potential (bar)				
Species	**Aug. 5, 2003**	**Aug. 4, 2004**	**Aug 7, 2005**	**Aug. 23, 2006**	**Aug. 9, 2007**
Pinus halepensis	-7.3	-6.5	-9.0	-23.7	-21.0
Quercus coccifera	-19.0	-20.0	-14.5	-28.5	-34.5
Cistus creticus	-20.5	-43.6	-26.0	-61.0	-45.0

When fires starting in this explosive situation were faced with ineffective initial attack from the ground the stage was set for disaster. Two fires started on Thursday, August 23, on mount Parnon (east of Sparta) and on mount Taygetos (west of Sparta) in Peloponnese. They soon started raging out of control. A new fire in the morning of Friday erupted near the towns of Oitylo & Areopolis roughly 30 km south of the fire of Taygetos. This fire caused the first six deaths. It attracted immediately the attention of the Fire Service and the media until in the afternoon the news about massive fatalities in a new fire in Ilia (western Peloponnese) started coming.

As the news about the deaths started adding up, coordination started failing. New fires that started in other parts of Ilia, Arcadia, Messinia, Corinthia in Peloponese, and on Evia island north of Athens, did not receive proper initial attack. They escaped and started growing quickly. They were not attacked methodically. Fire trucks were sent to the villages in the way of the fires (1-3 trucks per village) to protect them. Evacuations were ordered or spontaneously started in panic. The perimeter of all fires (not only the front, which was anyway too difficult to confront) was practically abandoned. Fires kept growing until some of them united with each other. The large fleet of aerial means did not manage to offer effective help partly because of the extreme conditions (on some occasions Canadair planes were not able to operate safely due to the wind) but also due to lack of ground forces below them to complete extinguishing the fire..

For the four following days, due to the large number and size of fires and the countless pleas for help, many of them relayed through the 24-hours live TV broadcasts, aerial means and ground forces were used ineffectively as they were not finishing any job. The planes and helicopters were sent here and there for a few drops, then called-off to another fire.

Not realizing that "tactical firefighting", based only on Fire Service resources, was doomed to fail, by Saturday morning the whole mechanism kept pushing people to evacuate villages indiscriminately, instead of coordinating capable villagers to help the state mechanism: prepare their homes and agricultural fields (such as clearing grasses in their olive groves) in advance, fight flanking fires with their agricultural equipment, protect themselves in the village, etc. On the other hand, the government declared a general state of emergency, mobilized the army and asked for international help while at the same time it started mobilizing the army.

The fires in Ilia started merging with each other by Sunday. The situation was critical as the first aerial reinforcements from other countries started arriving. On Sunday afternoon one of the fires reached the ancient site of Olympia, which was surrounded by mature pine forest. The site itself, including the museum, was barely saved due to focused ground forces concentration, strong aerial support and an on-ground automatic sprinkler system installed there before the 2004 Olympic Games. All the forest around it, however, burned down.

Things started improving by Monday as relative humidity increased substantially, the wind calmed down and the temperature dropped. Locals, realizing that their fate would be to become homeless if they abandoned their villages often refused to evacuate, stayed and defended their homes (which are generally built with stones or bricks and reinforced concrete) and cultivations. Foresters with forest workers started building firebreaks and performing small scale firing-out operations. A ground crew from Cyprus that came to help, successfully used backfiring techniques on Evia island, to the surprise of the reporters who had never witnessed this technique being used by the Fire Corps. Heavy equipment from the army created firebreaks on relatively flat ground.

By that time, a huge aerial fleet was operating in the skies of Peloponnese and Evia. Twenty-three aeroplanes and eighteen helicopters from European Union and non-European Union countries were added to the Greek aerial means, probably forming the largest aerial firefighting fleet assembled and operating anywhere. At the same time significant international ground forces that had started arriving by Sunday resumed operations (Table 2). All this help was greatly appreciated by the Greek people. It also created a solidarity example which will hopefully be repeated if the need arises in any country in the future.

Table 2. A list of the countries that offered help with firefighting and the type of resources they contributed (Source: Official announcement of the Greek Fire Corps).

	Aerial resources		Ground resources	
Country	Airplanes	Helicopters	Personnel	Vehicles
France	4		72	
Spain	4			
Italy	1			
Croatia	1			
Turkey	1			
Portugal	1			
Russia	1			
Romania		1		
Serbia	7		55	7
Germany		5		
Switzerland		4		
Netherlands		3		
Austria	3	2		
Norway		1		
Sweden		1		
Slovenia		1		
Cyprus			139	14
Israel			60	
Hungary			19	5
Albania			4	1
Bulgaria			46	5
International Volunteers			7	
Total	**23**	**18**	**402**	**32**

By Tuesday, taking advantage of the calmer winds (2-4 BF), the firefighting forces brought most of the fires under partial control. The Greek TV channels, most of them having continuous 24 hour coverage of the fires for five continuous days, were showing a continuous battle against fire re-starts along the large fire perimeters. Much of their footage looked as a textbook example of the ineffectiveness of aerial firefighting when it is not followed by well coordinated ground firefighting.

Sixty six people died due to these fires. Most of the dead were caught in the open, either trying to flee or surrounded by the fire as they were trying to save their property. Added to the 10 people who died earlier they add-up to 76 dead, a huge death toll that exceeds by far anything that the country had experienced in the past.

More than 110 villages were destroyed leaving thousands of people homeless, surrounded by blackened land. The government tried strongly to handle the situation on the public relations side. It announced increased support for the people whose properties were destroyed. It also talked about an organized arson plan, without, however, presenting any evidence.

More than 2/3 of the prefecture of Ilia burned. Large areas also burned in the prefectures of Arcadia, Laconia, Messinia, Corinthia, and on the island of Evia. Much of the burned area is agricultural, mainly olive groves. Estimates about the total financial damage of these fires vary tremendously at this time as they are influenced by politics. An independent estimate by the international assessment firm "Standard & Poors" brings the damage in the range 3-5 billion €, corresponding to 1,4-2,4% of the Gross National Product of the country.

According to the European Forest Fire Information System, Greece has lost about 270,000 hectares of vegetation to fire this year. The vast majority, 184,000 hectares, went in just four days, between August 24 and 27, more than have been lost in any year since records. The fire in Ilia exceeded 40,000 ha by far, breaking the all time record set in Aigialia only a month earlier.

Some comments on the fire season of 2007

There is no question that the fire season of 2007 was a very difficult one in Greece. However, it cannot be considered unique, and it would be very simplistic to attribute the disaster to "extreme conditions due to climate change". For example, the 1992-1994 period was so rainfall-deficient that the water reserves of Athens dropped to such alarming levels that special measures had to be taken to reduce water consumption. Fires were difficult in those years and lives were lost (Xanthopoulos 2007a) but the burned area remained at about 60,000 ha for each of the three years.

If adverse conditions are not the only one to blame for this disaster one should look for other contributing reasons. In the opinion of this author such reasons are the specific errors described earlier, but also some long term weaknesses of the current fire management scheme:

Firefighting organization (Greek Fire Corps) operational weaknesses:

- Heavy reliance on aerial means support during initial attack, which has led to relative complacency of the ground crews. Unfortunately this approach failed in 2007 due to the quick acceleration of the fire and the lack of timely and adequate aerial support due to the large number of fires.
- Nearly total reliance of ground forces on water for extinguishing the fire. Use of hand tools is limited and there is no provision for use of fire for fire control (backfire, or even burning-out). As a result, effectiveness in areas with few roads (such as in high elevation forests) was very low.
- Lack of sophistication in coordinating large scale firefighting operations. Use of maps, fire behavior prediction tools, fuel maps etc., if any, is limited. Without good coordination by well trained and experienced officers, the often heroic efforts of the firefighters are wasted
- The huge budget spent for forest firefighting every year is used mainly for contracting helicopters. Very little funds are diverted for other important purposes such as modern training, purchasing personal protection equipment, obtaining additional tools for alternative fire operations (e.g. portable pumps, drip torches, etc.).

Flawed overall fire management organization:

- The Forest Service, after losing forest firefighting responsibility to the Fire Corps in 1998, has practically been excluded from fire management operations. Although, according to the law it is still responsible for fire prevention, its deteriorating status and lack of funding preclude any serious work on this.
- Forest management has nearly been abandoned for the same reasons. The result is increasing biomass in the forest.
- Forest road condition has been constantly deteriorating due to lack of funding for maintenance.

The problems have been obvious for sometime and have been explained in writing many times (Xanthopoulos 2000, 2004, 2007b). However, as firefighting is more straightforward and impressive, it has not been possible to this date to convince decision makers about the need for a balanced approach that will involve all players in system that will maximize their contribution towards an integrated and effective fire management scheme. It can only be hoped that the disaster of 2007 will bring second thoughts, realization of the flaws, and changes in the right direction. Otherwise, if emphasis is given only on increasing the firefighting capacity quantitatively, purchasing more aerial means and hiring more firefighters, it will not be long before Greece will experience another round of disaster.

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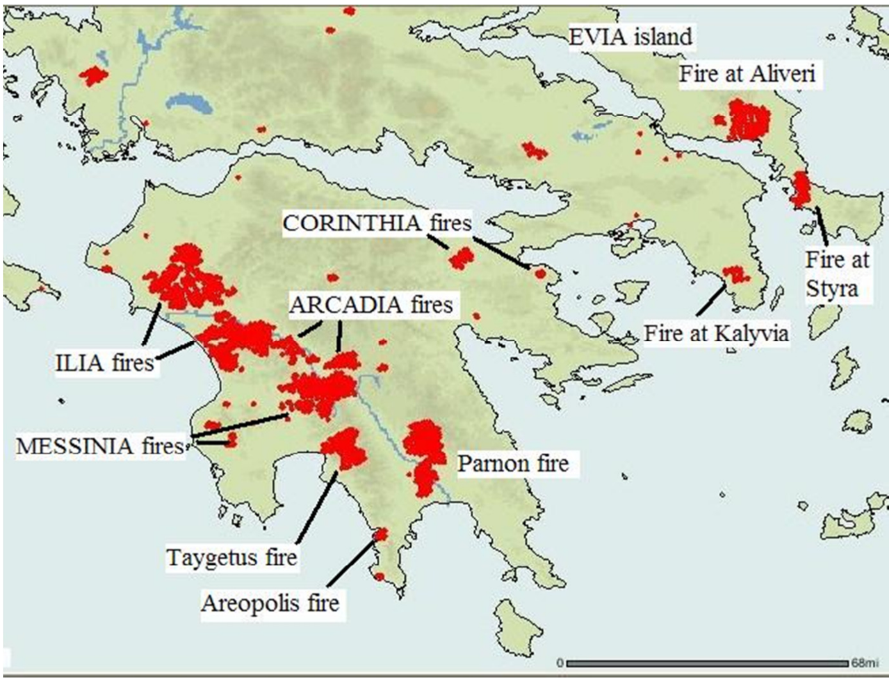

The burned areas in southern Greece between August 23 and September 5, 2007, obtained from the Web Fire Mapper of the Department of Geography of the University of Maryland (http://maps.geog.umd.edu/activefire_html/checkboxes/eur_checkbox.htm).

Explosive fire behavior in Ilia. The type of fuel, a mix of *Pinus halepensis* forest and olive groves is visible. (Photo: Miltiadis Athanasiou)

A crown fire burning *Pinus halepensis* forest in Ilia on Aug. 25, 2007. (Photo: Miltiadis Athanasiou)

A photo showing two fires mixing with each other in Ilia on August 25. The smoke of another fire behind the camera is visible at the top of the photo (Photo: Miltiadis Athanasiou).

Large convection column in Ilia on August 25, 2007 (Photo: Miltiadis Athanasiou).

Fire behavior in maquis in Arcadia on August 31 in Arcadia. A spot fire that has started growing is visible to the left of the main fire. (Photo: Miltiadis Athanasiou)

A well maintained olive grove in Arcadia that survived the fire (Photo on September 1, 2007 by Miltiadis Athanasiou)..

The fire of Penteli reaching the suburbs of Athens on August 16, 207 at 12:47 (Photo: Miltiadis Athanasiou)..

Explosive fire behavior as the fire of Penteli, on August 16, 2007, is reaching one of the suburbs making police, firefighters and the public run for safety (from footage offered to the Institute of Mediterranean Forest Ecosystems and Forest Products Technology by the Public TV Channel NET).

Explosive fire behavior as the fire of Penteli, on August 16, 2007, reaches one of the suburbs where it destroyed many houses (from footage offered to the Institute of Mediterranean Forest Ecosystems and Forest Products Technology by the Public TV Channel NET).

The draw through which the main fire entered into the core of the Parnis national park late in the evening of June 28, 2007. The true-fir (*Abies cephallonica*) forest burned completely. Average fire spread during this run was estimated at 4.5 km/h. (Photo: Dr. Gavriil Xanthopoulos)

TWO SIMULTANEOUS PARALLEL WILDLAND-URBAN INTERFACE FIRES NEAR ATHENS, GREECE, WITH VERY DIFFERENT RESULTS

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Introduction

Greece is one of the southern European countries that due to their environment face a serious forest fire problem. The climate is typically Mediterranean with mild and rainy winters and warm and dry summers. The fire problem is more pronounced in the south part of the country that is drier and hotter in the summer than the north part and faces a strong north-east wind called "meltemi". This wind blows in the Aegean sea and the coasts around it during the summer months.

The capital of Greece is the historic city of Athens, which lies in Attica, a peninsula surrounded on three sides by water: The Aegean sea to the East, the Saronic gulf to the south and the Corinthian gulf to the west (Figure 1). Athens has grown rapidly after the 1950s and currently has a population of more than four million people. As a result, starting in the 1980s, many people built houses along the coastline and in the forests at some distance from Athens, in an effort to escape city congestion and the heat of the summer. Some of these houses are used for vacations in the summer, whereas, starting in the 1990s, in many areas, people also started building expensive houses that they occupy throughout the year.

The vegetation of Attica is typical of the Mediterranean Sea region. From ancient times, olive groves and vineyards comprise a large part of the agricultural areas. Natural vegetation includes areas with a type of scrub vegetation called phrygana. At elevations up to 800 m most of the forest area is covered by Aleppo pine forests (*Pinus halepensis*) that commonly have an evergreen, quite thick and tall, shrub understory. Some areas that historically had semi-deciduous oak forests, due to fire and other disturbances, have been gradually converted to pine forests, evergreen shrublands or have been occupied by agriculture or buildings.

Wildland fires are a common phenomenon in Attica. The vast majority of them are human caused, either due to negligence or due to arson. In the last two decades, with the expansion of wildland-urban interface (WUI) areas these fires are becoming all the time more destructive. Two such fires that took place near the town of Rafina on the east coast of Attica (Figure 2) are the focus of this article. They were selected because they were unique in that they were practically simultaneous and run parallel and at a short distance from each other under nearly identical conditions, providing the opportunity for some interesting comparisons.

The town and port of Rafina is approximately 25 km east of the city of Athens. The sort distance of Rafina from Athens makes it a good choice as a site for vacation homes. As a result, the area near the coastline and the hills along the coast became sites of development of houses, in the form of loosely organized, often poorly planned settlements. The majority of these houses were intended to function as vacation homes. A significant number of them were built illegally. Furthermore, their majority was built with low building standards including inexpensive, often flammable materials, for their construction. Two of the settlements that belong to this category are Agia Triada and Agia Kiriaki.

In the late 1990s, development of the "Attiki odos" highway, which now surrounds Athens and improves access to many parts of it, encouraged many people to choose to build permanent houses around Athens at distances and at locations that allow easy commuting to the center of the city. Some of the settlements that developed, such as Neos Voutzas and Kallitechnoupoli (meaning "the city of artists") mainly consist of high quality 2-3 story houses built to offer comfortable leaving to the families that made this substantial investment.

The fires of July 28, 2005.

On July 28, 2005, at 10:40 am, a fire erupted in the heavily wooded residential area of Skoufeika, west of Rafina. It was a windy day. The fire danger prediction rating for the day in the area was at 4 in the 1-5 scale used in the country, a rating of five indicating red-flag alert. The NE "meltemi" wind was very strong, blowing at 30-45 km/h, with gusts reaching 50 to 60 km/h (Figure 3). Relative humidity remained around 30% for most of the day. The fire moved quickly through the wildland-urban interface (WUI) of Skoufeika, and then crossed, by short range spotting, the main road that leads to Rafina and its port. Following that, it run uphill to the top of a hill range that runs from Rafina to the north of Spata where the International airport of Athens is. The settlements of Agia Triada and Agia Kiriaki were on its path and were hit at around 12:30 and 13:30 respectively. Then the fire continued in the Aleppo pine forest along the hill top. It was controlled at about dusk, when it finished with the hills and came down to the plane and the agricultural fields that surround the hill range (Figure 4).

In the meantime, at 12:30 pm, a second fire erupted near the settlement of Neos Voutzas. The starting location was at a distance of 2.8 km to the NW of the Skoufeika settlement, where the first fire had erupted. Given the NE direction of the wind, this second fire was not a spot fire of the first, but a fresh start that can most probably be attributed to arson.

The new fire moved in the same southwest direction as the first one developing a parallel burn pattern. Within minutes it evolved into a crown fire and rushed through the Neos Voutzas settlement. Fire behavior was extreme at some points, especially as the fire burned in two fully forested draws in the settlement. Exiting the settlement it entered an area where the vegetation consisted mainly of evergreen shrubs that had regenerated by resprouting after the two consecutive fires of Penteli mountain in 1995 and 1998 (Xanthopoulos 2002) that had both reached the borders of the settlement. At that time it picked-up speed and moved to Kallitechnoupoli, the next WUI settlement in its path, lying at a distance of 1.8 km. Once there, it burned through the settlement and continued for one more km until it reached agricultural fields where it was controlled by dusk. This fire became wider than the first fire because it was not constricted by lack of forest fuels along the flanks as that one did.

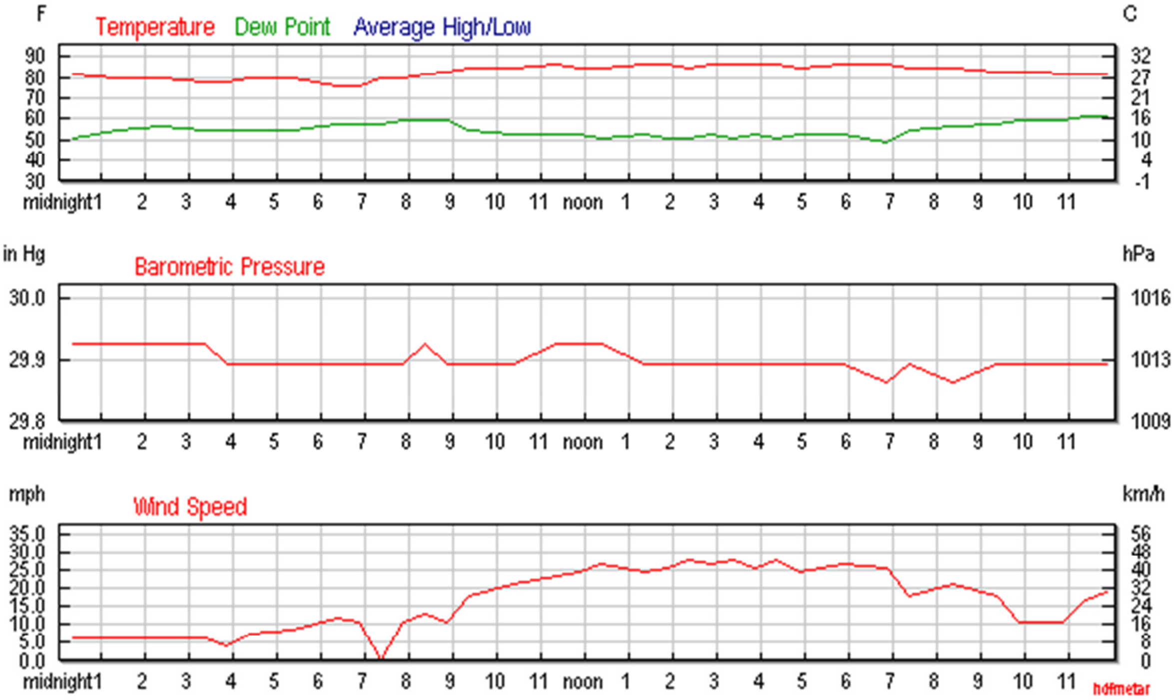

Figure 3. Meteorological history for July 28, 2005, from the closest to the fire weather station at the "Eleftherios Venizelos" Athens International Airport (from www.wunderground.com)

Figure 4 is an aerial photo of the area depicting the perimeter of the two fires. It was published by the Greek Army Georgaphic Service a few days after the event. The approximate fire starting points were added by the author after on site investigation. The figure also provides a good overview of the type of WUI areas found in Attica, especially along the eastern coast.

Firefighting

The firefighting effort was very strong because of the type of the fire (WUI area) and the proximity to Athens. According to the statement issued by the Greek Fire Corps at 14:00 of that day, 180 firefighters with 60 fire trucks plus and 100 firefighters organized in hand-crews were engaged in fighting the fire. They were aided on the ground by many trucks of the municipalities carrying water, and from the air by 8 Canadair CL-415 and 6 heavy-duty helicopters (mainly Erickson Air-Crane and MI-26). The final statement, issued on the next day, reported that the ground forces reached 240 firefighters with 80 firetrucks, 150 firefighters in hand-crews, 550 soldiers, 300 policemen and 31 police cars for regulation of traffic and evacuation operations. There were also 20 water tenders (trucks) contributed by the municipalities in the area. The aerial forces finally reached 12 Canadair CL-415 and CL-215, and 6 heavy duty helicopters. Unfortunately, all these forces were poorly coordinated as testified by the final size and shape of the fires: practically, all the forest vegetation in the path of the fire that could burn, was destroyed.

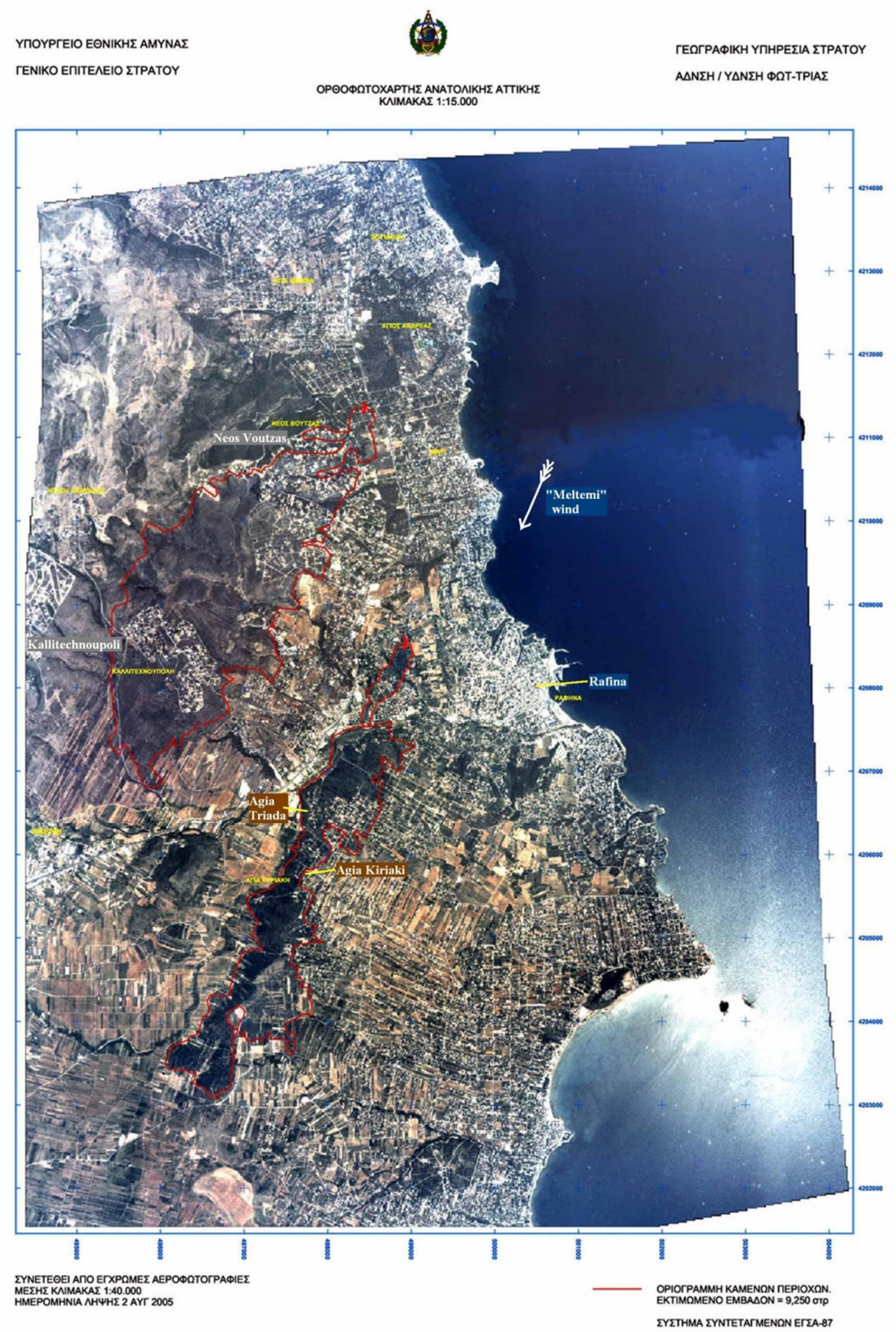

Figure 4. Aerial photo of the area of Rafina, from August 2, 2005, depicting the final perimeter of the two fires. Published by the Greek Geographic Army Service.

Figure 5. A firefighter aimlessly putting water on a totally destroyed house, working from the adjacent lot, in the settlement of Agia Kiriaki, about an hour after the passage of the fire front, while the fire was still spreading.

Figure 6. An oblique aerial view of the burned area in Agia Triada. Kallitechnoupoli is visible at the upper part of the picture (far). The lack of tree cover around it is because of the fires of Penteli mountain (1995 and 1998) that had preceded this one.

The firefighting forces lost the opportunity to control the fire at a number of locations where the fire front was quite narrow, in spite of the huge aerial support. The turn-around time of the aerial means was very short as the distance from the fire areas to the sea was less than 2-3 km. However, it should be recognized that the strong wind was hampering the work of the planes and helicopters, because of the large waves it caused in the sea near Rafina. One explanation for the poor overall result is that the majority of the fire trucks got involved in efforts to save individual houses. In doing so they did not support the efforts of the aerial means completing extinguishment of the fire after their drops, and they allowed the fire front to proceed without coordinated attack (Figure 5).

Damages

The final burned area of the two fires reached approximately 1000 ha. In addition to that, more than 160 homes and other structures suffered damages or were completely destroyed. Fortunately there was no loss of life. The most interesting information however, has to do with the distribution of damages. The burned area of the first fire was smaller than that of the second one due to the agricultural areas surrounding it. Furthermore, the second fire moved faster once it exited from the Neos Voutzas settlement and entered the previously burned area that was mainly covered by shrubs and small regenerating pines with a significant cured grass component in the fuel bed.

Contrary to the distribution of burned area, the number of houses destroyed exceeded 150 in the three settlements hit by the first fire (Skoufeika, Agia Triada, Agia Kiriaki), while only few houses suffered serious damage in the settlements of Neos Voutzas and Kallitechnoupoli. This sharp contrast can only be attributed to the clearly different quality of houses in the two fire areas. The settlements hit by the first fire included a significant percentage of houses of poor construction quality, built with non fire-resistant materials. Examples are external walls of houses or sacks for storage made wholly or partially of burnable materials such wood and particle board, or gypsum boards. These were often attached to metal frames. Roofs were often made with ceramic tiles, which are commonly used in Greece. However, the weathered wooden supports for many roofs and the use of tar paper as a cheap material for moisture insulation under the tiles were often the weak points that allowed ignition and destruction of the roofs and subsequently of the whole structure. Another weak point of many homes, observed repeatedly in many WUI fires in Greece including this one, is the use of plastic window shutters. These are deformed easily even without direct flame contact, and often melt falling on the ground. As a rule, in the hot days of summer, the glass window panes behind the shutters are left open by the homeowners to allow air circulation. When the shutters collapse due to the heat, burning embers enter freely in the house starting furniture, mattresses, curtains, etc. on fire, and finally causing destruction of the structure. Such phenomena occurred repeatedly during this fire.

Discussion

The two fires in the area of Rafina present a rare example of two simultaneous fires spreading close to each other, in similar fuel and weather conditions, but hitting two sharply different sets of WUI settlements. Being directly comparable they offer the opportunity for direct comparisons and allow drawing conclusions about the importance of developing well-planned settlements and well-built homes when these are mixed or in contact with wildland vegetation.

The difference in the number of damaged houses between the settlements of Skoufeika, Agia Triada and Agia Kiriaki on one hand and the settlements of Neos Voutzas and Kallitechnoupoli on the other is as sharp as the difference in the characteristics of the two sets of settlements. The former are inhabited by low to middle class people. Although there is a city plan with adequate street network (Figure 6) and most of the houses are built legally, the quality of houses is generally poor. Also, little landscaping, if any, has been performed around the structures. Many flammable materials, ranging from wood for fireplaces to plastic furniture, tents, etc. can be found in the lots around the homes. The majority of lots are small (less than 0.1 ha). There are, of course, some notable exceptions.

Since there are adequate roads, firefighter access at the time of the passage of the fire was not a problem. Most houses sustained some damage and many were totally destroyed. Some relatively better houses suffered serious damage in the upper floor only. The fire did not spread to the lower floor thanks to the non-flammable construction. The percent of seriously damaged houses at some points exceeded 30-40%, which is uncommon in Greece. Factors that affected the degree of damage, other than their construction, include the position of the house on the slope and in relation to the roads, the vegetation around it, and the fuels in the adjacent plots. Where a plot was undeveloped and had many pine trees in it, the probability of damage to the houses downwind from it was sharply higher.

Figure 7. An oblique aerial view of the burned area in Neos Voutzas. The ruggedness of the topography and the density of the forest are obvious.

In the settlements of Neos Voutzas and Kallitechnoupoli, the houses are of very high standards and are built with high quality materials. They have a steel-reinforced concrete frame, brick walls, double pane windows with aluminum window and door frames, aluminum shutters, and ceramic tile roofs. As a rule, these tiles are positioned for decorative and insulation purposes on a sloped solid roof made of reinforced concrete. There is a settlement plan but the topography is rugged and the roads are necessarily winding, often quite steep. At Neos Voutzas the houses are often built on the steep slopes of draws with tall Aleppo pine forest covering the non-built lots around them on the sides of the draws. In some cases the conditions are close to the textbook example of a box canyon (Figure 7). This would seemingly increase greatly the probability of these houses burning. However, it did not happen. Only 4-5 houses suffered serious damage at Neos Voutzas (Figure 8) and a few more houses were destroyed at Kallitechnoupoli where the slopes are less steep. Walls separating the lots from natural vegetation, landscaped gardens and non-flammable construction materials were the main reasons that helped keep the damages to low levels.

Figure 8. One of the houses that suffered minor damage at Neos Voutzas. It is on a steep slope in the middle of a draw and was surrounded by Aleppo pine forest that burned completely.

The poorly constructed houses in the settlements of Skoufeika, Agia Triada and Agia Kiriaki easily succumbed to fire. Pre-fabricated houses and houses built with plywood or chipboard walls on metal frames burned down completely (Figure 9). Roofs and windows were the weak points for the brick and mortar built houses that remained standing after the fire burned inside them (Figure 10). Plastic shutters often melted letting firebrands to enter. The volatile tar paper and wooden frame under the (non-volatile) clay tiles of the roofs were the weak points where the fire that led to the destruction of the roof and the house, started. The presence of tree crowns near or in contact with the roofs, was a further reason that, combined with the vulnerability of the houses, led to the heavy damages of that day in the three settlements. Few houses had appropriate clearing of vegetation.

Figure 9. One of the very low quality houses in the Agia Triada settlement that burned down completely. The green vegetation remaining around it shows that this point was not affected by a massive fire.

Figure 10. One of the houses that burned down in Skoufeika settlement. The source of heat were the two tree crowns that burned next to its roof.

In regard to firefighting, the fires of Rafina illustrated many of the problems present in fighting a difficult fire in a WUI area. In such cases, coordination is a very difficult task and can easily break-down organizations that are not fully disciplined and well organized. The outbreak of the second fire certainly created confusion and reduced the chances for successfully handling the crisis.

The firefighting paradigm that has developed in Greece does not help in facing fires in the WUI. Currently the system is based on massive intervention of aerial means (Table 1). Practically all fires of some difficulty are offered aerial support. The pilots are quite experienced and take the initiative to a large extent. Given the large numbers of aircraft and helicopters, avoiding mid-air collisions often becomes a serious concern. The ground forces do not attempt intervention during the water-bombing phase, due to safety reasons among others. Once the flames subside they deploy around the perimeter for final control and mop-up.

Table 1: Aerial means that participated in the firefighting campaign of 2005 in Greece

<table>
<tr><td colspan="3">STATE OWNED MEANS</td><td></td></tr>
<tr><td rowspan="4">AIRTANKERS AND AMPHIBIAN WATERBOMBERS</td><td rowspan="2">LARGE</td><td>CL-215</td><td>14</td></tr>
<tr><td>CL-415</td><td>10</td></tr>
<tr><td rowspan="2">SMALL</td><td>PEZETEL M-18 DROMADER</td><td>18</td></tr>
<tr><td>GRUMMAN</td><td>3</td></tr>
<tr><td colspan="2">HELICOPTERS</td><td>BKK 117</td><td>3</td></tr>
<tr><td colspan="2"></td><td>EUROCOPTER SUPER PUMA</td><td>1</td></tr>
<tr><td colspan="3">TOTAL</td><td>49</td></tr>
<tr><td colspan="3">CONTRACTED MEANS</td><td></td></tr>
<tr><td colspan="2" rowspan="4">HELICOPTERS</td><td>MIL MI-26</td><td>4</td></tr>
<tr><td>ERICKSON S-64 “AIRCRANE”</td><td>3</td></tr>
<tr><td>MIL MI-8-MTV</td><td>2</td></tr>
<tr><td>KAMOV KA-32</td><td>3</td></tr>
<tr><td colspan="3">TOTAL</td><td>12</td></tr>
</table>

This paradigm has led to less-than-perfect command and coordination of the ground forces. For example, little is done for fire behavior prediction, perimeter prediction, identification of fire evolution potential, etc. There are no fuel maps. Even topographic maps are rarely used. Furthermore, there are little pen-and-paper or computer logistics that would allow efficient identification and tracking of who is involved in fire operations and how they are engaged. Without such command, however, in cases of difficult WUI fires the situation easily gets out of control. Firefighters. without specific orders and objectives, easily get sidetracked into protecting individual homes without concern for the fire front. Opportunities for fire control, such as firebreaks, roads, agricultural fields are not identified, whereas if such information and ground mobilization was combined with the power of aerial means it could offer high probabilities for controlling difficult fires before they cause huge damages in WUI areas.

The two fires of Rafina clearly demonstrated all these problems. The firefighting forces, involved in saving individual homes were not able to react in an organized way to stop the fire fronts even where there were obvious opportunities, availability of roads and heavy aerial support.

Conclusions

The conclusions that can be drawn from analyzing these two fires are quite obvious and similar to those drawn by other authors studying earlier well-known fires in WUI areas: The quality of house construction in WUI areas and the landscaping in the immediate vicinity of structures are the main factors determining the probability of a house surviving a fire (Cohen 2000). Furthermore, the house survival probability is greatly influenced by the existence of weak points in its construction (e.g. tar paper on the roof, plastic shutters, etc.) (Xanthopoulos 2004).

The house survival rate at the Neos Voutzas settlement, with its high quality brick and mortar houses that survived the intense fire behavior in the two box canyons, also offers a very good example to those homeowners investing substantial funds for good looking but highly vulnerable homes in WUI areas in other countries. It is quite clear that in WUI area development the priority should be on building houses that can withstand a forest fire. Vegetation treatment around the houses, although very important can be a second priority. Furthermore, it can be carried out a little later or gradually whereas making significant changes to the structure of a house is much more difficult.

Acknowledgements

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7.2 Bulgarian Case Study

THE CASE BISTRISHKO BRANISHTE SANCTUARY

1. General information

Bistrishko Branishte was declared a nature reserve in 1934. The aim of its creation was the preservation of the flora, which is typical for the mountain - centuries-old spruce, bushes and grass covered areas. Since 1977 Bistrishko Branishte has been a biosphere reserve under the UNESCO Programme on Man and the Biosphere (MAB).

It is located in the oldest protected area on the Balkan Peninsula - Vitosha Nature Park, on the north-eastern slopes of the Vitosha Mountain, on the territory of the Sofia Municipality. Its surface area is 1061.6 ha, elevation between 1430 and 2277 m. Hundreds of plant and animal species can be seen in the reserve and thirty of them were included in the Red Book of Bulgaria.

2. Assessment of the risk of fire

Unfortunately Bistrishko Branishte is an example for a “dying” reserve. On May 22, 2001 heavy storm (tornado) felled 620 ha of spruce forest in the reserve. One of the main goals of the management of biosphere reserves is the preservation of the natural character of ecosystems and the processes in them. That is why the clearing and disposing of the fallen trees is not envisaged. Only scientific research can be carried out in the park. The devastation of the forest lead to another disaster – the appearance of pest: Ips Typographus that usually exists in the ecosystem without being a threat, has now reproduced uncontrollably in the wood fallen by the wind. In 2004 it was widespread throughout the reserve, and a predominant part of the forest is already dead – over 600 ha. In the end of that year the pest also affected a population of trees found outside the reserved. There are scattered spots of tens and hundreds of spruce trees are found throughout the surrounding mountain areas. The institutions refuse to interfere explaining that the decaying wood is useful for the growing of the young forest, but they underestimate the potential risk of pests.

A couple of years later the dry fallen trees made the access of humans almost impossible. On the other hand, in one single area there are hundreds of hectares of fallen dry wood in a place which is not especially rich in water. The reserve has turned into a potential huge bonfire.

3. The fire on July1, 2012

On July 1, 2012 around noon, the inhabitants of Sofia noticed thick fog rising from the Vitosha Mountain. The temperatures during this period reached 35 degrees every day. It became clear that the reserve of Bistrishko Branishte was burning. The fire spread over an area of about 10 ha, at an elevation of 1700-1800 meters above sea level. The fire was located on a very steep slope. At first predominantly dry and dead forest vegetation was burning but
the fire spread very fast into areas with live vegetation.

The access and movement through the area were extremely difficult because of the fallen one above the other dry trees. No machinery could even approach the center of the fire. The firemen moved slowly and carried with them only hand tools to fight the fire.

This fire is also emblematic for one more reason. For the first time, a volunteer unit for fighting disasters was mobilized together with the governmental rescue service. The volunteer unit at Sofia Municipality which is the first of its kind in the country was notified shortly after the outbreak of the fire and arrived ready for action in the mountain two hours after the fire began.
It was Sunday and a lot of hikers were waking in the mountain. The first task of the firemen and volunteers was to walk around the reserve divided into groups (although moving slowly and with difficulty) and look for hikers needing help and help them find their way out of the burning forest.

After the reserve was searched for lost hikers, actions for fighting the fire had to be taken. It became clear that the emergency situation was extremely grave. The mountain wind quickly spread the fire and often changed its direction. The nearby village of Bistrica with a population of about 5000 inhabitants was also in danger. A possibility for evacuation was envisaged. The dry vegetation allowed the fast spreading of the fire. It became clear that the fire could not be stopped without using heavy machinery.

On the next day, units of the army, police and foresters were mobilized. Together with the firemen and volunteers they started to make a clearing around the fire in order to stop its spreading. In the meanwhile two helicopters from the Air Force started extinguishing with water from the air but for security reasons they could fly over the area only during the day.

In the following 4 days of hard labor on the part of the security services and volunteers, excavators and other types of specialized machinery were used. Huge fallen trees were removed. At some points it was necessary to cut live trees. Through the created clearing fire brigade cars could pass and start the extinguishing of the fire. In the fight against the fire even a second matters – the captain of one of the helicopters reported that the situation was getting more and more complicated and at any moment the fire could get ahead of the making of the clearing. There was a danger for the firemen and the volunteers to get trapped without a possibility to escape.

Four hundred people took part in the extinguishment - including students at the Academy of the Ministry of Interior and over 100 units of heavy machinery. Millions of levas were spent.

The balance showed that about 60 ha or 6% of the reserved had burned. In addition to that, using heavy machinery and cutting live trees lead to the destruction of additional forest areas but without using them the extinguishment of the fire was almost impossible.

The investigation could not establish the cause of the fire. There remain some doubts of a deliberate arson but they cannot be proved, since the area of the disaster has been almost inaccessible for humans for years. The possibility of hikers' negligence also exists but nothing can be proved. The important thing here is that after the fire and the involvement of heavy machinery things in the reserve will never be the same and it will take the nature hundreds of years to restore the forest.

Video materials

https://www.youtube.com/watch?v=B39w6q5eUiw

http://vbox7.com/play:803ea9f8a1

http://vbox7.com/play:6f29bbb3a9&pos=vr

https://www.youtube.com/watch?v=gV0F3YxtnF0

https://www.youtube.com/watch?v=bj6RJheuhcQ

https://www.youtube.com/watch?v=HsRLy8IVzgE

7.3 Italian Case Study

This case study on the forest fire has a particular focus on the “fire interface”. It is a new issue , still underdeveloped at regional level.

The “Fire interface area” means an area where man-made structures and buildings are intertwined and overlap with areas wooded , with fuel vegetation.

This particular issue was analyzed with reference to the “Piano Regionale di Previsione, Prevenzione e lotta attiva contro gli incendi boschivi” prepared by “Regione Liguria” in 2003 , as provided by the relevant national legislation (Law Framework 353/2000) and the “Manuale per Corsi di II livello sulle Procedure Antincendio Boschivo”, created by the Province of Savona in collaboration with the “Corpo Forestale dello Stato”, the State Fire Service and Voluntary Organizations , at the instigation of the Prefecture - U.T.G. Savona .

It is a brief description of an “interface forest fire” that affected wooded areas behind the town of Savona, but above all also threatened several civil rooms .

It is the forest fire of August 6, 2003 that for 4 days has affected the hills of Savona in a particular area named “Conca Verde”.

Between 7 and 11 of August, it burns the Hill “Conca Verde” and the hill “Madonna degli Angeli”, between the Legino valley and Lavanestro valley (Savona Province, NW of Liguria) closed to the Beigua Geopark area.

Fig. 1 – Study area: Conca Verde (Savona Province, NW Liguria)

The fire was disastrous, it rised and fell unpredictably in the hills of the area at the end it will be wider than the city of Savona.

The personnel working on the fire-fighting operation was very large: Volunteers of "AIB - Anti Incendio Boschivo" were more or less 90: teams of volunteers belong to the province of Savona and also to the municipality of "Valdobbiadene" of Treviso Province (NE of Italy). In fact in 2003 there was an exchange program between team of AIB of Savona and Treviso province.

The volunteers were coordinated by the State Forestry of Savona in collaboration with the Fire Department. Moreover teams of firefighters of Savona worked with some teams of Bergamo , Cuneo, Turin , Pavia and Biella. Even the Red Cross of Savona fielding his men to combat the fire , giving aid to the machine protection civil.

Also Canadair(two planes of civil protection) and a helicopter of Regione Liguria were used in the fighting operations.

The presence of volunteers AIB Savona and Treviso that alternate in the four days were over 90 and worked 640 hours in four days.

This number of hours of consecutive work for a single fire had never been reached in the history of the AIB organization.

The fire has a strong impact on the population : the affected hills were visible from every district and a blanket of ash and smoke hit the city already plagued by the heat . The hilly districts were living hours of fear of the approaching flames.

The highway was closed on several occasions, pouring on city streets the intense summer traffic.

The flames approached the camp of nomads "Fontanassa" and a hundred people were forced to leave the area.

At the end of four days there are 400 hectares paths by fire.

According to the Forest Service first outbreaks were lit around at 23.30 on Wednesday evening (the 6 August) in different points. This factor has directed the investigations to track arsonists. So much so that the substitute Public Prosecutor opened a case against persons unknown.

The fire has devoured woods and Mediterranean shrub; around three night the wind turned bracing and fuelling the fire. The fires have assailed trees and shrubs. Often were the pine trees that "Explode" throwing pine cones burning up to 50 meters causing new outbreaks.

Fig. 2 – Pictures of forest fires

Numbers:

- 400 hectares of Mediterranean vegetation already destroyed
- Over 90 volunteers of AIB
- 20 homes evacuated
- 200 nomads evicted the field “Fontanassa”

- Least 350 people discussing the shutdown
- 80,000 dead mammals
- 4 million between reptiles and birds dead
- Over 2 billion dead insects
- 30 years of soils desertification risk

The occurrence of a fire in the woods dramatically invests all its many functions, providing any direct and indirect damages. The former are represented by the value of wood mass; the latter are connected to the functions of considerable importance, such as the hydrogeological defense, oxygen production, nature conservation, the call tourism, employment opportunities for many productive sectors.

If these are the main consequences in case there are forest fires, try to hypothesize what happens when the fire of the woods crosses the border into the so-called "Urbanized".

In this case we speak of FIRE INTERFACE, ie a "Fire vegetation that spreads or can spread to lines, surfaces or areas where buildings or other structures manmade meet or mingle with vegetated areas creating conditions particular danger "(definition from" Manual Courses Level II on procedures prevention of forest fires ").

This aspect is particularly important when, especially in coastal areas, composed mostly of pine woods and Mediterranean bush, in the event of fire, being closely with the towns, there are situations of high risk to people, housing and road infrastructure. Also housing facilities are not generally equipped with safety straps devoid of plant fuel, and this makes them particularly vulnerable in case of fires of high intensity.

In fact there is no real buffer zone imposed by the legislation must It must be respected by the owners of land and / or houses near the forest cover.

The fire described above provides further evidence of how important prevention and the proper preparation of manpower, equipment and materials , to be ready for emergencies .


SAVONA

IL SECOLO XIX

9 agosto 2003, Sabato • 19

IN LIGURIA

INFERNO SULLA CITTÀ, SECONDO GIORNO

Volontari in mezzo al fuoco un impegno straordinario

EMERGENZA CONTINUA L'incendio ha sconvolto la vita privata di centinaia di savonesi. Insonnia e paura per il fumo

Le fiamme dietro la porta

Coppia sfrattata dal rogo, ospitata dai vigili

STORIE

«Due notti in bianco e la cenere sui balconi»


SAVONA

IL SECOLO XIX

8 agosto 2003, Venerdì • 19

IN LIGURIA

UN GIORNO DI ANGOSCIA Boschi in cenere tra la Conca Verde e la collina della Madonna degli Angeli. La Procura ha aperto un'inchiesta

Un inferno di fuoco sopra la città

Paura a Mongrifone. Evacuati campo nomadi della Fontanassa e ostello
Traffico in tilt: Aurelia paralizzata dopo la chiusura dell'autostrada

le TESTIMONIANZE

«Siamo fuggiti con i bambini in braccio»

il SINDACO

«E' un crimine che grida vendetta»

Fig. 3 – Press review of forest fires of 6 August 2003

7.4 Spanish Case Study

FOREST FIRE IN NATURAL PARC OF "MONTGÓ", PROVINCE OF ALICANTE (REGION OF VALENCIA)

Introduction

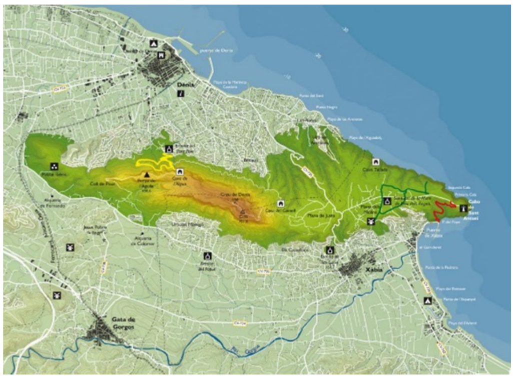
The Region of Valencia is one of the regions most affected by the increase of forest fires in decades. The fire, despite being a traditionally risk inherent in the Mediterranean forest, has become over the past two decades in one of the most serious threats to the conservation of some ecosystems characterized by its extraordinary vulnerability and the advanced state of degradation in which they are the vegetation that populate.

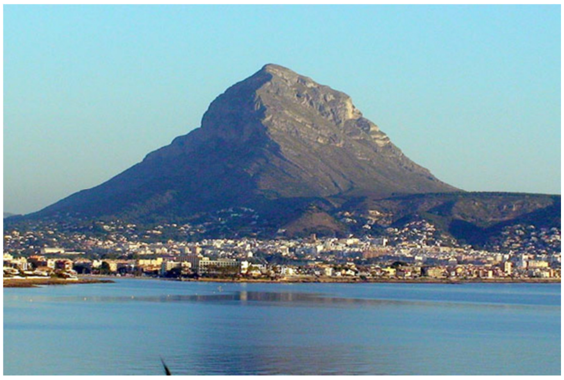
Despite the severity of fires and the popularity they have gained as a result of the diffusion of which have been main topic by the media, it is very low degree of awareness that exists in this regard in the Region. Studies on this subject are, however, very many, although not always been carried out with correct and appropriate systems. Indeed, it has been suggesting for some scholar applying "experimental methods" that reduce a stereotyped outline the complex dynamics of natural ecosystems and, through the use of simulators rains and obtaining artificial data on parcels of small size. They are trying in vain to quantify certain effects of forest fires.

It is true that the risk index has increased markedly since the sixties, as a result of a number of socio-economic changes, that have affected the demand for forest products and the perception and use of the mountain. However, there is a great disproportion between the increase of the potential and the actual increase in the area affected by forest fires surface.

The Montgó, located in the northeast side of the province of Alicante, covers an area of 2117.68 hectares and was declared a Natural Park by the Generalitat Valenciana on 16 March 1987. In November 2002, it is regulated an impact damping area of 5386.31 hectares around the massif, in order to avoid ecological isolation, spreading out among a total area of 7503.99 hectares.

This impressive mountain runs almost parallel to the coastline reaching its highest 753 meters above sea level. The Montgó is located very close to the coastline, which connects through a plain called "Les Planes" and ending at Cape San Antonio, reaching to the Mediterranean Sea by steep cliffs. In addition, the coastal area around the Cape of San Antonio was declared Marine fishing interest reserve the November 9, 1993, and the diversity of both environments and living beings sited in the seabed, extends the protection framework with the declaration of Natural Marine Reserve by Law 11/1994 of Natural Areas of Valencia.





The extension of the Natural Park of Montgó is 2117.68 hectares; extension is included within the boundaries of the towns of Denia and Javea.

Facts

On 5 November 2002, the Valencian Government Decree 180/2002 approved the Plan of Management of Natural Resources Montgó. This Decree regulates a buffer zone impacts of 5386.31-hectare surrounding massif, thus expanding the protected has a total area of 7503.99 hectare.

City	Km^2 of the city belonging to the park	Surface of the city in	% of city surface in the park	% of park in the city
Dénia	12,11	66,18	18,30	57
Javea/Xàbia	9,07	68,59	13,22	43

Figure 1. List of municipalities in the area of Montgo Natural Park.

The forest fire occurred September 11 on Thursday, 2014. The fire started in the Plana de Jávea. The rapid action of the Jávea Local Police in evacuating all the rural homes in the area possibly saved many lives. The fact that the fire had started in several places almost simultaneously indicates it was started deliberately. The origin was like an explosion. The road between Jávea and Denia remained closed at Planes.

The flames have affected low mountain land in the Montgó Nature Park.
The day after, seven emergency brigades remained in the zone with two Military Emergency Units. (UME). 82 soldiers and 29 vehicles collaborated in the operation. Air support restated at 7.30am and a total of twelve airborne planes and helicopters were in service. 15 aerial forest fire control, together with ground staff, participated in fighting flames. The Spanish Government sent 5 helicopters (2 amphibians with a discharge capacity of 5.500 liters, 2 of a discharge capacity of 3.100 liters and 1 bomber helicopter of 4.500 liters). It was also sent a communication and monitoring airplane-recording images with infrared of fire, a meteorology mobile and transmissions unit.

Around 20 pm the fire seemed under control, according to sources firehouse. Nevertheless, it was not true, because once the wind shifted and caused the flames relighted completely. The thick smoke made that health services were required to meet a hundred people with respiratory problems in the forward command post that was installed in a restaurant. Others, such as occurred with Les Rotes hotel workers, were taken to the health center to be treated for smoke inhalation.
Military Emergency Unit arrived after 22 hours to work on Sella. The aim was to prevent the fire had just crossed the road and all the woodland of Montgó.

After 444 hectare burnt and 1.800 residents evacuated, the City Hall of Javea demanded responsibilities for the abandonment that La Plana area suffered by professional operating units. Once the fire was officially declared "extinct", the mayor of Javea wanted to give voice to the feeling on the operation deployed to fight the fire. "Those who were in La Plana Thursday night, had a perception that is now supported by the reports of the local police and the Department of Environment, and that is that the area of Plana was abandoned, leaving fire containment practically in the hands of local media, composed mostly by volunteers.

Owners of affected houses were supported by the municipality of Javea, for instance, exemption of payment of 100% of water consumption in the next two months or specific advice for dealing with insurance.

The areas in which the natural park bound to fail, in reaction to situations that required their intervention (the fire itself or advertisements as oil exploration that would affect the marine reserve or projects to build hotel at the lighthouse) and its obligations in preventing fires and protocols in case of emergency (has been revealed that there is no evacuation plan and, as announced at the time, a record of the means available for refills as air assets are the pools).

The nature reserve was found that the fire was the result of "two years of high economic cuts", to which the Government reduced by 40% and the funds must now share resources with other natural park of the region (the Pego-Oliva). In this sense, the municipal official recalled that the Marina Alta Council stayed out of the regional plan of forestry employment (already tried to find out at the last governing board) and park management has been ignored claims of the municipality (as it was formulated in April 2012, when the city requested the incumbency of two fire in the park for quick action in case of fire and that in times of high fire risk have a permanent fire brigade).

Apart from this situation, the investigation into the cause of the fire has reached the conclusion that it was started deliberately. Investigators originally attributed the blaze to a BBQ, but having carried out preliminary investigations, specialists are now convinced that someone who wanted to set the hillside on fire started the blaze deliberately.
Fire crews emphasize that the area affected has received eight times less rain than would be normal over the winter months, meaning humidity is at a critical low and the risk of fire, heightened.

Response

A special forest monitoring service is to be launched this week as a consequence of the continuing drought conditions and increasing risk of forest fires. The head of the municipal Department of Public Safety, explained that the monitoring will began the Thursday 15th May, the ongoing conditions forcing the council to bring forward the essential vigilance campaign which is normally carried in July, August and September.
Earlier this month, it was reported that weather stations in Valencia and Alicante have never recorded a drier autumn, winter and spring since their records began in the 18th century with conditions in some areas

of the region being described as "Saharan". AEMET, the state meteorological agency, confirmed that the first four months of 2014 have seen the southern half of the Alicante province receive just 10% of the rainfall normally falling during that period whilst temperatures have been gradually increasing with April almost four degrees above normal making it the hottest April for 75 years. The Valencian countryside has been proliferation of devastating forest fires, including the largest for 15 years on the slopes of the Montgó, which destroyed some 40 hectares at the beginning of the month.
Volunteers from the Protección Civil, supported by members of the Bomberos Voluntarios de Balcón al Mar during the weekend, will begin monitoring woods and forests in the municipality from this week. There will be two pumps available for the monitoring campaign since, in the case of fire breaking out, the local volunteers are normally first to arrive on the scene and their quick reaction is key to stopping a potential disaster. Among the tasks being performed by these volunteers will be ensuring compliance with the ban on lighting fires in forests and natural spaces as well as the prohibition on bonfires which has been expanded and will be in force between May 15th and September 30th, in addition to monitoring the forested areas of the municipality.
The Department of Public Safety has appealed to the public to respect the rules and abide by the prohibitions posted on signs in parks and public areas as well as special warnings that are issued during the highest risk days. Residents are reminded that their collaboration is essential for detecting fire and they are asked to ring immediately the emergency number 112 or the Policía Local on 96 579 00 81 should they spot a column of smoke anywhere in the municipality.

Recovery:

- Firstly: dissemination tasks of regeneration performed in La Plana
- Secondly, to incorporate the future management of the park to the residents of that environment, which traditionally have felt marginalized from it.

During 2015, it has been taken place, in collaboration with the Department of Environment, numerous efforts to try to recover forestry area and curb pests drillers are primed with pines they saved from the flames. An emergency work that occupied the first months (removal of burned trees, treatments for survivors, encouraging wildlife, construction anti erosion barriers on the slopes, repair of municipal infrastructure such as roads or dams and restoration of masonry of the terraces at risk of collapse), have joined the actions to respond to boring insects that plague was detected in September and has still finished with more woodland.

http://lamarinaplaza.com/2015/11/24/cuatrocientos-dias-del-incendio-del-montgo/
http://www.javea.com/xabia-aborda-la-futura-gestion-forestal-del-montgo-400-dias-despues-del-incendio/#
http://www.accioecologista-agro.org/spip.php?article4349
Video: Los vecinos evacuados por el incendio en Jávea empiezan a volver a sus casas
Video: Un gran incendio forestal en Jávea obliga a desalojar a cerca de 1.500 vecinos de la zona

8. Glossary and Acronyms

Aerial attack	A fire suppression operation involving the use of aircraft to release water or retardant on or near a wildfire.
Aerial detection	The act or process of discovering, locating and reporting wildfire incidents from aircraft.
Aerial fuels	Any fuel found at a height of more than 3.5 metres above the ground surface
Aerial resources	Aircraft, including helicopters, aeroplanes and drones, which can be used to attack the fire or observe its development. Italsoincludessupportingpersonnel and equipment.
Amphibious vehicle	A vehicle capable of travelling over both land and water.
Beaufort Scale	A system for estimating wind speeds based on observation of visible wind effects. A series of descriptions of visible wind effects upon land objects or sea surfaces is matched with a corresponding series of wind speed ranges, each being allocated a Beaufort number
Burn severity	A qualitative assessment of the heat pulse directed toward the ground during a fire. Burn severity relates to soil heating, large fuel and duff consumption, consumption of the litter and organic layer beneath trees and isolated shrubs, and mortality of buried plant parts
Canopy	The upper layer of aerial fuels which will contain the crowns of the tallest vegetation present (living or dead)
Chain of command	The line of authority and responsibility along which operational orders are passed. Also commonly referred to as “line of command”.
Crown Fire/Crowning	When a fire burns freely in the upper foliage of trees and shrubs. There are three different types of crown fires: 1.Active Crown Fire – A fire that advances as a wall of flame engulfing all surface and aerial fuels. 2.Independent Crown Fire - A fire that advances through aerial fuels only. 3.Intermittent Crown Fire - A surface= fire involving torching behavior but without sustained crowning activity. Rate of spread iscontrolled by the surfacefire.
Dead fuels	Fuels with no living tissue. The moisture content of dead fuels is mostly controlled by external weather conditions, for instance, relative humidity, precipitation, temperature, and solar radiation
Disaster risk	The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period.
Drought	A prolonged period of abnormally low precipitation within a particular area.
Duff	A surface fuel consisting of partly or fully decomposed organic material lying on the mineral soil.
Emergency management	The organization and management of resources and responsibilities for addressing all aspects of emergencies, in particular preparedness, response and initial recovery steps.
Equipment	A collective term for all hand tools, mechanized tools, supplies and vehicles used for wildfire suppression, prevention and/or restoration activities.
Erosion control	A collection of measures implemented to limit the loss of soil under the action of water or another erosive agent (for instance, wind or human action)
Evacuation	The removal of people from dangerous or potentially dangerous areas and their subsequent relocation to safe areas.
Extended Attack Incident	A wildland fire that has not been contained or controlled by initial attack

	forces and for which more firefighting resources are arriving, en route, or being ordered by the initial attack incident commander. Extended attack implies that the complexity level of the incident will increase beyond the capabilities of initial attack incident command
Extreme fire behaviour	Fire behaviour that becomes erratic or difficult to predict due to its rate of spread and/or flame length. Thistype of firebehaviouroftenin fluencesitsenvironment.
Fine fuel moisture	The moisture content of fast-drying fuels. Measurement of moisture content will indicate the relative ease of ignition and flammability of a fine fuel.
Fine Fuels	Fast-drying dead fuels which are less than 6mm in diameter. Fine fuels ignite readily and are rapidly consumed by fire when dry. Examples of fine fuels include: grass, leaves, ferns, mosses, pine needles and small twigs. When dried, fine fuels are referred to as flash fuels.
Fire	Fire is the product of the chemical reaction of combustion. The three factors of fuel, oxygen and heat must all be present in the correct proportions for combustion to occur. When the combustion process is initiated, heat and light are emitted and a fire occurs.
Fire behavior	The reaction of a fire to the influences of fuel, weather, and topography
Fire break	An area on the landscape where there is a discontinuity in fuel which will reduce the likelihood of combustion or reduce the likely rate of fire spread.
Fire damage	The loss that is caused by a fire. This loss will normally include financial costs, but will also include other direct and indirect costs to the environment and society.
Fire danger	A general term used to express an assessment of both fixed and variable factors of the fire environment that determine the ease of ignition, rate of spread, difficulty of control, and impact. Firedangerisoftenexpressedas an index
Fire danger index	A quantitative indicator of fire danger, expressed either in a relative sense or as an absolute measure. Fire danger indexes are often used to guide fire management activities.
Fire ecology	The study of the relationships and interactions between fire, living organisms and the environment.
Fire effects	The physical, biological, and ecological impacts of fire on the environment
Fire environment	The surrounding conditions, influences, and modifying forces of topography, fuel, and weather that determine fire behaviour, fire effects and impact.
Fire extinction	The ceasing of the combustion process, either naturally or as a result of suppression activities.
Fire intensity	The rate at which a fire releases energy in the form of heat at a given location and at a specific point in time, expressed as kilowatts per meter (kW/m) or kilojoules per meter per second (kJ/m/s).
Fire management plan	A plan detailing predetermined fire suppression strategies and tactics to be implemented following the occurrence of a wildfire within a particular area.
Fire perimeter	The entire outer boundary of a fire.
Fire prediction system	A method or tool used to forecast future behaviour of a fire.
Fire prevention	A collective term for all proactive activities that are implemented with the aim of reducing the occurrence, severity and spread of wildfires
Fire risk	The probability of a wildfire occurring and its potential impact on a particular location at a particular time.
Fire season	The period or periods within a year when wildfires are likely or most likely to occur.

Fire shelter	A small single person aluminized cover that can provide an individual with some protection from the effects of fire in a fire entrapment situation.
Fire spread	The movement of a fire through available fuels arranged across the landscape.
Fire suppression plan	A pre-determined scheme or programme of activities which is formulated in order to safely and effectively accomplish fire suppression objectives. A fire suppression plan will outline the selection of tactics, selection of resources, resource assignments and how performance and safety will be monitored and maintained at a particular incident. Fire suppression plans need to be dynamic to take into account any changes in conditions or circumstances.
Flame length	The total length of a flame measured from its base at ground level to the flame tip.
Fuel	Any material that can support combustion within a wildfire environment. Fuelisusuallymeasured in tonnes per hectare
Fuel load	The amount of fuel present within a particular area. Fuel load is measured in weight per area measured (usually in kilograms per square meter).
Fuel management	The process of managing fuel or fuel arrangement. The aim of fuel management is usually to create a discontinuity in fuels to achieve fragmentation or to reduce the fuel load.
Fuel moisture content	Water content of a fuel expressed as a percentage of fuel weight when oven dried.
Fuel type	A group of fuels that will respond to fires in a similar way.
Gabion	A wire container filled with rock, broken concrete or other similar material which is used to construct dams or artificial embankments to reduce erosion
Hazard	A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
Ignition	The initiation of combustion.
Incident	An occurrence or event that requires action to prevent or minimise loss of life, damage to property or damage to the environment.
Incident Command System (ICS)	A standardized emergency management system which is specifically designed to allow its users to adopt an integrated organisational structure equal to the complexity and demands of single or multiple wildfire incidents. An ICS provides a standard framework within which individuals and teams present at an incident can work together safely and effectively.
Indirect attack	A method of suppression in which the control line is located some considerable distance away from the fire's active edge. Generally done in the case of a fast-spreading or high-intensity fire and to utilize natural or constructed firebreaks or fuelbreaks and favourable breaks in the topography. The intervening fuel is usually backburnt; but occasionally the main fire is allowed to burn to the line, depending on conditions.(
Initial attack	The first suppression work on a fire.
Ladder fuels	Fuels that provide vertical continuity between strata. Fire is able to carry surface fuels into the crowns of trees with relative ease.
Litter	The top layer of debris fuels consisting of twigs, sticks and branches, it can also include recently fallen leaves and needles. The structure of the material within the litter layer has not been altered significantly by the process of decomposition.
Live fuels	Fuels with living tissue. The moisture content of live fuels is controlled largely by internal physiological mechanisms
Mega fire	A wildfire demonstrating abnormally extreme fire behaviour. Mega fires will

	usually represent a significant challenge to suppression agencies because they are very resource intensive to suppress and can pose a significant risk to the safety of suppression personnel.
Mitigation	The lessening or limitation of the adverse impacts of hazards and related disasters.
Natural regeneration	Regeneration composed of seedlings grown from the soil seed bank or from stump sprouts.
Post-fire succession	All of the different stages involving the growth of different species of plants within an area that has been affected by the passage of a wildfire. A number of different post-fire succession stages (seres) can occur, dependent upon the environment. The first and last stages of post-fire succession are always referred to as the growth of “pioneer species” and the “fire climax”:
Preparedness	The knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions.
Preparedness plan	A pre-determined scheme or programme of activities which is formulated in order to satisfactorily prepare an organisation or a geographic area to respond effectively to wildfire incidents
Prevention	The outright avoidance of adverse impacts of hazards and related disasters.
Rate of spread	A measurement of the speed at which a fire moves across a landscape. Rate of spread is usually expressed in metres per hour.
Recovery	The restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors.
Reforestation	Re-establishment of forest through planting and/or deliberate seeding on land affected by a wildfire which was previously classified as forest
Relative humidity (RH)	The amount of water vapour present in the air expressed as a percentage of the amount of vapour needed for saturation to occur at the same temperature. Saturated air isreferred to as 100% relative humidity
Resilience	The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.
Response	The provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.
Risk	The probability of a hazardous event occurring and the potential outcome/consequences of that hazardous event. Risk is calculated using the following equation: Risk = probability of occurrence x potential impact
Risk assessment	A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend.
Risk management	The systematic approach and practice of managing uncertainty to minimize potential harm and loss. Risk management comprises risk assessment and analysis, and the implementation of strategies and specific actions to control, reduce and transfer risks. It is widely practiced by organizations to minimise risk in investment decisions and to address operational risks such as those of business disruption, production failure, environmental damage, social impacts

	and damage from fire and natural hazards. Risk management is a core issue for sectors such as water supply, energy and agriculture whose production is directly affected by extremes of weather and climate.
Rural-Urban Interface (RUI) environment	The zone of transition between rural land and human settlements
Shrub	A woody perennial plant characterized by its low stature and habit of branching from the base. Shrubsnormallycontain a high quantity of fine fuels.
Slash	Debris left lying on the ground after logging, pruning or thinning operations within woodland. Slash may consist of both course and fine fuels and sometimes forms a significant surface fuel.
Soil erosion	Transportation and partial or complete elimination of soil.
Spot Fire	A fire outside the main fire perimeter which is caused by flying embers transported by the wind or convection column.
Suppression	All work involved in controlling and extinguishing a wildfire.
Surfacefire	A fire that burns within the surface fuel layer
Understory	Vegetation found beneath the canopy. Understory vegetation is normally found growing or lying on the ground.
Wildfire	Any uncontrolled vegetation fire which requires a decision or action regarding suppression.
Wildland-Urban Interface (WUI)	The zone of transition between wildland and human settlements and/or development.

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