HAWASSA UNIVERSITY

WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES

TRAINING MANUAL ON:

FOREST/WILDLAND FIRE PREVENTION AND CONTROL FOR SUSTAINABLE FOREST MANAGEMENT

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PART-I: FOREST FIRE BASICS AND PREVENTION

1. INTRODUCTION

1.1. History of Forest Fire Risk in Ethiopia

One important task for forest management is the protection of the forest resource base. Out of many sources of attacks against the forest, fire is often the most dangerous. This danger is also a real threat for the people living inside or adjacent to the forest area. Each year thousands of people lose their homes due to wildfires, and hundreds of people die in these accidents; additionally tens of thousands of domestic animals perish. Fire destroys agricultural crops and leads to soil erosion, which in the long run is even more disastrous than the accidents described before. When the soil is barren after the fire, and heavy rains soak the soil, huge mud- or landslides can occur. If it is according to (Jurvélius, Mike, 2011); it is estimated that every year:

- 10 to 15 million hectares of boreal or temperate forest burn.
- 20 to 40 million hectares of tropical rain forest burn.
- 500 to 1,000 million hectares of tropical and subtropical savannahs, woodlands and open forests burn.

More than 90% of all this burning is caused by human activity. Therefore, it is quite clear that fire prevention and control should receive top priority among forest management activities.

Following similar scenario in Ethiopia, historical evidence indicates that high forests of Ethiopia remain victims of war, conflict and forest fires. Yodit/Gudit (849-897 A.C.) ordered her army and the local people to set fire to forests stretching from Tigray to Gonder and Wello in suspected hiding grounds for the soldiers of Emperor Dilnaad. Similarly, Grange Mohamed (1527-1542 A.C.) ordered his troops to clear and burn all the forests stretching from the eastern lowlands to the central highlands to make access to battlefields easier and to destroy strategic hiding grounds of the soldiers of Emperor Libne Dingil and clergies (Wolde Selassie, 1998). Whatever the causes may be, fires in different parts of Ethiopia damage every year large areas of forests. Despite the country's long time experience in using fires, there are no available statistics on the causes, risks and extent of damage caused by forest fires. Prior to the forest fires in 2000, the last major outbreak was in 1984 when the fires damaged approximately 308,200 ha of forests (George and Mutch, 2001). After almost three months of large scale wildfires that consumed over 300,000 ha natural forests, Ethiopia is still not prepared and does not give adequate attention to efficiently protect its last natural forest resources (Dechassa Lemessa, 2001).

1.2 Early warning in Ethiopia

Early warning in Ethiopia dates back to 1973/74 which was established in response to the then drought. Since then, it has gone a number of organizational progresses: **RRC**, **DPPC, DPPA, and now DRMFSS.**

The essence or definitions of early warning have three major parts:

- Monitoring *indicators* relevant to the sector (agriculture, health, conflict);
- Warning of the *threat of disaster* ahead of time; and
- Trigger timely and appropriate *response* (food and non-food assistance; health care, peace keeping/building).

Early warning is a process of *monitoring* various *indicators* affecting livelihood with a view to warning of the *threat of disaster* ahead of time. The warning should, in principle, trigger *timely* and *appropriate preventive response* (DPPC/EWD, 2000). As indicated in the definition, early warning is not merely meant for warning of threat of disaster ahead of time, but it involves provision of appropriate response. The response could be immediate/short term response and long term response. Here are some examples of emergency responses like the provision of essential goods and services to a disaster affected population to save lives and protect livelihoods in times of disaster:

A. Relief

Activity undertaken in the immediate aftermath of a disaster to save lives, protect livelihoods, and address immediate humanitarian needs, including the provisional restoration of essential services.

B. Reconstruction

Longer-term activities required to restore physical infrastructure and services damaged by a disaster.

C. Recovery

Actions taken after a disaster to restore the living conditions of disaster-stricken people or communities while encouraging and facilitating necessary adjustments to build resilience to prevent similar crises in future.

D. Rehabilitation

The measures applied after a disaster which are necessary to restore normal activities and build resilience to future shocks in affected areas, communities, and economic sectors.

The Levels of response could be form International bodies, Federal, Regional, Zonal, Woreda, and Kebele. Accordingly, early warning objectives could be oriented towards relief, &/or disaster risk management (development),

Maine activities in early warning

- Identifies surplus and deficit producing areas
- Detects the likelihood of a disaster as early as possible
- Provides advice and warning about impending disaster in a given area, So that the necessary preparedness measures can be taken
- Provides estimate of beneficiaries of food shortage and the amount and types of emergency assistances required
- Regularly assesses nutritional status of people in most seriously affected areas
- Follows up the food security situation through regular monitoring systems already established and provide timely regular informative reports to the decision makers of different levels of different partner agencies
- Conducts disaster area assessments whenever disasters occurred etc

Early warning indicators:

What is an Indicator?

An indicator is a sign of the state of health of something. For example, in a business environment profit is an indicator of a company's performance
Examples of indicators:

I. food security indicators

- Weather (rain fall , temperature)
- Area planted
- Amount of input used
- Total production
- Market
- Prevalence of pest and disease

II. Could you please list forest fire indicators in general and in Ethiopia particularly?

2. POLICIES AND RELATED ISSUES IN FOREST FIRE PREVENTION/CONTROL

The purpose of this session is to:

- Discuss the importance of forest protection and forest fire prevention (FFP), principles of FFP and policy on FFP.

(1) The essence of forest fire prevention

a) Overcoming forest fire is obligation of all stakeholders related to forestry activities.
b) The activities are emphasized in pre-fire activities:
    - Prevention,
    - Monitoring,
    - Awareness and
    - Readiness to decrease or lessen the impact caused by forest fire

(2) Principles of FFP

a) Principle of togetherness and voluntary
b) Principle of coordination, synchronization, and integration
c) Principle of autonomy/self-funding
d) Principle of promptness and accuracy
e) Principle of prevention and preparedness
f) Principle of totality
g) Principle of global

(3) The direction of policies

- Often forest fire becomes large and difficult to handle although in-conventional equipment are available.
- In order to implement forest fire prevention in line with sustainable forest management, the activities are directed:
    a) To prevent impact and losses caused by larger fires.
    b) To safe human life, government assets.
    c) To manage impacts after fires.

(4) Vision and Mission

a. Vision

- To control forest fire and to protect people from damages caused by forest fire.

b. Mission

- To optimize the aspect of forest fire prevention
- To improve monitoring, alertness and readiness
- To improve aspect of rehabilitation of forest after fire
- To enhance judicial aspect

(5) Targets of forest fire prevention

- To master technology of prevention, monitoring, alertness, readiness, early warning system, early detection, early fire extinguishing, and post-fire handling.
- To utilize all potential resources to overcome forest fire nationally supported by appropriate software and hardware.
- To improve coordination and cooperation nationally, regionally and internationally.

(6) Normative steps of **FFP**

Steps of forest fire prevention include:

1) Prevention,
2) Monitoring,
3) Preparedness,
4) Early Warning,
5) Early Detection,
6) Respond/fire suppression and
7) Post Fire Management

3. BASICS OF FOREST FIRE

A forest fire involves combustion of organic material (fuel) that releases a large quantity of energy. The combustion energy is transferred from the burning fuel to unburned fuels ahead of the fire front. This phenomenon ensures the fire spread. The fire start depends on the flammability of the vegetation. The fire spread depends on a number of variables, including fuel characteristics (size, moisture content and arrangement), weather and topography.

3.1 Combustion

Definition: Combustion is a fast and exothermic oxidative reaction that releases heat, requiring an oxidizing agent to burn the fuel. In the case of a forest fire this oxidizing agent is the air in the atmosphere with the vegetation being the fuel.
The combustion requires the presence of three elements called fire triangle: (a) fuel, (b) oxidizing agent, and (c) initial energy. The process develops in three phases:
(a) Evaporation of water in the fuel, (b) emission of flammable gas by pyrolysis, and finally (c) ignition; the ignition is ensured by an external energy source. In the following process one part of the released combustion Energy is reabsorbed by the fuel in order to sustain the combustion. In the case of a forest fire the released energy is absorbed by the vegetation/fuel ahead of the flaming front, which causes the fire propagation.

3.1.1 Fire triangle (Fuel, oxygen and temperature)

I. Fuels (Forest fuels and characteristics)

a) Fuel Structure

This is the horizontal or vertical and spatial distribution.
The horizontal and vertical structure can be continuous or discontinuous (e.g., distribution in small clusters or patches; lack of understory).
b) Fuel macrostructure/size and arrangement
The spatial arrangement of the fine fuels (leaves, needles, and branches) influences the fire intensity:

Loosely packed fine fuels have better contact with oxygen and ease the combustion process as compared to densely packed heavy fuels
c) Fuel chemical composition

A plant is composed of organic matter and water

- Water content

A condition for the beginning of combustion is dehydration of the vegetation by evaporation of water, followed by thermal degradation (pyrolysis) and release of flammable gases. This physical mechanism requires a high amount of energy due to the high latent heat of the water. Thus, vegetation with high water content is not very flammable and combustible. The water content varies in function of the species, but also in function of the phenology, the physiological plant condition and the climatic influence.

- Dry material

Dry material is composed of organic matter and minerals. Only the organic matter burns, releasing the necessary energy for the fire propagation. Thus, a plant with high mineral content has a reduced heat yield and is less combustible.

II. Combustive agent (oxygen)
In the case of forest fires oxygen is abundant in the atmosphere. Ignition and combustion depend strongly on this element. In order to ignite flammable gases (the product of pyrolysis) and maintain a flame, there has to be oxygen content of at least 15.75 % in the air; average oxygen content of the air is ca. 20 %. The wind plays an essential role for the fire spread because it supplies oxygen to the active fire.

III. Energy source/kindling temperature
The capacity of a fuel to catch fire depends on its characteristics, the energy source and the exposure time

- A weak energy supply allows the ignition of grass, whereas the energy supply has to be much higher for the ignition of wood.
- In order to ignite dry vegetation by a glowing ember the presence of wind is required.

- An electric arc cause by a broken power line or by lightning provides sufficient energy for ignition of dry Vegetation

3.2 Released Energy – Fire Intensity

Some definitions …

Total fuel load: This is the quantity of all aboveground combustible materials. Fuel load is usually measured in grams of organic matter (dry weight) per square meter, or tons per hectare. During a forest fire only a fraction of the total fuel is consumed.
Available fuel: The portion of the total fuel that actually burns or would actually burn under specified burning and fuel conditions.
Energy release: The computed total heat release per unit area, expressed in kilojoules per square meter (kJ/m2)
Fire front or flaming front: The part of a fire within which continuous flaming combustion is taking place.
Unless otherwise specified, the fire front is assumed to be the leading edge of the fire perimeter.
Rate of spread: This is the speed of advance of the fire front. It is strongly correlated to the wind speed. It is computed in meters per second or in km per hour.
Fire line intensity: This is the released energy per time unit and per length of the fire front and calculated in kilowatts per meter of the fire front (kW/m). This fire line intensity equals the product of available combustion energy and the fire rate of spread.

3.2.1 Heat transfer and fire spread

The mechanisms of fire spread are distinguished in three phases:

- Combustion of vegetation material with heat emission;
- Heat transfer towards the fuel ahead of the fire front by conduction, thermal radiation and convection;
- Heat absorption by the plant before the flaming front and its ignition

Types of Heat Transfer
Heat transfer is an energy exchange process between two points in space that occurs when a temperature difference exists between these two points. It is maintained by the three fundamental physical processes: conduction, radiation and, convection.

a. Conduction

The conduction is the result of molecular movement. It is related to the composition and the temperature of the environment. It can only happen in a material that is solid, liquid or gaseous. The heat spreads from the warm to the cold body. In practice the conduction is negligible during the spread of a vegetation fire, since it accounts only for 5 % of the heat transfer. The only exception is a ground fire or a peat fire where conduction is the predominant heat transfer. On the other hand, the solid particle conduction explains the different behavior of fuels as a function of their depth.

b. Thermal radiation

Radiation is a type of energy transfer in form of electromagnetic waves with or without particles. All bodies with an absolute temperature above 0 K (=–273°C) emit an electromagnetic radiation, where the radiation frequency is a function of the temperature. The quantity of the transferred energy from one body to another body augments with the increase of the temperature difference between these two bodies. Heat transfer during a forest fire is mainly by electromagnetic infrared radiation.

c. Convection

Convection is a heat transfer by macroscopic movements of a fluid (gas in the case of a fire) who's mass transports the containing heat. In vegetation fires, combustion produces hot gases which mix with the also heated ambient air. These hot gases are lighter and go up quickly. They bring a great quantity of heat to fuels located above (crown), desiccate them and raise their temperature up to the ignition point. The wind, by pushing hot gases ahead of the flaming front -even in the lower layers of the vegetation - accelerates the fire spread.

The variations of the topography also influence the displacement of hot gases. For an upslope fire, the convection ahead of the fire front is more marked with increasing slope steepness; it is the opposite in a down slope fire. The convection is the dominating process of heat transfer in the forest fires spread. In addition, the moving gases often transport burning materials ("firebrands"), which can fall down up to several hundred meters in front of the fire and ignite new fires ("fire spotting").

3.2.2 Types of Fire Spread

Except for ground fires, a vegetation fire is propagated mainly by convection and radiation. Fire spotting can accelerate the fire spread. Various types of fires are distinguished in accordance with the layers they are spreading:

a) Ground fires:

- Burn in organic material of the soil layer (e.g. a peat fire) and usually do not produce a visible flame.
- They can penetrate in very deep organic deposits and smolder several decimeters under the surface.
- They are relatively rare in the Mediterranean region.

b) Surface fires:

- Burn the low and contiguous layers on the ground (litter, grass, undergrowth). They are the most common.
- Crown fires set ablaze the tree tops and spread quickly. There are two types:

  1. Independent crown fires, which spread in the crown independently from a surface fire.

  2. Dependent crown fires, which spread in the tree tops only because of the heat released by the surface fire.

  They are «passive» if they contribute less to the propagation than the surface fire and «active» in the contrary case.

Fire spotting is caused by flying sparks or embers (firebrands) ahead of the flaming front. These particles, lifted up in the convection column and transported by the wind, can be the cause for a second fire in front of the first. Large firebrands can burn a long time and be transported very far (up to 10 or 20 km in exceptional cases). Very many fire spots can lead to multiple fire starts within a small area and thus create an extremely dangerous blow up. Fire spotting can occur on short or long distances according to the environmental conditions.
The rates of fire spread are extremely variable. A fire in a peat swamp advances only by a few meters in several weeks. The rate of spread of a surface fire or a crown fire depends on the characteristics and the state of the vegetation, the slope and the wind

The rate of fire spread is higher in low and continuous fuel types where the biomass is small (grass, heath, open garages), sometimes exceeding 10 km/h.

- In stands with a dense understory, this speed decreases because the vegetation forms a screen obstructing the wind and the heat transfer. Under these conditions the spread rate is 5 to 6 km/h. On the other hand, more biomass is burned.
- Fire storms often move at speeds ranging from 5 to 10 km/h.

3.2.3 Flammability & combustibility

Flammability and combustibility characterize the reaction of the vegetation during a fire:

- Flammability influences the ignition.
- Combustibility, or fire intensity in relation to vegetation characteristics, influences the fire spread.

These two concepts can be defined for a plant (branch, leaves, bark fragment), for a species or for a vegetation formation.

a) Flammability

Flammability qualifies the proneness of the fuel to ignite under heat. It characterizes the quantity of energy necessary to the desiccation of the plant and the pyrolysis.
One of the methods employed to estimate this flammability consists in measuring the following
Parameters of vegetation samples that are subjected to thermal radiation:

- The time of ignition, corresponding to the exposure time necessary to the appearance of a flame.
- This factor can be measured using a stop watch.
- The frequency of ignition, i.e., the number of samples where a flame appears, in relation to the total number of samples.

The average values of these two parameters allow classifying the plants according to their flammability.

b) Combustibility

Combustibility is the **fire intensity related to the characteristics of the vegetation**. It describes the fire intensity that a vegetation formation can build up, without taking into account the topography and the wind.
It characterizes the proneness of the vegetation to burn by releasing sufficient energy and to induce, by heat transfer, the ignition of the next plants.
The combustibility of vegetation is correlated to:

1) The amount of biomass combusted,
2) The heat content of the particular species burned,
3) The spatial structure, and
4) The water content (i.e., the season).

c) The importance of these parameters

The flammability of a plant varies according to its parts. The bark of the Aleppo pine does not have the same flammability as its needles. The fire in a pine forest starts in the litter, made up mainly of dry needles. The risk analysis of an ignition in such a stand requires the knowledge of the flammability of these needles.
A vegetation formation is made up of plants. The flammability and the combustibility of a stand depends on its species composition and their structural arrangement, as

well as theirs water content. These two parameters are thus variable according to the vegetation formation, but also according to the season.
Flammability and combustibility are important for estimating the fire hazard of a forest:

- The study of flammability starts with the analysis of the risk of a fire occurrence, either temporal (follow-up in time), for example, resulting to a preventive mobilization of fire fighting forces at days with high risk, or spatial.
- The combustibility study allows defining fuel types in function of fire behavior models.

3.3 Fire behavior

It's a general designation given to what forest fire does, intensity &/or Spread?
Three principal environmental elements affecting wild land fire behavior:

A. Fuels
B. Weather and
C. Topography

A. Fuels

a) Fuel types :
- Grass
- Shrub
- Timber litter
- Logging Slash

b) Fuel Moisture:
- The amount of water in a fuel expressed as a percentage of the oven-dry weight of that fuel

c) Fuel categories (size and shape)
- Light fuels:
  Grass, Leaves, Shrubs
- Heavy fuels:
  Limbs, Logs, Stumps

d) Fuel Loading:
- The quantity of fuels in an area.
- Generally expressed in Tons per Acre.

e) Horizontal continuity: Continuous Vs patchy
& Vertical arrangement of fuels: - Ground, Surface & Aerial

Ground fuel:

- All combustible materials lying beneath the surface including deep duff, roots, rotten buried logs, and other organic material.
- Usually called a "PEAT FIRE"

Surface fuel:

- All materials lying on or immediately above the ground including needles or leaves, grass, downed logs, stumps, large limbs and low shrubs

Aerial fuels:

- All green and dead materials located in the upper forest canopy including tree branches and crowns, snags, moss, and high shrubs.

B. Weather

a) Temperature
b) Wind
- Increases supply of oxygen
- Drives convective heat into adjacent fuels.
- Influences spread direction and spotting.
- Carries moist air away replacing it with drier air.
- Dries Fuels.
- Raises fuel moisture if the air contains moisture.

c) Relative Humidity - As RH increases, fuel moisture increases
d) Precipitation - Increases fuel moisture

C. Topography

- Aspect - direction a slope faces: **Leeward: light fuels sunny dry; Windward: Heavy fuels, shade moist**
- Slope - Steepness. **Steep Slopes Cause Rapid Fire Spread**
- Position of Fire - Top, middle, or bottom of slope. **Fire near to bottom of the slop has rapid spread up slops.**
- Shape of Country - Narrow canyons & box canyons.
- Elevation - Relates to curing of fuels, precipitation, length of fire season, etc

3.4 Fire Danger And Risk Analysis

The term **fire hazard** describes the fuel complex (the combustible materials), defined by volume, type, condition, arrangement, and location, that determines the degree both of ease of ignition and of fire suppression difficulty.
Vulnerability defines the threat to property which is at stake in the area concerned ("values at risk": dwellings, buildings, heritage, etc…). It should be noted that the forest, being both a fire vector (fuel) and a fire victim, is simultaneously subject to the risk and the vulnerability. This is also the case for humans who with their activities can start a fire as well as suffer the negative impact of the phenomenon.

In general, the disciplines which conduct research on natural or technogenic hazards (e.g., flooding, earthquakes, major technological accidents, etc.) call a **danger** the product of the arising probability of a phenomenon (risk) and the value of the damage (vulnerability). However, as generally accepted concerning forest fires, the term risk is used in this guide in the sense of ignition probability, and the term danger in the sense of its given definition (see above).

It is necessary to distinguish the concepts of fire danger evaluation and forecast:

- To evaluate a danger, is to assess both fixed and variable factors of the fire environment that determine the ease of ignition, rate of spread, difficulty of control
- To forecast a danger, is the effort to determine a period of time when the phenomenon could occur.
- The fire danger varies in time in accordance with weather and vegetation conditions.

This is the **temporal forecast** of the danger. The fire danger is not homogeneous for the whole territory. Its intensity depends of natural environmental conditions and the land use. The **spatial evaluation** takes this aspect of fire danger into consideration.
It should however be noticed that:

- The temporal danger is not inevitably identical for the entire area looked at. This area can be divided into zones which each has its own temporal fire danger level.
- The spatial danger is analyzed on a well defined date, and can evolve over time (new human activities, change of vegetation stress, etc.)

4. EFFORTS IN FOREST FIRE PREVENTION

4.1. Avoid any Fire Occurrence

Introduction

We call prevention all actions aiming at preventing any fire occurrence.
Actions of prevention include:

- Fire-cause investigation
- Education and sensitizing of the public: since fire origins are mainly related to human activities, it is necessary to inform and sensitize the various population groups who can generate fires, such as farmers, forest workers, local inhabitants, tourists, industrial companies, and small enterprises
- Inspection of buildings and facilities likely to cause fire ignition (power lines, lanes, garbage dumps...)
- Fire law enforcement: dissuasive surveillance, definition of a dissuasive and repressive legislative framework
- Forest access regulations
- Actions of education and sensitizing allow an awareness rising for the fire hazard and a better knowledge of the fire danger.
- It is necessary to aim well at the target groups and to choose diligent means and actions to be implemented.
- A legal framework - preventive and repressive - is the essential complement of the preceding actions. According to the existing fire risk and available economic resources for financing prevention activities and fire suppression, various strategies can be adopted:
- Avoid **all** ignitions and protect **all** zones threatened by fire.
- Develop a strategy of the "**acceptable minimum**", realizing the technical and financial impossibility of protecting the entire territory against fire.

4.1.1 Education and Sensitization

One of the major objectives of awareness rising is to explain why the Mediterranean forest should be protected, and how to protect it. The purpose of education and sensitizing is not to provide scientific knowledge to the citizens, but to give them a desire for acting to protect the forest and for taking the responsibility. Forest fires are mainly caused by human activities, due to negligence, accidents, or incendiary acts. Therefore, it is essential with regards to prevention, to create awareness that forest fire protection is the business of all. This awareness-building process builds on public education and sensitization of people.

The responsibility to inform, communicate, and train is in the hands of forest fires experts and decision makers.

An effective communication program must answer the three following questions:

- Who is the target group?
- What message is to be passed?
- Which media should be used?

Each answer is closely linked to the two other questions.

Training allows looking further into scientific, technical, and practical details, or teaching techniques. But before beginning any public relation campaign, it is important to analyze the preceding actions and to evaluate the short, average and long-term impacts of messages on the target groups as a feedback for new campaigns.

Analyze preceding actions

To evaluate the impact of communication campaigns, two methods are possible:

- Campaigns with objective verifiable criteria for evaluation of previous achievements (e.g., reduction of fire occurrences or area burned in the period following the communication campaign in comparison to a reference period).
- Campaigns with an interest in the communication itself: is the message received, understood, appreciated?
- During the campaign design, pretests gather first reactions for documentation of a restricted population sample of the target group, using qualitative interview techniques. (E.g., is the message comprehensible? Which visual elements are observed attentively?) The feedback is used to modify documents. These pre-tests are more a help for the campaign design than an analysis of existing situations.
- The impact test samples from a targeted population variables like “recognition percentage” of the campaign, the remembered content... These methods assess the members’ memory of the sample population.

The target groups

Good communication needs a good knowledge of the targeted groups and their information level, opinions, attitudes, motivations, and values... A feasibility study is essential for assessing better the behavior and the sensitivity of the public with respect to the forest, fires, prevention, and suppression.

Targeted sensitization

It is always more effective to target only one population group. This allows to adapt the public awareness campaigns according to the characteristics of the group of individuals. Different target groups can be distinguished:

- Children and teenagers within the education system, teenager movements, or holiday centers. The children are privileged interlocutors because they are sensitive to the safeguarding of the forest. They can transmit the message to their parents:

- Persons in charge for the regional planning (local counselors, officials...)
- Farmers or foresters working in or near the forest
- All the people residing in forests and its edges
- Forest owners
- Tourists

Mass sensitization

The general public represents the entire population and the individual can only be targeted via a group within this population. Public awareness campaigns for the entire population appeal to the responsibility of the general public in order to avoid any act of imprudence. These campaigns are more effective if they take place when conditions are such that the public constitutes a risk for the forest.

The messages

The information about the Mediterranean forest is mainly related to fire. First, people have to be convinced that forest protection is essential. Second they have to be informed how to participate in forest fire protection:

- The message must be adjusted to the targeted public.
- The communication must carefully avoid bringing misleading messages to people by spreading simplistic formulas, whereas the reality is often quite complex, asking for a long-term campaigning until the concept being accepted.
- Not only simple messages should be chosen, since citizens are ready to accept that the problems are rather complex.
- The forest functions have to be defined: place for livelihood, resources for rural population, wood production, public recreation, landscape element, part of balanced ecosystems...
- It should be avoided that the population sees the forest only as a fuel complex burned by fire in the dry season, but to sensitize people for the benefits of forested land. It is the green forest, the living forest which is essential.

Messages can be conveyed by impressive images. The options include:

- A forest engulfed in flames, a catastrophe, a spectacle if the message shows some pictures of a fire and ongoing firefighting.

A fascinating image

- A fire-killed forest, images of black trunks and ash, destined to disappear.

A shocking image

- A well preserved green forest, synonymous for life quality, beauty, and future.

An aesthetic, sensitive, and encouraging image

The messages include:

– Utility message

- To prevent the forest from burning - targeting groups of individuals identified as persons in charge of fires (farmers, shepherds, foresters, hunters...); mainly informing about laws, regulations, prohibition, and training.

– Shock message

- To recognize that fire is a catastrophe - destined to the general public. The aim is to make people reject fire and make the population attentive towards fire. The effect is mainly of short-term.

– Educational message

- To love, to know, to protect - destined to children and the general public; teaching the functioning of the forest and to provide information to build up a positive long-term attitude.

The vectors

Actions of education and sensitization can be direct (advertisements) or indirect (participation in forest work). These actions use various vectors (media, ground patrols, panels, public meetings...) and can be organized by various speakers such as representatives of the state or local communities, non-governmental organizations, voluntary associations...

The vector is a tool which strongly depends on the target and the message.

Mass media

Television, radio, and press can be a good means to transmit a message, in the form of advertising films, specialized emissions, newspaper articles...

E.g.: Turkey calls upon personalities known to give more weight to these media messages. In Cyprus, a fire danger index is shown with the weather forecast. On the other hand, the use of the media, in particular of television, has disadvantages:

– The impact of the image can be too attractive, thus being more fascinating than inspiring a desire for preventing.

– The message aims the general public and is not focused at all. The information passes can be passed to journalists who have necessarily to be interested and who have to be provided with:

– A press release with short information. It is a short text (approximately thirty lines) which:

* Goes directly to the essential message
* Answers basic questions (Who? What? Where? How? Why?)
* provides additional information in order of decreasing importance

– A press kit with more detailed information.

The information is presented in form of few leaflets (maximum 12 pages) structured as follows:

* A synopsis
* A synthesis in 2 or 3 leaflets
* Short texts dealing with various topics: technical, economical, social, practical...

It is useful to build up a network of partners, contact in advance journalists of local daily newspapers, regional weekly magazines, local radio stations, regional television, as well as regional reporters of the national press.

Other direct vectors

Many vectors can be used to carry out a public relation campaign:

- Posters
- Patrols on foot, horse...
- Conferences
- Exhibits
- Written documents (booklets, books for children, specialized reviews...)
- Audio-visual documents
- Botanical paths
- Guided tours
- Special advertising gadgets

The sensitizing of children can be done by conferences in schools, by the creation of clubs working. Moreover, the participatory approach allows establishing or reinforcing relations of confidence between the forest managers and the local population. For the protection of forests, by the edition of specialized reviews, plays... Specific information campaigns can target tourists by presentations in hotels, panels written in several languages...

Public relation campaigns targeting the general public can take various forms:

- Specialized patrols charged to inform and to sensitize the public in forest and in periphery.
- Panels prohibiting starting camp fires in the forest, to picnic, and to smoke, or panels to sensitize people for the fragile forest ecosystem.
- Intervention in the everyday life by information campaigns on the market, during religious services... or the distribution of posters and stickers.

Indirect actions

The participatory approach can also be a good means of sensitizing:

- The participation of the population in aforestation can raise the awareness for the need of preserving and regenerating the forest.
- Forest work by young people (undergrowth clearance, pruning) offers teenagers a possibility to discover the natural environment.

Training

The training allows acquiring thorough knowledge about fires and the close connections to human activities. It can be carried out targeting:

- Young people, during their education, by the way of specific training kits
- Teachers, who will sensitize then their pupils
- People working in the forest: precautions to be taken during the use of equipment, activities to be performed, use of certain less dangerous exploitation techniques...
- Elected officials of local communities
- Personnel working in fire prevention and suppression
- E.g., in Turkey, workers in charge of fire detection and suppression receive three weeks of training
- People volunteering for forest fire protection

4.1.2 The legal Framework

To sensitize and to inform is not always enough; it is also necessary to enforce. The definition of a legal framework, at the same time preventive and repressive, regulating human interventions in the forest or its periphery (agricultural work, picnic, constructions in the forest...) allows to reduce the risks of fire ignitions.

4.1.2.1 Preventive legislation

Control of human activities

The agricultural, pastoral, or forest activities in the forest or in the vicinity must be controlled, even prohibited when the fire danger is high.

Land use

The cutting of the territory into properties (land register) must be consigned on official documents and be demarcated clearly on the ground, particularly when there are state forests. This allows discouraging any attempt at land appropriation (real estate speculation, clearings for the extension of agricultural zones...). To constraint the scattering of constructions in the forest (dwellings, tourist residences...), it is essential to regulate the use of land, in particular by prohibiting building in zones with a high fire hazard.

Vegetation clearing

Vegetation clearance and including maintenance can be made compulsory in zones with a high fire hazard: around dwellings or constructions, garbage dumps, along roads and tracks, railroad tracks, power lines.

E.g., in Morocco, dwellings, buildings, or building sites located in the forest or at less than 200 m of the forest limit must be surrounded by a fire break of 25 m without vegetation.

4.1.2.2 Repressive legislation

Enforcement aims at deterrence: persons responsible for fire starts must be identified, judged, and convicted. The sentence is variable according to the degree of the responsibility of the culprit and the damage generated: it can go from a fine to prison.

4.1.2.3 Law enforcement

The existence of a legal framework allowing regulating human activities in the forest or its periphery is not enough. In practice, it is necessary that laws are applied, and a control is necessary to take care of this enforcement. It can be carried out by a forestry police (Syria), by forest district guards (Tunisia), or by surveillance teams (committees for vigilance and immediate suppression in Morocco). Even if the repressive legislation envisages sanctions for the persons causing the fire, their application can be a problem:

- The identification of fire causes is difficult; that of the arsonist is even more difficult.
- For an arson fire, the degree of responsibility of an individual must be investigated beyond any doubt: morbid pyromania or deliberated act?
- For an involuntary fire, it is sometimes difficult to judge the degree of responsibility of the arsonist: imprudence or accident?

4.2 Fire prevention: contain the fire spread Principles

The fire ignition proves the failure of the prevention activities. The prevention is defined in this handbook as all preliminary actions carried out to prevent fire occurrence as well as to reduce fire consequences.
There exist two types of prevention approaches:
– Measures preparing fire suppression, such as:
   * Controlling the fire at its initial stage by rapid initial attack; and
   * Containing the spread of the fire which could not be suppressed by initial attack.
   * Pre-suppression measures by fuel management (fuel reduction, fuel break construction).

In practice, these two approaches are closely interdependent. Indeed, the reduction of fire intensity due to fuel modification facilitates the work of the fire crews and increases fire safety.

Identification and Mapping of Fire sensitive areas

a) Identification techniques forest fire-sensitive areas
b) Techniques of sketch making of forest fire-sensitive areas

4.2.1 Identification Techniques of Forest Fire-Sensitive Areas

(1) Definition:

- Forest fire-sensitive areas are areas where elements and factors causing fires are available in a sufficient amount to start fire.

Characteristics of these areas are:

- Availability of potential fuel
- Human activities using fires
- Long drought

(2) Identification

- Forest fire-sensitive areas and the results are drawn in a sketch or a simple map.
- The sketch is used as a base in forest fire prevention plan.
- The checklist below is useful for identification:

Checklist for fire-sensitive areas:

a) Why do fires frequently occur?
b) Where do the fires happen?
c) What activities are done?
d) Where the activities are done?
e) How often the activities are done?
f) What natural factors caused the fires?
g) When do the fires usually happen?
h) What months do dry season usually take place?

To answer these questions, we need a toll; Participatory Rural Appraisal (PRA).
Some PRA techniques are described below:

I. History of Fires

- History of forest fire occurrences in and around the village

Information that can be dig from this history is:

- Chronology of forest fires in recent years
- Story based on facts on causes of fires
- Story based on facts on impacts or losses of forest fires
- Story based on facts on community participation in fire prevention

Steps in discussion:

- Explain about objectives of the process of history making
- Discuss with the participants about forest fires that occurred in their village (in practice/field work interview village elderly)

- Complete the information by asking the causes, the impacts, and how people cope with it during and after the fires
- Ask them to start writing the history in a flip chart
- Write the history chronologically
- Discuss further to dig participants' responds and perceptions

II. Village Transect

- Transect is done by walking through the village following a certain pattern to get information as complete as possible.

The results of observation will be presented in a chart for further discussion.

Output of information:

- Land use pattern
- Land ownership status
- Vegetation
- People activities
- Fires potential

Steps:

- Prepare team to conduct village transect.
- Prepare material and tools.
- Determine transect lines.
- Travel and observe condition along the lines. Interview the local people met during observation.
- Take notes on observation in each location.
- Draw the results.

III. People Mobility map

- This map shows location of people activities and frequency of mobility in their daily life that could influence the emergence of fires.
- This is done by collecting information (direct information or interview) on local people and outsiders' daily activities to estimate the fire sensitivity.

Output of information

- Where do people go to do their activities?
- What kind of activities do people have and how often?

Steps:

- Explain about local people and outsiders' mobility to know where they go.
- In a flip chart, draw position showing where people live.
- People mobility can be drawn with the help from local people.
- Put arrow to show people activity.
    - The number of arrow shows frequency of mobility in a certain activity.

IV. Season calendar

- Season calendar for the purpose of identification of fire sensitive areas is a tool to identify critical periods that facilitate forest fires.
- This calendar can be used to reveal relation between dry seasons and people activities that can trigger danger of fires.

Output of information: people activities from January to December. .
Steps:

- Explain the purpose of this activity.
- Discuss with the participants about dry seasons and fire danger.
- Identify people activities in the dry seasons.
- Ask the participants to draw a season calendar in a flip chart.
- Analyze the calendar (What causes fires? Is there any relation between season and fires? What is possible solution?)
- Write down all problems, potential and information related to fires causes.

4.2.2 Fire detection

It is essential to set up an effective surveillance network which allows reducing the time between the ignition and the detection of the fire. It focuses particularly on all activities which can cause a fire. The surveillance is based on the combination of various observations and detection means; it could be mobile or fixed, terrestrial or aerial. The combination of the surveillance and the first intervention, performed by the same team having terrestrial or adequate aerial support, proves particularly effective for quick intervention on a starting fire during days at very high risk.

4.2.2.1 Fixed observation

It is preferable that the fixed observation is ensured based on specific infrastructures: fire lookout towers. The absence of these installations renders the surveillance more difficult. The tower must be located on open high point with a good visibility on the surrounding area. Their number can be variable, in particular according to the topography which can strongly limit the visibility, but essence is to ensure the best possible surveillance coverage of the territory. These towers must be protected from fire (undergrowth clearing, watering system).
The surveillance quality of a watchtower network depends mainly on three factors:

- The location of the stations;
- The equipment specifications (technical quality and equipment of the stations);
- Rules for safeguarding the network efficiency (quality of the personnel, work specifications).

DESIGN OF AN OPTIMAL NETWORK OF FIXED FIRE WATCHTOWERS

The network of fire watchtowers must allow, for the greatest possible number of fire starts:

– A fast alert;

– An accurate localization of the fire (with a precision of one kilometer).

In order to achieve this:

– The area covered by the network must include the maximum of the zones at risk.

– It is necessary to seek an overlapping coverage of the zones at risk by two or three towers to allow a fast and precise localization of the fire by triangulation.

Study of the environment according to the fire phenomenon

Before any choice of building sites for the fire watchtowers, it is important to study the area in order to be able to delimit the zones to be covered by the network.

The delineation is determined by various considerations:

- Mapping of the fire danger (risk and vulnerabilities), and in particular the ignition risk.
- Analysis of the firefighting constraints (topography, distance to fire centers, forest fire protection equipment, etc.).
- Analysis of alternative means of alarming (fire reporting). An effective vigilance by the population in certain zone (revealed, for example, by the study of filed fire reports) allows accepting a less dense coverage of this zone, especially when this economies on needed investments (villages located at the end of steep-sided valley where the visibility from lookout towers is difficult).

First selection of available installation sites

An inventory of all the points likely to be of an interest is made starting from the topographic map of the zone that has to be covered by the network. After field visits a first ranking is carried out in order to preserve a number of points still higher than that which will have to be finally retained.

Establishment of the zones seen from each selected station

The sight range

For a given zone, it is initially advisable to determine the limit of the visible area, i.e., the acceptable maximum distance for discovering smoke during periods with a high fire danger. This one is a function of:

- Factors related to the fire guard (eye acuteness, experience, state of tiredness, work attention, etc.).
- Atmospheric factors:

  * Fog, urban and domestic smoke as well as dust, which decrease the visibility

* The sun position. The more the observer faces the sun, the more appears the smoke clear to him.

The maximum distance to which a small smoke column can be seen depends more on the clearness contrast between smoke and its background than the colour contrast. Although it is more unpleasant and fatiguing for the human vision to inspect a landscape against the sun, the observation under these conditions is more effective. Other factors affect smoke detection:

- The wind tilts and disperses the fume of starting fires; this complicates the localization;
- The height and the density of the forest cover influence the appearance time of the smoke into the sight of the observer.
- The sight (visibility) range limit will in general be fixed between 20 and 25 km, but can also be reduced to 10 km for zones with bad visibility conditions (fog, clear background, etc.).

Eye level of the observer

It is the height of the observer above ground-level which minimizes blind zones. This height is a primarily function of the height of the lookout tower cabin. In hilly terrain, this height influences little the visibility of more distant zones but can be essential for zones located below the tower.

Mapping of visible and hidden zones

When the tower location and the tower height are determined, it is advisable to determine the observation coverage and blind spots. That can be done by:

- Using a topographic map with contour lines (e.g., maps at a scale of 1:50,000 with contour lines every 10 m):
    * Draw section lines from the tower location (e.g., every six degrees one line, totaling 60);
    * Determine for each section the visibility limits as well as blind spots for the observation from the lookout tower;
    * Draw these limits on a map and interpolate between sections.
- Using a computer and a digital terrain model.

Determination of the optimal network

The contours corresponding to each site considered are compared. The final choice of the installation points for the fire lookout towers is complex and the decision will be the result of a compromise taking into consideration:

- Examples for the coverage for the land under forest fires protection are:
    * 80 to 90 % in very high risk zones
    * 75 to 85 % in high risk zones
    * 50 to 60 % in moderate or low risk zones
- The simultaneous coverage by two or three fire lookout towers.

The use of data processing and a geographical information system (GIS) allows synthesizing the studies carried out for the considered sites. E.g., Turkey has a very important network including 783 fire towers, which meets the requirements of a mountainous topography (forest surface: approximately 20 million hectares).

EQUIPMENT SPECIFICATIONS

Fire lookout types
The choice of the installation type depends on the:

- Needed eye-level height above ground-level for the observer;
- Equipment that the observer uses;
- Possible choice to lodge the guard on the spot;
- Available budget.

Three types of possible stations of watchtower are enumerated below:

- Caravan. Bad visibility - Possibility of lodging the observer
- Pylon with platform at the top. Good visibility
- Good possible equipment if the platform is large and roofed - Possibility of placing the observer in installations annexes
- Solid tower. Good visibility - Good possible equipment - Possibility of lodging the observer - High cost.

Certain constructions have a double utility. E.g., in Syria, the bottom of the tower is reserved for the forest police, which control illegal activities and the top for fire detection. The fire protection operational centers also have a lookout room on the highest floor of the building.

Tower equipment
The observers can have the following localization and detection equipment:

- Maps indicating visible and hidden zones;
- Binoculars;
- Instruments to measure the azimuth (compass, alidade, etc.) allowing locating the fire location.

It is obligatory that each tower is equipped with communication tools (radio or telephone) in order to transmit quickly any fire occurrence to the fire management centre.

SURVEILLANCE RULES

Mobilization
First of all, the fire surveillance must be assured during the period with the highest risk (e.g., three months in France, seven months on Cyprus); for zones with a high fire risk outside the general fire season, it can be judicious to operate some towers all year long (e.g., Turkey). The duration of a surveillance day depends on the available human and material resources and the temporal distribution of the fire

occurrence. The surveillance can be carried out in day time or 24 hours a day, but the night visibility is much reduced.

Organization

The personnel of the lookout towers consist of two to three people working in shifts. In some cases, the tower provides lodging to ensure permanence. The surveillance can be ensured in two different ways but which can be complementary by personnel having:

- A very good knowledge of the area, able to locate very precisely smoke without having recourse to sophisticated hardware (nevertheless binoculars are strongly recommended);
- The localization and detection equipment described above.

4.2.2.2 Terrestrial mobile observation

A terrestrial mobile observation supplements usefully the surveillance from fixed lookouts. They are patrols on foot, bicycle, horse, or vehicle. Their role is the fire detection, education of the public, control of human activities which can increase the fire risk, enforcement, and dissuasion. The patrols have a radio to inform the responsible organization. In the case of equipped patrols, the patrols carry tools for a first intervention (water tanks, motor-driven pumps, etc.). The effectiveness of the initial attack depends not only on early detection, but also of the quality of the alarm message. The patrols are more effective than untrained volunteers if its personnel are professional and have a basic knowledge of fire behavior. The alarm message then has much more of detailed information (slope, vegetation, smoke column, necessary firefighting equipment, etc.).

4.2.2.3 Aerial observation

There exist two types of surveillance using aerial platforms:

– **Aerial reconnaissance.** The airplane has only the task of detecting fires and to alert the firefight services;

– **Aerial reconnaissance with water tanks**. The planes have a water tank and combine surveillance and initial attack. These reconnaissance planes (e.g., Tracker S2F) are equipped with a small water tank and able to intervene directly on the fire immediately after detection. This type of surveillance remains little developed in the Mediterranean basin. The reserves come from the inherent cost of this detection system. The armed aerial reconnaissance is nevertheless very useful for the zones that are not accessible on the ground.

Automated systems

This type of surveillance, thanks to the development of new technologies, starts to develop. It is used either in backing up the fire lookouts or in an autonomous way.
There are three principal types of hardware:

– **“Visible” cameras**: The reception of images is carried out by a camera operating in the visible spectrum.
The images are transmitted to the observation post. The fire detection is made on a screen by an observer or automatic image comparison. The disadvantage is that this hardware can be used only day light.
– **Video sensors**: The system is composed of several CCD video cameras and a central processing unit able to identify the “signature” of the smoke of forest fire. At night or day, it provides the functions of smoke detection on an area of approximately 3 000 ha and rapid information transfer to one or more control stations.
– **Infrared sensors**: A sensor operates in the thermal infra-red field (wavelength from 10 to 12.5 mm).
The detection is made by automatic image comparison. These sensors have the advantage of being usable during the night, but the costs of installation are high. All these apparatuses function only in direct aiming. The often irregular topography of the edges of the Mediterranean basin forces to multiply the sensors if one wants to cover the territory correctly.

4.2.2.4 Intervention of the population

The participation of the population in the fire detection can be of a great help. A toll free phone number is at the disposal of the public linked directly to the forest fire management centers, the forest services or the police.

4.2.2.5 Fire localization

The people informing the fire services of a fire start must specify the fire localization as precisely as possible. The use of a co-ordinate system by the responsible authorities allows to synthesize the localization in the form of a code and to be avoiding vague descriptions.

4.3 Localized Undergrowth clearing/ Fire safety strips;

4.3.1 Along roads

The strips along public roads are cleared of vegetation:

- To secure transit.
- To avoid the start of a fire («anti-cigarette strips »).

If maintenance is insufficient and regrowth of the herbaceous layer develops the functioning of safety strips decreases.
The objectives of clearing safety strips along roads and forest fire protection roads include:

- To maintain safety conditions sufficient for the traffic of firefighting vehicles and surveillance. The width of cleared ground depends on the vegetation height, and it is at least 5 m on both sides of the road
- To establish intervention zones in the case of a fire occurrence. The minimal width of the strips cleared of vegetation is then 25 m on both sides of the way.
- Taking into account the topographic conditions and wind pattern of the site, undergrowth clearing can be asymmetrical. For example, the width cleared of undergrowth must be larger on side of the prevailing wind or below a road located on a slope.

4.3.2. Around dwellings

Dwellings in the forest represent a double risk:

- They constitute potential sources for a fire start (cooking fires, barbecues, burning of wood debris from undergrowth clearing, garden fires, etc.);
- When a fire occurs in a forest, they can be directly threatened.

To protect dwellings, it is necessary to clear the undergrowth in their neighborhood. This instruction also applies to industrial areas, very sensitive to fires, as well as to recreational areas (campsites, picnic areas, etc.). The scattering of dwellings within the forest constitutes an important problem, even when ground clearance is carried out correctly. It indeed causes the dispersion of fire fighting means which prioritize the protection of human lives and their values at the costs of the forest. Moreover, the access roads to these dwellings are often dead ends, and the entrance and the exit road can be cut by the fire.

4.3.3. Forest-agricultural interface

The agricultural activities in the forest periphery constitute a potential ignition source (debris and field burning, etc.). It is thus necessary to limit the risk of a fire spread towards the forest and to reduce the combustible biomass in periphery of the forests. E.g., on Cyprus, at the beginning of June, strips of 30 to 50 m width are burned at the forest edge and then with the crusher to clear the ground.

4.3.4. Other important zones

Garbage dumps, power lines, and railroad tracks also constitute potential fire sources. It is thus advised to create a zone cleared of undergrowth near these installations, when close to a forest.
E.g., in Morocco, the National Electricity Company must ensure ground clearance under power lines and the National Railroad Company has the same obligation along their railway tracks.

4.4 Spatial Planning

The creation of large-scale spatial discontinuity of fuel complexes combining undergrowth clearance, forestry activities, and agricultural or pastoral activities (fuel breaks and fire breaks) aims at the establishment of:

- Firefighting support zones;
- Prepared fire lines, where fires can be more easily contained.

These discontinuities can be installed in the forest periphery (at the forest / urban interface) or inside the forest.
These discontinuities allow stopping low- and medium-intensity fires. However, high-intensity fires may jump over these fire protection belts. Strong winds reduce the effectiveness of these discontinuities because flying embers carried by the wind easily cross over (spotting) and light a second fire (spot f re) on the other side.

4.4.1 Firebreaks

Firebreaks in a strict sense are linear discontinuities where the vegetation is absent or reduced to a low herbaceous layer. These breaks must be located at forest / urban interfaces or on ridges for a better effectiveness. They are built with the bulldozer or by hand and must have a minimal width of 20 m to allow transport and intervention of fire crews, while ensuring their safety. These discontinuities have nevertheless disadvantages:

- They are easily jumped over by a fire. Their width is very insufficient to prevent that a fire does not spot beyond the break.
- They require a very regular maintenance at 1- to 4-year intervals to control or even to eliminate the vegetation by hand, bulldozers, or phytocides (herbicides).
- They are very sensitive to erosion, especially when slopes are steep because of absence or reduction of vegetation. The maintenance techniques accentuate this.
- The absence of wind breaking vegetation increases the fire acceleration by winds.
- They have a negative landscape impact.

4.4.2. Fuel breaks

The objective of fuel breaks is to create a discontinuity of the vegetation cover, to decrease the fire intensity, and to allow the direct attack by fire crews.

4.4.3. Fuel breaks with a tree cover

With a minimal width of 100 m, the purpose of breaks with a tree cover is to limit the fire spread by reducing the contact between plants, while creating:

– Horizontal discontinuity: separating trees by thinning, elimination of the under storey by undergrowth clearing.

– Vertical discontinuity: suppression of the interface crown/ under storey by pruning and undergrowth clearing. With a reduced tree cover density the vegetation re-growth is rapid and therefore the maintenance must be regular. Certain compartmentalization is done with different intensities:

- A centre area being the privileged fuel treatment zone.
- The boundary area, contiguous with the centre area, which is a zone simply grazed by animals without special labour activities.
- It is a part of an improved forest fire control by fuel load reduction at the edges of the firebreak.

4.4.4. Agricultural breaks (greenbelts)

The creation of spatial discontinuities can also be a result of agricultural land use (e.g., vineyards, orchards, olive groves, etc.), which, if they are regularly maintained, constitute obstacles for fire spread. The limits between agricultural land (slope, ditches, etc.) must be cleared of undergrowth in order not to function as "igniter cords" allowing the fire passage.

4.5. Fuel reduction techniques

The choice of the fuel reduction technique depends on the state of general conditions of the vegetation and its natural environment:

- First opening (severance cutting) or maintenance.
- Vegetation type and density.
- Topography and terrain type.

Two phases of fuel removal can be distinguished:

– The initial operation (opening of the vegetation): This is often an expensive operation because the fuel load can be high.

– Thereafter, undergrowth clearance for maintenance intended to limit the re-growth of the vegetation. This work must be carried out regularly, with a frequency varying in function of the vegetation density and the applied technique. This operation is less expensive per treatment, taking into account the slower plant growth but it requires a continuous budgeting. When the fuel load is high, for example, at the initial opening, it is advisable to carry out a manual or mechanical undergrowth clearing, or to use prescribed burning. If the fuel load is low, other techniques can be applied: herbicides or silvo-pastoralism.

The various techniques of undergrowth clearing are described below. They can be combined with, for example, a mechanical opening followed by silvo-pastoral maintenance. The periodicity of the treatments depends on the speed of vegetation re-growth, management objectives (tolerated maximum biomass loads), and financial capacities. For each technique a short description and a comparison of advantages and disadvantages is presented below.

4.5.1. Manual undergrowth clearing

Hardware: hand-tools (brush hook) or with an engine (tree dozer, slicer)
Periodicity of treatments: every 3 to 4 years
Advantages:

- Quality work that allows selectivity and thus the protection of regeneration.
- Low impact method, if it is used on a regular basis.
- Can be used under difficult topographic conditions and on very stony soils.

Plants that are less flammable can be favored at the expense of flammable species.
Disadvantages:

- Poor yield especially under difficult conditions.
- High costs if hand labour is expensive.
- Debris must be burned or crushed.

This technique is favored by countries where hand labour costs are relatively low.

4.5.2. Mechanical ground clearing

Hardware: modified / converted farm tractors or public work machines
Periodicity of interventions: every 3 to 4 years
Advantages:

- Rapidity.
- Advantageous cost/benefit t relation in easily accessible terrain.

Disadvantages:

- The equipment requires high investments and its maintenance is costly.
- The environmental conditions (topography, soil type, tree density) can be an obstacle for using the equipment.
- The heavy equipment has a negative impact on the soil by compaction; nevertheless an impact is limited on cleared zones, representing only a small percentage of the forested area.
- The de-rooting exposes the bare soil causing erosion on steep slopes.
- The debris must be burned or crushed/ shredded.
- Coppicing species which are usually very flammable are favored.

4.5.3. Chemical fuel reduction

Undergrowth clearing can be carried out by spraying herbicides or growth inhibitors. The use of these chemicals is an interesting alternative for areas where a mechanical maintenance is not possible (steep slopes, rocky terrain, etc.). Furthermore, when only limited funds are available for a too costly mechanical clearing. The applied substances function in general systemic, since they penetrate primarily by the foliage or the root systems and are transferred systemically (transported by the sap) to other parts of the plant. They have a persistence varying from a few hours (e.g., glyphosate) to a few months (hexazinone).
According to their nature, they contribute to:

– **Selective destruction of flammable species** with a progressive death of plants such as grass, weeds, semi-woody and woody plants. This destruction (to be practiced outside the season with a high fire danger) imposes a pruning of the trees parts above ground before summer. This intervention is interesting for perennial vegetation since it prevents any sprouting. Follow-up costs for maintenance are reduced. Moreover, the killing of the plant while letting untouched the root system protects still the soil against erosion.

– **Growth depression of the vegetation** with a temporary reduction of the woody increment and the foliar development, inhibition of germination or destruction of seeds in the course of germination. This reduces the fuel load (products classified under growth depressant substances or sprout inhibitors). Prior to use of these chemical substances in forest fire protection, it is advisable to consult all legal restrictions. Judicious combinations of products and mode of application will allow to:

- Find technical solutions adapted to the conditions: selection of the product according to the objective and the conditions for application;
- Treat any terrain: substances chosen according to the accessibility and the surface of the area to be treated;
- Apply quickly the treatment: use of the more adapted substances.

4.5.4. Intervention type

a) Prescribed burning

This technique uses fire to eliminate and contain the vegetation in a confined area. It remains generally little developed in the Mediterranean basin, except:

- In France where 3,000 ha were cleared of undergrowth in this way in 1999.
- In Portugal where this method was very much used in the years 1980 (more than 2,000 ha of maritime pine stands were treated in the area of Minho) and, after a period of less demand, a renewed interest is currently experienced.

Obstacles for the application of this technique are:

- The psychological reservation caused by the simple fear of fire or fear of the effects on forest stands.
- Lack of specific training in prescribed burning in some countries.
- Problems of legal liability in the event of an accident (fire escape). Prescribed fire can be can be used for periodic fuel reduction as well as for first undergrowth clearing, even when the fuel load is high. It is the case, for example, for vegetation openings:
- For pasture management in different types of heather formations.

Periodicity of interventions: every 3 to 4 years

Advantages:

– No topographical restrictions.
– Efficient on woody vegetation.
– Reduction of fine and medium fuels.
– Eliminates dead ground fuel (e.g., pine needles).

Disadvantages:

– Requires specialists.
– Surveillance obligatory.
– Negative impact on young plants or trees with a fine bark, except when a thermal thinning is required.
– Climatic conditions have to be considered

HOW TO USE PRESCRIBED BURNING?

Conditions for application

Prescribed burning requires the selection of weather conditions and fuel moisture adapted to the burn site topography, vegetation characteristics, and planned type of fire control in order to prevent a fire escape outside the defined zone and to protect, when existing, the tree canopy. For example:

- On a slope with eastern aspect an east wind results in a down-slope fire against the wind.
- Under a tree canopy, a strong wind will often be preferred for keeping down the hot plume of a fire backing into the wind and to support its dispersion and to prevent that the smoke column does stagnate too long within tree crowns.
-

Site preparation

During a prescribed burning the fire must be contained within a well defined area. It is thus necessary to delimit the perimeter of the burn site:

– Either by existing barriers (road, creek, cultivation, rock zone, etc.)
– Or by artificial barriers created especially through undergrowth clearance or ground cleaning, and whose width is related to:
* Position of the barrier.
* Topography, vegetation, weather conditions, fire control fire envisaged.

E.g., for a prescribed down slope back fire (against the wind and top down) it is sufficient to rake a litter free strip of 50 cm as a control fire line.
It is also advisable for limiting the physiological damage on stems as well as on the landscape, to protect the tree bottom, in particular those trees with a fine bark, by using one of the following methods:
– The protection most commonly sufficiently to keep the flames far from the stem. The width of this raking is at least 50 cm but can reach 3 m downhill of the tree foot; in the event of a high intensity fire, the upslope directed flame is more destructive.
– It is also an option to humidify the trunk (by possibly adding a foaming product) using a backpack pump when the fire is not very intense, or with a water lance in the case of an intensive fire. Before ignition, it is essential to check the control lines. The weak points are to be supervised particularly.

Fire control… some examples
Down slope fire against wind: because of safety measures, the burning is generally led against natural fire dynamics: the ignition starts on the highest point and against the wind.

Strip fire on successive strips along contour lines:
The fire is lit on successive strips (from top to bottom) following contour lines. This technique allows to burn larger areas, but the fire intensity is increased, which requires the creation of adapted barriers.

THE DRIP TORCH

Designed in the USA and imported from North America (the European market is still too narrow), the drip torches are the essential tool of a perfect fire control. The drip torch has a fuel capacity of 5.7 l, a seamless aluminum fount, a double bottom and a full length handle, a fuel trap on spout and check valve in cover prevent flashback into fount. This equipment, used for a long time, is highly reliable and robust. Only the spout is clogged after long use. Indicated to function with kerosene in North America, the torches have been used in Europe without incident for 15 years with a mixture of gasoline 30-50 % and diesel to 70-50 %, mix rate: 1/3 gasoline - 2/3 diesel is most convenient, most usual and the least expensive. When using the gasoline/diesel mixture, it is advisable to be vigilant, and:
– Always to fill fully the drip torch tank or to open it far from any fire source: burning in progress, hot ashes, or a burning cigarette.
– To make sure before and after use that the lid is correctly closed.
– To protect the torch from any radiation exposure of dynamic fires and the sun (particularly spring to autumn) in order to avoid the piston effect caused by gas dilation in the container.

b) Silvo-pastoralism

The silvo-pastoralism uses forest areas for cattle rising. In many countries, it is a technique usually used by the local population. However, if it is not controlled, the pasture becomes the enemy of the forest by damaging the regeneration and frictions on the tree stems... On the other hand, this activity, if it is well managed, can be of a great effectiveness in the maintenance of forest areas.

This is controlled pasture because the pasture zones and range are well defined and limited. The silvo-pastoralism introduced for forest fire protection can only succeed if the forest areas which are to be maintained are well integrated within all available pastoral resources of the stockbreeder. He/she will always prefer the health and the correct feeding of his/her herd to actions of undergrowth clearance. Thus, it is necessary to integrate the zones for undergrowth clearance in the stockbreeder's breeding system, based on baseline studies, and not to start *a priori* with a zone definition that are to be maintain, hoping that the stockbreeder accepts heavy constraints modifying and disturbing his/her pre-existent system breeding. The controlled pasture with heavy animals can be used for an initial undergrowth clearance, but only combined with other forage zones in fuel breaks and some environments.

Advantages

– Control of the vegetation.

– Management of existing resource.

– Revalorization of breeding and abandoned landscapes in some countries.

– Maintaining of human activity in the forest.

Disadvantages

– Requires a protection of the regeneration against browsing.

– Irregularity of resources: food complements are sometimes necessary (e.g., pastoral improvements by sowing).

– Necessity to eliminate plants refused by animals.

– Negative environmental impact:

* Soil settlement, especially in the case of heavy animals.
* Erosion risk when the pressure of the animals is too strong.

c) ***Combination of methods***

The various methods can be used successively to improve the effectiveness of undergrowth clearance. Two combinations for the opening then maintenance of the fuel breaks with a tree cover are presented below.

Mechanical undergrowth clearance and controlled pasture

The opening of the environment is carried out by a mechanical undergrowth clearance, accompanied, if possible, by stump removal. The controlled pasture limits then the re-growth of the vegetation regularly browsed.

A pastoral improvement (e.g., by sowing without further site preparation) constitutes a food enrichment for the animals. A manual undergrowth clearance eliminates the plants refused by the cattle. This combination allows reducing the frequency of interventions.

Prescribed burning and controlled pasture
The environment is opened by burning, and then maintained by animals, intensive pasture at the beginning of the summer season. The refused plants also can be eliminated by burning.

4.6 Preventive Silviculture

The objective of a preventive silviculture is to obtain a composition and a structure of forest stands with the objective to:

- reduce the fire spread and fire intensity;
- Limit the tree damage caused by the fire passage.

These two objectives are closely interdependent. All measures aiming at reducing the fire intensity try to limit the damage caused to trees. If the fire remains a surface fire and does not turn into a crown fire, the crowns will be less affected and chances of survival increase for a greater number of trees in the stand.
There are only a few studies on preventive silviculture in Mediterranean forests. Forest management has to cope with a low profitability of forest stands and strongly depends

- on available financial means;
- on revenues and products which can be drawn from the forest.

In this context, only a few examples for preventive silviculture will be presented.

4.6.1. What types of forest stands?

The stand characteristics with a potential effect on fire sensitivity are:

- Structure: existence of vertical or horizontal discontinuities.
- Canopy density, directly and by its action on the vegetation of the lower layers.
- Species.

4.6.2. Structural discontinuity

Breaking the continuity between surface (ground) and crown
The presence of a single tree layer, isolated from the ground, without intermediate layers, avoids the fire spread from the surface to the crown layer. Suppressed or sick trees and low tree branches can be eliminated by thinning and pruning.

Mosaic of different stands

A mosaic (1 to 5 ha) of even-aged stands and different species, by creating ruptures inside the forest (spatial discontinuity), seems to be the most appropriate way to limit the vulnerability of large forests to the fire passage. These mosaic stands must have a sufficient depth so that the fire will lose power when entering. The minimal size of a mosaic is a function of topography and stand type. For instance, coppice forests with their dense clumps and the consequences of the selection management system (uneven-age management) develop characteristics of multiple-layered vegetation formations that support the spread of wild fires. In order to decrease the risks of fire spread, a vigorous coppice forest can be converted into a stand on stocks (standards): for each clump, one preserves only one or two maiden. This conversion requires frequent interventions however to limit shoots and sucker branches.

4.6.3. Canopy density

A thick and shady forest canopy:

– Reduces fire spread in the low layers by:

* Limitation of the vegetation desiccation and acceleration of the decomposition of organic matter due to aerial moisture increase in the under storey (moist microclimate).

* Reduction of the shrubby fuels and better natural pruning because of a photosynthesis reduction below the canopy level.

– Supports the fire spread in the crown layer.

The creation and the maintenance of a dense canopy allow limiting the intensity of surface fires but increase the risk of crown fires. To avoid the development of a mass fire, the effect of a dense canopy therefore must be supported by a cleared under storey. A dense canopy is obtained by:

– The choice of Mediterranean species having dense foliage. In fact, the quality of the foliage of a species depends on the soil fertility on which it grows. The Aleppo pine, whose foliage is generally light, has dense foliage which covers the ground well when it is growing on a fertile soil. The umbrella pine generally has dense foliage, but it requires fertile soils.

– A dynamic silviculture with sufficiently strong thinning, with a canopy being closed again by the development and closure of crowns. A dense canopy should not be synonymous with badly cleared up tight stands and strong density, with many trees suppressed and dying. With the beginning of the stand regeneration the young regeneration favors the spread of fires. In order to avoid the loss of regenerated areas by fire it is recommended to increase the rotation cycle of the over storey seed trees.

The tree density must be higher at the forest edge that is exposed to strong winds in order to form a windshield. Stands with a dense canopy cannot be obtained everywhere in the Mediterranean basin. On the one hand the environmental conditions have to be favorable (sufficient fertility), on the other hand it has to be compatible with the forest management objectives and the financial means. In the particular case of fire and fuel breaks, the recommended tree density is much lower (not "touching" crowns) to avoid the fire spread between crowns, as well as allowing the movement and interventions of fire crews. This opening of forest stands supports the vegetation development on the ground. The operations for undergrowth clearance must be much more frequent.

4.6.4. Species composition

With regard to the fire spread the species composition plays a much less important role than the structure.

Diversity: The species mixture allows reducing the sensitivity of a forest to fire. It is necessary to choose species which have the same growth characteristics in order to avoid the formation of several arborescent layers creating a vertical continuity.

Species with strong juvenile growth: They ensure a fast reconstitution of the canopy; therefore limit the vegetation development on the ground. They are moreover very competitive compared to the shrubby vegetation.

Less flammable species and less fuel:. They must be favored at the time of forestry interventions in the existing stands like during aforestation (cf. table below).

Species resisting the fire passage: Stands made up of trees with a sufficiently thick bark will resist better to surface fires which will have only a low or average intensity. The cork oak is particularly resistant, except when it was harvested recently.

4.6.5. Silvicultural operations

THINNING

In the specific context of forest fire protection, the principal objective of thinning is the reduction of fuel loads; sometimes the secondary objective is the improvement of wood production.

Nature: Preventive thinning is first of all selective: the suppressed trees are removed, and, in certain cases elite trees for production are selected. It can be also sanitary when it allows the elimination of dying trees.

Type: A vigorous crown thinning is conducted:

– If the remaining stems will respond to the thinning operation by developing their crowns, thus quickly reconstituting the canopy;

– In the case of a fuel break, where the objective is to obtain a distance between crowns. In the contrary case, a low thinning allows to eliminate the overtopped trees. The choice of selecting the individual trees to be preserved can be made in accordance with the objective of production objectives (plus trees) and forest mechanization (alignments to allow the passage of machines for maintenance and harvest). However, the remaining lines of trees constitute an "ignition cord" for the fire spread.

Intensity: The thinning intensity can be strong if the fast reconstitution of the canopy is possible. For fuel break construction and maintenance the intensity of thinning must create sufficient space between the individual trees.

Periodicity: It is variable according to the species, but generally, the thinning is made every 10 to 15 years, when the stands are 20 to 30 years old. Ideally the rotation (time between two interventions) is reduced in order to intervene more frequently but less intense. However, that is often not always economic, taking into account the low profitability of forest stands.

CLEANING

Cleaning aims to reduce the density of the stems in a regeneration area in favor of residual tree support. Except in the case of a fuel break, it must carry out in a moderate way because it supports the development of under storey.

PRUNING

This operation consists in cutting the lower tree branches with the following objectives:

- In the case of forest fire protection, it is especially important to create a discontinuity between the upper tree canopy and the lower layers. All trees must be pruned up to a height of two meters. In general this measure is expensive.
- Improvement of the accessibility of the stands.
- In a production forest the pruning improves the wood quality by eliminating the nodes.

SLASH MANAGEMENT

Accumulated thinning and pruning slash supports fire spread and intensity and therefore must be eliminated by chipping or other means.

5. INFRASTRUCTURES FOR FIRE FIGHTING SUPPORT

The objectives for construction of infrastructures for fire suppression include:

- Facilitate access for fire crews in order to reduce the travel time to reach the fire (access roads).
- Facilitate the intervention of fire crews (firefighting support zones, water points).

The design and construction of these infrastructures must provide working conditions for rescue squads with a maximum of safety.
Access roads can also be used for surveillance (patrols, some with slip-on tank units).

5.1 Access roads

Fire fighting vehicles use the entire accessible road system to reach a fire, to position themselves on strategic points, or to supply water: road network, gravel and dirt roads for different use (forest fire protection, public circulation, forestry development, etc.).
The roads fulfill the following functions:

– Allow the movement of fire engines (fast access to fire and water supply).
– Secure in some cases protected zones where fire crews can fight fires.
– Assure the circulation of surveillance patrols within a forest fire protection program.

ROAD NETWORK
The road network must be cleared of undergrowth along the sections located near forests
Tracks
Tracks are very important for forest fire protection. Connected to the road network, they must allow movements and the fight inside a forest or in its periphery and that with full safety. One distinguishes various types of tracks, according to their principal function:
– Transit ways and access ways to the forest. They are primary forest roads allowing vehicles with full water load to access quickly the important zones of the forested area.
– Their infrastructure must allow fast movement of the fire engines: moderated slope, low banking, and sufficient width to allow the passing of vehicles or passing zones in a sufficient number and regularly spaced, places of reversal.
– They are flanked on both sides with a strip cleared of undergrowth ensuring the safety of the traffic.
– Fire lines that allow fighting against a fire of moderate intensity.
* They are more extensively management than transit ways.

* Nevertheless, the undergrowth clearance of fire strips must be carefully planned and carried out.

– Secondary roads (tracks) allow approaching an initiating fire or a low intensity fire.

* Their length must be less than 1,000 m. They can be opened by bulldozers.
* They are bordered on each side by security strips cleared of undergrowth. Dead end roads are to be avoided in order to ensure the evacuation of crews under all circumstances.

Any dead end must be indicated and must have a turning platform cleared of vegetation.
Many tracks have multiple uses: forestry development, linking roads between villages, access to dwellings, tourism. This multi-functionality increases the fire risk related to human activities in the forest. To limit the visiting of forests, certain tracks located in sensitive zones can be prohibited for public access during the fire season, even all year long.

ESTABLISHMENT OF TRACK NETWORKS
Two essential elements have to be taken into consideration for road construction:
– Topography;
– Fire scenarios.
In flat terrain, the road network can form a regular squaring. In relief zones, roads will be built according to the diagram below. In certain cases the establishment of a track network can also take into account the landscape constraints.

Network density
There is not standard for the road density. This depends on the fire sensitivity of the zone, the values at-risk, but also of financial constraints, because the building of any infrastructure is expensive.

5.2. Support zones – defense lines prepared in advance

Localized undergrowth clearances (for example along tracks) or on large areas (fuel breaks) represent essential fire fighting support zones since the fuel load is here much lower.

I. Spatial compartmentalization

Within large forested or otherwise vegetated areas spatial discontinuities must be created by fire breaks or fuel breaks to provide secure support zones for fire attack

II. Reinforcement of fire fighting zones

Certain tracks used for firefighting and completely cleared of undergrowth on both sides can be reinforced by a second line of attack. It could be, for example, a secondary road located on the windward side, building a first shield against the fire.

III. In Advance Prepared Fire lines

An in advance prepared fire line (IAPFL) allows to create a containment line by concentrating fire fighting means along access lines (road or track) ahead of the fire front, with the aim of stopping the fire spread on this line or at least breaking up the f re in smaller fires.

Establishment

To stop large fire fronts, the (IAPFL) must build a connection between other strategic areas impassable for fire: rocks, water surfaces, other IAPFL. The establishment of this infrastructure on ridges is aimed to slow down fire spread and intensity in these sectors. The choice of mountain ridges on which these defense lines will be constructed is based on fire scenarios and strategic options for fire fighting.

Elements of the IAPFL

The circulation track is a traffic axis along which fighting means will be concentrated. It is selected according to the topographical and the meteorological characteristics of the sector.

The width of undergrowth clearance on both sides of the circulation track is defined:

- According to the nature of the vegetation and the topography of the sector,
- As an operational minimum allowing fire fight from the track, and so that personnel and equipment are never directly exposed directly to fire radiation.
- The minimum width is 100 meters.

The maintenance of a tree canopy aims to create a barrier in order to limit the chances of fire spotting and to "slow down" winds on the IAPFL. Moreover, it allows a better integration of the defense line into the typical landscape characteristics

Water supply is secured by setting up closed metal cisterns with a capacity of 30 m3 along the road approximately every 700 to 1,000 meters.

Vegetation free strips create a complete fuel break between the vegetation and the IAPFL area. These will facilitate the maintenance of the zone in which undergrowth is cleared with prescribed fires and which could possibly be used as back fire line.

Access to the IAPFL

The last success factor of the containment line is the possibility of concentrating rapidly and in full safety all types of fire engines. It is thus necessary to have a coherent strategic road network that takes into consideration fire fighting plans by:

– integrating any existing road axis (main road, secondary road, communal road, track), if required to be supplemented by new tracks,

– managing safety of personnel and equipment (cf. chapter on roads and tracks).

5.3 Water points

Since the water storage capacities of fire engines is limited, it is necessary to include the use of artificial or natural water resources. These water resources must be distributed in a sufficient number to reduce transport distances.

WATER RESERVOIRS

These are large water bodies, e.g., natural (lakes) or artificial (water reservoirs). They must be arranged locally to allow the operation of fire engines on the ground and are very useful for the supply of air tankers.

Air tankers (scooping planes) require a minimum water surface of 2,000 m length, 100 m width, and 2 m depth.

CISTERNS

Fixed cisterns: are built of concrete or metal, can be constructed underground or on the ground. In general cisterns, with a varying capacity of 10 to 150 m3, are fed naturally (spring water, rainwater collected with an *impluvium*, etc.) or artificially. The charging of fire engines must be carried out using motor-driven pumps or by benefiting from the topography to give sufficient pressure to the water. Some cisterns can be especially equipped for the supply of helicopters, for example, using a trap door on the cistern's top for the supply by aspiration.

Mobile cisterns: have a much lower capacity than fixed cisterns; these cisterns, constructed of metal or sometimes of impermeable fabric, have the advantage to bring the water point close to the fire fighting zone. Swimming pools can be used locally by the fire fighting services to refill water tanker and by owners to protect their dwelling.

E.g., in Turkey, some hotels use the swimming pool water and a motor-driven pump to protect the establishment in the event of a fire.

POTABLE WATER SUPPLY NETWORK

The potable water supply network can be used by fire engines via fire hydrants, which have the advantage of providing water under pressure. When several water tankers are supplied, the pressure strongly decreases.

In Syria, the water tower providing drinking water to the village is generally located close to the fire protection centre.

CISTERN NETWORK DENSITY

The number and site of cisterns depend on the fire hazard, topography, cistern size, the capacities of available vehicles, and the distance to the next water point. A cistern of 60 m3 every 4 km road seems sufficient. Along a fuel break, one cistern every 1 to 2 km is calculated.

MAINTENANCE
The water points must be regularly controlled (filling, operation, access), each week in a period of high risk, and a report of state must be sent to the responsible services (forester, firemen).

5.4. Water sprayers

Water sprayers create a cloud of fine water droplets which limit the fire spread. The cloud of small water particles attenuates the heat radiation emitted by the fire and reduces the temperature. Consequently the heat-generated drying process and pyrolysis are reduced in front of the fire. Fine water droplets can be generated by fixed or mobile metal pipes; fire engines with sprayer guns, special nozzles connected to hoses and pressurized hand-held fire extinguishers. This technique can also be used as a prevention measure in order to reduce the fire ignition risk when climatic conditions increase the fire danger.

6. LAND MANAGEMENT PLAN

All activities in establishing infrastructures to support fire forecasting, prevention and fire fighting, will inevitably lead to failure if not properly planned. A Regional Fire Management Plan is a document for a specific forest that:

- Defines and plans actions and infrastructures required to meet the fire fighting strategy and the particular requirements of the forest owner;
- Assures coherence between these activities and the general management plan of the territory.
- The regional fire management plan is based on the analysis of the variables of the natural environment (climate, topography, vegetation) and anthropogenic components (settlements, attitudes, stereotypical behavior, land use).

6.1 Delimitation of the intervention perimeter

Since the fire risk in a forest does not know administrative boundaries, it is necessary to define a risk zone, i.e., a continuous zone inside which the phenomenon fire must be studied in order to apprehend its physical dimension.
The risk zone will be easy to delimit in an area having average forest coverage of less than 40% where forest areas are generally well separated from each other. In the contrary case, various methods can be used to establish risk zones.

– Search for almost insurmountable obstacles by analyzing historic fire events and weather data on the dominant wind direction (sometimes it is possible to find obstacles that a fire did never cross over or has very low chances to ever cross).
– Increase the study area to avoid the phenomenon of artificial boundaries.

6.2. Collaboration

The need to harmonize activities within a defined risk zone implies that various stakeholders collaborate for the elaboration of a fire management master plan. The dialogue between the administration, forest fire protection organizations, and forest users is essential to establish an optimal fire protection plan of the zone at risk; often this will be based on compromises.

6.3. Elaboration of a fire management plan

ANALYSIS OF THE STUDY ZONE

A fire management plan for the territory requires a good knowledge of the environment and an analysis of its ecological (climate, relief, type of vegetation...) and socio-economic (uses of the forest, occupation of the ground, etc.) components. The study of historic fires allows determining the forest fires risk.

FIRE SCENARIOS

Taking into account the results of the analysis, scenarios are given by defining the most probable causes of ignition and characteristics of fire propagation. To model these scenarios, it is essential to feed in practical knowledge, i.e., real fire situations experienced by fire crews during past fire events. The fire rate of spread can be estimated with the help of fire propagation models.

PROPOSAL FOR PREVENTIVE ACTIONS

For each scenario, it is necessary to propose various actions allowing to:

- Reduce the ignition risk.
- Limit the burned area.
- Limit the damage caused by f res.

These various actions may include:

- Sensitizing of the population and its participation in preventive activities in the forest.
- Installation of preventive infrastructures (lookout towers, tracks, water points, fuel breaks, etc.).
- Interventions in forest stand (undergrowth clearing and other forest operations, etc.).

SYNTHESIS

Based on different scenarios and selected preventive actions, the best compromise has to be found, ensuring the coherence and the effectiveness of prevention system. This choice is of course strongly dependent on financial constraints.

6.4. Implementation of the study

When the final document is completed and approved, it is necessary to implement the proposals formulated in the study, i.e.:

- To plan the actions and the work envisaged.
- To allocate the financial means.
- To execute the actions and to build the infrastructure in the field; to maintain this infrastructure.

It is also important to question certain elements of the infrastructure plan in order to take account of new situations. In particular, after a fire in the zone, it is recommended to take advantage of the experiences gained and to improve the infrastructure for forest fire protection. This experience feedback is done in consultation with the actors and the witnesses of the fire.

7. FIRE FIGHTING/SUPPRESION

Introduction

The ignition of a human-caused fire marks the failure of the prevention activities. The fire fighting capacities, organized beforehand for the forecast, must then be put into action. The quality of the forecast system is determining for the success of the suppression operations. The reaction to the fire depends on the importance of the fire. The number of deployed forces increases with the size and the virulence of the fire.

– The firefighters can be of very diverse origin: professional firefighters, foresters, volunteers, rural population. The quality and training of the personnel is a significant success factor for forest fire suppression.

– The firefighting equipment is much diversified: at an early stage, a fire can be controlled using rudimentary tools (shovels, fire beaters) provided that it is not too intense (not very abundant vegetation, low fuel loads and low wind speeds). Very often, it is necessary to intervene directly with machines designed specifically for wild land fire fighting: vehicles with a small water tank for the first intervention, then tankers, water bomber planes... However, to be effective, the deployment of means must take place according to:

- A strategy, which defines the general rules (principles, objectives) on which are founded the fire fighting operations

- Attack tactics adapted to the local context (characteristics of the environment, forces available, and weather conditions).
- The good course of the fire fighting actions requires:
- A clearly defined line-of-command.
- Coordinating structures ensuring the coherence of operations, fire intervention tactics, the organization of the equipment, logistics, and public relation. These structures can be developed as the fire increases in size.

Fire fighting is a difficult, tiring and dangerous operation. Thus it is necessary to take care of safety (individual protective equipment), food supply and resting (recovery) of the staff. The weather conditions influence much the fire behavior. Weather data must be collected and analyzed during the operations in order to forecast wind speed and direction, temperature or humidity. Approaching cold weather fronts are to be observed particularly, because they generate sudden variations of these parameters. The experience feedback, i.e., the analysis of fire fighting actions and their impact on the fire re progress, allows to improve interventions on later fires.

7.1 Strategy

In order to be effective, forest fire fighting must be implemented according to a strategy defined at the national level, and whose objectives are the following:

- To formalize fundamental principles and principal objectives regulating fire fighting; principles and objectives which will guide then the persons in charge for the design and implementation of the operational fire fighting activities.
- To serve as common reference for all firefighters.

The definition of a fire fighting strategy is based on the analysis of:

- Fire risk;
- Forest fire effects;
- Principles of fire fighting that have been proven useful;
- Available capacities and techniques

7.1.1 The fundamental principles

The strategy of fire fighting is based on fundamental principles where all operations have to fit in. These principles can relate to the fight alone or connect fire fighting to the complex of forest fire protection, thus harmonized within an overall solution concept.

7.1.2. The principal objectives

Fire fighting strategies generally define two principal objectives:

- Control the fire at initial stage;
- Contain the spread and extent of fires which could not be suppressed at initial stage.

These objectives will be all the more easily to be met when they will be integrated into a general fire protection policy (principle of a general solution quoted above) with its primary objective to prevent all fire occurrence.

CONTROL OF FIRE OCCURRENCE AT INITIAL STAGE

When a fire is detected, the first attack must allow controlling it as long as the burned surface is small and the fire intensity is still controllable. The success of this operation depends on the speed, the force and the quality of the initial attack. The preventive mobilization, i.e., the anticipated installation of the adapted fire fighting capacities, is a very effective tool to ensure the success of the first attack. The initiation of the preventive mobilization and its intensity level depend on the estimate of the fire risk, by using, for example, the daily results of a weather risk index. The preventive mobilization can include:

- A terrestrial coverage (patrols with light vehicles for first intervention, preventive intervention dispatching, initial attack groups, etc.)
- An aerial coverage (aerial patrols with air tankers). The effectiveness of preventive mobilization depends mainly on:
    - The deployment of means and timing.
    - Its capacity of a fast initial response to the event.

In France, the initial attack of incipient fires has, under all circumstances, priority before all other intervention forms, and all adequate means must be allocated for this purpose. The effectiveness of the first attack depends on the information collected at the time of the alarm and the preparation of the fire crews.

CONTAINMENT OF FIRES WHICH COULD NOT BE SUPPRESSED AT THE INITIAL STAGE

When the initial attack failed and when weather conditions are difficult, then the starting up fire can reach a critical phase, generally characterized by a true fire explosion and a random spread for which the initial means are not sufficient. The deployment of large fire fighting forces, difficult to coordinate, does not obtain satisfactory results. Other techniques must then be considered and implemented.

7.2 Human resources management

Fire suppression often requires the mobilization of many fire fighters. The local population participates sometimes in the fire fighting. However, it is necessary that personal specialized in fire fighting is responsible for the fire operations. This personal indeed has a good knowledge of fire suppression, has specific equipment, is

organized in operational command structures and develops a fire fighting strategy adapted to the fire context.
Forest fire suppression requires two types of firefighters:

- Specialists (professional firefighters and foresters).
- Local population.

7.2.1. Fire fighting personal

SPECIALIZED PERSONAL
Varying in different countries, various actors intervene for forest fires suppression:

- The professional firefighters, who also intervenes on urban fires,
- The foresters, who fight only, forest fires.
- The specialized personnel receive training.

NOT SPECIALIZED PERSONNEL
Local population
In some countries, the local population takes an active part in fire fighting in an obligatory or spontaneous way.

Volunteer associations
Sometimes, forest workers, for example those working in forest exploitation or cork harvesting, are called in to support fire fighting activities. However, the involvement of the local population must be limited because people are not trained and their equipment is often rudimentary. They generally have no protective equipment.

Reinforcements: When a fire size increases and becomes uncontrollable, other types of personnel can intervene as reinforcements.

7.2.2. Individual protective equipment

This equipment must ensure the protection of the firefighter without reducing his/her mobility which is necessary for firefighting or to escape a possible dangerous situation.

7.2.3. Organization and coordination

Forest fire fighting sometimes involves different categories of people, professionals or volunteers. It is important that the service in charge of fire fighting is clearly identified, and that command lines and responsibilities are well defined.

RESPONSIBILITY FOR FIRE FIGHTING

Forest fire fighting is under the responsibility of the administrative authority, which delegates it to the qualified service. Thus three models of responsibility are distinguished:

– **"Integrated forester" model**. The services for forest management are responsible for the fire

suppression. They coordinate possible intervention of other services (e.g., firefighters intervening normally only on urban fires).

–_ **"Fire and rescue" model**. The general services for fire suppression and rescue deal with all the types of disasters, including forest fires. All other services are placed under their authority.

– **"Mixed" model**. Various services can intervene independently. This organization causes problems, because it is difficult to define the limits of responsibilities and to coordinate the various actions carried out during the fire suppression. For an effective system, coordination structures have to be determined.

ORGANIZATION OF FIRE SUPPRESSION CAPACITIES

The level of responsibilities involved depends on the development of the fire: when the fire becomes bigger, the higher hierarchical levels are involved level by level up.

Optimal average density of fire fighting personnel (Examples)

Spain uses the following densities as indicative figures:

– In zones with a moderate risk, at least one fire protection brigade of 7 to 10 members for 10,000 ha.

– In zones with a high risk: one brigade for 5,000 ha the densities depend on the available financial means.

MANAGEMENT TOOLS

Especially designed dated-processing tools can support the management of forest fires. They are still little developed in Mediterranean countries.

7.3 Firefighting equipment

Terrestrial or aerial forest fire suppression requires equipment adapted to the:

- Fire type: surface or ground fire
- Development phase: ignition, large uncontrolled fire
- Environmental conditions: access, topography

7.3.1. Terrestrial equipment

DIRECT FIRE INTERVENTION

Standard equipment

These are shovels, hoe-rakes (Pulaski), fire beaters, pickaxes, which are only used during the initial attack, but seldom after the ignition, when a fire is still small or fires of low intensity or for mop-up. Those hand tools are used in France in zones difficult to access, for example by crews transported by helicopters.

Backpack sprayers

These are also reserved for low intensity fires or first intervention, because the water reserve is small and the range of sprayers is limited to 5 m.

Initial attack vehicles

Used for prevention surveillance, these cross country vehicles are provided with a water tank allowing an immediate first intervention on starting fires. Taking into account this double function, the characteristics of this type of equipment is a compromise between:

- Mobility allowing an effective surveillance and a fast access on the spot of ignition.
- Sufficient water capacity to suppress fires with a first intervention or to slow down them in waiting for reinforcements.

Water tankers

These are cross-country vehicles specifically equipped for fire suppression, equipped with pumps, lances, and high capacity water tanks. The tanks are variable in size according to the type of equipment, the whole set-up has to reconcile, as for the vehicles for initial attack, mobility to reach fire, functionality during the fire fighting activities, and an optimal water tank size.

- On one hand, the higher the water capacity, the more the mobility of the vehicle is reduced. Thus, it is necessary to choose the water capacity adapted to the access conditions of the forest area.
- On the other hand, a water lance can only fight approximately ten meters fire line. Therefore, it can be advantageous to deploy several average sized trucks (2,000 l) with one or two lances or heavier trucks (4,000 to 6,000 l) with 4 or 5 lances. Very big engines (10,000 l and more) can be used for restocking smaller trucks or be equipped with several water lances.

It is advised to equip these vehicles with self protection systems; various techniques can be employed, for example a good heat insulation of the driver cab or a watering by outside spraying the vehicle.

INDIRECT INTERVENTION

Opening of access roads and vegetation strips:
Machines of public works such as the bulldozers can be used during fire fighting to build provisional tracks providing access to the fire, to limit the spread of the fire front by removing any vegetation on a strip (fire line) in front of the fire. The equipment for forest exploitation such as chain saws are also used to establish these fire lines before the advancing f re front.

Transport of fire crews: this can be assured, when the fire fighting vehicles are not available in sufficient quantity, by not equipped "ordinary" vehicles: pick-ups, minibus.
In Turkey, for example, a part of them is rented from companies during the fire season.

Monitoring of weather parameters: small portable weather stations measuring in real time humidity, temperature, wind direction and force allow to follow the

7.3.2. Aerial equipment

TYPE OF EQUIPMENT IN USE

Helicopters and airplanes are very useful for fire suppression, like for the tactical support of fire crews on the ground or, when the access conditions to the fire are difficult on the ground.

Helicopters

They can be used for personnel transport or active fighting such as dropping water (in French so-called "water bomber helicopters" or HBE1). There are several back-up systems for water re-filling:
– Bucket suspended on a winch below the helicopter. The filling is done by immersion in water. The bucket is difficult to fill and to handle and, during transport, under the effect of swinging, much from water is lost.
– A plastic bag fixed beneath the helicopter, filled with a hose, connected to a tanker or of a fixed water point.
– Combination of the two preceding techniques. A bucket is fixed on a reinforced chassis, and is equipped with a pump and a filling hose. This system allows to carry until 5,000 l.
Having a great flexibility, helicopters have the advantage of being able to operate independently of an airport for the water supply, which can be carried out by aspiration in hovering above a water point, when the water reserve is located under the flight engine. Their capacity is, however, reduced, if compared to planes.

Airplanes

Fixed-wing airplanes are used for surveillance, for example as reconnaissance plane which is equipped with water tanks and for active fire suppression. Faster than helicopters, they also have a much bigger water reserve (3,000 to 6,000 l), which allows increasing their intervention capacity on a f re. With the exception of amphibious planes (Canadair), airplanes are strongly dependent of an airport for the refilling of their water tanks. The water supply of the Canadair planes requires a water stretch of 2,000 m length by 100 m of width by 2 m depth, having a refilling (scooping) distance of 800 m.

Planes used in agriculture (Thrush Commander, Grumman Agcat, Air Tractor, Dromader) are used in some countries like Spain. These planes have low requirements for airport infrastructures. A non-tarred air strip of 500 to 800 m length is sufficient. However, these airplanes are limited by their load capacity.

METHODS OF USE

In the Mediterranean basin the use of aerial firefighting means is still restricted as compared to other countries. The necessary investments for the acquisition of such equipment (more than 100 million francs for a Canadair CL 415) and the significant intervention costs constitute a considerable financial obstacle. Certain countries circumvent this difficulty by renting planes or helicopters from other organizations, like the army or the police, or from private companies. International co-operation allow certain countries not having the necessary financing for the acquisition of aircrafts to call for air support of adjacent countries.

The air means can also be used outside the fire risk season for other interventions (transport of people, equipment or food in the case of natural disasters, conflicts, etc.).

7.3.3. Chemical additives

These are chemicals that are added to water to improve its physical and chemical extinguishing properties. The following additives are distinguished:

– **Dampening agents:** By decreasing the surface tension of water, a greater diffusion and better penetration is ensured. They are used however little, because of to their performances more limited compared to the other products

– **Short-term retardants:** These are principally foaming agents which by their physical action increase the quantity of water retained by the vegetation. The mixture of water with the foaming agent is done during the flight using a foam container and a pump that allows a flow that is programmed in accordance with the weather conditions and the vegetation density (proportion ranges between 3 to 6 per thousand). Its employment is generally limited by winds higher than 40 km/h. It is not advisable for direct attack.

– **Long-term retardants:** A product is classified a long-term retardant when its duration of effectiveness reaches 2 to 6 hours, even several days if no rain comes to wash the treated zone. Its active part is due to the presence of a chemical compound (fire proofing salt) which is degraded under the action of heat according to endothermic reactions. Mixed with water in proportions of about 20%, the product is primarily dropped from the air, for building up retardant barriers before the fire front in order to limit fire spread and to narrow the fire front. The better performance of the retarding product, compared to water, varies by a factor of superiority from 4 to 9 according to the type of plane. These chemicals can be used aerial (plane, helicopter) as well as terrestrial (tanker, vehicle of first intervention).

7.4 Communication systems

An effective high quality communications network allows a good communication and coordination between the various actors of fire prevention and suppression. If well organized, it allows reducing delay times until initial attack. The transmissions system for information generally used for forest fire protection is the radio operator system. However, a particular telephone network is sometimes also used. In any transmission network, the quality of the procedures and their precise definition are essential, so that only information circulates that is necessary, clear, precise, and concise.

7.4.1. Radio

CHOICE OF THE FREQUENCIES

The most used frequencies vary from 30 MHz (low frequencies) to 3 000 MHz (very high frequencies). The waves having the lowest frequencies have the best direct carrying distance but they are less easily reflected and less penetrating.

TYPES OF NETWORKS

Simplex network: it functions only on one frequency (emission and reception) and does not require a relay. The installation cost of such a network is reduced, but the range of the communications is very limited by the relief. In practice, the network simplex is used only in complement of another communication system (e.g., *Tunisia, Syria*).

Duplex network: emission and reception can simultaneously take place on two different frequencies constituting a channel. This type of network makes it possible to establish communications between a central station and several private radio stations. However, the latter cannot communicate directly between them and must always pass by the central station.

Semi-duplex network: emission and reception are done successively on two different frequencies, by means of a relay which reverses the frequencies. The advantage of this type of network is to ensure a permanent and optimal cover of the territory, insofar as the relays are established judiciously. However, the installation cost of such a system is comparatively much higher, and there remain obscured zones in which the communication is impossible.

NETWORK HARDWARE

Automatic relays

These are stations which retransmit the frequencies that they receive. They are necessary as soon as the area to cover is too big or that the relief is too steep. For semi-duplex networks, automatic relays must function in duplex, in order to retransmit immediately the received emissions.

Stations

Stationary radios: in general stationary and powerful equipment is linked to offices, (with an antenna on the roof of the building), they are the main points of the exploitation of the network.

Mobile radios: with a power of 10 to 15 Watts, these mobile stations can be installed in a vehicle and be fed by the battery of this one.

Portable radios: they have the advantage of being light and easily to operate, therefore they are very practical on the ground; their principal weakness is the power limitation (2 to 5 Watts), which makes them much less powerful than from mobile stations. Provided with an autonomous battery, they cannot function more than 24 hours.

DESIGN OF A SEMI-DUPLEX NETWORK

Installation of an automatic relay

The range of the relays is in general approximately 30 km. It can be much more significant if the relay is located on a high point.

The relays will be established in order to:

- To cover with a minimum of relay the greatest possible area (a cover of 95 % must be regarded as excellent). The relays will be established on high points.
- Minimize the installation costs (access, energy supply). There is an advantage if there exists a certain overlapping of zones covered by the relays, because that provides some security in the event of breakdown of one of them.

7.4.2. Distribution of the stations

The stationary radios will be located at the level of headquarters, coordination centers or communication units having the goal to centralize various calls. With regard to mobile or portable stations, the personnel ensuring the surveillance (lookout towers, patrols...) must be equipped in priority. When the fire danger is high, it is advised, in order to avoid the saturation of the network or confusion, to set up specialized cells tasked to handle the communications coming from the personnel ensuring the surveillance (e.g., communication centers in Turkey). If the equipment is insufficient or defective to ensure a total cover of the territory, it is necessary to resort to indirect communications (from station to station), but this requires much more time.

Telephone

TELEPHONE NETWORK

The national telephone network can be used to transmit information, but its use for the surveillance remains generally limited, because it can saturate very quickly in the event of significant fire risks. A specialized telephone network can supplement the radio operator network. E.g., in Cyprus, the forest service has its own telephone network with a manual switching standard, effective and free of charge except for maintenance costs. This network connects the various forest units, divisions to the lookout towers. Moreover, phone terminals connected to the forest office are at the disposal of the public in the forest, and particularly close to picnic areas.

MOBILE PHONES

This mode of communication is increasingly used by persons in charge of forest fire protection. However, it does not ensure a total coverage of the territory. Moreover, the operational standard can sometimes be saturated at the time of a fire occurrence.

CALL FREE NUMBER

A call free number can be placed at the disposal of the public

7.4.3. Standard operation procedures

To successfully use a communication network requires not only powerful hardware but also a rigid operation procedure and operating discipline, and security of correct use. The procedure must be simple, clear, effective and be especially followed. The communications must be short. With the beginning of each call, the speaker must announce him/herself on the network by his/her specific code. It is thus advisable to create a code table which will have to be rigorously respected. Clear codes are often retained: generally, the function is followed a geographical place, person names have to be avoided.

8. POST-FIRE MANAGEMENT AND REHABILITATION

Introduction

When the last embers are finally extinct, the damage caused by the fire can be fully assessed. Its consequences are most serious when fires destroy inhabited structures, forest areas serving as a resource for the local population, large areas, or if the fire burned near a city or tourist area.

The population, elected officials, and the media usually demand that actions are taken in order to repair what was destroyed and to make sure that fires do not reoccur. These requests are legitimate, since the social impact of fires and their psychological impact should not be neglected. However, too hasty and unwise actions should be avoided. On the contrary, it is necessary to take time to define what it is necessary to do and what is not, what is urgent and what can wait.

- *Most urgent is the control of erosion risks. A quick diagnosis allows to define the necessary work load and to take actions in the weeks after the fire.*
- *The control of plant health risks is also part of short-term actions. The damaged or weakened trees must be monitored. It is essential that effective measures (cutting and burning) are taken as soon as a risk of an epidemic is detected.*
- *It also can be interesting to cut quickly the standing dead trees, when the selling of blackened wood is feasible.*
- *Finally, a fast cutting back of most deciduous trees supports coppicing.*

All other actions can wait. Then the question arises what should be done with the burned area. Is it necessary: To reconstitute the initial state (restoration), or, on the contrary, to benefit from the fire and to reorganize the landscape (refitting or rehabilitation).

The activities for landscaping do not relate only to the forest, but the entire area burned by the fire. Here also a situation analysis precedes all restoration or rehabilitation actions. Various studies support the decision making process:

- *The feedback of experiences, which allow to analyze the means of prevention, forecast and fire fighting to be implemented and to learn the lessons (existence of potential fire sources, lack of fire equipment or fire management, non-operational command structures...).*
- *Monitoring of spontaneous regeneration of forest vegetation.*
- *Scientific analysis: investigations of soils, meteorology, ecology...*

- *Analysis of economic and social forest functions (wood production, resources for rural population, landscape, public recreational areas). With regard to the rehabilitation of vegetation, the persons in charge must give each other the time of a detailed situation analysis, and in particular the natural regeneration capacity of the vegetation. Natural regeneration, if possible at all, should be given preference to artificial aforestation, except in some particular cases. The lessons learned from these studies allow, if necessary, to adjust the landscape management plan, or to revise the existing* *management plan. This plan defines new management guidelines which decrease the fire hazard, while preserving forest functions.*

8.1. Forest Fire Mop up and Patrol

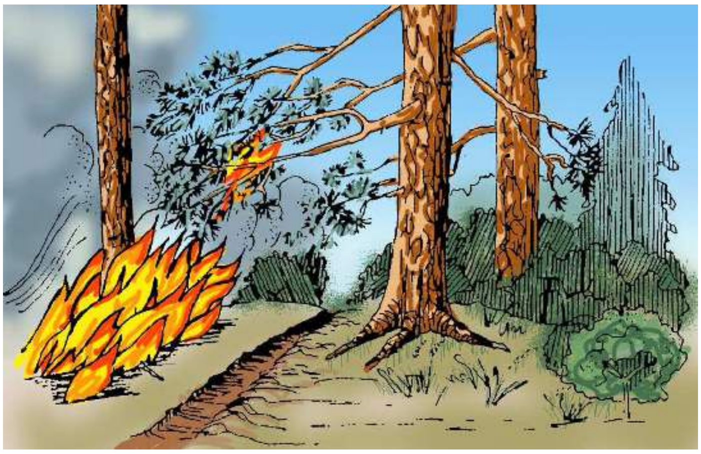

Figure 1: Low-hanging limbs can spread fire across fire Line

Remove branches overhanging the fire line to prevent fire "breaking out" if it rekindles.

Strengthening Control Line Build "cup trenches" where needed

Figure 2: "Hot spot" to find and extinguish burning areas close to line

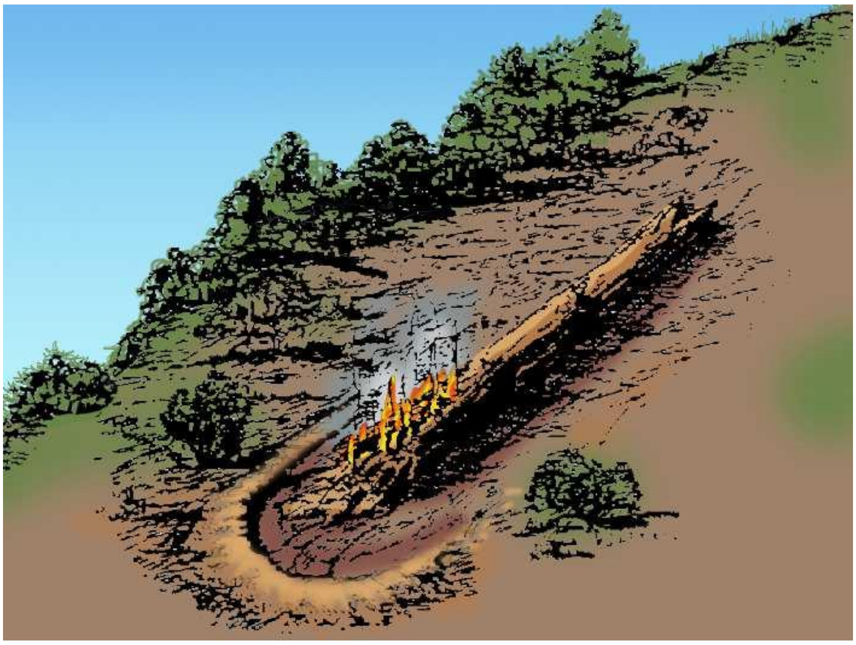

Figure 3: Turn logs and other burning material to prevent rolling

Systematic Mop up

- **Work the fire perimeter first, then proceed inwards**
- **Work from hottest to coolest area.**
- **Plan a beginning and ending point.**
- **Examine entire assigned area.**

Figure 4: Look for wispy smoke, Walk around the area to view it from various angles

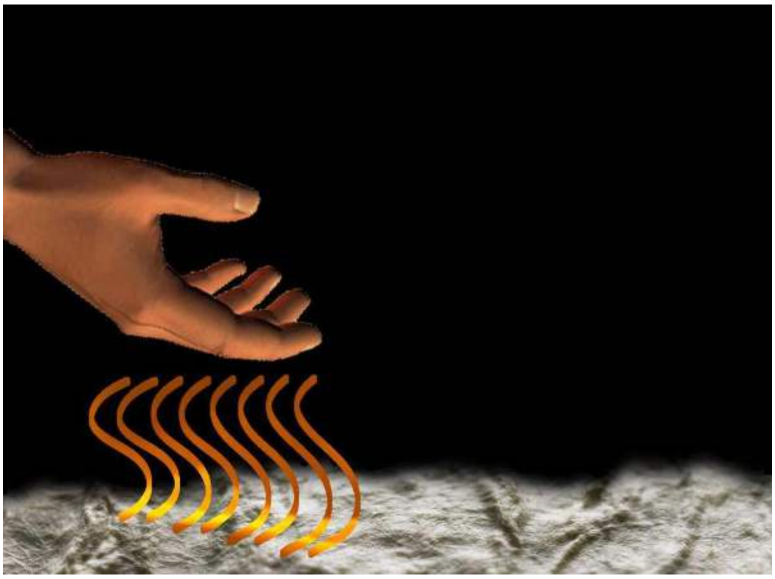

Figure 5: Touch

Figure 6: Smell: use your nose to "sniff out" undetected smokes

Listen for "popping" sounds that may indicate hidden hot fuels

Dry Mop Up

- **Separate burning material from fuels by scraping.**
- **Use dirt to cool the hot fuels (Rub onto areas after scraping and mix embers with dirt)**
- **Isolate and scatter burning material from unburned material**
- **Spread out heavy concentrations of materials near control line or inside burned area**
- **DON'T bury burning materials! They could smolder for a long time.**

Figure 7: Always work in pairs!

Spray water conservatively to cool the burning material

Mix the wetted material with dirt to further cool and smother the fire

Work the area until all embers are out.

Check area by "cold trailing"

Figure 8: Covered Fuels

- **Break up and disperse any fuels that are "buried".**
- **These are common along the fire line where dirt has been scraped or piled on the inside of the line or where dozers or graders have worked.**
- **Fuels will smolder for long periods in these "covered" areas**

Mop Up Guidelines

- **Make sure the fire line is secure!**
- **If the fire is small, mop up the entire burned area**
- **On larger fires, mop up an agreed distance in from the perimeter**
  - **This distance is variable based on fuels and expected weather**
- **If personnel are scarce, extinguish hot spots near the control line first**
- **Don't forget to check for spot fires outside the burned area periodically**

Patrol the Fire Areas that once appeared cool or "out" can re-ignite, creep across fire lines, or flare up

Figure 9: A routine patrol is needed to check and detect hot areas left along the line

Things to Consider when Patrolling

- **How far in from the control line will you check for hot spots?**
- **Are you responsible for checking the entire area or only a portion?**
- **What information should you report to your fire line supervisor?**
- **Work in pairs using a systematic approach**

When patrolling, check for Spot Fires outside the control line

Especially where you know the following to be true:

- Snags or torched-out trees exist near the fire line
- Winds blew across the fire line in this area
- Rotten logs and tree roots were found hidden beneath the fire line in the soil
- Flashy fuels exist on the outside of the fire line in this area.

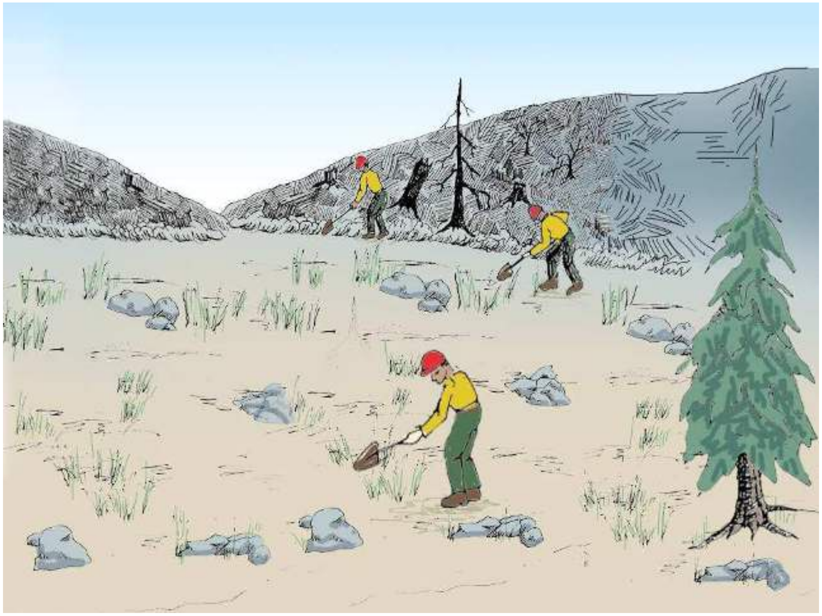

Figure 10: Searching for spot fires

Declaring the fire "OUT"

The fire should only be declared "OUT" or "Put off" after the following are true:

- **The fire has been thoroughly patrolled and checked inside and outside the fire perimeter for spot fires and………**
  - **All fire is out of logs, stumps, roots, etc.**
  - **All rotten material and duff pockets have been re-checked to ensure they are dead out.**
  - **The entire fire edge -- on the head, rear, and flanks--- has been checked**

8.2 Fire effects on the natural environment

Fire Effects on the Forest Stand

Damages caused by the fire
The passage of a fire results in the more or less serious deterioration of vital parts of the plant, such as foliage, stem and roots, resulting in a loss of tree vitality which can cause death. The deterioration degree is a function of the combined damage of various tree parts (foliage, stem, and roots), resulting from fire type (surface or crown fire) and fire intensity, as well as the species' fire sensitivity. A rapid passing fire causes much less damage than a slow fire with longer "residence time".

EFFECTS ON THE FOLIAGE
The destruction of leaves or needles by a fire reduces temporarily the photosynthetic activity. The deterioration of the buds stops any growth of the branch. The resistance of these vital parts to heat is variable according to the species: in some cases, a layer of protective cells covers the needles (e.g., waxes) or the buds (e.g., scales). The development stage of the plant also conditions its resistance to thermal stress. Visually, fire effects on the foliage result in crown scorch (browning). Browning is followed by the loss of leaves and needles.

EFFECTS ON THE STEM
The bark protects sub-cortical tissues (phloem and xylem) responsible for the diameter growth and the sap circulation. These are more or less modified according to the heating of the stem at the time of the fire passage. The slightly damaged tissues are regenerated by the sapwood, with appearance of an healing mark. On the other hand, the destruction of the phloem prevents the storage of photosynthesis assimilates in the roots and the tree survival time is then one to two years (use of

reserves accumulated before fire. If even the xylem is destroyed, any communication between the foliage and the root system is interrupted, and the tree dies within a few weeks. The fi re resistance varies according to species, in particular in function of bark thickness. In the case of the cork oak, the sapwood is protected by cork, building a thick bark which serves as insulating thermal material (except if the tree was harvested recently), which makes this species one of the least sensitive to fire. The destroyed branches are replaced by new branches developed from dormant buds.

EFFECTS ON ROOTS
The deterioration of the root collar (buttress) reduces the vigor of the tree, often resulting in death. The heating of the ground at the time of the fire passage can also be responsible for the tree weakening, affecting the root tips located in the upper soil layer. Ground fires kill roots and trees.

8.2.1. Phyto-sanitary risks

The deterioration of vital parts results also in a weakening of the entire tree, which becomes vulnerable to parasitic or fungi attacks. The burned forest stands can then become potential hearths of contagion of the adjacent vegetation.

8.2.2 Effects on the regeneration of a forest stand

REGENERATION TYPES
The regeneration of a forest stand can be done in two ways: germination (characteristically coniferous trees) or the re-sprouting of coppice. Many deciduous trees and a very small number of coniferous trees (*Juniperus* spp., *Thuja* spp., *Pinus canariensis*) have the capacity to coppice. These are shoots on stocks with underground parts that have survived the fi re. Aerial parts of certain tree species resprout; for instance, *Quercus suber* rebuilds relative easily its crown after the passage of a moderate fire.

FIRE EFFECTS ON REGENERATION
The heat of fire favors the regeneration of certain forest species. This is the case for *Quercus coccifera* (France, Italy), *Quercus calliprinos* (Syria), *Pinus brutia* (Syria, Lebanon) and *Pinus halepensis*:
–_ For *Quercus calliprinos* and *Quercus coccifera*, the stand opening and the absence of competing vegetation supports the regeneration by coppicing. Nevertheless, if a fire is too strong, the capacity of resprouting decreases and even disappears, following the more or less irrevocable deterioration of the sapwood. of the vegetation are at the origin of contributions out of nitrogen, potassium and phosphorus, in a form where it can be assimilated by plants. This compensates for the losses of these

elements in the ground. In the surface ground, the cation exchange capacity is reduced.

Micro-organisms
Sterilization starts between 50 and 125°C, and generally effects the first five or the first ten centimeters of the ground. In fact, the surface layers, which are richest in organic matter and most active biologically, are damaged. Micro-fauna is destroyed and recovers only slowly.

Erosion
The exposure of the soil following the fire as well as the structural modifications induced by the fire increase very strongly erosion risks. These depend on:
– **Slope** - the steeper the slope is, the more significant the risks of gully erosion.
– **Geological and pedological nature of the ground** - Clay soils are very sensitive to erosion.
– **Distribution and intensity of precipitation**
- Violent rains on a cleared ground can generate considerable damage on the spot and downstream (floods, flow mud...).

EFFECTS ON VEGETATION DYNAMICS
In almost all cases, after a fire, the vegetation recovers quickly to its initial state, without human intervention. However, recovery of the vegetation cover depends on the fire severity and frequency.
– Following a moderated fire, the vegetation cover gradually reconstitutes, by resprouting, germination, or starting from underground parts that survived (bulbs, rhizomes). The ecosystem evolves to a state, which is comparable to the initial floristic stadium before the fire, gradually in structure, quasi immediately in composition, successively loosing pioneering transitory plants which disappear slowly.
– An intense fire reduces the regeneration capacities: heat can destroy the underground parts or seeds necessary for survival, and thus strongly limit the regeneration of the vegetation. It results in a floristic impoverishment.
– Repetitively occurring fires lead to a significant floristic impoverishment. Many plants do not have time to mature for sexual reproduction before the passage of a new fire. The species with the highest capacities of dissemination and heat resistance (*cistus*, *calycotomus*) constitute then the dominant species of the vegetation cover.

EFFECTS ON THE FAUNA
The fire affects in different ways the various faunistic groups: some do not survive because they are burned or asphyxiated by the fume (weak individuals); others escape fire (birds) or find shelter, e.g., in the ground. Survival chances depend on the fire severity (ground heating can be very high and animals do not survive), but also of the time period (season) the fire is occurring (e.g., the damage is higher at the time

of bird nesting). Fire disturbs, moreover, in an indirect way the biological cycles of animals. Repeated fires may cause faunistic impoverishment by killing animals or extortion due to reduced food resources, destruction of habitats, etc.

EFFECTS ON THE LANDSCAPE

Fire may cause a significant change of the landscape by transforming the life conditions of the population into a charred environment. Low vegetation seems to cope easier with the impacts of fire than forest trees.

ECONOMIC LOSSES

The various elements which constitute the costs of a fire are:

– **Direct costs** - fire fighting activities, destroyed equipment (dwellings, infrastructures, and vehicles), destroyed forests.

– **Indirect costs** - loss of the uses, restoration of the vegetation and the landscapes, influence on the economy of tourism and the recreational activities. It is very difficult to evaluate the economic losses caused by fire due to the problem to properly estimate the indirect costs.

Examples:

– In France, the Mediterranean forest has a relatively low direct economic value, since forest products are often not used. On the contrary, in the surroundings or tourist areas the landscape change through fire induces economic losses which are poorly known and linked to an "affective" value to the natural landscape destroyed by the fire.

– In Morocco and in Syria, the forest is a subsistence resource for the local population. Therefore, economic losses caused by the passage of a fire are considerable

8.2.3 Post-fire Diagnosis of a Forest Stand

After a fire, it is useful to select trees for elimination in order to ensure the renewal of the forest stand with the help seed-bearing trees and to improve the ground protection. If the extreme cases are easy to recognize, it is more difficult to predict the future of trees with little damage, apparently untouched and partly with a recovered tree crown after the fire. Therefore, it is of primary importance to development a post-fi re diagnosis tool with the objective to have indicating criteria for tree survival or death. In practice, few studies were carried out in the Mediterranean basin on this subject.

Assessment of crown damage

The assessment can be carried out in two ways:

– Visual estimation of the crown volume percentage turned red.

– Measuring the height of dried crown. It can be related to the total tree height or be used to calculate the proportion of desiccated volume. It seems that the best prediction is the visual estimate; this method is, however, very subjective and causes strong heterogeneity between notes assessments of different observers.

Estimation of stem damage

This estimate can refer to:

– Protection criteria of sub-cortical tissues. The thicker the tree bark, the lower the damage to the tree. By correlating the thickness of the bark to the diameter at 1.30 m height, it is feasible to assess the tree damage.

– Damage descriptors of the stem: height or depth of charring.

– Damage descriptors for the cambium:

* Chemical tests with fluoro-chrome or orthodolidine, specifying exactly the state of cambium but having disadvantage of being destructive.

* Bio-electric measurements: The electric resistance of cambium (ERC) can be measured using a vitalo-metre; a low ERC translates into little cambium tissue damage.

Estimation of root damage

The root damage is very difficult to estimate because of the underground position of these parts. The degree of ground charring is assessed by a charring degree, which serves as an indicator for the intensity of deterioration.

Conclusion

It can be concluded that there is great diversity of descriptors to assess the damage generated by the passage of a fire. The choice of the criteria assessing deterioration is all the more difficult since there is a great variability of reaction to fires varying from species to species. The parameters to be retained for the diagnosis can be different according to the forest species. This variability, moreover, is accentuated by other factors, like the physiological state of the tree at the time of the fire occurrence, the site characteristics...Essential is, however, to facilitate the work of the manager in charge of the diagnosis, by using easily measurable variables on the ground.

8.2.4 Rehabilitation of forest stands

At short-term

The emergency activities aim at controlling erosion risks with their irreversible consequences.

The deterioration of the vital tree parts following the fire passage involves more or less irreversible damage. It might be preferable to cut the dead trees:

- For plant health and landscape reasons.
- For selling the wood, if possible. The commercial value of dead trees finances sometimes the cutting costs. However, the use of these charred forest products is very limited: use for fascines, firewood, & charcoal.

- For security reasons. Thus, the wood of the Aleppo pine breaks quickly and, only two or three years after the fire, stems of the dead trees can be toppled over by wind.

The cutting back of charred deciduous trees supports the re-shooting (Holm oak, cork oak).

At long-term

In most cases, the ecosystem (fauna and flora) recovers spontaneously. However, rehabilitation work of forest stands after fire is necessary in the following cases:

– To protect the forest of high human pressure:

    * Risk of use of the burned area for cultivation or pastoralism.
    * Risk of land squatters - When the legislative framework is badly defined (absence of delimitation of the forest or absence of enforcement), local population or realtors could bring the land in their possession.

– To restore social functions quickly:

    * To reassure the local population, when it uses forest resources.
    * Existing serious landscape constraints, or when the forest plays a major role for public recreation.

– When the stand has a protective function, e.g. against protection against falling rocks.

– To reconstitute a degraded ecosystem – The fire, when it is intense or repeated, degrades in a more or less irreversible way the ecosystem by erosion and impoverishment of fauna and flora. To stop this degradation requires reconstituting the vegetation cover by regenerating forest stands.

Rehabilitation at short term

EROSION CONTROL - "FASCINAGE" (FASCINE LINES)

The first weeks which follow a fire, erosion risks are sometimes very high due to the absence of a vegetation cover. A steep slope and violent rains make the ground all the more sensitive to erosion. A fast intervention in the weeks following the fire is thus necessary if there are reasons to fear strong erosion (fires in the summer season on a steep slope and vulnerable sandy or clay soils). The fascine lines help to limit erosion. The burned trees are cut back to 50 cm or 1 m above ground, which allows preserving trunks as anchor piles. The cut down vegetation is placed after pruning parallel to the contour lines, left on the spot leaning against trunks. This technique thus allows building "barriers" limiting material erosion. It has, moreover, the advantage of cleaning the disaster zone while using charred material. On the other hand, it is labour intensive, since all operations are performed manually. However, this work is not necessary if the erosion risk is low (spring fires, moderated slope, grounds resisting well erosion).

CUTTING OF BURNED TREES

It is advisable to cut down only trees which are not likely to recover and to survive. The preserved trees constitute seeding sources favoring an inexpensive natural regeneration. They contribute to the protection of soils which have been exposed by fire, and to the safeguarding of the landscape.

CUTTING BACK AND PRUNING OF BURNED DECIDUOUS TREES

To be effective, these interventions must be carried out before the end of the winter following the fire. The cutting back is to remove the entire tree until its stock which is still alive and where coppice shoots will grow. The cutting back close to the ground facilitates the re-sprouting by stock shooting. A cutting back a few centimeters above ground-level is on the other hand very harmful. The pruning is the removal of certain branches. This technique can be applied to the cork oak, when it is very damaged by fire. All branches of small diameter are cut and the crown re-growth is supervised.

Rehabilitation at long term - Regeneration of forest stands

The passage of a fire can provide the opportunity for reconsidering the management and offers the opportunity for a total adjustment of total burned area, like writing a new regional plan. The contemplation relates to the whole fire-touched area, including the forest area, with the following management objectives:

- To redefine the objectives of medium- and long-term forest management, and means of achieving these goals.
- To define necessary actions so that the risk that such a disaster reproduces is very strongly reduced virtually identical to the one which was burned, will regrow more or less quickly. However, various constraints can make an artificial aforestation preferable to natural regeneration.

THE NATURAL REGENERATION

The natural regeneration must be favored where possible. It requires a low initial investment. This degeneration can result from coppice rejections, tree suckers, or seeds originating from survived trees. Where pressures are strong on the natural regeneration, the protection of the regeneration zones strongly advised, in particular against cattle and game. When natural regeneration is insufficient, it can be supplemented by artificial enrichments.

E.g., in Tunisia, most of the time, the burned zones are fenced for 7 to 10 years in order to allow natural regeneration to reach a height above browsing line.

ARTIFICIAL REGENERATION

Artificial regeneration is used especially in countries where a strong population pressure is a serious threat and where a conversion of burned forest areas to other uses or appropriation of encroaching dwellers has to be avoided.

E.g., in Morocco, each burned zone is fully replanted within five years after the fire event.
In Syria, each burned zone is reforested immediately in order to use the next rain.

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PART-II: FOREST FIRE SUPRESSION METHODS AND TECHNIQUES

1. Parts of a Fire

Head: That part of the fire which is usually moving with the wind or upslope. It is usually the most intense part of the fire and does the most damage. Usually, the head fire should be stopped first if safe to do so.

Origin: This is where the fire originates or starts.

Rear: That area of the fire backing against the wind.

Flanks: The "sides" of the fire

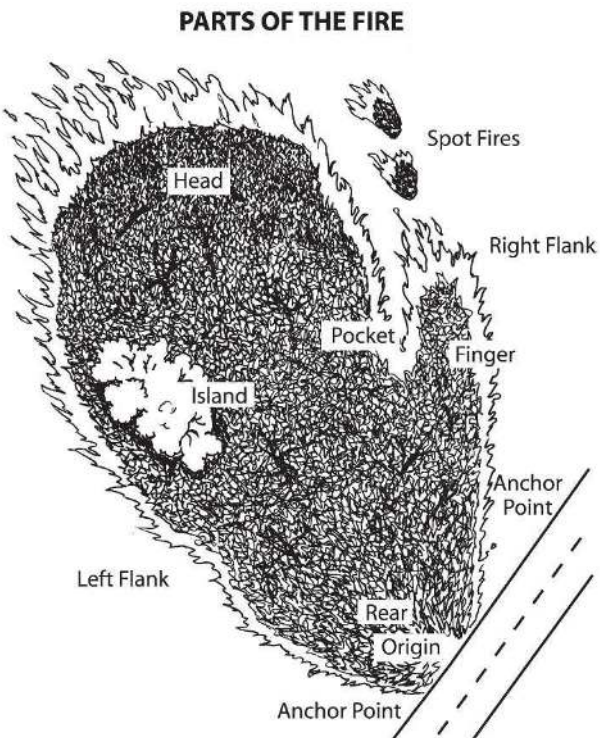


Figure 11: Fingers: Long narrow strips of fire extending out from the main fire.

Pockets: Indentations of unburned fuel along a fire edge formed by fingers or slow burning areas. A fire line should ordinarily be built across the mouth of the pocket and then the pocket should be burned out.

Spot Fire: Spot fires are small islands burning outside the main fire. Spot fires commonly occur within 200 meters of the main fire. These spot fires must be detected and suppressed immediately or they will become head fires. Spot fires can be dangerous since fire fighters could become trapped between a spot fire growing rapidly and the active head or flank of the fire.

Island: An unburned area within the fire perimeter (wet areas or sparse fuels).

Perimeter: The total length of the outside edge of the burning or burned area.

Anchor Point: A safe and advantageous point to start fire line construction or initiate burn out operations.

The Fire Triangle

All of the methods and tactics discussed in this section are based on breaking the Fire Triangle. Remove one of the three legs and the fire will go out.

- **There are three basic ways to achieve this:**
- **Digging a line or trench to separate the fire from the surrounding fuel**
- **Spraying water or using dirt to "smother" the fire in order to remove the oxygen.**
  - **Note: It's very important not to bury the fire or burning material since it can continue to smolder under the ground.**
- **Cooling with water or dirt to remove the heat.**

Figure 12: The Fire Triangle (Fuel + Oxygen + Heat = FIRE)

Remove one or more of these elements and the fire is extinguished by cutting a line removing the fuel, by spraying water or throwing dirt, by hot spotting cooling with water or dirt, no fire (fire will out)

Fire line Tactics

- **Anchor**
  - **Always start from a safe anchor point**
- **Flank**
  - **Flank the fire on both sides using a "progressive" line method**
- **Pinch**
  - **Pinch the fire off at the head to contain it**
- **Attack the head**

  - **Only when fire is small, the intensity is low and it is safe to do so**

- **Use a shovel to throw dirt to cool hot spots**
  - **Attempt to keep the fire intensity low by cooling down areas that are heating up**

- **Know your escape routes and safety zones!**
  - **No matter what kind of fire you are on or tactics you use always have a safe area close by!**

2. Methods of Attack

- **Direct Attack**
- **Flanking/Parallel Attack**
- **Indirect Attack**

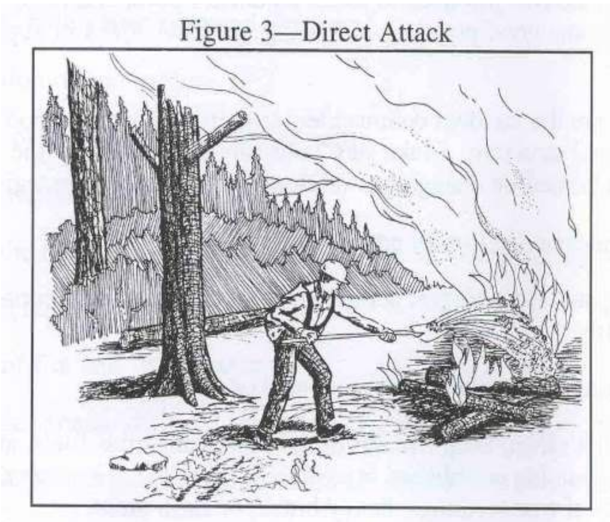
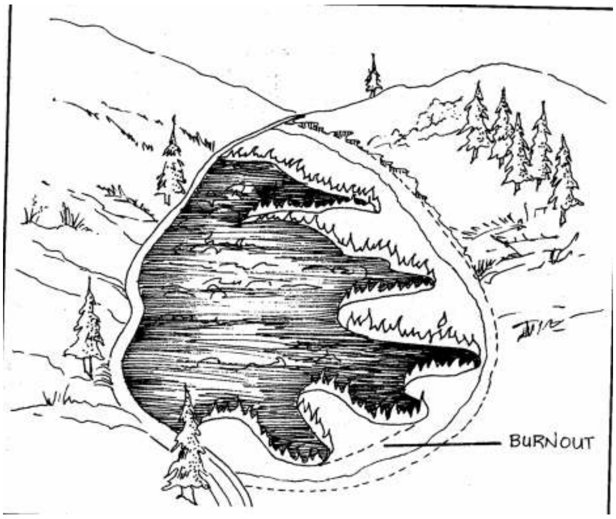


Figure 13: Direct attack



Direct Attack

Some Advantages of Direct Attack

- **Limits chance for fire to gain momentum or size.**
- **Reduces need and risk involved with burnout operations.**
- **It's the safest place to work since you can generally use burned area as safety zone.**

Some Disadvantages of Direct Attack

- **You work in heat and smoke.**
- **Control line follows fire edge and is irregular.**
- **There can be more potential for spot fires**
- **Does not take advantage of existing fire barriers (natural or man-made)**

PARALLEL ATTACK

Use when:

1. The fire is too intense for firefighters to work close to the flames (2-3 meters)
2. There are many fingers and it's more efficient to cut them off and burn out.

Figure 4—Parallel Attack

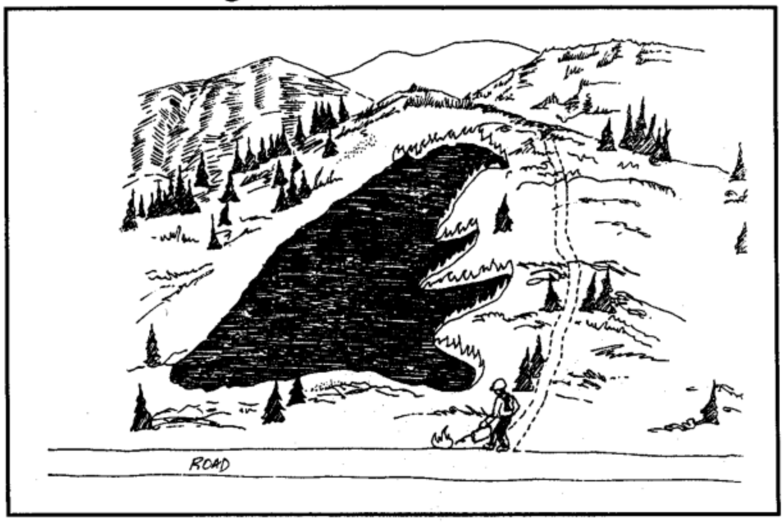


Figure 14: Parallel attack

INDIRECT ATTACK

Use when:

1. The fire is very intense (flame lengths > 4 m) or spreading very rapidly
2. There are natural barriers or other opportunities to establish a line and burn it out before the fire arrives.

Figure 5—Indirect Attack

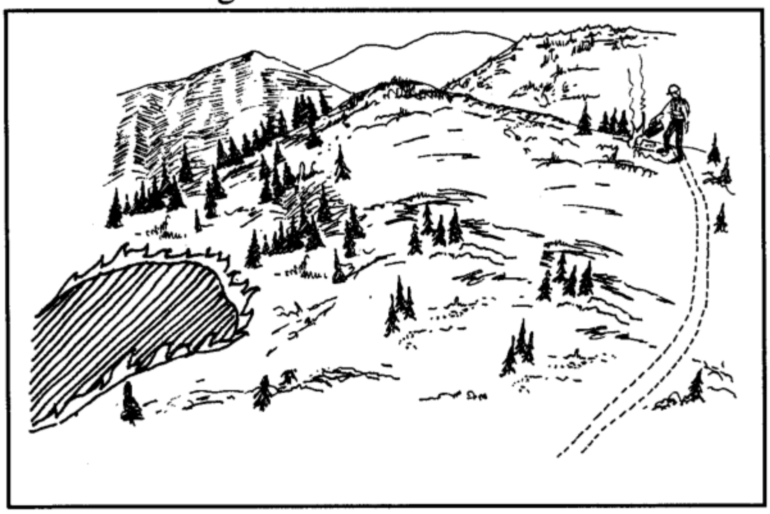


Figure 15: Indirect attack

Indirect Attack

- **Indirect attack is the most dangerous method because there are unburned fuels between the main fire and the firefighters**
- **When completed, the indirect fire line becomes the anchor point from which burn out operations occur. Burn out is generally considered a required second phase of indirect attack**
- **Safety zones MUST be considered when using the indirect method in case fire activity increases and firefighters have no place to escape.**

<u>Some Advantages of Indirect Attack</u>

- **Takes advantage of natural or manmade existing barriers**
- **You are not working near the heat and smoke**
- **Eliminates irregularity of lines**
- **Allows more time to establish control line**

<u>Some Disadvantages of Indirect Attack</u>

- **Its more dangerous…you may be flanked by main fire**
- **More acreage will be burned**
- **Burn out operations may be difficult or slower than expected or may go out of control**

FIRE LINE TYPE SUMMARY

Direct

Parallel

Indirect

- **One foot in the black**
- **Safety zone close**
- **No unburned fuel between you and the fire (i.e. "black line")**
- **Cut off islands and burn them out as you go**
- **Unburned fuel between you and fire**
- **Escape routes and safety zones a MUST!**
- **Takes advantage of fuels and terrain away from fire edge**
- **Back off and burnout**

3. Control Line Location

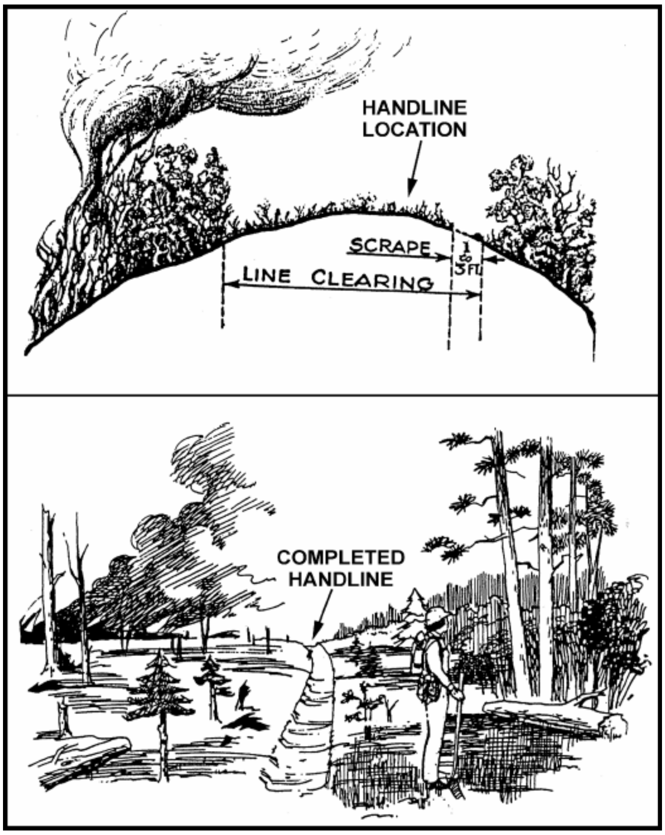
- **Use cold fire edge as an anchor point**
- **Take advantage of natural breaks or areas of light fuel loading**
- **Look for and use previously constructed barriers such as roads or trails**

Figure 16: Fire line Construction Standards

- **Factors that influence fire line requirements:**
  - **Fuel type (grass, brush, forest, slash)**
  - **Fuel moisture**
  - **Vertical and horizontal continuity and arrangement of fuel**
  - **Temperatures**
  - **Wind**
  - **Slope**

Fire line Construction

1. **Cut and clear both aerial and surface fuels with tools such as axe, panga, Pulaski, and chainsaw.**
2. **Eliminate the lower branches, shrubs, small trees and other light materials. The material extracted is scattered on the <u>exterior</u> side of the line, or the side away from the fire.**
3. **Logs, branches, and other materials should be removed from the line and be dispersed as far as reasonable away from the fire line.**
4. **The amount of the clearance depends on the size of the combustibles. It can be from 1/2 to 4 meters.**

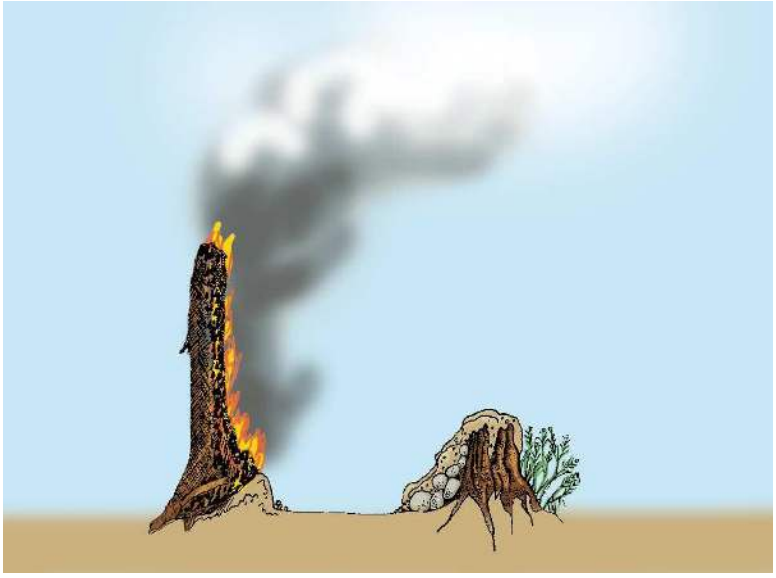

HANDLINE
LOCATION
SCRAPE
1 to 3 FT.
LINE CLEARING
COMPLETED
HANDLINE

Clean the surface fuels to the mineral soil.

- **With tools, such as the hoe, shovel, and rake, cut and scrape the combustible material down to the soil. This last aspect is very important to avoid spread by humus or roots.**
- **The width of the area cleaned varies from 50 cm to 1 meter or more depending on the situation. Why?**
- **The greater the wind velocity the greater the width of fire line! The taller the fuel the wider the fire line.**
- **The lines in brush should be wider than the lines in the open forest. Why?**

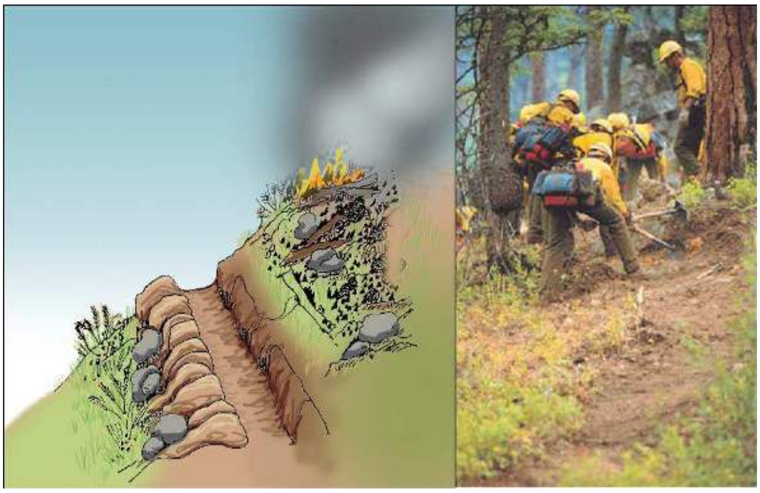
- **The lines on the slope above the fire should be wider than the lines below the fire. Why?**
- **Cut a cup trench with dirt to stop rolling burning material on under slung line.**

Control Line Basics



Cup Trench

Under-slung line: Line constructed beneath a fire that is burning on a slope



Threats to Existing Control Line

- **Spotting**
- **Rolling Debris**
- **Creeping**
- **Radiant Heat**
- **Unburned Fuel**

Coordinated Crew Techniques

- **Alternate Advance (Leap frog)**

  Each firefighter completes a short section of line and then "leap frogs" to the front and starts on another section

Other Suppression Methods

- **Scratch Lining**
- **Wet Lining**
- **Burning Out**
- **Hot Spotting**
- **Cold Trailing**

Scratch Line

Scratch line is an unfinished, *preliminary* control line hastily established to check or slow the spread of a fire

Wet Lines

- **A temporary fire control line prepared by treating the fuels with water to slow or stop the spread of fire**
- **Works best in light, flashy fuels**

Hot spotting

Hot Spotting is a term used when firefighters cool down hot areas along the line or go after the remaining hotspots to stop the fire spread and cool the fire down. A fire line is still needed to ensure the fire won't rekindle and start spreading at a later time.

Burning Out:

Setting fire inside the control line to consume fuel between the line and the fire

"Black-line concept"

Burning Out

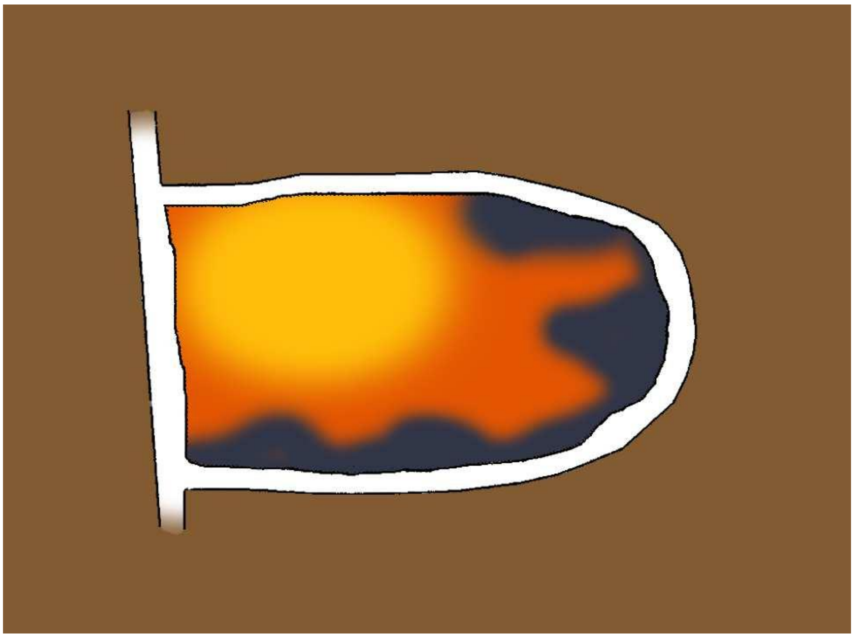
Burning the vegetation between the control line and the fire edge

Firing Operations

- **Do not burn out without obtaining approval from IC.**
- **Coordinate firing operations with those around you.**
- **Don't burn unless you have favorable conditions.**
- **Make sure you have adequate holding forces.**

Burnout & Black Line Concept

By burning out, you bring the "black" with you and always have a safety zone!



Cold Trailing

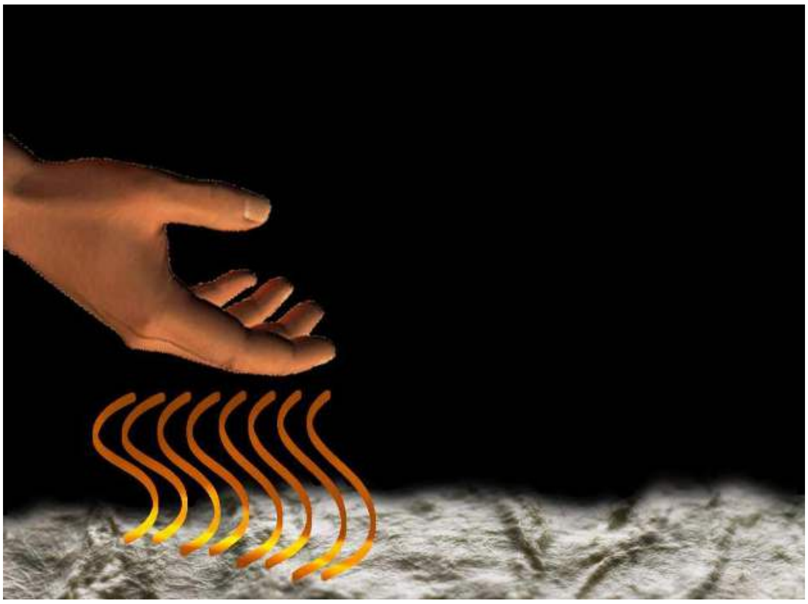
Cold trailing is using your sense of sight, smell, and touch to search and check for hot spots or any remaining heat.

This is done after the fire is lined, controlled and the perimeter is mopped up.

Cold Trailing

Use the back of your hand to feel for heat… it is very sensitive and detect heat otherwise hidden.

Be careful not to burn yourself



PART-III: FOREST/WILDLAND FIRE MANAGEMENT PLAN AND LEADERSHIP

1. Wild Land Fire Management Plan

Provide decision support to aid managers in making informed decisions on the management of wild land fires.

- There needs to be a Fire Management Plan for every area that could potentially have wild fire on it.

Fire Management Plan- Main Parts

- Introduction
- Policy
- Resource Management Planning
- Fire Management Area Description
- Operational Guidance
  - Unplanned ignitions Preparedness
  - Planned Fuels Treatments
  - Prevention, Mitigation and Education

Fire Management Plan- Introduction

- **Introduction**
- The intent of this Chapter is to introduce the reader to the area covered by the FMP.
- State the reasons for developing the FMP.
- Provide a general description of location of the area covered by the FMP with vicinity map and agencies involved.
- Identify areas of different management designations (e.g. wilderness, timber harvest areas, research natural areas, cultural/religious areas, habitat management areas)

Fire Management Plan- Policy

- <u>Fire Policy</u>

- Identify sources of guidance and direction that relate to actions described in the FMP.
- These may include unit specific policies (e.g. tribal direction, local land management planning, etc.) , kebele, regional or national policies.

Fire Management Plan- Resource Management Planning

- Describe fire management related goals, objectives, standards, guidelines, and/or desired future conditions that apply across the entire area
- Examples of these goals, objectives, standards, guidelines, and desired conditions are:
    - o firefighter and public safety,
    - o using fire to maintain pastoral health,
    - o desired plant community composition and structure

Fire Management Plan- Area Description

- Physical and biological description (e.g. topographic features, fuel types, special conditions that may result in extreme fire behavior, access, Fire Regime , high value concerns, special areas),

  Jurisdictional boundaries (e.g. adjacent or intermingled federal, private, tribal, state, county ownership),
- Communities and other values at risk to include: Threatened & Endangered species, cultural concerns, areas of special concern, water quality, invasive species, and infrastructure (power lines, fences, etc.)
- Fire behavior and weather descriptions , past fire behavior and perimeter histories, control problems
- Areas within the plan can be further divided into smaller areas if there is enough of a difference in how that land is affected by fire and actions you would take on that land would be different.
    - Smaller areas within a Fire Management Plan, Fire Management Units.

Fire Management Plan- Preparedness

- preparedness (including training, qualifications, readiness),
- cooperative or mutual aid fire management agreements,
- size up, initial response and extended response procedures,

- Early Warning procedures
- records management,
  - A plan to keep track of fires and to share that information
- Water sources
- Communication Plan
- Available Resources
  - Equipment
  - Personnel
- Available Maps
- Access Routes
- Detection
- How to ask for and get assistance

Detection

Fire Management Plan- Preparedness

- Detection

- Use of Satellite Technology
- Use of Local Community
- Use of Patrols
- Detection can be a part of Early Warning
- Use of aircraft
- Others?

Fire Management Plan- Planned Fuels Treatments

- Describe or reference planning and implementation processes for fuels treatments by mechanical, chemical, biological or prescribed fire methods. Procedures to be included are dependent on local needs.
- Examples include:
- procedures for implementing prescribed fire (requirements for development of burn plan, responsibilities for preparing and approving prescribed fires)
- local coordinating or special interest groups,
- Many of these topics may already be addressed in other parts of your forestry management practices

Fire Management Plan- Prevention and Education

- Prevention Plan
- human caused ignition patterns and problems,
- community involvement
- education programs,

2. The Art of Forest Fire Management Leadership Values and Principles

Why is Leadership Important in forest/Wildland fire fighting?

- A fire can be chaotic, confusing and complex.
- A successful fire line leader is able to make sense of the chaos and develop a credible plan and then communicate that plan.
- In this way, a fire line leader will win support from others and have the ability to control the situation and implement a strategy.
- Leadership is needed to influence people by providing purpose, direction and motivation in order to accomplish the mission and improve the organization.

What makes a good Leader?

- Being appointed a supervisor doesn't make you a leader.
- Being a leader means that you influence people by providing purpose, direction, and motivation.

Organizing firefighting efforts takes Leadership!

Figure 17: Organizing firefighters

OPERATIONAL LEADERSHIP

- Take charge of the situation
- Motivate with a "can-do" attitude
- Demonstrate initiative by taking action
- Communicate by giving specific instructions and acting on feedback
- Supervise the scene of action
- Leaders provide Purpose by communicating intent.
- Leaders provide Direction by developing a plan and clear objectives.
- Leaders provide Motivation by setting the example

Values	Principles
Duty	Be proficient in your job, both technically and as a leader.
	Make sound and timely decisions.
	Ensure tasks are understood, supervised, and accomplished.
	Develop your subordinates for the future.
Respect	Know your subordinates and look out for their well-being.
	Keep your subordinates informed.
	Build the team.
	Employ your subordinates in accordance with their capabilities.
Integrity	Know yourself and seek improvement.
	Seek responsibility and accept responsibility for your actions.
	Set the example.

Wildland Fire Leadership Values and Principles	
Duty	**Be proficient in your job, both technically and as a leader.** –Take charge when in charge. –Adhere to professional standard operating procedures. –Develop a plan to accomplish given objectives.
	Make sound and timely decisions. –Maintain situation awareness in order to anticipate needed actions. –Develop contingencies and consider consequences. –Improvise within the commander's intent to handle a rapidly changing environment.
	Ensure that tasks are understood, supervised, and accomplished. –Issue clear instructions. –Observe and assess actions in progress without micro-managing. –Use positive feedback to modify duties, tasks and assignments when appropriate.
	Develop your subordinates for the future. –Clearly state expectations. –Delegate those tasks that you are not required to do personally. –Consider individual skill levels and development needs when assigning tasks.
Respect	**Know your subordinates and look out for their well being.** –Put the safety of your subordinates above all other objectives. –Take care of your subordinate's needs. –Resolve conflicts between individuals on the team.
	Keep your subordinates informed. –Provide accurate and timely briefings. –Give the reason (intent) for assignments and tasks. –Make yourself available to answer questions at appropriate times.
	Build the team. –Conduct frequent debriefings with the team to identify lessons learned. –Recognize individual and team accomplishments and reward them appropriately. –Apply disciplinary measures equally.
	Employ your subordinates in accordance with their capabilities. –Observe human behavior as well as fire behavior. –Provide early warning to subordinates of tasks they will be responsible for. –Consider team experience, fatigue and physical limitations when accepting assignments.

Integrity	**Know yourself and seek improvement.** -Know the strengths/weaknesses in your character and skill level. -Ask questions of peers and superiors. -Actively listen to feedback from subordinates.
	Seek responsibility and accept responsibility for your actions. -Accept full responsibility for and correct poor team performance. -Credit subordinates for good performance. -Keep your superiors informed of your actions.
	Set the example. -Share the hazards and hardships with your subordinates. -Don't show discouragement when facing set backs. -Choose the difficult right over the easy wrong.

Incident Briefings

- **One of the key factors in directing and communicating any plan is to conduct an operational Briefing.**
- **Make sure everyone CLEARLY understands what is expected of them.**

Briefings are used to express the Leader's Intent

- Provide an overview of the SITUATION
- Describe the MISSION and EXECUTION of the plan
- Provide COMMUNICATION information – how to contact you and each other
- Discuss who else will be arriving at the fire and any other SERVICE/SUPPORT issues that need to be covers
- Discuss potential hazards and other RISK MANAGEMENT issues
- Provide an opportunity for your workers to ask QUESTIONS or express CONCERNS

Leadership Traits

- Leaders Communicate Clearly
- Leaders Respect Others and Their Opinions
- Leaders Make Difficult Decisions
- Leaders Build Highly Reliable Organizations

- Leaders Reflect and Learn from Their Mistakes

After Action Reviews (AAR)

- A debrief or AAR is a leadership tool that fosters learning and improvement for everyone:

- What was planned?

- What actually happened?

- Why did it happen?

- What lessons can we learn for next time?

“The ultimate measure of a man is not where he stands in moments of comfort and convenience, but where he stands at times of challenge and controversy