FOREST FIRES

GUIDELINE FOR COMMUNICATORS AND JOURNALISTS

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Efficient fire risk communication for resilient societies

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Efficient fire risk communication for resilient societies

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Introduction

Fires are among the main natural disturbances affecting the world's forests. In some regions like the Mediterranean basin, forest fires are defined as the major and most relevant disturbances because they can stay active for long time periods and damage forests irreversibly. Despite the big efforts of society in the contexts of fire prevention and extinction, large forest fires are recurrent events and often impact human settlements and infrastructures, threatening people's lives. What are the reasons of this paradox? Does this mean that forest fires are uncontrollable?

This publication explains the complexity of the forest fire phenomenon and it provides a precise and updated picture of the current challenges that fires risk management has to deal with. It also offers recommendations to facilitate the handling and transference of information about forest fire. The main goals of this publication are promoting an improved understanding of the forest fire phenomenon and fostering the use of risk management procedures aimed at minimizing the hazards associated to forest fires and the vulnerability of the territory to this disturbance.

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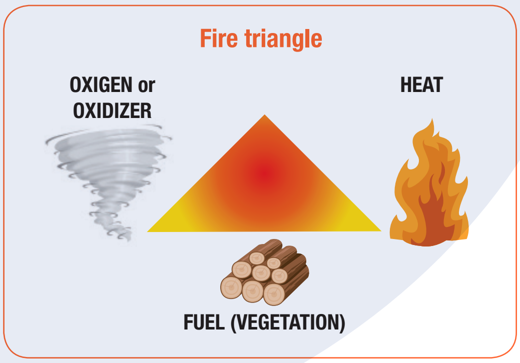
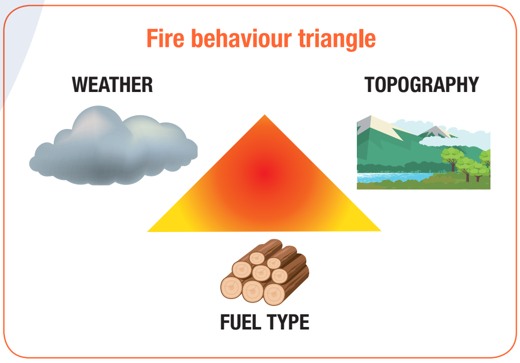
1.- What is a forest fire? Are all fires burning in the same way? Can we predict how they behave?

Forest fires result from the uncontrolled spread of fire in a forested area. They cause combustion of the vegetation (trees, scrubs, grasslands and croplands) and they can be originated by natural or human causes. While it is common to use indistinctly the terms "**fire"** and "**forest fire"** to refer to a forest fire, it is important to underline that "fire" is the cause of the event while "forest fire" is its expression, just like an avalanche is caused by snow and a flood by water.

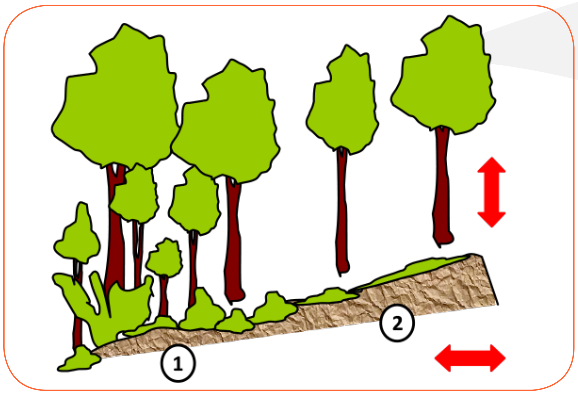
To get a forest fire starting, three elements must be contemporarily present: a heat source, fuel and oxygen (Figure 1). If one of the three elements is not present (anymore), the combustion reaction cannot start (or it ends immediately). Once the fire is ignited, its spread is influenced by three factors: the fuel type, the weather and the topography (see Figure 2). Depending on the combination of these factors, fire behavior will be more or less severe. For instance, steep slopes (topography), high temperatures and strong wind speed (weather) and high fuel load (vegetation) generate high intensity fire rates.





Figures 1 (left) and 2 (right). The first Figure shows the fire triangle that is composed by the three elements that cause the ignition of a forest fire. The second Figure shows the fire behavior triangle that is composed by the factors that influence fire behavior.

"**Fuel**" (or fuel load) refers to the amount and type of vegetation available for combustion. The way a fire ignites and spreads depends on the quantity of biomass present in the three main vegetation strata (herbaceous, scrubs and trees) as well as on its moisture. Fuel moisture is influenced by the humidity (water content), inflammability (easiness to ignite) and combustibility (easiness to burn) of biomass, which vary according to the species involved. The most virulent forest fires take place during the dry season, into a dense forest with high strata continuity (see Figure 3) which promotes crown fire (when a fire burns freely in the canopy of trees and shrubs; see Figure 4). In the same forest conditions, during the wet season fires mainly burn the understory and spread more slowly.



Pictures: Fire Brigade of the Government of Catalonia

Figure 3 (up), 4 (left) and 5 (right). The first Figure shows different forest structures with (1) and without (2) vertical continuity of fuel strata. Both cases are characterized by horizontal fuel continuity. Figure 4 represents a high intensity fire in a dense forest with full fuel strata continuity. The fire is affecting all the fuel strata with an extreme behavior that exceeds extinction capacity. Figure 5 is a low intensity fire produced during a controlled burn on the understory in an open forest not characterized by vertical fuel continuity.

The **weather** plays a crucial role in determining the fire risk degree. As temperature and wind speed rise and humidity decreases, fire spread capacity increases and it results in long flame lengths and high speed of fire spread. In technical jargon we refer to the "three thirties" to indicate the conditions favorable to the development of large forest fires or high intensity fires: temperatures above 30° C, wind speed faster than 30 km/h and relative humidity below 30%. The closer the weather conditions to these values, the higher the fire risk. When the worst weather conditions occur, a forest fire can develop and create its own **fire environment**, a set of circumstances that exist only within the area that is subject to the fire. The fire environment is characterized by particular temperatures and wind speed that exist independently from the surrounding environment.

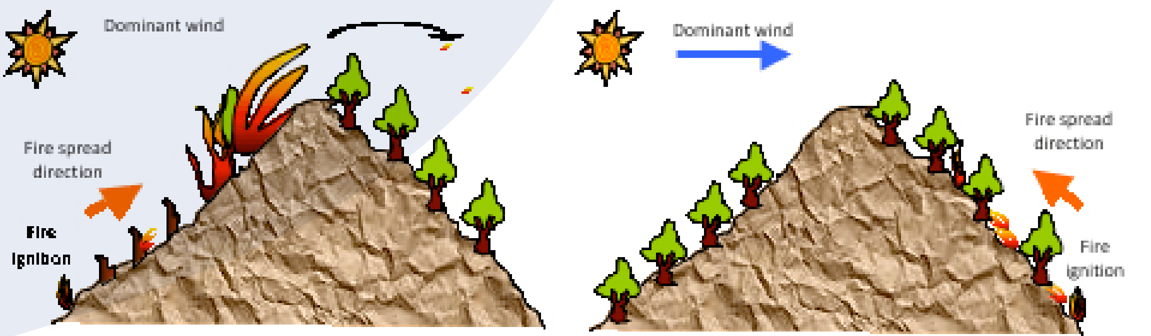
FIRE DOESN'T ONLY DEPEND ON YESTERDAY'S RAINFALL: THE IMPORTANCE OF SEASONAL RAIN REGIME

Besides weather conditions during the fire event, the seasonal rain regime strongly influences fire behavior. Long dry periods generate high water stress for the vegetation and affect the moisture of alive fuel to the extent that dead fine fuels (such as recently dead needles in conifers) develop in the trees' crowns. Wet periods stimulate an important fuel growth especially in the herbaceous strata. As long as this biomass stays alive, it contributes to limit the fire spread due to its high moisture. However, once this vegetation dies due to the effects of the dry season, this huge amount of dead fuel load can bring on the fire spread. As a consequence, the combination of a wet spring and a following dry summer increases the fire risk by making available big amounts of fuel susceptible to the fire propagation.

With respect to **topography**, the presence of hilly reliefs creates windbreaks, speeds up the wind in ravines and increases the impact of topographic thermal winds (uphill/valley during the day, downhill/valley during the night). In sunny slope forests, fuel is drier than in the shady sides of the hills. Steeper slopes facilitate the heat transmission to the upper fuel, accelerating the loss of fuel moisture. Consequently, fuel is more subject to combustion.

The combination of two topographic factors - **slope** and **aspect** – together with the **wind direction** represent the **fire's alignment forces** (Figure 6), which determine the fire intensity in a specific territory. The worst condition occurs when these three elements favor fire spread, namely when fire spreads up slope, in the sunny side of the hill and with the same direction as wind flows. In this case we talk of a situation of full alignment (3 factors aligned out of 3). Better conditions instead occur when one, two or even all three factors are unfavorable to fire spread. This situation generates a lower level of alignment (2 factors aligned out of 3, 1 factor aligned out of 3 and 0 factors aligned out of 3 respectively). For example, the most favorable condition occurs when fire spreads down slope, in the shadow side of the hill and in the opposite direction of the wind. Fires developing in conditions of full alignment present higher intensity than fires which ignite in a situation characterized by lower levels of alignment. The second types of fires are also safer and easier to control and extinct. Independently of the fire intensity, all fires have a common anatomy and life phases (Figure 7).

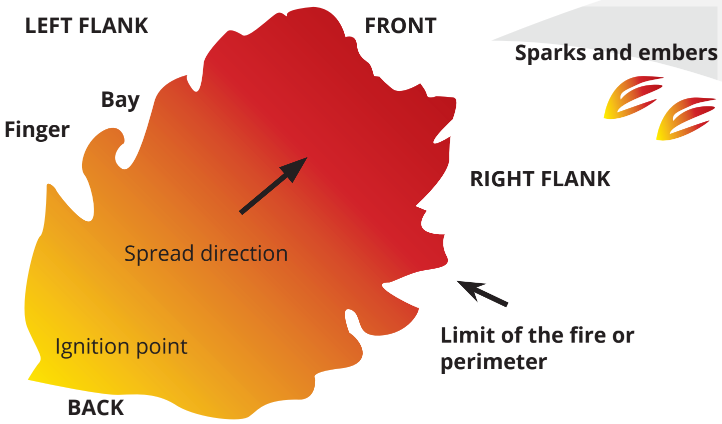
EXAMPLE OF FACTORS ALIGNMENT FORCES



Full alignment; 3 factors aligned out of 3: Fire spreads in the sunny slope (1 alignment force), in the direction of the wind (1 alignment force) and upslope (1 alignment force). A forest fire with these characteristics can generate a Crown fire and emit sparks when reaching the crest of the mountain.

Low alignment; 1 factor aligned out of 3: Fire spreads uphill (1 alignment force), into de shady slope (0 alignment force) and against the wind direction (0 alignment force). A forest fire with these characteristics is likely to burn with less intensity rates and is mostly unable to support crown fire and sparks emission.

Figure 6. Two examples of different forces' alignment situations in the same fuel, weather and topographic conditions.



In each fire we can distinguish the **head** or front of the fire (the more active part of the fire), the **back** (area opposite to the head characterized by less burning activity) and the **flanks** (aside to the central body of the fire, they vary in size and location depending on factors like wind direction.

In the development of a fire which is being extinguished, different phases can be identified:

1) The **active phase**, during which the fire keeps growing.
2) The **stabilization phase,** in which the fire spreads but it does not exceed extinction capacity.
3) The **control phase**, during which the fire is under control thanks to extinction efforts and it cannot spread further but within the burned area hot and smoking points are still present.
4) The **extinct phase,** in which extinction efforts managed to obtain the result that the fire cannot restart.

Figure 7. Parts and lifecycle phases of a forest fire.

FIRE INTENSITY AND FOREST FIRE TYPES

We can differentiate between 4 typologies of fire by looking at flame intensity. From lower to higher intensity and according to the main fuel strata which supports the fire spread and progression, we identify:

Under ground fire: *under specific conditions like those characterizing peat bog ecosystems, fire spreads through the underground organic matter and roots. Even though flames are not visible, the fire can stay active for long periods.*

Surface fire: *fire spreads through the surface fuel strata (herbaceous strata, duff and shrubs).*

Torching fire: *fire spreads from the surface strata and into the crown of a single tree or small parcel of trees.*

Crown fire: *fire spreads through tree crowns. Two ways of spreading are possible: 1) the heat of the surface fire ignites and burns the crowns (passive crown fire) and 2) the crown fire is independent from the surface fire (active crown fire). The last type of crown fire is characterized by the highest severity.*

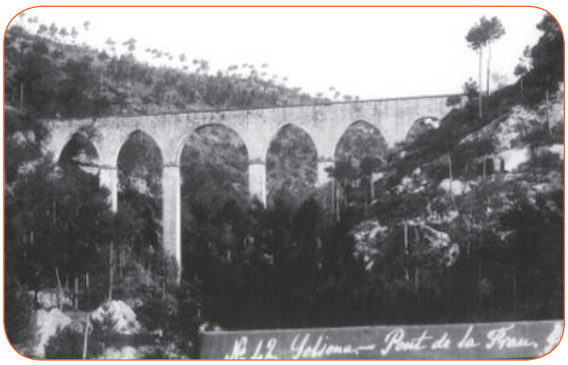
When they are characterized by high intensity, forest fires might generate **sparks** *that have effects hundreds of meters away from the fire's front. These sparks are transported by thermal airflows and wind to the ground and might ignite* **secondary fires**. *This particular mode of fire spread disables many fire prevention infrastructures like firebreaks. Fire brakes are areas in the landscape where there is a fuel discontinuity which reduces the likely rate of fire spread. This is the reason why it is very important to maintain a mosaic landscape characterized by open forest structures with low horizontal and vertical fuel continuity which are not prone to support high intensity crown fires.*

According to the intensity of a fire and in particular the length of the flames, the strategy to extinguish it can vary between **direct attack, indirect attack and parallel attack.** Direct attack consists in extinguishing the fire acting directly on the flame by means of hand tools (any piece of hand-held equipment operated manually or with power assistance used to dig, rake, scrape, chop, cut or remove fuel) and water supplies such as water tankers or water bombing aircraft.

This type of strategy can be used when flame length are lower than 2.5 meters. The indirect attack is used when flame length is between 2.5 and 3.5 m. Such strategy relies on suppression methods implemented away from the fire edge, such as the creation of a control line (a constructed or natural barrier used to control a fire). The parallel attack is used when flame length exceeds 3.5m. It involves the construction of a control line approximately parallel to the fire edge and locate at some distance from the fire, which is supported by a back fire (a fire set intentionally along the inner edge of a control line to consume the fuel which is in the path of a forest fire in order to create a fuel discontinuity and consequently minimize and the spread of the forest fire).

To summarize, the **factors that determine the development of large and intense forest fires** that exceed humans' extinction capacity are:
1) high availability of fuel load distributed along the territory;
2) specific weather conditions, which in the Mediterranean region occur especially during the dry season.

Fuel availability is aggravated by **land use changes** like the abandonment of rural activities, represented for example by the exploitation of forest resources to obtain fire wood and sawmill wood and by grazing activities. Traditional rural activities played an important role in keeping a mosaic structure in the landscape. It is important to acknowledge the role that forest management and agricultural activities play not only in the economic and social contexts but also in the context of fire risk prevention and mitigation. For instance, when forest management and grazing are not performed anymore, a natural reforestation of former farmlands or pastures is likely to take place, with an increase in forest cover and density and the loss of landscape mosaic (see Figures 8 and 9). Nowadays, social demand towards touristic and recreational uses of the landscape is increasing at the expenses of traditional rural uses. In this situation, prevention of fire risk may be an additional argument to boost rural activities that manage and preserve a type of landscape which is less prone to fires. Weather conditions are affected by **climate change** and its effects, which can increase fire risk in terms of degree and duration of the drought. This can result in drought that extends beyond the summer season and in areas historically not affected by forest fires (see Figure 10). Increasing availability of fuel load and worst weather conditions cause the occurrence of forest fires characterized by unusual conditions like high intensity and extreme behavior. They also bring an extension of fire risk periods and an increase of areas potentially affected by fires. These conditions make the extinction task very difficult and jeopardize firefighters' safety.



Picture: Solsonés County Council

Picture: M. Serra

Figures 8 and 9. Both Figures show an example of land use change taking place in the Solsonès area (Catalonia) between the mid XX Century and present. In a few decades the abandonment of forest uses and livestock grazing has developed into a forests grow, creating a continual and dense forest layer that contributes to the occurrence of mega-fires.

Picture: E. Plana

Figure 10. Figure shows the occurrence of a severe fire in a pinus forest *(Pinus uncinata)* in the Catalan Pyrenees (Cerdanya valley), an area not usually affected by high intensity forest fires.

THE ECOLOGICAL ROLE OF FIRE

While being considered an important disturbance for the forest environment, forest fires originated by natural causes play a relevant ecologic role in many forest ecosystems worldwide. In some regions of the world like USA and Australia scientists reconstructed the development of the natural fire regime (see Figure 10), namely the regime of a fire which does not undergo modifications caused by human activities. They discovered that some forest structures characterized by low tree density and by the absence of vertical strata continuity are well adapted to recurrent surface fires that take place every 5 to 30 years (see Figure 11). Also Mediterranean forests are adapted to forestfires (see Figure 12) and use a broad variety of strategies to survive to fire effects. These include for example thick bark that protects trees from the effects of heat (see Figure 13), the ability of the vegetation to regrow after fire and reproduction strategies like the production of seratonous pine cones which need heath to activate seeds' dispersion. The reconstruction of fire regimes showed also that some types of forest are well adapted to high intensity fires which take place every 100 years or more. These intense fires affect all forest strata and stimulate the forest regeneration process.

Picture: E.Plana

Figures 11, 12, 13 and 14 (from left to right). Figure 11 shows a pine forest managed with the method of prescribed burns in Florida (USA). Such management method allows reproducing the effect of a low intensity fire which pine forests are adapted to. The main goal of this type of management is to get mature trees structures that allow conserving an endemic bird species. Figure 12 shows a pine forest in Catalonia region (Spain). The forest is managed through understory grazing and traditional silvicultural treatments which reproduce the effects of low intensity fires. Figure 13 shows a tree reporting lightning strike marks in its bark, this lightning could originate a natural forest fire. Figure 14 shows the section of a pine trunk where it is possible to see the tree's growth rings (the dark circular lines which can be observed in the picture). Each ring represents a year of the tree. In the picture it is also possible to see the fire wounds (showed by the white arrows) between the growth rings. When a fire affects a tree without killing it, it produces a wound on the part of the trunk which was in contact with the flames. This region of the growth tissue stops temporally to grow until it is healed. During this period, the rest of the unaffected tissues continue growing and this generates a growth discontinuity. These discontinuities allow us to estimate the number of fires occurred in the past as well as their frequency and represent the basic data to reconstruct the natural fire regime of a specific ecosystem.

2.- Forest fires statistics and prediction of fire events and of their impacts

All forest fire events occurred in European member countries are recorded in national forest fires data bases managed by National Forest Services and Civil Protection Services. Data on these forest fires are transferred to the European Forest Database developed within the European Forest Fires Information System (EFFIS). Among other functions and tasks as supporting forest fire prevention and forest fire fighting in Europe through the provision of timely and reliable information on forest fires, EFFIS has the goal of creating an easily searchable collection of data that allows identifying trends of the evolution of forest fire events occurred in Europe. In response to the need of European institutions such as the Monitoring and Information Centre of Civil Protection, the European Commission and the European Parliament of collecting standardized information on forest fires, the European Forest Database was created by two bodies of the European Commission (Directorate General Environment and the Joint Research Centre) jointly with the national fire services of Member States. The database includes data on uncontrolled forest fires affecting forests, other wooded lands (shrub lands) and other non-wooded natural lands (grasslands). It excludes data on fires affecting agricultural and other artificial lands, as well as fires set intentionally with management purposes like prescribed burns.

For each fire included in the database, the main elements considered are the location of the ignition point, the duration of the fire, the ignition cause, the land use affected by fire (divided in three categories, forest, non-forest[1] and agricultural) and the size of the surface affected. Fires that affect less than 1ha are denominated "incipient fires", while "large fires" are those affecting more than 500 ha (in the Spanish fire statistic system) or up to 100 ha (in the French fire statistic system). The compilation of statistic data regarding fire has been improving along the history of fire statistics. For this reason, in some cases it is difficult to compare data on fires occurring in different periods and draw conclusions about trends regarding the effectiveness of extinction and prevention actions.

The continuous development of the fire extinction system has allowed improving constantly the fire control capacity. As a consequence, nowadays most of the fires recorded by statistics are small fires, and just few of them are classified as large fires. This means that extinction efforts are effective for the majority of fires that are restricted to small areas, while only in a limited amount of cases fires reach extreme values. These are the cases in which fires are impossible to control because they exceed human extinction capacity. These fires can burn broad land surfaces until their behavior becomes less severe and fire fighters are able to fight them safely. Large fires are not only negative events for the landscape, but they have also a positive effect as they generate large fuel gaps that result in a mosaic landscape which eases up future extinction efforts in the burned area. A very difficult situation to manage from an extinction point of view is the simultaneous occurrence of fires in different places. In such case, extinction resources have to be shared between different locations and this results in a reduced extinction effectiveness.

In the European Mediterranean region, which includes France, Spain, Italy, Portugal and Greece, the average number of forest fires is very variable (see Figure 15). For example, during the period 1980-1989 statistics recorded an average of 34644 forest fires per year, while during the period 1990-1999 an average

[1] Non-forest land uses include for example urban and industrial uses

of 58851 forest fires per year were recorded. In the period 2000-2009, the average is around 56677 forest fires per year. In the last decades the number of fires in the Mediterranean region had an increasing trend, while the fire size (burned area) a decreasing one.

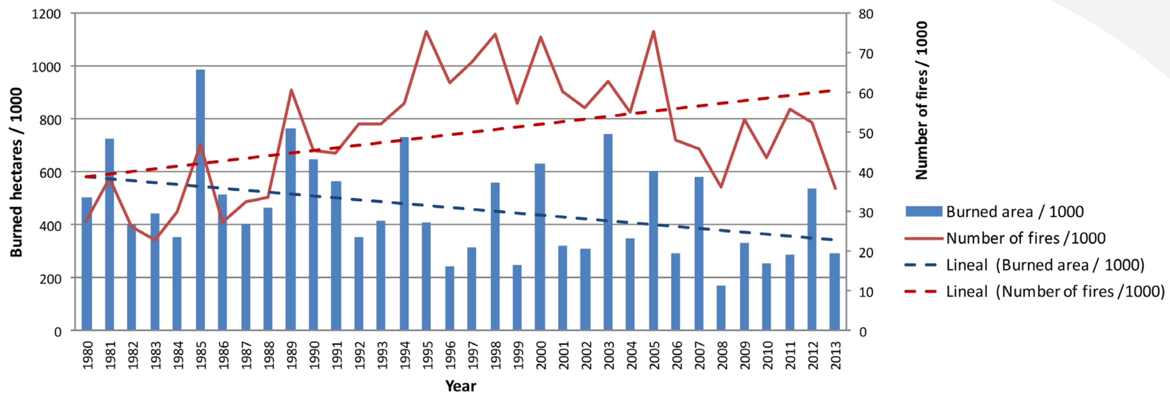


Figure 15. Number of fires and number of burned hectares (divided by 1000) with a representation of their lineal trends in the European Mediterranean region during the period 1980-2013. Source: European Forest Database

Table 1 shows that during the period 1990-2000, almost 10% of the Mediterranean forested area was burned. In more recent years, this percentage assumed a downward trend, mainly due to the improved effectiveness of fire suppression policies emanated in the last decades. It is also important to notice that during the last 25 years the forested surface in the European Mediterranean region increased of about 9%.

Period	Burned Forested Areas (ha)	Burned Forested Areas (ha/year)	Forested Areas (ha)	Rate of Burned Forested Areas / Forested Areas (%)
1990-2000	4.489.376	448.938	47.578.690	9,4
2000-2010	4.327.882	432.788	50.841.260	8,5
2010-2013	1.366.981	341.745	51.788.970	2,6

Table 1. Evolution of the forested areas burned in the European Mediterranean region during the last two decades. Source: Forest Europe/UNECE/FAO and European Fire Database (EFFIS)

Forest fires affecting less than 500 ha represented the 98% of forest fires occurring in European the Mediterranean region during the period 1985-2010. These fires were responsible for burning 20% of the land surface that was affected by fires in that period. 2% of forest fires were considered large forest fires (>500 ha) and were responsible for 80% of the burned surface in the same period (Figure 16).

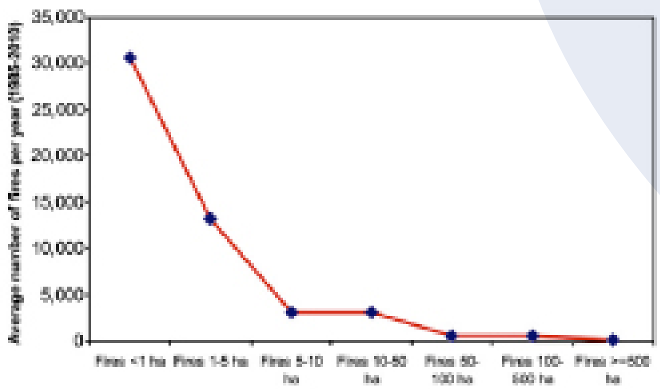


Figure 16. Forest fires occurred in the European Mediterranean region during the period 1985-2010 distributed by size. Source: San-Miguel-Ayanz J, et al. 2013. Analysis of large fires in European Mediterranean landscapes: Lessons learned and perspectives. Forest Ecology and Management. 294:11–2

Figures 17 and 18 show that in the Mediterranean part of Europe the average burned area is higher than in Northern Europe, even if in both regions the number of fire events occurred is similar. This fact indicates that the Mediterranean region is more prone to the occurrence of large forest fire. This is due to the fact that Mediterranean weather (very dry and hot summers) and forest fuel (high amount of fuel loads available) make more difficult forest fire suppression. The area of the Mediterranean basin characterized by the higher fire density is the North-East of the Iberian Peninsula, mainly due to winter fires that occur from February to April. Traditionally, during winter, land managers use fire to regenerate pastures, sometimes giving life erroneously to forest fires. At the same time, the vegetation experiences severe changes of moisture content, which can favor fire spread.

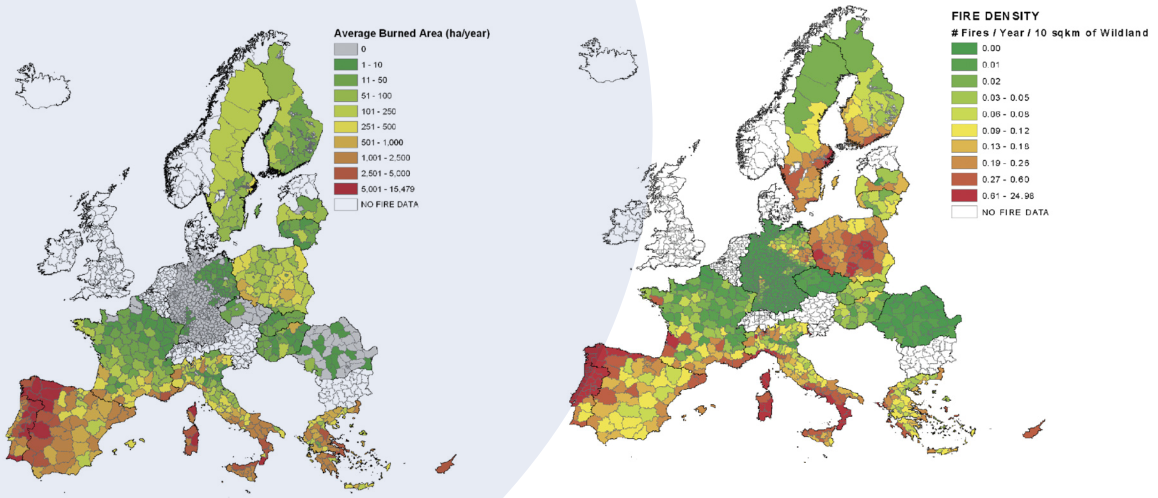


Figure 17 (left) and 18 (right). The first Figure shows the geographical distribution of burned areas (average per year) at EU level and by provinces during the period 1980-2006. The second Figure shows the relative rate of forest fires (fire density) per year for the same period. Source: Ybes Birot (ed) 2009. Discussion paper 15. European Forest Institute. 82p

Is it possible to predict how future forest fires will be by means of analyzing the historical ones?

Analyzing fires occurred in the past in a determined region can be useful for predicting future fires and their development, even though the prediction task is extremely demanding. Differently from floods, fires do not affect a defined area such as a basin or a watershed. Moreover, they do not occur in recurring periods like those determined by storms' regimes. Fires spread freely over the land where fuel is available. Moreover, their ignition, spread and extinction are influenced by anthropogenic factors. This makes difficult the estimation of a fire's likelihood in a specific place. The prediction is based on a combined study of local topography and weather conditions. A given fire in a determined place evolves following spread patterns similar to historical fire events that occurred in a location with same topography and weather conditions (Figure 19). Fire's intensity varies depending on fuel moisture. The only sure statement that can be made about a fire is that a high fire risk (usually due to human causes) and a wide fire spread capacity (a function of the fuel load, distribution and moisture) increase the chance that large fires occur. Identifying the "**fire type**" to which a specific fire event belongs to allows to predict the development of the specific fire, with the goal of designing efficient prevention and extinction strategies tailored on the fire' characteristics.

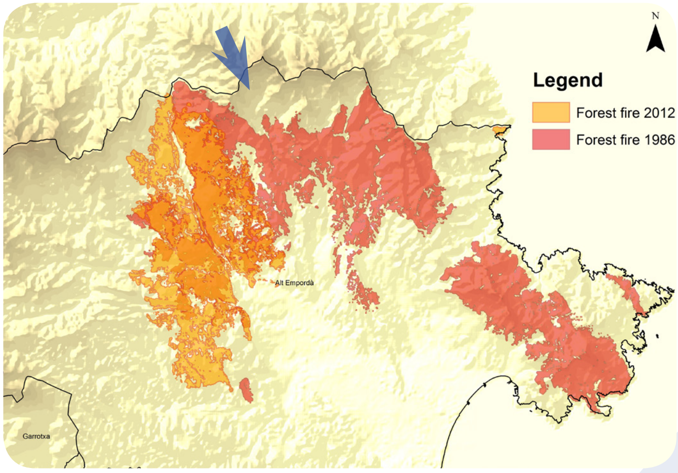
Three “fire types” can be defined according to the fire spread drivers, namely the factor with more influence on the development and spread of the fire:

Topographic fires: the spread drivers are the reliefs and the local winds (mountain or valley breeze).

Wind driven fires: wind direction dominates the spread direction.

Convection fires: heavy fuel load is responsible of the fire spread.

When we know the specific location and the “fire type”, we can identify the “**Strategic Management Points**” (see Figure 20), areas where fuel treatments are needed in order to ensure safety and efficiency of extinction efforts. In these areas fuel treatments are envisaged as an opportunity to promote a lower fire behavior (get fire into the suppression capacity) and ensure safer fighting operations.



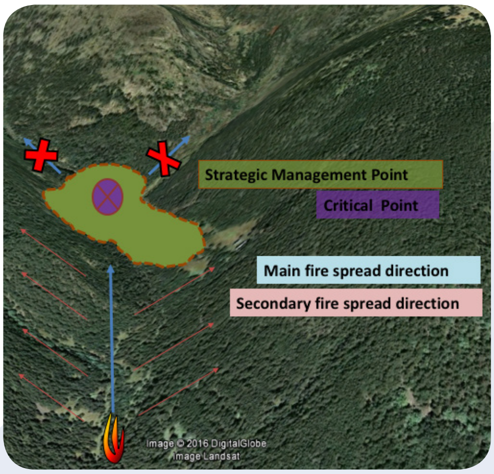


Figure 19 (left) and 20 (right). The first Figure is a representation of two historical wind driven fires that occurred in the North-eastern part of Catalonia, Spain. Both fires had the same spread patterns and behavior and generated long and narrow burned areas because of the strong wind flowing from the North (blue arrow) acting as the main spread driver. The second Figure shows the location of a Strategic Management Point in bifurcation located among three valleys. This area is managed with the goal of reducing the impact of fire in terms of burned area by avoiding that fire spreads from the main valley indicated by the fire symbol towards the two valleys indicated by red crosses. The bifurcation is a critical point, because if fire reaches it, it could spread to the other two valleys, but if the point is properly managed it can be ensured that fire does not exceed the suppression capacity.

Indistinctly of the fire type, forest fires have important environmental, economic and social impacts. Environmental impacts are mainly related to temporal loss of forest cover. Bare soil is more vulnerable to erosion and this condition persists until new vegetation appears. Ecosystems’ responses to the fire disturbance can vary depending on the severity of the fire. In areas subjected to high intensity fires all the vegetation is affected and tree strata regeneration will take more time, starting either from roots or trunk sprouts or from seeds (Figures 21 and 24). Drought episodes, over grazing or a further fire event can influence and affect the natural regeneration and restoration capacity of the ecosystem. Low intensity fires (usually surface fires) can have beneficial effects on the forest, for example by acting as tree competence regulator, accelerating the incorporation of nutrients in the soil and generating vertical fuel discontinuity that decreases the forest’s vulnerability to eventual future large fires (Figure 22). Flames can also affect forest wildlife and promote the settlement of new species adapted to open spaces. This process can result in an increased local biodiversity.

Regarding CO_2 emissions, it can be considered that forest fires do not have a significant influence on these emissions because ideally the CO_2 stocked in the wood and released with the fire will be captured again with the growth of new vegetation. From an economic point of view, burned wood is usually bought by wood industries even if its economic value has decreased. From a social and emotional perspective, forest fires have an important impact on society because of the desolation of the landscapes after the event (Figure 23). However it needs to be considered that a forest is a dynamic ecosystem whose aspect is changing in time.

Picture: E. Plana

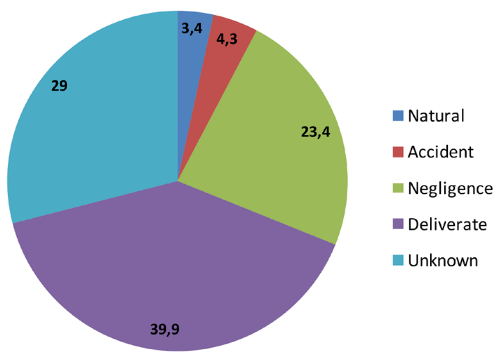
Figures 21, 22, 23 and 24 (from left to right). Figure 21 shows a young pine (*Pinus halepensis*) germinating after a fire. Figure 22 shows a mature Aleppo pine forest affected by a low intensity fire, which generated a forest structure highly resistant to future fires. Figure 23 shows a dark landscapes immediately after a high intensity forest fire which inspires bleakness to the social perception. Figure 24 shows a cork oak (*Quercus suber*) that is regenerating after a fire.

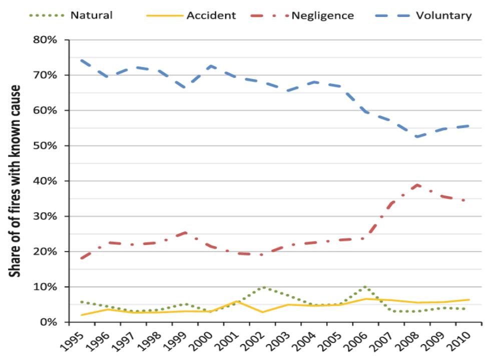
3.- What are the causes of forest fires?

Two types of causal events are important when analyzing the development of a forest fire: the causes of fire ignition and the causes of fire spread.

The **causes of fire ignition** are usually recorded in the national official statistic registers and transferred to the European Forest Fire Information System (EFFIS) which classifies causes in 4 main groups: 1) unknown, 2) natural (e.g. lightening, volcano eruption), 3) accidental or negligence (fire ignition connected to a human activity but not linked to any intention of causing the fire, for example accidents caused by railways, forest works and power lines, or ignition connected to reckless behavior such as fire camps that went out of control) and 4) deliberate or voluntary (Figure 25). The objective of EFFIS is not to duplicate or substitute national databases, but to provide information with a European scope. The analysis of the evolution of fire ignition by means of the analysis of ignition causes helps to attribute responsibilities and promote specific preventive policies. This contributes to achieving the reduction of social behaviors like throwing lit cigarette butts into the forest (Figure 26).

The **causes of fire spread** are related to factors like topography, weather and fuel which are treated in Section 1 (Figure 27), but they also include the response capacity of the fire extinction system. For example, the improvement of extinction strategies, technological developments and a good coordination of the actors involved in the management of the fire emergency enable an efficient performance of the extinction efforts and influence the fire spread behavior. Also preventive measures like fuel treatments, improvements to the accessibility of forest roads and to the self protection capacity of WUI areas can have the same effects (Figure 28). During the extinction of a fire, priorities are focused on ensuring the safety of citizens and fire fighters, protecting human infrastructures and finally safeguarding the natural environment. As a consequence, in a region with high WUI concentration, the more prepared the WUI residents, the better managed their properties and the more efficient the control of the forest fire spread.





Figures 25 (left) and 26 (right). Figure 25 shows the percentage of fires determined by the different ignition causes during the period 2006-2010 in the European Mediterranean region. Figure 26 shows the temporal evolution of fire ignition causes during the period 1995-2010 in the European Mediterranean countries. Source: Ganteaume et al., 2012. A review of the main driving factors of forest fie ignition over Europe. Environmental Management

WHY IS IT SO IMPORTANT TO ACT INTO THE RESIDENTIAL AREAS SUBJECT TO FIRE RISK?

As fire risk increases due to forest expansion and climate change effects, human settlements built nearby forested areas (in the so called Wildland Urban Interface "WUI") are seriously exposed and vulnerable to dangers related to fire. In the case of a forest fire, the flames or the sparks can reach homes and gardens and easily burn them. Furthermore, the smoke and the lack of visibility during a fire event make more complex the evacuation and the isolation of the population at risk. The protection of the population and of human settlements requires to allocate a lot of fire extinction resources in WUI and urban areas. This often leads to neglecting the extinction resource needs of forest lands. This is why it is very important that human settlements adopt self protection measures against fire and that the population knows exactly how to proceed and react in case of a forest fire event.

Pictures: Fire Brigade of the Government of Catalonia

Figures 27 (left) and 28 (right). Figure 27 shows a large forest fire in central Catalonia region during the summer of 1998. Independently of the fire ignition origin, the structural cause of large forest fires is the wide forest areas able to generate and support high intensity fires characterized by an unlimited spread capacity and that are out of suppression capacity. Figure 28 shows a residential area exposed to fire risk. Similar areas are a priority in the protection operations and the need of protecting these areas jeopardizes the ability of focusing efficient fire extinction strategies on forested areas. This highlights that it is very important to reduce homes' vulnerability to fire and to incorporate fire risk into the framework of land use planning.

4.- Risk management, forest fire prevention and extinction tools

Managing forest fire risk requires taking actions belonging to the realms of prevention and preparation, response or extinction and restoration of affected areas.

Prevention and preparation actions include:

- Preparing prevention and action plans to implement previously to or in case of a forest fire event. These plans can be designed at different levels like forest, municipal or regional levels.
- Investigating the causes of forest fires occurred in the past, taking actions of surveillance on the territory and implementing legal measures to regulate activities that increase fire risk (e.g. controlling the status of power lines and clearing the nearby vegetation, clearing road's sides, regulating public access to the forest).
- Undertaking actions of forest fuel control and reduction and fostering the development of prevention infrastructures (e.g. sites for water supply and forestry roads). Together with these actions it is important to ensure that WUI's perimetric areas are characterized by limited fuel load (this is sometimes achieved with prescribed burns).

USING FIRE AS A FOREST MANAGEMENT AND FIRE PREVENTION TOOL.
"GOOD FIRES PREVENT BAD FIRES"

In many regions around world, fire has been traditionally used by men as a land management tool, especially for grassland maintenance and to eliminate vegetation debris. In fact, the use of backfire, namely low intensity fire to fight high intensity forest fire as an extinction technique, is intrinsic into traditional knowledge and uses of fire. Nowadays, risks associated to using fire as a landscape and forest management tool have increased hand in hand with changes in the landscape (presence of more continuous and dense forests), in the size of the population exposed and in the distribution of human activities on the territory (many commercial, touristic and industrial activities taking place nearby forests). This imposed the need to revise the rules of fire use traditions. The always growing knowledge of forest fire ecology has allowed integrating the use of fire in forest management by means of prescribed burns which became a tool to prevent forest fires. Prescribed or controlled burns refer to a fire set intentionally to be used as a means for managing the vegetation. Prescribed burns can control fuel growth and accumulation subjecting the forest to a fire regime that improves ecosystem's health. They allow to reduce the forest fuel load and prevent future extreme and severe large forest fires. The use of fire has to be applied under specific conditions and relying on evolved techniques that demand a broad professional knowledge. The application of prescribed burns methods needs also to take into account the social acceptance and perception of fire and the related safety and health conditions (mainly linked to the smoke generated by the fire). Nowadays, prescribed burns are also used by firefighters as a tool to train the understanding and experiencing of the occurrence of a fire in safe conditions. Comprehending how a prescribed fire works allows learning to manage low intensity forest fires by letting them burn while keeping them always under control. In the context of both prescribed burns and natural low intensity fires, the following figure of speech applies: "good fires prevent bad fires", as these types of fire foster forest and social safety (further information on how fight fire with fire at: http://goodfires.org).

Response and emergency management actions include:

- Development of an extinction system usually supported by expressly dedicated financial resources, vehicles and specific training of personnel. The extinction system works with terrestrial and aerial vehicles (e.g. trucks, helicopters and aircrafts) and it relies on extra personnel during summer.
- Coordination of civil protection, extinction system, police and health services. As coordinating actions in the WUI requires more resources, specific efforts are dedicated to these areas.

The **restoration of affected areas** takes special importance when the forest that burned has the potential to play an environmental protection role, for example by preventing soil erosion, snow avalanches or reducing the effects of floods. In this situation, actions can be undertaken with the goal of providing such protection until the forest vegetation is again in place, for example building structures to fix the snow and avoid the avalanches. These actions however can be very costly.

At EU level, forest fires are considered major hazards, reason why during the last years different specific regulations and policies have been established to face these threats. The European Union did not emanate a common forest policy, but it did develop a set of measures to support forests and forestry. Various Directorates-General (DGs) at the European Commission, like DG Environment, DG Agriculture and Rural Development, DG Regional Policy, DG Research or DG Humanitarian Aid and Civil Protection, are involved in the development and monitoring of measures in the fields of information, prevention, fire fighting and restoration of burned surfaces.

MAIN ACTIONS UNDERTAKEN IN RELATION TO FOREST FIRES PREVENTION, MONITORING AND RESTORATION AT EU LEVEL

- Directorate General of Environment.

Many specific forest fire prevention regulations were emanated as of 1992 by DG Environment. In 1998 the Commission's Expert Group on Forest Fires was created with the aim of exchanging information concerning lessons learned and forest fire prevention practices and developing as well as maintaining the European Forest Fires Information System (EFFIS). EFFIS is jointly managed by the EU Joint Research Centre (JRC) and the DG ENV, and aims to provide EU level assessments for situations before and after fires, to support fire prevention through risk mapping and to promote preparedness, firefighting and post-fire evaluations.

- Directorate General of Agriculture and Rural Development.

This DG has been supporting the financing of fire prevention and restoration actions through rural development programs until 2006. In 2007 a new regulation on rural development came into force, which among other aims had the goal of providing the legal basis for supporting the restoration of forests and fire prevention activities. The new regulation also requests Member States to classify areas according to fire risk in their forest protection plans as well as setting the measures for preventing fires and for restoring damage from fires in the areas characterized by high or medium risk.

- Directorate General of Humanitarian Aid and Civil Protection.

Every year before the beginning of the forest fire season, the European Commission's Emergency Response Coordination Centre (ERCC) organises meetings joined by representatives of all European Member States that are joining the EU Civil Protection Mechanism to exchange information on the state of preparedness related to the occurrence of forest fires. EU Civil Protection Mechanism was set up on 2001 to enable coordinated assistance from the participating states to victims of natural and man-made disasters in Europe and elsewhere.

Over the summer period, the ERCC is in contact on a weekly basis with the representatives of the countries that are at high risk of forest fires. When forest fires occur and when national capacities to respond are exceeded, European countries can show solidarity by providing assistance in the form of water-bombing aircrafts, helicopters, fire-fighting equipment and personnel. To provide a joint and coordinated response, countries frequently channel assistance and exchange of real-time information through the EU Civil Protection Mechanism. The EU Civil Protection Mechanism was activated more than 55 times (including pre-alerts and monitoring requests) since 2007 to respond to forest fires within and outside European borders.

- Directorate General of Research.

DG Research has supported forest fire research since the late 1980s with the aim of strengthening research activities and initiatives in various fields related to forest fires. An example of the action of this DG is the FIREPARADOX Project which had the overall goal of developing a scientific and technical basis for integrated land and fire management practices and policies.

MAIN LEGAL FRAME FOR FOREST FIRES PREVENTION, EXTINCTION AND RESTORATION IN EU CONTEXT

-Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD)
-Council Decision of 20 December 2004 amending Decision 1999/847/EC as regards the extension of the Community Action Programme in the field of civil protection
-Commission Regulation (EC) No 2121/2004 of 13 December 2004 providing some detailed rules for the implementation of the Forest Focus Regulation
-Proposal for a Regulation of the European Parliament and of the Council concerning the Financial Instrument for the Environment (LIFE+). 29.9.2004, COM(2004) 621
-Communication from the Commission "Financial perspectives 2007 - 2013" 14.07.2004, COM (2004) 487
-Communication from the Commission "Reinforcing the Civil Protection Capacity of the European Union". 25.03.2004, COM (2004) 200
-Regulation (EC) No 2152/2003 of the European Parliament and of the Council of 17 November 2003 concerning monitoring of forests and environmental interactions in the Community (Forest Focus)
-Council Regulation (EC) No 2012/2002 of 11 November 2002 establishing the European Union Solidarity Fund
-Regulation (EC) No 805/2002 of the European Parliament and of the Council of 15 April 2002 amending Council Regulation (EEC) No 2158/92 of 23 July 1992 on protection of the Community's forests against fire
-Council Decision of 23 October 2001 establishing a Community Mechanism to facilitate reinforced cooperation in civil protection assistance interventions
-Regulation (EC) No 1485/2001 of the European Parliament and of the Council of 27 June 2001 amending Council Regulation (EEC) No 2158/92 of 23 July 1992 on protection of the Community's forests against fire
-Council Decision of 9 December 1999 establishing a Community action programme in the field of Civil Protection
-Commission Regulation (EC) No 1727/1999 of 28 July 1999 laying down certain detailed rules for the application of Council Regulation (EEC) No 2158/92 of 23 July 1992 on protection of the Community's forests against fire
-Council Regulation (EC) No 1257/99 of 17 May 1999 on support for rural development from the European Agricultural -Guidance and Guarantee Fund (EAGGF) and amending and repealing certain Regulations
-Commission Regulation (EC) No 804/94 of 11 April 1994 laying down certain detailed rules for the application of Council Regulation (EEC) No 2158/92 as regards forest-fire information systems
-Commission Regulation (EEC) No 1170/93 of 13 May 1993 laying down certain detailed rules for the application of Council Regulation (EEC) No 2158/92 of 23 July 1992 on protection of the Community's forests against fire
-Council Regulation (EEC) No 2158/92 of 23 July 1992 on protection of the Community's forests against fire

5.- Recommendations for a communication strategy aimed at providing information on forest fires and increasing social awareness

The complexity of the forest fire phenomenon makes rather difficult the transferring of information about this topic. In this section we offer some recommendations for easing the communication of forest fire related concepts which take into account the social and political perceptions of forest fires. The goal of these recommendations is increasing social awareness about the forest fire problem.

HIGHLIGHTS LINKED WITH FOREST FIRE AND THE RELATED RISK

- As it is not possible to eliminate the fire risk completely, we have to assume that **forest fires are an intrinsic elements of many forest ecosystems** like the Mediterranean one. Policies which address forest fire risk management have to focus on minimizing risk levels and people's vulnerability, infrastructures and the natural environment instead of trying to suppress the fire phenomenon completely.
- In specific weather conditions, strong drought, high temperatures and wind presence, the accumulation of much fuel in the forest often due to the abandonment of forest management activities increases the intensity and severity of forest fires, which can exceed the capacity of extinction systems. **Such accumulation of fuel establishes "new" fire behavior patterns** that force the system of fire prevention and extinction to renew the technical knowledge and experience developed in the past in relation to smaller and less aggressive fires.
- In order to face the problems presented by large and extreme forest fires, **extinction efforts need to be backed up by a lower vulnerability of the landscape to the spreading of the flames**, by means of forest structures unable to support spread rates that are above the suppression capacity.
- **To understand the forest fire phenomenon it is necessary to make a clear difference between concepts related to fire ignition and to fire spread capacity**. Ignition risk is increased by the augmented size of WUI areas and social demand of forest activities. Fire spread causes are mainly linked to the abandonment of forestry and agricultural activities and exacerbated by climate change effects.
- Though the ignition risk is constant, we are facing a changing fire context characterized by increasing vulnerability of social and environmental assets. **Such changing context needs to be addressed by building up a risk culture and learning to coexist with forest fires** as we already do with other natural hazards.

THE SOCIAL PERCEPTION OF FOREST FIRES

Urban societies have often **a limited knowledge and awareness** of the real causes of the forest fire problem. In the common understanding of forest fires, this problem has been simplified by reducing it to the relevance of the ignition causes and their motivations (with special attention to the arsons). Also exceptional and extreme weather conditions receive attention in the common view of the forest fire problem. The general public has limited acquaintance with the concepts of extinction capacity and fire spread capacity. This complicates the social understanding of the fire phenomenon. Below we list the more common social myths and facts regarding forest fires:

- **Forest fires** are often seen by society as a public enemy to fight at whatever price. The ecological role of fire and its pertinence to some forest ecosystems has not received much attention in the communication to the public, as it did not the need to lower landscape vulnerability as a fire prevention strategy.
- In modern societies, the **acknowledgment of the role of forest management** and agricultural activities for forest fire prevention is limited. Myths such as the “virgin forest” or the untouchable forest values which foster a low level of interventions in forest areas make difficult the comprehension of what we can do to prevent forest fires.
- The “**technological myth**” which holds that with the necessary suppression and prevention technology all forest fires can be controlled and extinguished creates a **false sense of security** and increases vulnerability of people and properties. The occurrence of a “catastrophic” large forest fire event is often what urban but also rural populations need to recognize that fire can have an enormous impact.
- **Exposition to fire risk** is augmented by land abandonment and consequent increase of fuel loads, as well as by the lack of fire prevention culture. Social frustration due to the loss of lives and goods after a fire is let out on the fire service, which is actually not responsible for landscape management flaws. At the same time, the **individual responsibility** of carrying out fuel reduction operations in the homes’ surroundings **is mostly not assumed** by homes’ owners and other representatives of society.
- In many rural areas the population went from conceiving **fire as a useful tool,** to be victims of **large and severe forest fires** perceived **as a threat**. This revolutionizes and limits the employment of traditional knowledge and use of fire.
- The complexity of the fire phenomenon needs **long-term measures** based on prevention strategies which often have no short-term benefits, as well as a strong **transversal coordination** of efforts by the institutions and actors involved.

SET OF RECOMMENDATIONS FOR IMPROVING COMMUNICATION ON FOREST FIRES AND INCREASING SOCIAL AWARENESS

- **Improving the social understanding of forest fires** by informing the public about fire's structural causes (such as abandonment of rural activities and increasing size of WUI areas) and by making a clear distinction between the roles of ignition, fire spread and extinction capacity factors. In this context it is essential to overcome the simplified vision that all fires are due to arson ignition causes and extraordinary weather conditions, as well as to demystify the technologic myth.

- **Improving the understanding of the role of fire as a natural disturbance** in Mediterranean ecosystems and highlighting that it is unrealistic to exclude fire from these ecosystems. It is also important to show the necessity of avoiding large forest fires by creating a landscape as much as possible resilient to fire spread .

- **Improving the understanding of the fragility and vulnerability of the environment.** This would help to increase awareness about the risk exposition and need of self-protection of WUI areas, as well as about the need of adopting prevention measures and acting with a responsible behavior (for example avoiding ignitions and reporting to the authorities negligent behaviors of others).

- **Reducing the attitude to make a "show" out of forest fire events that is proper of media**, in order to avoid to motivate fire-prone attitudes (e.g. the action of pyromaniacs and of people who want to "enjoy" the "game" of seeing the fire service in action).

- **Acknowledging the important roles played in preventing forest fires by rural activities** and by actions aimed at improving landscape quality (for example by fostering tourism and increasing life quality of local populations and by incentivizing the related economic activities, like agriculture and forestry)**.** This can help delivering a clear message about the social role and value of the forest and the importance of its protection.

- **Avoiding the political instrumentalization of the forest fire phenomen**on by using arguments for failed fire prevention and extinction actions like the lack of coordination between firefighters and land stakeholders. These arguments make more difficult the development of a realistic post-emergency debate.

- **Treating the management of forest fire risk as an opportunity rather than a problem.** In light of an increasing social demand of landscape use, forest fire risk prevention can be an important argument to promote forest management and support the rural activities that conserve forest landscapes.

GLOSSARY OF FOREST FIRE RELATED TERMS

Backfire: A fire set intentionally to burn and consume the fuel that lies in the path of a forest fire. Such fuel would be otherwise burned by the forest fire and would contribute to increase its intensity.

Burn plan: A pre-determined scheme or program of activities formulated in order to safely and effectively accomplish the objectives of a managed burn. A burn plan outlines the selection of strategies and resources, the assignments of these resources and the monitoring of the managed burn. The plan needs to be dynamic and adaptable to take into account eventual changes in conditions or circumstances.

Combustibility: Easiness with which the vegetation can start a combustion reaction.

Control line: A constructed or natural barrier used to control a fire.

Convection: The transfer of heat caused by the movement of a gas or liquid. In meteorology, convection is the predominantly vertical movement of warmed air. Convection in the context of a forest fire can lead to spotting processes, such as sparks emission.

Critical point: A point in time or space when/where there is a significant influence on the fire spread rate and/or fire intensity rate, usually increasing the value of these variables.

Fire containment: An area of a fire that is under control.

Fire extinction capacity: The technological and human competence capacities to control and extinct a fire.

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 regime: The pattern of fire occurrence, fire frequency, fire seasons, fire size, fire intensity, and fire type that is characteristic of a particular geographical area and/or vegetation type.

Fire spread: The movement of a fire through available fuels arranged across the landscape, expressed in m/min or km/h.

Firebreak: An area with a specific fuel load to minimize the fire's intensity and fire spread capacity.

Flame height: The vertical extension of a flame. Measurement of flame height is calculated perpendicular from ground level to the tip of the flame. Flame height is lower than flame length if flames are tilted due to wind or slope.

Flammability: Easiness with which a given fuel ignites and burns.

Forest fuel: Forest biomass that can be burned by a fire, expressed in kg/ m^2.

Horizontal fuel continuity: Distribution of fuels on the horizontal plane. The horizontal arrangement of fuels influence the easiness with which fire can spread horizontally across an area.

Incipient fire: A forest fire that affects less than 1 ha of land.

Large fire/mega fire: A forest fire characterized by extreme behavior. Mega fires usually represent a significant challenge to extinction systems because substantial resources need to be dedicated to the extinction and they can pose a significant risk to the safety of personnel.

Non tree forestland: An area of brush and grasslands with a tree canopy cover less than 20%.

Prescribed burn: A planned and supervised fire set with the purpose of removing fuel either as part of a Fire Suppression Plan (an operational burn) or a land management exercise .

Preventive silviculture: forest management interventions aimed at controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet fire prevention purposes.

Sparks: An ignited particle of vegetation thrown out from burning material.

Spot fire: A fire outside the perimeter of the main fire that is caused by flying embers transported by the wind or by convection columns.

Tree forestland: An area of woodland characterized by minimum 20% of canopy cover.

Vertical fuel continuity: Distribution of fuels on the vertical plane, from the ground up to the canopy levels of vegetation. The vertical arrangement of fuels influence the easiness with which fire can spread vertically through the fuel layers.

Wildland Urban Interface: The area where human settlements meet or intermingle with the wildland.

TO KNOW AND LEARN MORE

Further information about forest fires in Europe

http://forest.jrc.ec.europa.eu/effis/

http://www.lessonsonfire.eu/

Further information about forest fires emergencies and journalism

http://efirecom.ctfc.cat

http://www.unisdr.org/files/11705_91358948mediatraininghandbookEnglis.pdf

http://www.unisdr.org/files/20108_mediabook.pdf

http://emergency.cdc.gov/cerc/resources/pdf/cerc_2012edition.pdf

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