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Wildland Fire Management Handbook for Trainers

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Food and Agriculture Organization of the United Nations
Forest Management Team
Forestry Department

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FOREWORD

Fire is an important land management tool, but careless or criminal use of fire may have catastrophic impacts. Wildfire can be a major cause of ecosystem degradation and may result in loss of human life, economic devastation, social disruption and environmental deterioration. Each year, fires destroy millions of hectares of valuable timber, other forest products, and environmental services provided by forest ecosystems. However, in fire adapted ecosystems, managed fire plays a positive role in ecosystem health and vitality whilst in fire sensitive ecosystems, damage is incurred. In many ecosystems, good management practices help to reduce the extent and severity of unplanned fire. Countries benefit if they develop the capability to manage fire as an integral part of their approach to ecosystem management.

Globally more than 350 million ha were burned in 2000 of which 95 percent were caused by people. The continued expansion of agriculture and other forms of land conversion activities in developing countries; the increased use of wildlands for recreational purposes and tourism in both developed and developing countries; are among the factors that are contributing to the increasing incidence and impacts of wildland fire. In 2005 an estimated 230 million hectares of forest, savannah and grasslands were burned south of the equator in Africa. Many fires were intentionally set to clear land for agriculture, and many of these fires burnt much larger areas than were originally intended.

It is not possible to state conclusively that there is a long-term upward trend in fire at the global level, since historical data are available for only a small minority of countries, however, an increasing number of national and local governments are elevating fire as a priority, requiring increased policy attention and increased allocation of resources.

The FTP-21 Handbook on Forest Fire Control, A guide for Trainers was first produced by the Finnish National Board of Education in 1993 to train people in the developing countries in fire detection and suppression; as was the global priority at the time. Since then, the Voluntary Guidelines for Fire Management highlights that the risk, frequency, intensity and impacts from wildfire can be reduced through more holistic approaches to fire management that include monitoring, early warning, fire prevention, fire preparedness, fire suppression and restoration following fire events. Sound policy, legal, regulatory and planning frameworks need to be supported by mechanisms to ensure compliance, including law enforcement. However, equally as important is the adoption of community based fire management approaches and public awareness raising programmes that improve knowledge of fire impacts (positive and negative) on food security and rural livelihoods, including linkages and conflicts between uses of fire in the forestry-agriculture and wildland-urban interfaces.

Many countries are adopting fire strategies that address the root causes, prevention and preparedness for fire that are proving more cost effective than investments in fire suppression technologies and resources, which are often only used during a few months each year.

The majority of today's wild fires stems from fire uses outside the forest ecosystems. The sustainable management of forest ecosystems requires the participation of the local population in landscape level management of wildland fire, adjacent to these

areas. Where people have a direct interest in protecting their natural resources, haphazard or unplanned wildfire started by people is significantly reduced. Successful fire management produces direct benefits to local communities. Only when local communities understand that they will benefit from protecting their natural resources will they be mobilized to prevent fires.

Fire management requires that trainers and instructors, including at community level, be trained to facilitate the new holistic approaches in fire management, including ecology and local communities. Also land-use authorities and managers around the world, need to be educated in principles of ecological fire management.

The Finnish Ministry of Foreign Affairs (MFA) have supported implementation of the Voluntary Guidelines for Fire Management by financing review of the Handbook on Forest Fire Control, A Guide for Trainers, to incorporate the more holistic approaches. This new *Handbook on Wildland Fire Management, for Trainers*, will target field trainers/instructors, and thus complement the other recent Wildland Fire Management Handbooks; for Sub-Sahara Africa (2004), for North-East Asia (2006) in Russian, produced by the UNISDR and the Global Fire Monitoring Center (GFMC).

Since 2002 the UNISDR Regional Wildland Fire Networks facilitates regional and global dialogue and facilitates transfer of knowledge and technology. It is proposed that each country will analyze its fire situation, develop a strategy for preventing and managing wildland fire and assess the risks and impact on forest ecosystems. As many countries lack the capacity and capability to implement an effective programme, the Voluntary Guidelines for Fire Management, supported by this Wildland Fire Management Handbook for Trainers, will form the bases for a programme of institution strengthening and capacity building in fire management, particularly in developing countries. It is hoped that Governments and other stakeholders will embrace the approaches outlined in this handbook and the Fire Management Voluntary Guidelines and commit the resources to implementation of the principles and practices necessary for effective fire management.

Helsinki, January 2007

Mike Jurvélius

The Forestry Department of the Food and Agriculture Organization of the United Nations was requested by member states to develop with other partners a Global Fire Management Strategy and Fire Management Voluntary Guidelines to support national fire management policy development and revision. These guidelines, published in 2007, together with this handbook and FAO legislative study 99: “Forest Fires and the Law”, form a package of base documents for institution strengthening and capacity building in fire management, especially in developing countries.

FAO, Rome, November 2009

Jim Carle

Chief

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THE SAN DIEGO DECLARATION ON CLIMATE CHANGE AND FIRE MANAGEMENT

WAS PRESENTED AT THE THIRD INTERNATIONAL FIRE ECOLOGY AND MANAGEMENT CONGRESS 1.
BY THE ASSOCIATION FOR FIRE ECOLOGY, NOVEMBER, 2006¹.

PREAMBLE

As scientists and land managers who focus on fire and its effects on natural ecosystems, we recognize that climate plays a central role in shaping fire regimes over long time scales and in generating short-term weather that drives fire events. The science surrounding human-caused climate change continues to strengthen and the weather patterns that shape the ecosystems where we live and work may be altered dramatically over the coming decades. In anticipation of such changes it is important to consider how fire management strategies may enable us to respond to a changing global climate and thereby reduce potential disruptions to plant communities, fire regimes and, ultimately, ecosystem processes and services.

Currently, we are observing serious wildland fire conditions, such as increasing numbers of large and severe wildfires, lengthened wildfire seasons, increased area burned, and increasing numbers of large wildfires in fire-sensitive ecosystems (*e.g.* tropical rain forests and arid deserts). Recent research suggests that these trends are, in part, related to shifts in climate.

As temperatures increase, fire will become the primary agent of vegetation change and habitat conversion in many natural ecosystems. For example, temperate dry forests could be converted to grasslands or moist tropical forests could be converted to dry woodlands. Following uncharacteristic high-severity fires, seedling reestablishment could be hindered by new and unsuitable climates. Plant and animal species already vulnerable due to human activities may be put at greater risk of extinction as their traditional habitats become irreversibly modified by severe fire. Streams and fisheries could be impacted by changing climates and fire regimes with earlier peak flows, lower summer flows, and warmer water even if ecosystems don't burn. Finally, extreme wildfire events and a lengthened fire season may greatly increase the risk to human lives and infrastructures, particularly within the wildland urban interface.

We acknowledge that there are uncertainties in projecting local impacts of climate change, however, without taking action to manage fire-dependent ecosystems today and in the absence of thoughtful preparation and planning for the future, wildland fires are likely to become increasingly difficult to manage.

We, the members of the Association for Fire Ecology that endorsed this document at the Third International Fire Ecology and Management Congress, support the following considerations for planning and management to enhance ecosystem resiliency to wildland fire in a changing global climate.

¹ This declaration represents the position of the Association for Fire Ecology and other signatories and may not represent the position of other organisations or agencies sponsoring the Congress.

BACKGROUND

1. Both fire and climate regimes interact with other natural processes to direct the formation of vegetation in ecosystems. Given that climate and fire regimes are linked through vegetation, changes in climate can lead to large or small changes in fire regimes. Climate and fire regimes are also directly connected through the climate drivers of ignitions and fire weather. Climate influences both where and how vegetation grows and thereby creates the fuel conditions that drive fire frequency, intensity, severity, and seasonality. Precipitation and temperature patterns regulate the accumulation of fuels. In some ecosystems, wet years may promote "boom" vegetative (fuels) conditions, while drought years promote "bust" and the burning of the "boom" vegetation. Further, we know that the inevitable dry years, particularly when warm, are associated with larger fires, both in size and number, especially where fuel is abundant. Fire can also contribute to the problem of increasing green house gas emissions because it is a source of CO₂ and particulate emissions, which may affect local and regional air quality and worldwide climate.

2. Historical fire regimes have been disrupted in many ecosystems. Factors such as human activities and land development, loss of indigenous burning practices, and fire suppression have all led to changes in some plant communities historically shaped by particular fire regimes. Human activities have significantly increased the number of ignitions in many temperate, boreal, and tropical regions. Fuel loads have increased in some temperate forests where low intensity fires were historically the norm. In some rangelands, shrubs have been replaced by annual grasses or colonizing trees. Human caused burning has increased fire frequency in some tropical regions where fire-sensitive ecosystems dominate.

It should be noted that not all vegetation types have been significantly altered by fire suppression. Many shrubland ecosystems, such as California chaparral, burn with high severity under extreme weather conditions and fire management in the 20th and 21st centuries has not appreciably changed their burning patterns. Coastal, mesic coniferous forests in the Northwestern US have not been modified to a great extent by fire suppression policies because fire rotations in this area are much longer than the period of fire suppression. In other forests such as Rocky Mountain lodgepole pine, high severity fires every 100-300 years are ecologically appropriate and fire suppression has probably not affected these ecosystems to a great extent. The ecosystems most impacted by fire suppression are forests that once experienced regimes of frequent, low-moderate intensity fires; these ecosystems are probably the most vulnerable to altered fire regimes from changing climates.

Approaches to restore fire-adapted ecosystems often require treatment or removal of excess fuels (*e.g.* through mechanical thinning, prescribed fire, or mechanical - fire combinations), reducing tree densities in uncharacteristically crowded forests, and application of fire to promote the growth of native plants and reestablish desired vegetation and fuel conditions. Excess fuels are those that support higher intensity and severity fires than those under which the particular ecosystem evolved or are desired to meet management objectives. For example, in dry western US forests that once burned frequently, a high density of trees and a large surface fuel load often promotes crown fires that burn over very large areas. Some of these same forests once flourished under a fire regime where frequent, non-lethal low-intensity surface fires were the norm, and large-scale crown fires were rare. Managers should

determine if forests can be restored to what they once were or if another desired condition is more appropriate. If it is not appropriate to restore ecosystems to a previous condition because of expected novel climate conditions, then managers should develop new conservation and management strategies and tactics aimed at mitigating and minimizing uncharacteristic fire behavior and effects.

3. Climate change may interact with other human activities to further change fire regimes. For example, in much of the western US, since the 1980s, large fires have become more common than they were earlier in the century. This has often been attributed to increased fuel loads as a result of fire exclusion. However, a number of research studies suggest that climate change is also playing a significant role in some regions, elevations, and ecosystem types. In the western US, researchers recently identified an increase in fire season duration in mid-elevational forests. These changes were correlated with earlier spring snowmelt dates. With global temperatures projected to rise throughout this century, increases in fire season length and fire size can be expected to continue.

4. Climate change can lead to rapid and continuous changes that disrupt natural processes and plant communities. Are managers safe in assuming that tomorrow's climate will mimic that of the last several decades? Increased temperatures are projected to lead to broad-scale alteration of storm tracks, thereby changing precipitation patterns. Historical data show that such changes in past millennia were often accompanied by disruption of fire regimes with major migration and reorganization of vegetation at regional and continental scales. Exercises in modeling of possible ecological responses have illustrated the potential complex responses of fire regimes and vegetative communities. These exercises indicate that dramatic changes in fire regimes and other natural disturbance processes are likely. Indeed, some believe that the impacts of climate change may already be emerging as documented in widespread insect infestations and tree die-offs across some areas in the western US and British Columbia, and more rapid and earlier melting of snow packs. Developing both short- and long-term fire and fuels management responses that improve the resilience of appropriate ecosystems while reducing undesired impacts to society will be critical.

5. Changes in climate may limit the ability to manage wildland fire and apply prescribed fire across the landscape. Under future drought and high temperature scenarios, fires may become larger more quickly and could be more difficult to manage. Fire suppression costs may continue to increase, with decreasing effectiveness under extreme fire weather and fuel conditions. In some temperate and boreal regions, it is expected that more acres will burn and at higher severities than historically observed. In humid tropical regions exposed to severe droughts, vast forests could burn making it difficult for forest managers to prevent farmers from entering destroyed forests and establishing new farms. Globally, new fire regimes would be associated with shifts in ecosystem structure and function and likely, changes in biodiversity.

6. Approaches to fire management that recognize the potential for greater variability and directional change in future climates may help to reduce ecological and societal vulnerability to changing fire regimes. Such approaches are likely to improve fire management and ecosystem health. A goal could be to reduce the vulnerability, both ecologically and socially, to the uncertainties that accompany a changing climate. For example, if managers restore some forests as a means to increase ecosystem resiliency to climate change, they will also be improving biodiversity and protecting important forest resources. In the humid tropics, if managers make a concerted effort to prevent fire from entering rain forests during drought years, then they would be reducing the risk of future fires and illegal logging, even if droughts did not become more frequent and severe with a changing climate.

CONSIDERATIONS FOR MANAGEMENT, RESEARCH, AND EDUCATION

Recent changes in climate and fire patterns have been observed in many areas of the world, and current projections are that ongoing and long-term changes are likely. We believe that the actions outlined below could help managers to be better prepared to anticipate and mitigate potential negative effects of variable and changing future environments.

Fire and Ecosystem Management

- Incorporate the likelihood of more severe fire weather, lengthened wildfire seasons, and larger-sized fires in some ecosystems when planning and allocating budgets, which traditionally are based on historical fire occurrence.
- Make use of both short-term fire weather products AND season-to-season and year-to-year climate and fire outlooks that are increasingly available from "predictive services" groups in federal agencies, and particularly the sub-regional variations in anticipated fire hazards that enable strategic allocation of fire fighting and fire use resources nationally.
- Continually assess current land management assumptions against the changing reality of future climates and local weather events.
- Develop site-specific scenarios for potential weather events linked to climate change and redesign fire management strategies to make room for rapid response to these events.
- Consider climate change and variability when developing long-range wildland fire and land management plans and strategies across all ownerships.
- Consider probable alternate climate scenarios when planning post-fire vegetation management, particularly when reseeding and planting.

Fuels Management

- Prepare for extreme fire events by restoring some ecosystems and reducing uncharacteristic fuel levels through expanded programs of prescribed burning, mechanical treatments, and wildland fire use to meet resource objectives. Burning under the relatively mild weather conditions of a prescribed fire produces lower intensity burns and, generally, less carbon emissions than would a fire burning under wildfire conditions. Burning and thinning treatments should be strategically placed on the landscape in locations where they are more likely to influence fire spread. Some ecosystems will continue to burn in high severity stand replacement fires and this is appropriate for their sustainability.
- Incorporate emerging scientific information on the impact of changing temperature and precipitation on plant communities into fuels management project design and implementation at the local level.
- Expand wildland fire use at the landscape scale in fire-adapted ecosystems to restore fire regimes and reduce fuel loads. Be more aggressive in promoting fire use during lower hazard fire seasons, and fire use in landscapes that offer particular opportunities for relatively low-risk, large-scale burning. This will allow more acres to be burned under less extreme fire weather conditions than fires that might occur in the future under extreme heat or drought conditions.
- Control highly flammable non-native plant species and develop management options to address their increased spread and persistence. In some ecosystems appropriately timed prescribed fires can be used to reduce non-native species, while in others, continued fire exclusion may be the best management strategy. In some areas, reseedling and active restoration may be the best option.
- In some cases the removal and use of small diameter forest products (engineered lumber, pulp and paper, biofuels) and chipped fuels (for electrical energy generation) could be used to reduce fire hazards in appropriate vegetation types. Burning excess fuels in a co-generation plant has the additional advantage of producing lower emissions when compared to prescribed fires.

Research, Education, and Outreach

- Implement long-term biodiversity and fuels monitoring programs in the fire-adapted ecosystems that are expected to undergo the widest range of change and variability linked to climate change, such as those that once experienced frequent, low-moderate intensity fire regimes.
- Expand inter-disciplinary research to forecast potential fire season severity and improve seasonal weather forecasts under future climate change scenarios.
- Integrate the subject of climate change and its influence on ecosystem disturbance into curricula within natural resource management programs at the university and continuing education levels, and in science programs within primary schools.
- Disseminate information to the general public and government agencies regarding the potential impacts of changing climate on local natural resources and disturbance regimes, particularly those that interact with fire.

- Hold conferences or symposia to enhance communication among researchers and managers and to engage the general public in discussion on how best to adapt public land management to cope with fire in a changing environment.
- Form inter-disciplinary teams of researchers that include fire ecologists and climate scientists to identify and pursue emerging areas of climate and fire research.

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**BACKGROUND AND JUSTIFICATION
FOR INTENSIFIED
FOREST FIRE CONTROL ACTIVITIES**

1 BACKGROUND AND JUSTIFICATION FOR INTENSIFIED FOREST FIRE CONTROL ACTIVITIES

1.1 General

The rapid increase in human population is a major problem in most of the developing countries in Africa and South East Asia. In these developing countries forest produce has contributed to about 90% of domestic fuel for cooking, for drying of fish, meat and tobacco, for brick making, boat building, tool and weapon handles, and furniture making to mention just a few. This pressure on forests has resulted in a degradation of forest and other plant communities around the inhabited areas.

More land is required for growing agricultural crops to meet the needs of the increasing population. Likewise, more fuelwood and other forest produce is required to sustain the needs of the people. Larger areas are also required for feeding the expanded herds of livestock. The ecological imbalance is further aggravated by the uncontrolled ways of using fire as a means of clearing land and forests for human activities.

The main drawback which has not been significantly realized is the haphazard disappearance of both naturally existing and newly planted trees as a result of wildfires. Most of the wildfires are man-made and caused by various human activities. It is very seldom that wildfires are caused by nature (e.g. lightning). The most unfortunate existing situation is that to date most of the developing countries take forest fires as a surprise whenever they occur, though in tropical countries fire seasons occur regularly once or twice a year.

Forest fires have many times destroyed existing vegetation which unfortunately involved various investments in planting and caretaking. It is common that most developing countries have tree planting strategies and activities, but very few amongst those have any budget proportionally justifying the protection of the planted trees from possible fires.

1.2 Environmental Impacts of Forest Fires

When fire burns it has a number of effects which are negative to the environment, as described in the following sections.

1.2.1 Nutrient stability

When fire burns it burns off a number of nutrients which are volatile and these either evaporate or are easily leached. The end result is a lack of nutrients at the site in question. The situation gets worse with subsequent burnings.

1.2.2 Flora and fauna

As a forest fire burns it kills most of the microflora and microfauna within the top soil layer. Vegetation on the forest floor is in most cases completely burnt off. Most of the microflora and microfauna have a function of nutrient re-yielding. Once these are killed by excessive temperatures then the nutrient cycling is jeopardized.

1.2.3 Soil texture

As temperature rises and then falls the soil texture may be changed. This can even be accelerated by the change in nutrients, as mentioned earlier.

As the heat of the fire changes the soil texture, the small porous cavities in the soil are gradually filled with loosened soil. The reason for this is that many of the micro-organisms living in the top layers of the soil are killed by the heat. These organisms create the cavities in the soil which then absorb much of the excess water during rains. The absence of cavities in the soil reduces the water retaining capability of the soil. Repeated fires destroy the natural soil texture, which leads to escalated water run-off. Fast run-off of water is in fact to a large extent responsible for causing the excessive flooding in many areas in Southeast Asia.

1.2.4 Ecological stability

By a change of nutrients, flora and fauna, and soil texture, the ecology is checked by changing the environment to suit a different type of species community. This is very much pronounced when there is a lot of fuel (i.e. woody plants) on the ground.

1.2.5 Global temperature

Accumulation of pollutant gases after burning, as mentioned earlier, is a growing global concern. This has caused the global temperature to rise. This raise of temperature will in the long run have a very negative effect on living organisms and plants. Fire is therefore an enemy to the environment and hence also to human life.

1.3 Social and Traditional Beliefs and Practices

In most developing countries, the local communities take fires as a natural seasonal happening and believes that fires have to be lit. The following sections describe some beliefs or reasons that make some communities burn vegetation.

1.3.1 Rains

Local communities in some countries in Africa believe that when the drought is extreme burning forests and/or grassland will form a large smoke cloud. This smoke is believed to combine with dew clouds in the sky, or will actually make a cloud formation and hence bring rain.

1.3.2 Range management

This is practised by both range management professionals and by some locals. The professionals find it most efficient to have late burning, which clears almost all the old grass, giving room for new grass to germinate.

Local tribes like the Masai herdsmen in Eastern Africa practice the same, though no control is made and it is unfortunate that most of those people practising it do not pay attention to the negative effect of fire as mentioned in section 1.2. The new grass seems good for animals but in the long run the fertility of the soil is very much deteriorated.

In areas where there is a local community that keeps cattle, and also where wildlife exists, there is a possibility of wilde-beasts (gnu) and zebras coexisting with domestic animals. This is common in Masai areas. The Masai believe that when wilde-beasts have calves the after birth carries some bacteria that exist symbiotically. These bacteria then multiply and if the cattle graze within this area they pick up the bacteria, which are toxic to them. The Masai therefore burn the grass to destroy the bacteria wherever the wilde-beasts have been grazing. These fires may then grow wild.

1.3.3 Prestige

Some local communities burn in order to compete. This competition is only geared to see who had lit a fire which destroyed the largest of the areas. It makes the competitors satisfied and nothing else.

1.3.4 Agriculture

Clearing of areas for cultivation, especially shifting cultivation, is a common practice in developing countries. In most of these countries fire is used to burn the existing vegetation, as an easy practice which does not involve much labour. This also has a significant negative impact on desertification and ecology.

1.3.5 Beekeeping

Local beekeeping practices in developing countries use smoke to clear bees and make them less aggressive during the harvesting of honey. When honey hunters or collectors get their honey they may not bother to extinguish the fire they started to smoke out the bees. This may then cause a severe fire to spread in a forest.

1.4 Fire Prevention Background

By establishing a sound forest fire control strategy and executing it individually in each developing country, more seeds are going to germinate and survive naturally and money intended for reforestation or afforestation could be better invested.

When current burning practices are correctly identified as damaging and causing large scale deforestation, as in the case of most wildfires in Africa and Asia, the measures taken to combat then are often ineffective. The motive for burning must be removed, such as land speculation, tax or other incentives, and land documentation criteria that reward deforestation.

Prohibiting burning and attempting to enforce this through inspection and punishment is bound to fail. The above practice is one of the reasons for the failure to educate the masses about the negative effects of burning in most developing countries, with large scale deforestation as an end result. Forest fire control is one of the recognized forestry sciences in many countries where forestry has a high national priority. In these countries special academic degrees can be obtained in forest fire control. It would consequently be expected therefore that this also would apply in most developing countries, but this is not the case.

Australia, Canada, the UK and USA offer degree courses in this field. Technical level education in forest fire control is not available anywhere however. The reason is that fire-sciences are available internationally, but only for fire-men, not for forestry people. Additionally, fire brigades in developing countries are financed by the communities or by national airport authorities, and they only have mandates to operate in the near vicinity of their fire station. Their training does not include the combat of forest fires, nor is their equipment suitable for off-road activities.

Consequently therefore, forestry people are forced to form the core of any organisations combatting forest fires in almost all developing countries.

To remedy the present situation, the introduction of the Thai system of continuous education and training programmes and proper follow-up in localities that can have a positive response to forest fire prevention and control is needed.

This could be done by bringing about the proper knowledge and awareness to the foresters and the general public. This includes a massive effort of educating all students and teachers already at primary school level. Involving the media and press to its fullest extent will result in massive pressure from the public towards the government and the political leaders.

In Thailand this public education programme has had a widespread effect, and it has resulted in a reduction of haphazard burning in the country by 30%. This proves that massive campaigns are possible to execute. In some countries like those of Tanzania and Indonesia a positive response from the government has been assured and the public awareness is growing in a positive direction with the aid of decision makers, the media, and forestry personnel.

The long term efforts by Finland in providing training in prevention of forest fires justifies the continuous support by the Finnish Government. More than 25 years of training and education activities in this field, provided for by Finland, is now showing great promise for the future in some of the developing countries of Africa and South East Asia.

The training will also include the production of training material and teaching aids. The national forest fire control chiefs will of course also need national trainers and instructors for the further training of voluntary (village) fire brigades.

Apart from the institution building efforts in establishing special forest fire control units in each country the already existing ones need to be further strengthened. This institution building process requires not only sufficiently well trained personnel but also financial resources and basic tools and equipment available at reasonable cost.

The recent disastrous forest fire in China (3 million hectares) was to a large extent caused by lack of voluntary fire brigades and suitable fire control tools. Another giant forest fire in Kalimantan, Indonesia in 1983, which also scoured 3 million hectares of tropical rainforest in Bukit Soeharto was established as having been caused by arson.

An ITTO project has now been established to look into the rehabilitation of the above burnt forest. The large forest fires in Spain in 1989 (which resulted in scouring of close to half a million hectares of mixed scrub/pine forest, IFFN) were caused by lack of knowledge in how to control and educate the enormous amount of tourists and campers touring the region.

It is also very important to establish operational units in each country to cater for all forest fire activities. In some other countries the existing organisations would need strengthening, and the division of responsibilities between urban and rural fire organisations would need to become established.

Accidental fires do occur naturally, but more than 95 % of all forest fires are related to human activities. Consequently therefore, many fire situations may be completely avoided if appropriate training is provided. Additionally, communication equipment and appropriate tools are required to achieve acceptable levels of preparedness before the annual fire seasons occur.



**BASELINE DATA
FOR
FOREST FIRE CONTROL**

2. BASELINE DATA FOR FOREST FIRE CONTROL

2.1 Management Policies for Forest Fire Control

Consideration of general background facts

Before the onslaught of the industrial revolution almost 50% of the land surface of the world was covered with forest. In 1955 this area had been reduced by half, and in 1980 the original pre-industrial revolution area was estimated to be only 20% of the land surface.

Today, we can therefore say that every country must be concerned about the threat of fire to their forests.

The full comprehension regarding the negative impact of forest fires on the environment and the economy might not be clear enough.

When seeing a wildfire on communal land, grassland, savannah, and so on, many people may think that there is no reason to worry as there is nothing for the fire to damage and no losses will occur. On the contrary however, it can be proved that every wildfire causes some loss or damage to the environment and to the balance of nature.

Damage and fire loss can be summarised as, for example:

- lack of fuelwood for the people for cooking and heating purposes;
- economic losses in valuable timber plantations and forests;
- large scale soil erosion starting after a fire on steep slopes (soil erosion in turn causes other problems, such as siltation of the rivers and dams); and
- damage to the environment and natural resources.

Fire on the land or in forests can be either intentional or unintentional.

The intentional fire is usually under planned human control and has some beneficial objective.

The unintentional fire, or wildfire, is not under human control and normally causes damage to the natural resources and to the human population.

Unintentional fires are usually caused by one of the following activities:

- Grassfires for grazing purposes.
- Slashfires for cultivation.
- Prescribed burning for fire prevention in fire hazardous areas.
- Prescribed burning for silviculture (slash, litter, and debris burning for clearing, road maintenance, etc).
- All outdoor burning for farming, hunting, camping, ranchers, against animals, etc.

Long term experience of wildfires has shown that they are difficult to control without practice, and therefore that these fires may spread out of control. That is why in most countries a large number of forest fires start from some kind of controlled burning. There are also problems in not being able to differentiate exactly between arson and unintentional fires.

When a policy of forest fire management is worked out the first step should be to formulate clear directives and rules, and if needed, guidance for the people and farmers on how, where, and when to light a fire. A person may be allowed to light a fire on common land but who is then responsible for it?

When the rules and directives for forest fire control are laid down care will have to be taken of, and adaptations made to:

- the general protection needs and values of the land and forests;
- the farmers needs for fire in cultivation; and
- the use of fire in local conditions, considering religion and traditional uses by the rural people.

Often there exists a strong conflict between legislative forest fire control and the traditional ways of using fire in the rural areas. This is why all the traditional uses of fire by the rural people cannot always be taken into serious consideration.

If traditional fire methods are to be accommodated in the objectives of forest fire control it will need long-term planning and step by step education to achieve changes in the people's attitudes and ways.

2.2 The Objectives for Fire Control in Different Types of Forest

It is the responsibility of the high political authorities in government to determine the objectives and the extent of the National Forest Fire Control Programme. This is because government funds will be required to run the organisation.

Determining the full extent of national fire management will depend on the one hand on all the added costs, and on all the estimated and added benefits on the other.

Some of the products and benefits from the forest are difficult to value in economic or monetary terms, others are impossible. For example:

- hunting and camping;
- aesthetic values; and
- other recreational activities.

The objectives of fire protection on different types of land and forest will alter depending on their economic and environmental values and on the overall utilisation of the areas.

In forest fire management, land and forest areas can be divided into two main groups:

- (i) Protected forest areas (high value).
- (ii) Second growth or non protection requiring forest/land areas (non or very low value).

Maintenance of the forests and lands by the type of utilisation can be divided as follows:

- (i) Plantations.
- (ii) Forests under economic management and silvicultural forests.
- (iii) Multiple use forests and general mixed forest.

- (iv) Protected forests, natural and national parks (for wildlife, camping, tourism, etc.).
- (v) Farmers' forests (agroforestry).
- (vi) Livestock and cattle ranching and other areas of cultivation.
- (vii) Hardwood areas, such as savannah, etc.

The level of fire protection must be as high as possible in commercial plantations and silvicultural forests. Economic losses and damage are usually very high when an accidental fire occurs in these types of forests.

As opposed to the coniferous forests, in some of the broadleaf forests fire protection could be set at a very low level since these areas usually contain tree species that are very fire resistant.

Other broadleaf forest areas could have some special value or purpose, for the prevention of soil erosion for instance. In this case the level of protection must be high.

The use of fire on grazing lands is a common practice, but for fire control purposes it is important to ensure that the lands are burnt at the proper time of the day and year, and at the right frequency.

Any plantation or intensively managed commercial forest should not be established before sufficient funds have been allocated for fire protection and effective fire management. Also, the planning in regard to both the preparedness and fire suppression should be up to date. Plantation areas always involve important economic values and it is therefore worthwhile to allocate more than average amounts of money for fire protection to these areas. The protected forest could have different values and objectives, such as wildlife protection and the prevention of soil erosion on steep hillsides.

Often, the protected forest areas will also require intensive fire management control.

2.3 Forest Fire Management Plan

Successful forest fire management and the obtaining of good results presupposes profound and overall planning. The forest fire management plan should include:

- the objectives of fire protection;
- fire prevention;
- the procedures when a fire occurs; and
- suppression activities.

It is better to prepare separate plans for the different types of forest areas, such as plantations, protected forest areas, etc.

The fire plan should include information on the following:

- (i) a responsible personnel list;
- (ii) duties;
- (iii) activities; and
- (iv) preparedness for a fire.

It must also be planned at different levels:

- (i) government level;
- (ii) provincial and / or district level; and
- (iii) local or municipal level.

The most important, and also the most detailed plan, is the local fire plan. Before every fire season the fire plan must be re-checked. Planning and checking is the duty of the authority responsible for forest fire control.

Before starting fire management planning the following background information has to be obtained.

- (i) Description of the protection areas:
 - fire management objectives of the different areas;
 - ownership and utilisation of the land and forest areas.
- (ii) Fire history, coded by:
 - day and month;
 - time of day;
 - cause of fire;
 - size (estimated in hectares);
 - location (map co-ordinates, municipal);
 - types of fuel (forest, brush, grasslands).
- (iii) Fuel types of the main areas:
 - special fire hazard areas such as slashed areas and plantations;
 - history of the fire, rates of spread;
 - any special difficulty in fire control in the different fuel types.
- (iv) Climatic conditions and fire seasons (for each year and for each individual month of the year):
 - temperature: average, maximum, minimum;
 - humidity: average, maximum, minimum;
 - rainfall: average per month;
 - burning index: average;
 - fire season: start date, ending date (month).
- (v) Settlement conditions, wildfire regulations, and ways of the people:
 - rural and urban areas;
 - commercial forests and farming areas;
 - traditions, regulations, rules, and legislation for the control of wildfires;
 - means of transport, public roads, forest roads and tracks, etc.
- (vi) Alternative organisations who are responsible for fire control:
 - duties and responsibilities of the main governmental organisation;
 - results from other potential organisations.

A basic fire management plan will include information on the following items:

- (i) forest areas and fuel types;
- (ii) responsible organisation(s);
- (iii) fire prevention plan.
- (iv) fuel hazard reduction work;
- (v) fire danger measuring system;

- (vi) fire detection plan;
- (vii) fire reporting;
- (viii) alarm systems and communications;
- (ix) fire suppression plan;
- (x) fire suppression management plan;
- (xi) co-operating personnel;
- (xii) equipment and tools;
- (xiii) supplies;
- (xiv) safety measures; and
- (xv) maps and records.

If the fire plan and organisation is established for the average fire situation, it could then happen that there will be insufficient resources and provisions for a very serious fire situation. Figures show that statistically, most damage occurs during a severe fire situation and during the very few large fires, which account for only 10% of all fires.

2.4 **Losses Caused by Forest Fires and Economic Aspects of Fire Management**

The effect of economic losses and the total damage caused by forest fires will affect the people and the country as a whole. This is the basic reason for the organisation of forest fire management.

It will be possible to give a more accurate estimate of the economic losses if there is a clear view of the natural resources and if the full values placed on them are used. In addition, information of burnt areas and fires occurring during the past few years is needed.

By going through this regionally accurate analysis of loss and damage a regional fire risk record map can be created. This fire record map is needed for decision making by the fire management organisation to determine the level of its involvement and its authority.

The key questions to put forward to the authorities of government would be:

- What funds are available each year to support forest fire protection?
- How much damage (in hectares) is caused and how much money is lost per year?

Two simple rules to remember are:

- (i) If minimal funds are spent on fire protection then a weak protection force will result and the consequence could be a lot of damage.
- (ii) If maximum funds are spent on fire protection then an effective protection force will result and any consequent damage will probably be very small.

The optimum solution must be somewhere between these two.

A traditional and simple method for evaluating forest fire losses is to evaluate the loss against the amount of burnt area and to apply this to an established average price per hectare for the different types of forest. By using these basic facts the annual forest fire losses have been calculated, based on the total burnt area. In countries where timber production represents a large share of the national economy the effects of fire protection can best be calculated by showing the actual value of the timber.

Evaluating the real and total loss is not so simple and straightforward. In addition to the burnt forest, many other types of loss can occur. The total loss caused by the fires may only be known several years afterwards, for instance, in regard to soil erosion and the damage that follows soil erosion. The appraisal of fire damage in the case of recreational resources for instance is also extremely difficult.

The loss of human life caused by a forest fire is not an everyday occurrence, but is it so rare that it should be considered negligible? Also, financial resources are consumed in the fire. Both these facts must be calculated in order to achieve the total losses caused by a forest fire.

Naturally, the loss of houses, other buildings, roads, farmland, and such like must also be added to the total value lost.

Statistics based on average figures obtained from many countries show that less than 10% of all fires cause more than 90% of all the damage, and that these fires have a higher than average intensity.

Because of this, there is a need to consider at what level the forest fire organisation should be supported and from where the reserve forces may be obtained when a large fire occurs.

One principle that the fire manager must never forget is that the main purpose of the fire organisation and the fire budget is to minimise the damage caused by fires to the parent organisation.

The most important facts for an effective fire management programme and for its economic appraisal will be obtained from the accrued statistics on the number of fires, burnt areas, damage and loss, and suppression costs.

2.5 Climate and Fire Seasons

Those people who have been dealing with forest fire control will know that the weather elements have a big influence on the behaviour of fire, such as:

- the ignition of fires;
- the spreading of fires; and
- the degree of difficulty of fire suppression.

A very important condition for combustion is the moisture content of the fuel. The vegetation and the forest fuels absorb moisture during periods of precipitation and lose it during dry weather. This is why an analysis of the climate will form a sound basis for the right timing of the forest fire control activities.

The climate is related to forest fires in two ways:

- (i) it determines the length and severity of the fire season; and
- (ii) as vegetation depends largely on the weather conditions, it determines the amount and quality of the fuel available.

The climate is an expression of the weather experienced over a long time span at a certain locality.

The climate is usually expressed as the average of various weather elements and their reduced extremes. This information is very useful when a general picture of what might be expected from the weather is required.

For forest fire organisation purposes and for calculating the activity of the fire suppression units the following information about the local climate is needed month by month:

- Temperature.
- Precipitation.
- Humidity.
- The beginning and the end of the dry and rainy seasons.

With this information the local fire season, or fire seasons can be predicted quite accurately. Fire management organisations can use the climatic data to determine the local average fire occurrence over a length of time. To the climatic data the number of fires and burnt areas have to be added for use in any statistical analysis.

These facts when put together will give a sound basis for fire protection planning.

Month	Annual Average 1968 - 1977			
	Number of Fires	%	Area Burned in Hectares	%
January	13	-	30	-
February	6	-	7	-
March	43	-	541	-
April	651	7	20,895	2
May	2,012	23	166,202	14
June	1,493	17	438,563	38
July	1,906	22	370,915	32
August	1,781	21	151,172	13
September	507	6	14,517	1
October	222	3	4,420	-
November	44	1	1,714	-
December	6	-	10	-
Total	8,684	100	1,168,986	100

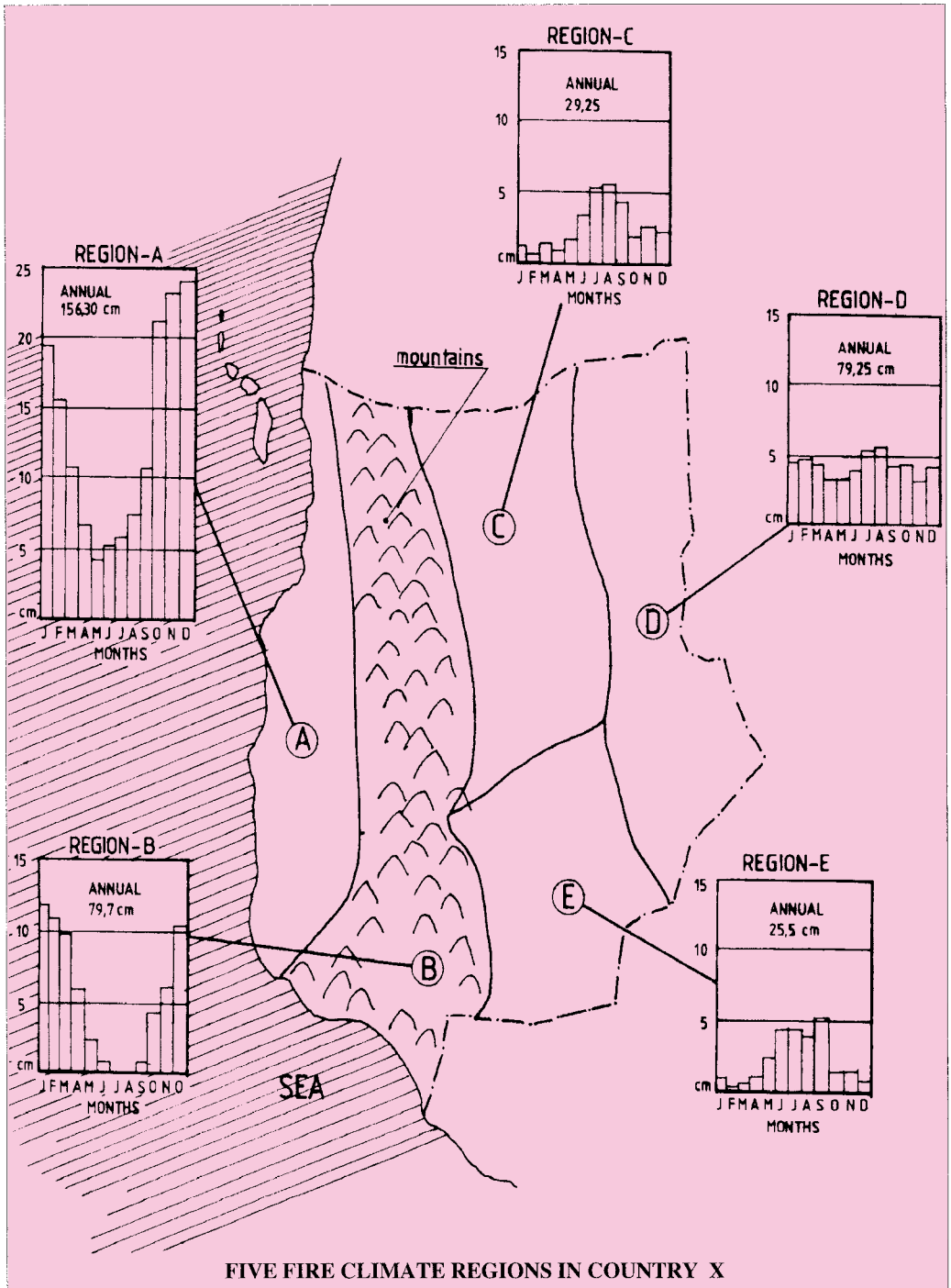
Enclosed statistical data from Canada; fire distribution by month

The fire climate of an area is dependent on its latitude, topography, and position relative to large bodies of water. In high latitudes the fire season is usually quite severe, but relatively short. The closer the area to the equator the longer, on average, the duration of the fire season will be.

If the country is very large and includes different climatic zones the differences between the zones must be considered. For planning purposes the country can be divided into the basic fire climate areas, according to the monthly precipitation, for example, and shown on a map.

This type of graphical information and pointing it out on a map will give a good review of the climatic differences between the areas, as well as indicating the approximate dates of the average fire season.

One special factor of the climate is **LIGHTNING**. The occurrence of lightning must be recorded as part of the fire climate, because lightning is statistically one of the biggest causes of forest fires.



2.6 Climatic Regions and Ground Vegetation

One important basic consideration of fire management and planning is to know the main forest fuel types and the ground vegetation around the protected area. Climate also has a significant effect on the vegetation patterns.

Koppen (Chandler et al 1983) has developed a mathematical system of climatic classification that ties climatic regions directly to the main vegetation types. With this system the main vegetation types in relation to the annual mean temperatures and the total annual precipitation can be seen.

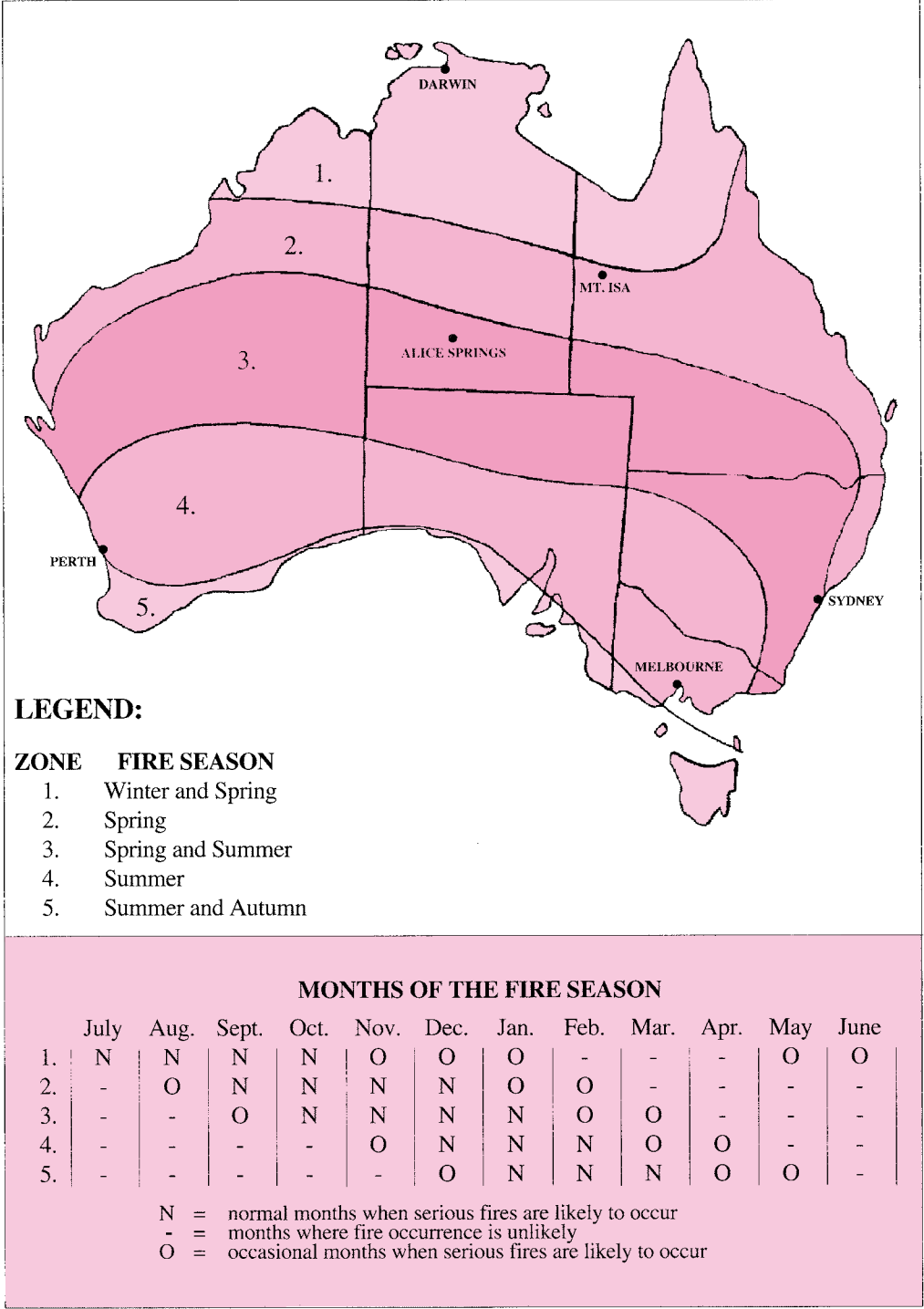
One example of how the local fire climate is statistically determined with this system is shown in the following table.

	Climate Data for Cover Type 8: Brush											
	Mild Winter, Nonhumid, Long Burning Season											
	Light Understory, Low Litter Weight											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des
Fire Probabil.	0.65	0.57	0.65	0.57	0.69	0.85	0.96	0.97	0.69	0.62	0.16	0.36
Burning Index	17.0	2.10	24.0	29.0	37.0	37.0	43.0	25.0	24.0	22.0	26.0	15.0

Fire climate of Murcia, Spain, 37° 56' N, 1° 14' W, elevation 75 m

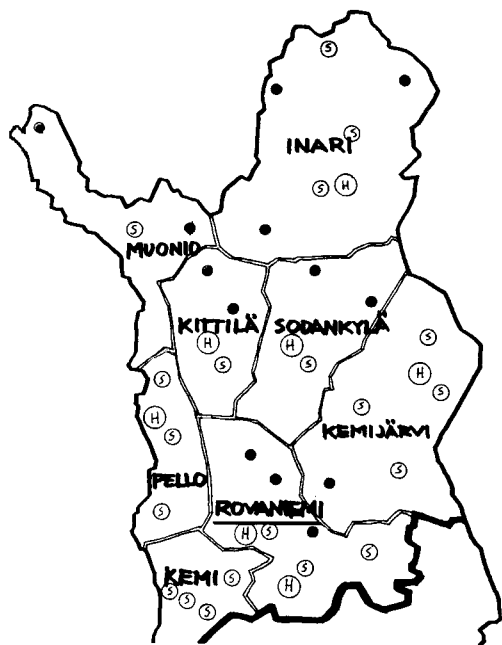
For fire management purposes more than merely the ground cover type must be known. As much as possible about fuel loading, the understory, litter, and the canopy should be known. Also when and how intensively the fires can be expected to burn. These facts are explained in chapter 5, Forest Fire Behaviour.

Finally, one example of a forest fire weather map. This map has been specially prepared in Australia. It will give a good example to the forest fire managers of how to assess the fire climate, the fire season, and the fire occurrence in their own areas.



Fire Weather Map of Australia

Some examples of fire management planning maps from Finland are given below.

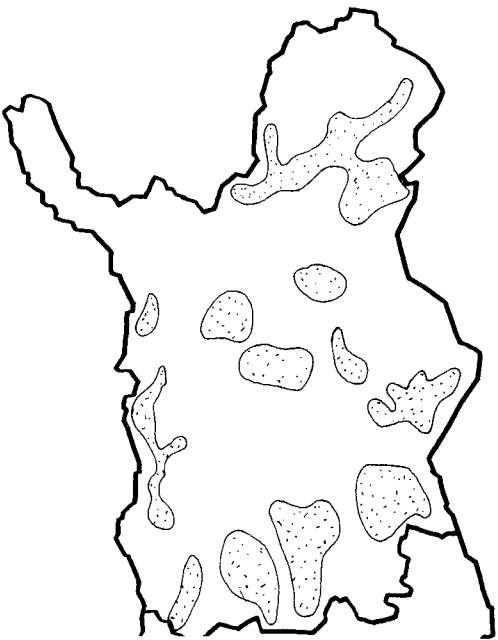


- Village fire unit
- Ⓢ Fire station, many units
- Ⓜ Forestry Headquarters
- Fire alarm region (responsibile area)

Responsible areas and resources of the fire service in Lapland province



- Government
 - Private
- Owners of the forest areas in Lapland



Fire risk areas in Lapland



**RESPONSIBLE ORGANISATION FOR
FOREST FIRE CONTROL
AND BASIC LAW ENFORCEMENT**

3. **RESPONSIBLE ORGANISATION FOR FOREST FIRE CONTROL AND BASIC LAW ENFORCEMENT**

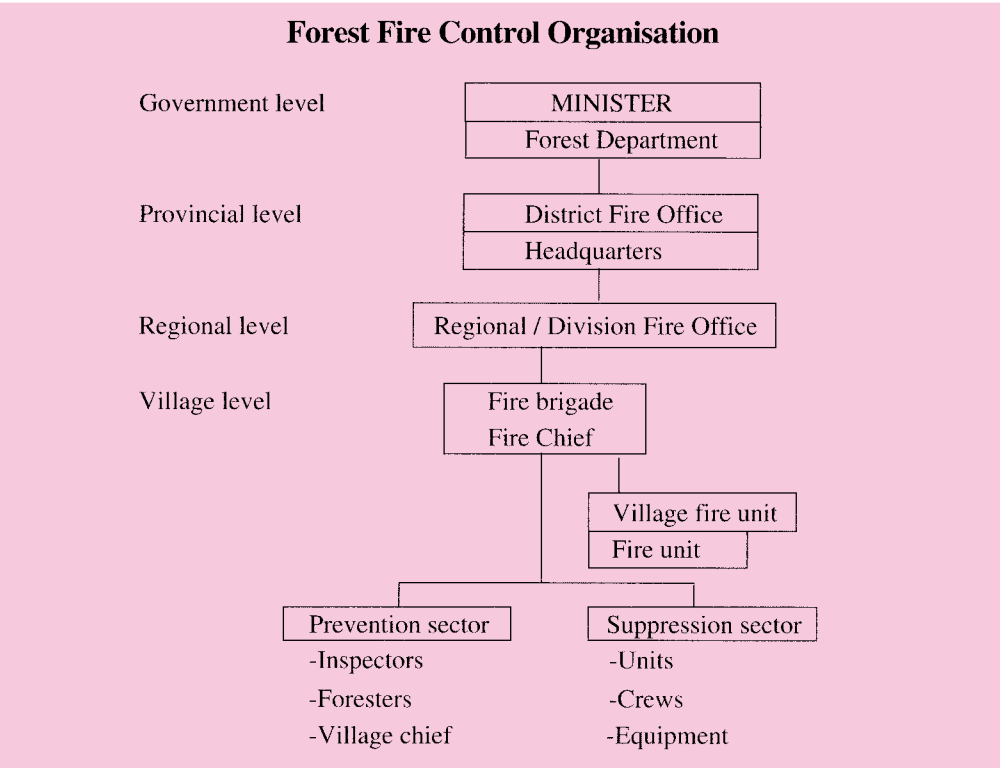
There are many variations in the ways to organise the fire control service. The laws, regulations, and duties of the responsible authorities may vary from country to country, depending on:

- the organisation of the government;
- local laws; and
- culture and traditions.

In this part of the manual some of the general principles for organisation and the steps to be taken to develop laws and regulations for forest fire prevention control are pointed out.

3.1 **Responsible Organisation for Forest Fire Control**

The responsibility for forest fire protection has, by law or in a fire ordinance, to be assigned to a public organisation. The responsibility and authority for all duties must be clearly outlined to all responsible bodies, from village level to the highest level of government. The main responsibility for fire protection is generally under a ministry, which has to know exactly what its duties are and the objectives of the regulations.



It is important that the highest level of responsibility is placed upon a ministry, because forest fire protection will be organised by using government budgetary funds. Therefore it is also important that the responsible ministry is, at all times, kept well informed of the problems and activities of forest fire control.

The lowest level of responsibility in the forest fire protection organisation is placed at local or village level. These local or village level activities are also the most important basic link for all organisations involved in forest fire control.

In practice, most countries have two appropriate alternatives for the selection of the main responsible organisation for forest fire protection, which could be as follows:

- (i) A national forestry organisation or department which normally attends to all forestry activities. In general the forestry organisation carries out these duties very well because:
 - foresters have a good knowledge of all the forest areas, forest types, maps, accessible roads, and so on; and
 - the forestry organisation covers all the forest areas.
- (ii) The national fire organisation or department could also be suitable for this duty. As the fire organisation is usually situated in an urban area there could be a problem when considering the distance of the fire brigade from the forest area.

It is a more common practice for the Forest Department to take the prime responsibility for forest fire control. However, a combined organisation could be used. This means that the duties will be divided between the forestry department and the fire organisation.

Responsibilities can be divided at different levels or between different duties. If there is a combined organisation then the perimeters of the areas and duties must be made very clear.

3.2 Cooperation and Collaboration

Very few fire services can afford or justify owning all the fire equipment nor be able to organise all the resources that are required to combat unusually large fires. Therefore, most districts depend on cooperation from other organisations, and in return cooperate with them. This cooperation takes many different forms, but it is a necessary part in the planning of any fire management strategy.

The most common of the organisations that cooperate in forest fire control are the:

- Police;
- Army;
- Air Force;
- Civil Defence;
- Public Works Department; and
- Department of National Parks.

The wildfire control services will often have to make a formal agreement of cooperation with one or more of the above organisations.

3.3 Law Enforcement and Regulations Affecting Wildfire Protection

To lay the foundation for wildfire prevention and the organisation of forest fire protection the country must have special laws and regulations. The regulations and law enforcement must consider the local situation of living conditions, farming, etc. Generally, these basic laws and regulations should include the following:

- (§) Naming the responsible authority for the individual duties of wildfire protection, such as prevention and suppression. Also to state the different levels, such as government, provincial, district, and village.
- (§) Leadership in forest fire suppression activities and the authority of that leader.
- (§) Local regulations stating how, when, and in which areas domestic fires are allowed to be started, and also stating dangerous and non-dangerous conditions.
- (§) Rules and limitations for campfires, farm fires, slash fires, and other fires.
- (§) That it is the responsibility of all members of the public to report a forest fire or any smoke seen within a forest area.
- (§) That it is the duty of all members of the public to stop the spread of a fire and take part in any fire suppression activity.
- (§i) That a punishment should be enforced if somebody has, through carelessness or neglect, caused a forest fire.
- (§i) Designating responsibility for the mopping-up operations.
- (§) Responsibility and liability for payments in regard to prevention, fire suppression, and mopping-up operations. Also, the responsibility for payment in cases of fire damage caused by carelessness or neglect.

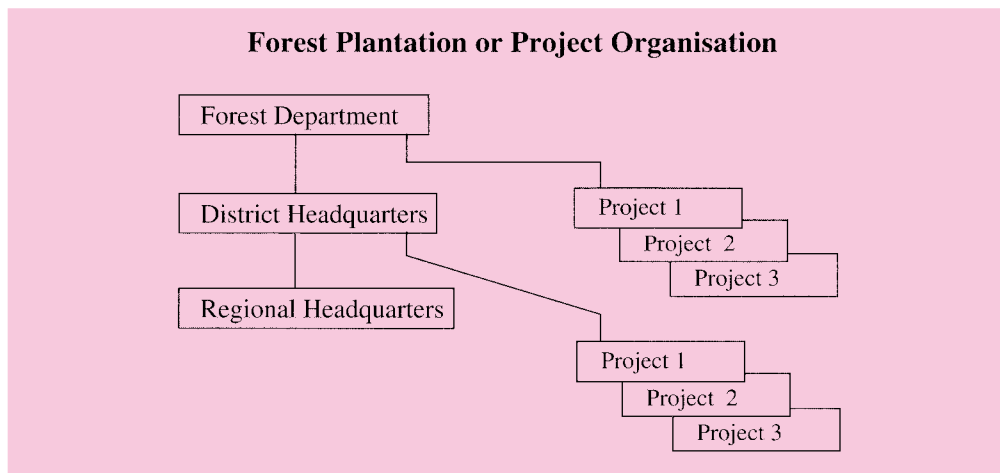
Naturally, the most effective way of fire protection is to educate the farming community, tourists, and the general public on the importance and value of the forests and the seriousness of the damage caused by fire. If the whole population understood this and took the necessary care when lighting a fire then most of the regulations would be redundant.

3.4 Plantation or Project Fire Organisation

In many countries the most important and most economic part of forestry development is the plantations and special forest projects. Because these areas are very valuable, with large amounts of the national forestry budget invested in them, it should be required by law to establish an effective fire prevention organisation for these areas.

Plantations and special forest projects can be placed within the framework of government:

- (i) under control of the Forest Department staff; or
- (ii) under control of the regional, provincial, or district headquarters.



3.5 Duties of the Responsible Authority in Fire Organisations

3.5.1 Fire protection manager (field manager)

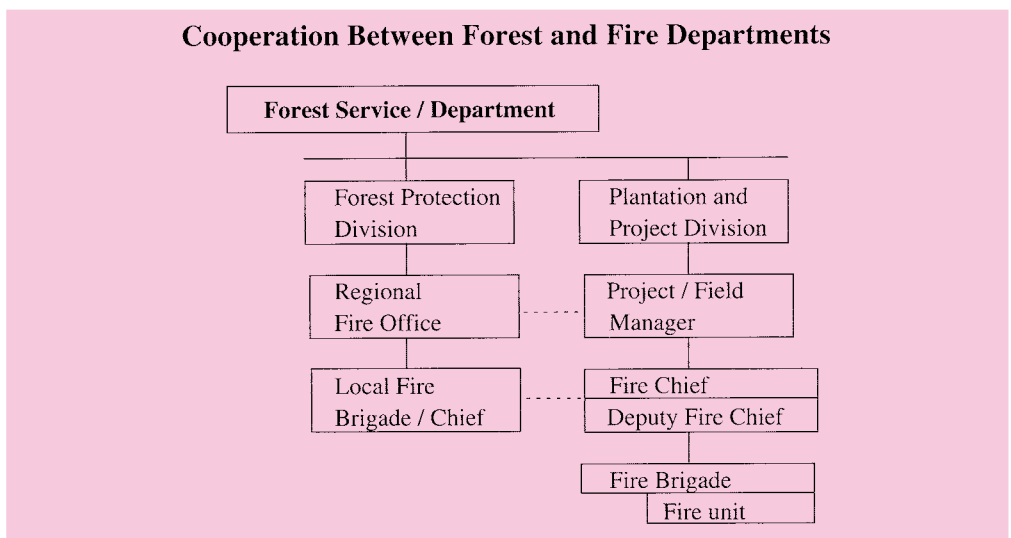
- Works out the fire plan, keeps it up to date, and makes sure that it is working.
- Makes proposals for emergency situations and develops the fire protection ability of the staff.
- Looks at the suitability of all the work methods applied and checks that any equipment purchased is suitable from the fire protection point of view.
- Looks after and supervises the fire service organisation and its future development.

3.5.2 Fire chief

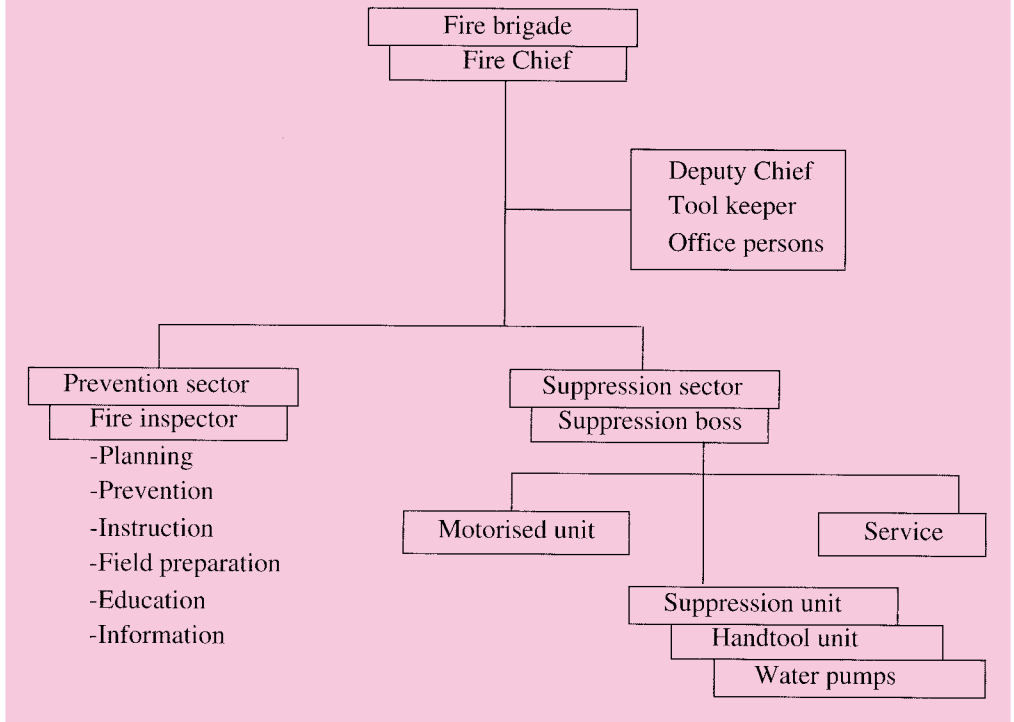
- Looks after fire security and protection methods, including observation and enforcement of the forest fire regulations.
- Makes sure that all fire risk conditions are minimised or removed.
- Makes sure that all fire prevention tools and equipment are in good condition and stored in the right place.
- Supervises fire prevention and pre-suppression activities as stipulated in the fire plan, such as grass cutting, controlled burning, preparing firelines and firebreaks.
- Prepares statistics and reports on all fires for submission to the correct authority.
- Leads the fire fighting units.
- Trains the fire brigade crews and fire fighting units.
- Makes proposals for intensive fire protection in general and increases the preparedness of all fire prevention units.

3.5.3 Storekeeper

- Keeps fire fighting tools and equipment in good working order, in a special fire tool store.
- Repairs or replaces all useless and broken tools and equipment.
- Makes regular inspections of the tools and equipment.
- Makes proposals for the purchase and delivery of new tools and equipment, and for their maintenance.



An Example Organisation Chart for a Fire Brigade



3.6. Fire Protection Plans

3.6.1 Purpose

The purpose of fire protection planning is to ensure that all state forests are adequately protected from fire by a continuing review of protection needs and organisational preparedness. A fire protection plan will provide in a readily accessible form all information required in organising a fire control operation. It will detail the existing protection system and incorporate recommendations for progressive improvement.

Information listed will include:

- (i) the effective access and firebreak system;
- (ii) the detection and communications system;
- (iii) the fire management plan;
- (iv) equipment and manpower resources; and
- (v) contingency plans for fire organisation.

Protection plans will be subject to regular review and will form the basis on which budget allocations for protection expenditure are determined.

3.6.2 Format

Plans need not conform to any rigid format. However, each plan should consist essentially of three parts:

- (i) A formal written plan detailing the existing protection system and incorporating recommendations for improvement.
- (ii) An organisation plan which will consist of a folder containing, in a clearly indexed form, all information likely to be required in an emergency (suggested content in 3.6.3.1).
- (iii) A map or series of maps showing all current information relevant to a fire control operation.

3.6.3 Content

Plans should include the following:

- (i) **Protection policy**
 - List all State Forests covered by the plan by broad forest types.
 - Define clearly the protection policy for each area.
 - Nominate the protection priority of each area covered by the plan
- (ii) **Existing road and firebreak system**
 - Outline the existing road and firebreak system.
 - Define the standards and specifications for roads and firebreaks particularly where there is any departure from the normal prescription.
 - Outline the annual maintenance requirement.
 - State the protection budget allocation.
 - List any planned improvements and allocate priority ratings of future works programmes.
- (iii) **Fire history**
 - A brief statement is required describing the incidence and severity of previous fires in the area and identifying historically high risk areas.
 - A map should be maintained showing all previous wildfires (location, area burnt, month and year of occurrence).
- (iv) **Fire management**
 - State the current hazard reduction burning policy for the various fuel types.
 - Describe the characteristics of local fuel types and comment on their burning characteristics.
 - Indicate the frequency and timing of hazard reduction burns.
 - List all areas which are burnt by ground crews.
 - List areas covered by co-operative burns (e.g. with villagers).
 - Record the current stage of the burning programme on the protection maps.
- (v) **Detection systems**
 - Outline the detection system - towers, other lookouts, blind areas, ground patrols.
 - Maintain maps showing areas seen from each tower or observation point.
 - Detail the formal system for deciding when towers are to be manned and when ground patrols or additional checks from observation points should be carried out.
- (vi) **Communication**
 - Indicate location of radio bases and telephone lines, and any deficiencies in the system.
 - Keep a list in the Fire Organisation Folder of each vehicle or officers having radios and the call sign of each.

- (vii) **Equipment** (including pumps, engines, water tanks, ploughs, and other equipment for making firelines)
 List all equipment, indicating its age and condition.
 Draw up a schedule for replacement.
 Include check lists for vehicles and plant, equipment test procedures and personnel responsible for testing the equipment or ensuring the right equipment is on each vehicle.
- (viii) **Training**
 State what training has been done and what is required, e.g. local training of tower observers, firecrews, truck drivers, tractor drivers, nominated fire bosses.
- (ix) **Contingency Plans**
 Record information or procedures likely to be needed in an emergency situation. Most of it will be duplicated in the Fire Organisation Folder for ease of access. This should include the following:
 - (a) **Sources of external assistance**
 List accurately what manpower and equipment is available in an emergency from villages, nearby plantations, fire brigades, other government departments, etc.
 List names and how to contact people authorised to release such equipment.
 List organisations which may be able to provide a service function such as supply of meals to fire fighters.
 - (b) **Formal crew dispatch system and initial attack standards**
 Define levels of preparedness, automatic dispatch procedures and initial attack standards. All activities should relate to the Fire Danger Index, Drought Index and forest type.
 - (c) **Local command structure**
 Define roles and responsibilities of staff required to act as:
 - (i) fire boss;
 - (ii) crew boss;
 - (iii) radio base operator; and
 - (iv) support staff (supply, records, liaison).

3.6.3.1 Suggested content of fire organisation folder

The fire organisation folder should contain all information likely to be required in organising a fire control operation or in organising to meet a changing fire weather situation.

The following information should be presented in a clearly indexed form to allow rapid extraction:

- (i) Current weather forecast, presented in loose leaf form at the front of the folder.
- (ii) Current stand-by arrangements. List staff actually on duty and those on stand-by. Detail location of tractor trucks, truck drivers and tractor operators and types of equipment they are authorised to operate, towers manned at the present time.
- (iii) Preparedness tables. Define level of activity in relation to Fire Danger Index and Drought Index. The duty officer on weekends requires such information to make any changes in stand-by arrangements in the event of changing weather situations.
- (iv) Radio call signs for all vehicles or officers with radios.
- (v) Telephone numbers of all staff (work and after hours for the local headquarters and neighbouring headquarters).
- (vi) List of regular and relief tractor drivers, truck drivers, and tanker drivers.

- (vii) List employees and how to contact them after work.
- (viii) Private hire arrangements (if any equipment is available for hire), including: dozers, trucks and low loaders, and aircraft.
- (ix) Checklists.
 - (a) Duty Officer
 - (b) Radio Base Operation
 - (c) Investigation Officer
 - (d) Dispatcher
 - (e) Fire Boss
 - (f) Vehicles
 - (g) Firefighters
- (x) Action plans.
 - (a) Dispatch system
 - (b) Strategic plans

3.6.4 Protection maps

Protection maps should include all information likely to be of value in determining fire suppression strategy.

The scale should be such as to allow all necessary information to be entered without cluttering. Each management area should be the subject of one single map if possible, but the map must not be too bulky for ease of field use at a fire.

All information entered on the map should conform to the standard map legend. Information of a temporary nature such as prescribed burning, firebreak maintenance, and recent logging or treatment is best recorded on one or more overlays on the base map. Annual updating of the overlays leaves the base map intact.

Plastic overlays may also be used to record the current fire situation and to plan suppression action. Such overlays will provide valuable records of fire development for post-fire analysis and reporting.

Standard map legend

- (i) Roads not presently recorded on the printed map
- (ii) Firelines, bladed tracks, and 4-wheel drive track.
- (iii) Natural scrub (forest) breaks or well developed village forest plots (dark green)
- (iv) Scrub (forest) breaks of limited effectiveness or areas where agroforestry is practised (pale green)
- (v) Any areas excluded from protection (red)
- (vi) Any huts, houses, dips, yards, pump sheds, or other improvements (YARDS)
- (vii) Permanent water points accessible by vehicle (W, blue)
- (viii) Fire towers (TOWER NO. 2, dk green)
- (ix) Lookout points (BAUPLE MT. LOOKOUT, dk green)

- (x) Areas of protection priority. Plantations should be adequately defined on existing maps by surveyed boundaries, year of planting, species and area. Other areas which need defining such as fire exclusion areas experiments, seed orchards, and so on can be shaded in yellow or any colour other than red or orange.
- (xi) High hazard areas which would produce abnormally severe fires should be shaded in orange, e.g. recent logging areas, unburnt alang-alang grass, etc. Such information is best recorded on an overlay as it is temporary in nature.
- (xii) Burning history. Areas on which co-operative burns, prescribed burns or buffer strip burns have been carried out are to be shown by cross hatching in red, together with date of burn on the map overlay, or by using a Standard Management Colour Legend as detailed below.

1980/81	Brown
1981/82	Red
1982/83	Orange
1983/84	Yellow
1984/85	Pale Green
1985/86	Dark Green
1986/87	Pale Blue
1987/88	Dark Blue
1988/89	Purple
1989/90	Black
1990/91	as for 1980/81

The simpler single colour system is preferred. Again, use of clear overlays is recommended for the purpose.

- (xiii) Other land users. Include lists of any person or organisation working or living in the forest area (e.g. farmers, gold-miners). Show the location of their activities on a map.

3.6.5 Protection plans - additional notes

The purpose of fire protection planning is to ensure that all state forests are adequately protected from fire by a continuing review of protection needs and organisation preparedness.

The following comments are made on the need for protection plans and the reasons for including the information listed:

- (i) **Protection policy**
Without a suitable statement of protection policy for specific areas, officers could attend fires which are in no way threatening state forest, life, or substantial private property, while others might wait for fire to enter a state forest before taking suppression action.
- (ii) **Existing road and firebreak system**
Detailing of the road and firebreak system on a protection map will show any weaknesses in the system. The logical sequence is for small discrepancies to be rectified almost immediately and for major works to be included in the works programme as soon as funds are available.
- (iii) **Fire history**
Incidence and severity of fires should be factors in setting the level of preparedness which is required in a given area. Historically high risk areas which emerge from the

study should be investigated. Thus the preparation of a fire protection plan could lead to elimination of a potentially serious hazard, whether it be a physical feature or unauthorised burning by a neighbour of group of neighbours.

(iv) **Fire management**

Deficiencies in prescribed burning practices should be highlighted by proper map records. The timing, frequency, and intensity of fires is something that evolves with experience over a number of years and unless such information is recorded in the fire plan for the benefit of successive managers the lessons have to be re-learned.

The plan will show the newcomer which areas are to be aerially ignited, cooperatively burnt, or handled by forestry ground crews.

The use of annually replaced overlays and regular recording of progress should ensure that no areas are overlooked.

Repeated failure to complete the annual burning programme in the limited period between when the fuel is too wet and too dry should cause initiation of an investigation of why this is so. Are there sufficient breaks? Are the breaks of sufficient width and suitably located to allow rapid lighting with adequate control? Are the burning units the appropriate size to allow the maximum number of minimum sized crews to cover the whole programme in the limited time? Should duties be reorganised so that more staff are involved when the weather is ideal? What action can be taken if additional staff cannot be engaged?

(v) **Detection system**

By plotting areas visible from each fire tower a clear picture can be obtained of blind spots, areas covered only by one tower, and areas capable of one or more cross-bearings. Such information will be particularly useful to:

- plan tower construction and maintenance;
- where ground patrols or secondary observation points are needed; and
- to avoid unreasonable expectation of the tower-man's ability to pinpoint a fire.

(vi) **Communications**

With planning, deficiencies will show up under emergency conditions. Such can range from lack of mobile number lists in all vehicles to lack of radios. Insufficient communications at a major fire can be a disaster.

(vii) **Equipment**

Failure to systematically replace old items of equipment results in failure due to metal fatigue, usually when the equipment is subject to sustained use at a large fire, when it is of course most needed.

Obviously there is a need to assess types and numbers of suppression hardware, adequacy, condition, replacement and garaging so as to minimise deterioration by the elements, borrowing, accessibility, and so on before the fire emergency.

The small plant mechanic can assist in determining requirements and with the selection of suitable equipment and facilities required. This should be carried out early in the new year prior to the next fire season.

(viii) **Training**

A formal plan should list all forms of training from tanker crew and hand crew drills to fireboss organisation and strategy sessions. It should also include fire brigade training.

Training is simply a means of spreading what experience there is in the organisation to as many people as possible. Formal records of what training has been done and what needs to be done will result in economy of effort as well as improved performance at fires.

(ix) **Contingency plans**

These are simple pre-determined procedures likely to be needed in an emergency situation and should allow deficiencies to be detected and rectified, besides educating the staff.

After analysing our own resources, those other bodies should be listed so that a fireboss is not doing basic research work at the height of a fire emergency.

Formulation of initial attack standards and crew dispatch systems should take the guess work out of organising a fire suppression effort and protect more junior officers from adverse criticism if they have to act in the absence of more senior staff. This presupposes regular maintenance of weather data (Fire Danger Index and Drought Index). This noon data should be broadcast in each area as a matter of course to alert field workers to the current fire danger. All preparedness levels should relate to the risk of a fire starting and its potential to spread and do damage. Otherwise the organisation will be “under-insured”, neither of which is desirable.

Revision of plans

ANNUAL REVISION of plans will ensure a compulsory refresher course for staff involved. The only disadvantage is the time required, but this is outweighed by the chaos which can result from lack of preparation.

3.6.6 Example of a fire protection plan from Indonesia for the Riam Kiwa trial and pilot plantation area

- Contents:**
- 1 Purpose of the plan
 - 2 Protection policy
 - 3 Existing road and firebreak system
 - 4 Fire history of the area
 - 5 Fire management
 - 6 Detection system
 - 7 Communications
 - 8 Equipment
 - 9 Training
 - 10 Contingency plans

- Appendices:**
- 1 Map of plantations in Riam Kiwa
 - 2 Fire protection plan map
 - 3 Report of the wildfire in 1991
 - 4 The course program for the fire crew and local training
 - 5 The course program for the training course for prevention and control
 - 6 Rainfall in Riam Kiwa, monthly averages 1989 - 1992 and long term average of 17 years

1 Purpose of the plan

The purpose of this fire protection plan is to ensure that the Riam Kiwa Trial and Pilot Plantation Area of the Reforestation and Natural Forest Management Project is adequately protected from fire. Since the project only works on reforestation trials, having a relatively

small area for demonstrating large scale operations, the plan does not intend to be a comprehensive example for industrial plantations. However, the plan will give some useful information and guidelines for further developing fire protection in Riam Kiwa area and also for the development of fire protection in a wider area in the South Kalimantan grasslands.

2 Protection policy

The fire protection policy of the project is to maintain an adequate preparedness for fire protection through efficient fire prevention and suppression methods. This will be gained only through sufficient supplies of equipment and training of staff.

Areas and forest types

The Riam Kiwa Trial and Pilot Plantation Area consists of a great number of species, with provenance and silvicultural trials on species promising the rehabilitation of alang-alang grasslands and the production of wood for various purposes.

The total area to be protected is 1000 ha. The area so far planted is approximately 650 ha out of which approximately 260 ha burnt in a major wildfire in October 1991. The area is split into many small patches, each having different fire behaviour characteristics. This makes the fire protection more demanding than the protection of plantations of only one or two species.

The area is dominated by strong growth of alang-alang (*Imperata cylindrica*) grass that formerly covered the whole area. There are also many alang-alang areas still within the trial plantations, causing an additional hazard to the main plantations. The aim is to reduce these areas to a minimum with plantations.

Methods

Development of fire protection is the most important part of plantation establishment in South Kalimantan as well as in other parts of Indonesia. Fires are almost always caused by people living in the area, thus the extension work among local people is an essential part of the fire protection policy. If a plantation resource is to be established and maintained to maturity, fire protection must be allotted top priority.

It is widely acknowledged that, except in the most abnormal seasons, fire problems are associated with the presence of alang-alang. Where there is no alang-alang there is no fire problem. Therefore, suppression of alang-alang is the most important activity in the fire protection activity.

Fire prevention involves the following components:

- proper silvicultural practices, aiming at a fast closure of canopies to suppress the grass through shading and through mechanized and chemical methods for weed control;
- control of grass;
- the follow up and development of a fire hazard rating system to better alert the people of the fire hazard;
- fire line and fire break maintenance, together with hazard reduction burnings in alang-alang areas adjacent to plantations;
- supply of equipment and material for controlled burning and fire suppression;

- training of personnel for fire protection and extension work among the people living in neighbouring villages;
- promotion of agroforestry practices in areas with high risk of fires; and
- continuous fire detection from towers and by use of motorbikes.

Suppression methods involve:

- fast initial attack with a 4 wd vehicle with a slip on unit and six man crew with hand tools;
- direct attack with water; and
- indirect attack (backburning).

Priorities

The priority areas to which most care is addressed in prevention are the trials holding most scientific interest and which are to be followed and analysed regularly by measurements. The failed trials and plantations established with inferior species or provenances are of secondary importance and will be soon replaced with better ones.

3 Existing road and firebreak system

Roads

There is a quite dense road network in Riam Kiwa now. The existing roads, even though not of the best quality, offer access to all plantations by vehicles. The total length of these roads is nearly 20 km, a density of 20 metres / km.

The main roads are classified and described in the following manner:

Hendratna road passing the project area in the north in a west-east direction

Hendratna 1 from the main road to the Impres area

Hendratna 2 stoned road from the main road to the new road

Hendratna 3 from the main road to the crossing near the previous location of tower no. 2

Utama road from the mosque to the seed stand

Utama 1 from the camp, passing species trials

Utama 2 starting from the heliport leading to the new plantations

Utama 3 leading to tower no. 3

Utama 4 new road

The roads are regularly maintained by grading and the main roads are gravelled to be passable all year round. However, the access road and the roads within the area do not allow for 2wd traffic other than trucks during drier times.

Firebreaks

Due to the importance and diversity of trials and pilot plantations there are altogether some 25 km of maintained fire lines in the plantation area. Fire lines are usually 5 m wide and maintained as bare earth by ploughing or with a tractor back blade twice a year, the first time in May-June and the second time in August-September. Maintenance is to be continued only until the canopy is closed and the internal hazard reduced. On steep slopes and other areas where tractors cannot be operated, fire lines are constructed by manual means.

Fire lines are constructed and maintained only where and while there is an identified hazard (i.e. expanses of alang-alang) or a recognized source of ignition (e.g. a farm or village).

The fire lines will be supplemented by controlled burnings of the width of at least 60 m adjacent to alang-alang areas. The maintenance of fire lines will be more intensive in the southern side of the area from where the winds blow during the fire season.

Natural fuel breaks

Fire line construction and maintenance is expensive. The creation of natural fuel breaks is a less expensive long term alternative. Fuel breaks are areas of non-flammable or low flammable fuels, e.g. well developed natural forest, *Acacia mangium* stands with closed canopy, and agricultural crops (e.g. tumpangsari). Growing of low-flammable cover crops reduces the fire hazard.

4 Fire history

Before the plantation programme was started fires occurred frequently in the area, preventing the grassland from turning into forests or even bushlands. The alang-alang burns on an annual basis unless fire protection is well taken care of. Under most conditions in Indonesia, alang-alang is the fuel type which burns most readily. However, provided that men and equipment can be quickly mobilised onto such fires they are relatively easy to control. Once conditions become very dry however, belukar can burn, and fires which are well alight in belukar are harder to put out than fires burning in alang-alang. There is a continuous record of minor fires burnt in Riam Kiwa trial plantations but only one major wild fire, in October 1991. This occurrence was due to the coincidence of all factors creating a situation where an uncontrolled fire is possible. The area burnt was 265 ha.

5 Fire management

Fuel types

Alang-alang - Observations in Riam Kiwa and several reports conclude the following features of alang-alang:

- Average fuel weights in alang-alang unburnt for 12 months will be in the range 10-15 tons / ha.
- 100% green alang-alang will not burn readily and if it does burn only a low intensity fire results. The accumulation of some dead material (either as residue from a previous incomplete burn or as material which has grown and died since the last fire) appears necessary to allow significant fire activity.
- After a complete burn it takes approximately 3-5 months (dependent on weather conditions) to accumulate sufficient dead material to carry a fire.
- By 9 months after a complete burnt the fuel burns readily and will carry a fire within two days of even heavy rain.

Forests

Selection of species is, among other criteria, very important in terms of fire protection. In this pioneer phase of the rehabilitation of alang-alang areas it is necessary to select species which can quickly suppress the grass.

The other important criterion is the rate of susceptibility to fire. Even though much effort is put on fire prevention there is a high risk of fire. Thus it is advisable to select fire tolerant species for reforestation of alang-alang lands.

Acacias, such as *Acacia mangium*, *Acacia crassicarpa*, and *Acacia auriculiformis*, as well as *Gmelina arborea*, *Dalbergia latifolia*, *Cassia siamea*, and *Paraserianthes falcataria* are favoured in this phase.

Hazard reduction burning

The fire hazard is associated with the presence of alang-alang grass. This is why alang-alang areas adjacent to plantations are burnt under controlled conditions.

Controlled burning should not be started too early. The best time for the controlled burning is when the consumption of fuel by fire is more than 80%. This time may be difficult to predict. Controlled burning can be tried in mid June on a smaller scale and if the fuel consumption is big enough the burning can be extended. It is important not to start burning too early to avoid the need to burn twice. However, some of the areas may have to be burnt twice, especially if the drought period is prolonged.

Prescribed burning for fuel reduction within the plantation will not be done due to the susceptibility of grown species to heat damage.

For farmers' "ladang" burnings outside the trial area the project will supply tools and possibly personnel. Extension work will be done to promote cooperation between the project and farmers.

High risk areas can be seen on the fire protection map attached to the plan.

Water points

There are several improved water points in the area. The target for water points is one per 200 ha of plantations. On top of this there are three concrete water tanks in the area, each of which contains 7,5 m³ of water. During the worst drought period, dams may be constructed to increase the volume of natural water points.

The accessibility to the water points should be maintained by road repair. The location of water points is indicated on the maps attached to the plan.

6 Detection systems

At present there are three fire detection towers in the trial area. This is a clear overcommitment to needs. Only tower no. 2, which covers the entire trial area, is manned at day time; on high hazard days during the period of June to October, starting at 8 am and ending at 6 pm.

Tower no. 1, nearest the camp, is used for detection in the evenings, from 6 pm until 12 pm. During that time the likelihood for fires is smaller.



Fire weather indicator, Indonesia



Set of basic high quality hand tools for forest fire control, Sri Lanka

From page 245.

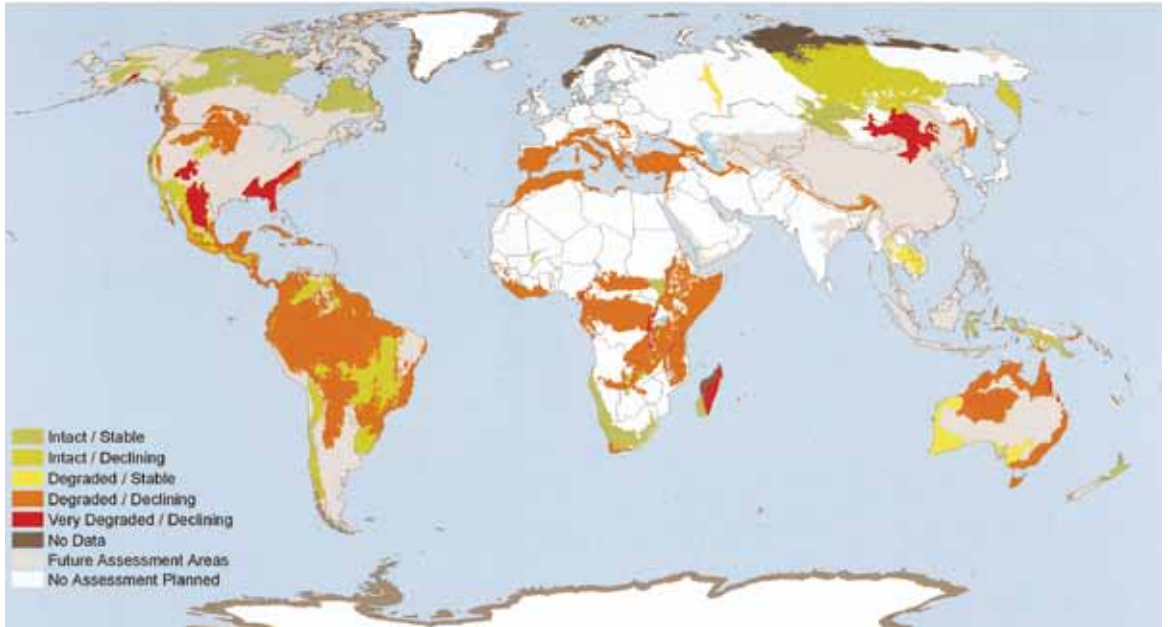


Figure 2 Priority Ecoregions and Dominant Fire (TNC, 2004. Fire, Ecosystems & People: A Preliminary Assessment of Fire as a Global Conservation Issue, The Nature Conservancy; (<http://www.nature.org/initiatives/fire/science>).



Prescribed burning crew constructing black line. The crew consists of professional burners as well as of trained HIV-orphans in the Working on Fire (WoF) programme in the Republic of South Africa.



Fire pick-up Attack Unit with crew; equipped with light motorized pump (capacity 80 l/min), knapsacks and fire swatters, Indonesia



Community theatre performing fire awareness drama play for children and adults, method selected due to low (20 %) literacy rate among local women, Zambezia, Mozambique.



Large fire line dividing plantation compartments, Zimbabwe



Wooden fire watch tower in tropical rain forest area, the Philippines



Fire survey among local women to find out their perceptions, beliefs and attitudes towards fire and burning, Katima Mulilo, Namibia



Mopping up with light motorized centrifugal pump (capacity 600 l/min), Thailand



Torch man setting fire to mixed along-alang grass (*Saccharum spontaneum* and *Imperata cylindrica*) for making a creeping edge during a controlled burning practice, Indonesia



Course on Training of Instructors in Community Based Fire Management (CBFiM), Zambezia, Mozambique.



Burning snag, Canada



Inspection of fuel break (constructed by burning) by members of local community; fuel load 11.000 kg/ha, grass height 4 metres, flood plains of Zambezi River, Namibia.



Controlled burning practice, note edges of fire; Indonesia



Overview of a succesful extinguishing of a large fire in natural pine forest, note the trees felled as a fire break, Finland



Overview of the world's largest area of burnt natural tropical rain forest (3,8 million ha) in Bukit Soeharto, Indonesia

Tower no. 3 is used for occasional check ups.

Blind spots near tower no. 2 will be checked on foot hourly by the person responsible for fire detection in the tower. Fire detection from the tower is supplemented by patrolling by motorbike.

At night there is no fire detection.

The fire detection tower has a compass and a map for locating the fire with the cell grid or cross bearing system. There is also a pair of binoculars for observation and a radio receiver in order to make the stay in the tower more comfortable. Listening to the radio does not disturb fire detection.

At the base camp there are maps and a radio to receive information on fires.

For confirmation of the fire's location it is agreed to use names for blocks as follows:

- Impres
- Block Keminting
- Block Awu
- Block Murai
- Block 86
- Block Tengah

All these names are well known by the fire crew and help to avoid mistakes in locating the fire.

The following information is given from the tower when fire is detected:

- location of fire;
- much or little smoke;
- whether in trial area or outside.

7 Communications

There is a main radio in the base camp and six portable radios for communications. There are no telephone lines in the area. The portable radios are used as follows:

- Stand by for the fire crew members in base camp	2 pcs
- Tower	1 pcs
- Truck	1 pc
- Pick-up	1 pc
- Fire boss	<u>1 pc</u>
	Total 6 pcs

To avoid losses the portable radios are numbered and a responsible person nominated for each of them.

8 Equipment

Vehicles and implements:

- Truck equipped with a pump, hoses and hand tools for transportation of 15 man fire crew and water	1	pc
- 4 wd pick-up truck with a 400 litre slip-on unit, Honda / Davey pump, a 19 mm water hose with jet and hand tools for six men	1	pc
- Motorcycles	4	pcs
- Bicycle	1	pc
- Farm tractor, 4 wd, 120 hp	1	pc
- Farm tractor 4 wd, 80hp with front-end loader	1	pc
- Farm tractor, 4 wd, 80hp	1	pc
- Tractor trailers	3	pcs
- Disc ploughs	2	pcs
- Disc harrows	2	pcs
- Rotavators	3	pcs
- Back blade of tractor	1	pc
- Tractor roller	1	pc

Pumps, hoses, and jets:

- Tractor pumps, Esa tractor	2	pcs
- Portable Mini Esa pumps	2	pcs
- Portable Kubota GS 300 pumps	3	pcs
- Portable Kubota GS 160 pumps	3	pcs
- Back pack sprayer, Mako	10	pcs
- Back pack sprayer, local	16	pcs
- Back pack sprayer, Fedco	12	pcs
- Canvas hoses, ½ ” diameter, 20m	42	rolls
- Canvas hoses, 3 ” diameter, 20m	13	rolls
- Suction hose, bigger	4	pcs
- Suction hoses for Mini Esa pumps	1	pc
- Suction hoses for Kubota GS 160 pumps	3	pcs
- Suction hoses for Kubota GS 300 pumps	3	pcs
- Couplings for canvas hoses	3	pcs
- Jets for Mini Esa pumps	12	pcs

Water tanks:

- Trailer tank with Honda/Davey pump, 800 l	1	pc
- Trailer tank, 1500 l	2	pcs
- Trailer tank, 2000 l	1	pc
- Truck tank, 4000 l	1	pc
- Stainless steel tank, 4000 l	1	pc

Hand tools:

- Parangs, long	16 pcs
- Parangs, short	2 pcs
- Brush hooks	20 pcs
- Axes	5 pcs
- Bow saws	6 pcs
- Chain saws, big	2 pcs
- Chain saws, smaller	2 pcs
- Clearing saws	4 pcs
- Drip torch, big	3 pcs
- Drip torch	3 pcs
- Swatters	40 pcs
- Rake hoes	30 pcs
- Rakes	20 pcs
- Hoes	15 pcs
- Shovels	16 pcs
- Log tongs	16 pcs
- Protective clothes, shoes, helmets, gloves	20 sets
- Binoculars	2 pcs
- Compasses	5 pcs
- Tools and spare parts for:	
- pumps	
- chain saws	
- clearing saws	
- hoses	

Meteorological instruments:

- Hygrothermograph	1 pc
- Hygrometer	2 pcs
- Wind velocity indicator	1 pc
- Maps	

9 Training

The permanent project staff have already participated in several training courses on fire protection during previous years of plantation establishment in Riam Kiwa. In 1991 the fire protection strategy was revised by an Australian fire protection consultant. His development work in Riam Kiwa was followed by slight changes in fire protection practices and some new material purchases. Following this work a team of project staff made a study tour to New South Wales and Queensland, Australia studying bush fire protection there. The results of this development are being introduced to the fire control of Riam Kiwa. Two training courses will be arranged to train the personnel in new methods and the use of new tools and equipment.

Training will also be arranged as formal courses prior to the fire season and refresher training as on-the-job training during control burning and whenever the need arises. Two courses will be arranged as follows:

- A four day training course on fire protection for the fire crew of the project and people living in nearby areas.
- Training course on grassfire prevention and control. This course will be arranged for the Fire Chief level personnel of different forest companies and public sector forestry institutions.

10 Contingency plans

Sources of external assistance

Seventy five families live in the three villages nearest the project area. In case of a big fire some 40-50 people from the villages are available for fire control. It will take approximately 20 minutes to get them into the area. There are very few other people living in Riam Kiwa. The cacao project in the vicinity employs some 15 people who assist when the need arises.

Next, help can be sought in Desa Lima, which lies about 7 km away. It takes about one hour to get more helpers from there. According to experience it is possible to get up to one hundred people to fight the fire within a reasonable time. Tools and supplies will be reserved accordingly.

During fires the base camp cooks and other catering personnel will take care of serving meals and pure drinking water to fire fighters.

Formal crew dispatch system and initial attack standards

During fire hazard days the fire crew will be stationed at the base camp. They are given light work at the camp during stand-by times. The fire boss is responsible for ensuring the preparedness of the crew to control fire at all times. During times when there is no fire hazard the plantation officer may appoint fire crew members to other jobs in the trial area.

Once a fire is detected the person in the tower immediately notifies the base camp. The person on duty at the radio in the base camp informs the fire boss of the location of the fire and other relevant information. The fire boss immediately dispatches the pick-up unit with six fire fighters for initial fire suppression.

The fire boss also promptly mobilises the truck with fifteen more crew and the tractors with water tanks. The fire crew has to suppress the fire using the appropriate methods, as learned in the training courses. After the fire is suppressed the fire crew prevents the fire from spreading again by mopping-up. The fire boss makes notes on the fire and gives permission to the crew to return to the camp when the fire is mopped-up. The fire boss is responsible for calling for additional assistance as needed.



PREVENTION

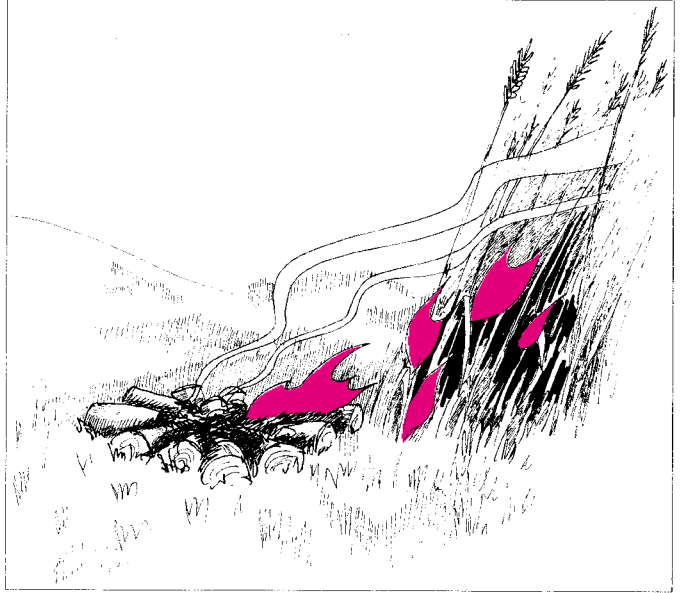
4. PREVENTION

Forest fire prevention is the means of reducing the number of unwanted, uncontrolled, or escaped wildfires.

4.1 Wildfire Prevention Activities

Wildfires may occur in any vegetation cover type when conditions are favourable for burning. Every fire requires some spark or flame to start it. At the beginning of any fire protection work it is important to investigate and establish the source of sparks or flames which under favourable conditions could start a forest fire.

Fire prevention is one of the most important functions of the fire control service. The prevention of unwanted or escaped fires is a never-ending job.



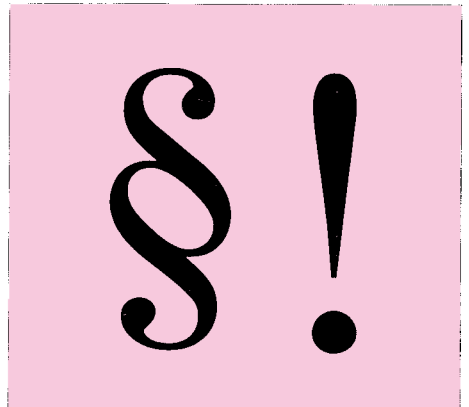
In addition, prevention activities are very often the most economical way of reducing fire damage and losses. Basically, wildfire prevention means stopping all unwanted, man-caused wildfires from starting in the first place. Fire prevention work can be started without any expensive equipment.

However, effective fire protection assumes, among other things:

- an adequately large organisation;
- knowledge of fires and their causes;
- trained firemen for fire prevention activities;
- good advanced planning for fire prevention;
- budgetary funds.

The best 'tools' that can be used for the prevention of fires are:

- education of the general public;
- elimination of the fire hazards; and
- fire enforcement laws.

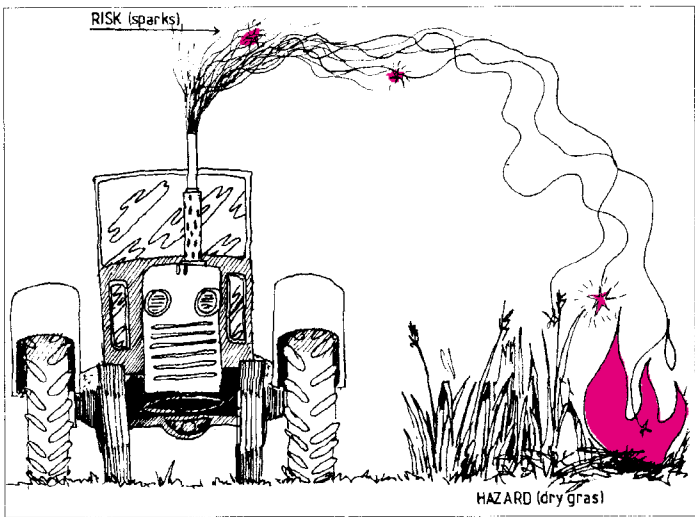


Risk

Can be defined as the chance of a fire starting from one cause or another, such as people, lightning, electricity, etc.

Hazard

Is the fuel complex by type, arrangement, volume, condition, and location that forms a special threat of ignition or difficulty in suppression. Areas covered with grass, brush, and forest fuels are examples of a hazard.



In organising wildfire prevention in a particular area one must first know what the usual causes of fire are, and the risks and hazards involved. The fire prevention efforts of any education should be effectively tailored in order to eliminate or reduce the causes, the task, and the hazards. The overall objective should be for everyone to know how to prevent wildfires, their causes, risks, and hazards, each of which may vary in different parts of the country.

4.2 Fire Prevention Planning

A fire prevention plan is needed for organising the fire prevention operations as effectively as possible. The written part of the fire prevention plan should include maps, tables, and graphs as required by the fire service. The material should be updated at least once a year.

Periods of years	Lightning		Railway carelessness		Careless use of fire		Cultivation		Re-generation		Military training		Other causes		Unknown		Alltogether	
	NF	HA	NF	HA	NF	HA	NF	HA	NF	HA	NF	HA	NF	HA	NF	HA	NF	HA
1952 - 55	32	2045	55	89	121	252	74	432	5	12	1	0.5	19	43	46	116	353	2989,5
1956 - 60	69	4356	76	303	260	1148	106	937	8	137	4	18	30	272	90	807	649	7978
1961 - 65	55	131	20	17	231	330	62	187	5	17	2	9	19	45	52	93	446	829
1966 - 70	96	233	9	8	263	590	36	72	5	63	6	12	35	140	77	760	527	1878
1971 - 75	220	339	3	3	287	202	21	16	3	19	5	8	26	93	68	174	633	854
1976 - 78	35	52	-	-	244	193	50	64	1	3	4	4	48	171	50	76	432	563
Average per cause	85	1193	27	70	234	453	58	285	5	42	4	9	30	127	64	338	507	2517

Legend: HA = burnt area (hectares) NF = average number of fires

Forest Fire Causes in Finland 1952 - 1978

The first step in planning is to collect all the basic facts and data from occurred fires. This information could be compiled, for instance, from data collected over the past five years on:

- How or why were the fires started?
- When were they started? (month, day, time of day)
- When do they occur most frequently? (weather, hazard, time)
- How many fires are started from the different causes? (number of fires listed under each cause)
- Where do they occur? (map location, forest type)

This analysis will determine the realistic and logical goals of the fire prevention plan. It will also help if, for instance, a summary of the main problems are made:

- What are the main causes of wildfires? (shifting cultivation, debris burning, etc.)
- Location of very high risk areas.
- Location of areas that should be protected.
- What are the main objectives and methods of fire protection?

The first step should be education. The second step should be to enforce the laws and regulations which control the fires caused by agriculture and shifting cultivation.

After that the next step could be the preparation of regulations to control campfires and fires caused by hunters through education.

After this summary of responsibility for the action to be taken for the prevention of fires has been completed, the following decisions will have to be taken:

- Will any new laws be needed?
- Who will talk to the general public and when?
- Who will talk to school children and teachers?
- Who will work on the problems of fire hazard reduction?

4.3 Contents of a Wildfire Prevention Plan

The following example for a fire prevention plan and its content may not be suitable for each fire district or department, but is a general guideline.

Table of contents for a fire prevention plan:

1. Basis of the fire plan
 - 1.1 Fire occurrence map
 - 1.2 Fire statistics, graphs
 - 1.3 Fire risk area map
 - 1.4 Forestry operations map
 - 1.5 Hazard areas map
 - 1.6 Sign and warning board map
2. Fire prevention objectives
3. Summary of problems and measures to be taken
4. Resources for fire prevention operations
 - 4.1 Use of firemen, foresters, police, etc.
 - 4.2 Contact persons and co-operation with village leaders

4.3 Finance

5. Laws, regulations, rules, and restrictions for fires
6. Public education, mass media, and guidelines for tourists, campers, hunters, etc.
7. Rules and regulations for forestry, farmers, etc.
8. Reduction of the physical hazards in high risk areas
9. Signs, posters, warning boards, and other information material
10. Fire prevention training and education
11. Feedback information

For every fire prevention plan there needs to be individual information and statistics on each of the above topics. The goals and methods of fire prevention will be based on this information.

After the fire prevention plan has been prepared, any fire occurrence during the fire season must be analysed to determine what effect the plan has had.

A much better review of the problem areas and a better start for planning can be made if relevant statistics, tables, graphs, and visual maps are prepared.

These maps could be separate or all the information can be on one map, using different colours to indicate the various pieces of information recorded.

4.4 Wildfire Causes and Risk

One part of fire prevention planning is to make an analysis of the fire risk and causes. The various types of risks and hazards in the protection area should be considered in a wildfire prevention analysis.

4.4.1 Land owners, farmers, and the rural population

- (i) In most countries, agricultural burning, such as in shifting cultivation, grazing, and fires to control vermin and insects, together with the many variations of rubbish and debris burning, are major causes of wildfires.

This type of wildfire is often the result of a failure to select the proper time, place, and method of burning or in the supervision and control of the burning operation. In order to minimise the number of escaped fires caused by agricultural burning there should be local regulations which would require that:

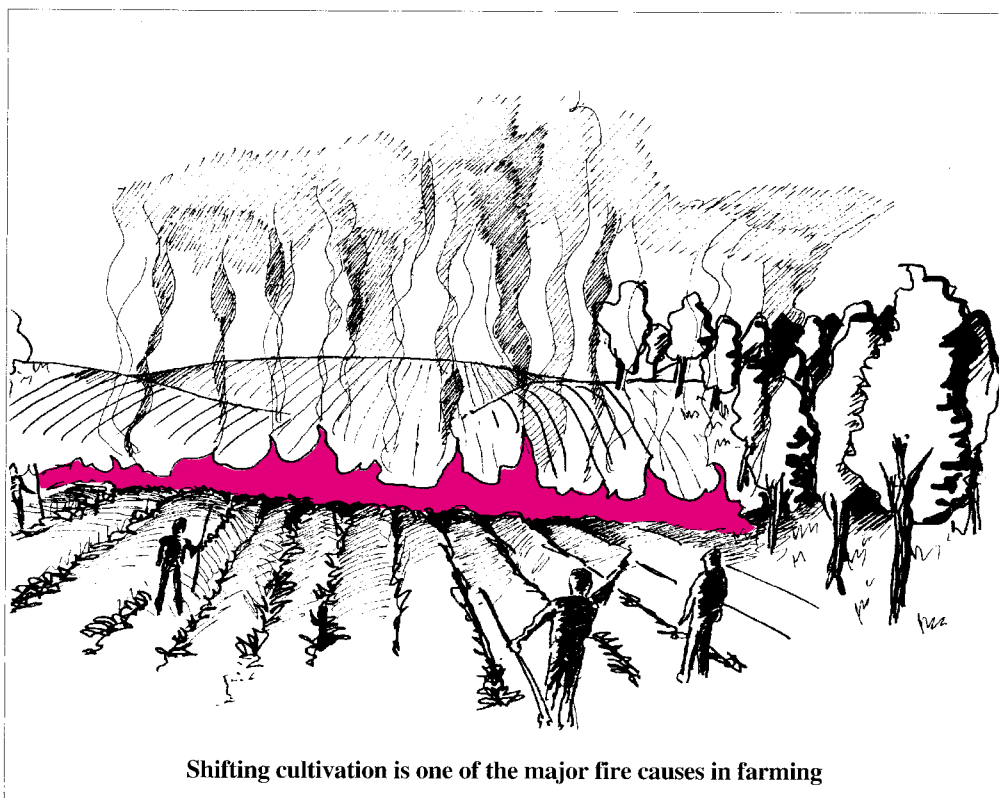
- a burning permit must be obtained;
- burning should be carried out only in designated areas; and
- burning should be carried out only in certain weather conditions.

- (ii) The best way to reduce the causes of fire is by education. First of all the public should be taught how to burn safely. Then the public should learn how to minimise all hazards safely. The public should learn how to minimise all outdoor burning during fire hazard periods. Good results have been achieved from the system whereby during fire hazard periods the local radio and television informs the public of the danger of fire when weather conditions show a high risk factor. The regulations should prohibit anybody from starting an outdoor fire during such a fire hazard period.

There is also a need for effective patrolling and fire detection during all periods of high fire risk.

The fire service should cooperate with the local people and the authorities. The objectives of this cooperation and the education of the public should be to encourage the right attitudes towards wildfires. When the public understands the value of the forests and the loss that comes from wildfires, they may be a little more careful when lighting outdoor fires.

In addition, there must be laws and regulations to forbid outdoor fires. However, before these laws and regulations are made, the living conditions, religious traditions, and the realistic needs of the rural people for outdoor fires must be taken into consideration. In some countries, cooperation with the local population is only possible through the village chief or the village elders.



When outdoor fires are allowed the public should be educated to know the following:

- (i) Burn only during safe conditions, for example, when there is little or no wind and after rain if possible.
- (ii) Obtain a permit from the local fire authority or forest fire headquarters.
- (iii) Start the fire in a safe place, not too close to the forest or woodland. Clear all hazardous material from around the fire area.
- (iv) Burn at a safe time and never on a windy day. Generally, the early morning or the late evening is the best time.
- (v) Before starting a large outdoor fire there must be stand-by fire suppression equipment and men available to prevent the fire from spreading.

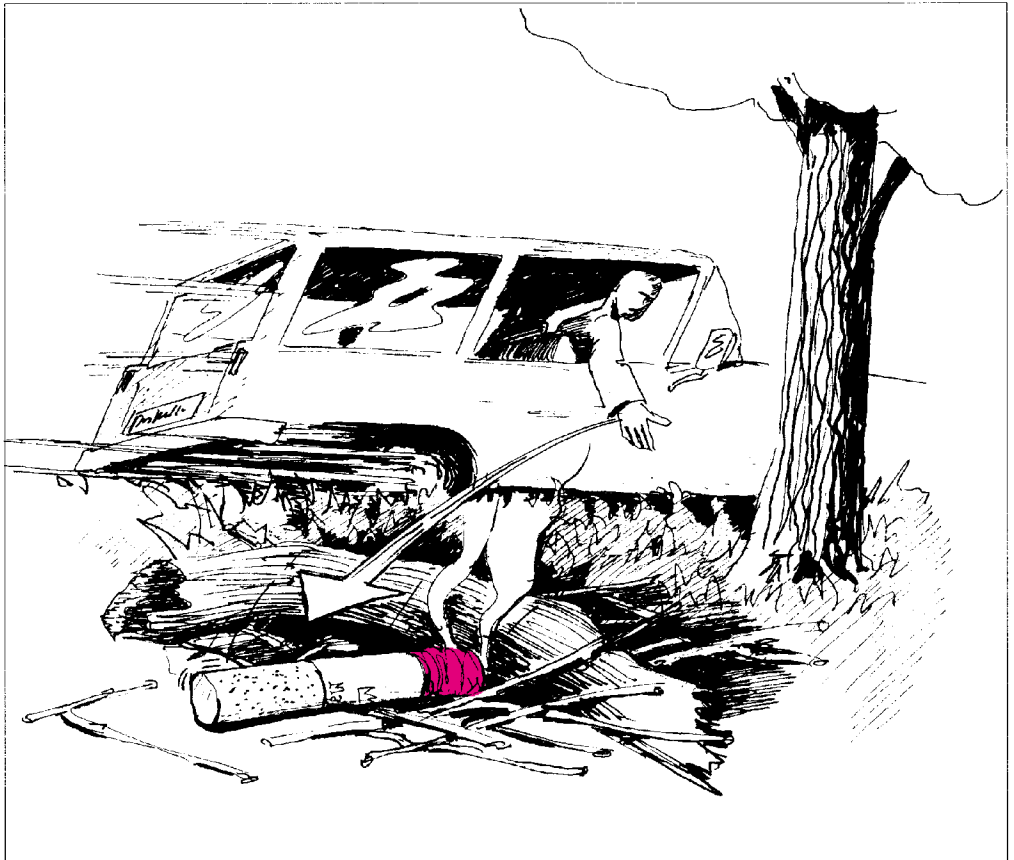
Special burning for farmlands

Some special fire regulations will be appropriate for agricultural purposes, when burning grain fields for example. These fires can be hazardous when the fuel is dry. It is therefore important to educate the farmers to burn when the conditions are safe.

4.4.2

Cigarette smoking

One of the major causes of wildfire is the careless smoker. Picnickers, campers, hikers, fishermen, hunters, tourists, or local residents who smoke while in a forest or grassland area can, through carelessness, cause a disastrous fire. To reduce the number of wildfires caused by smoking, each smoker should be made aware of the danger and precautions to be taken.



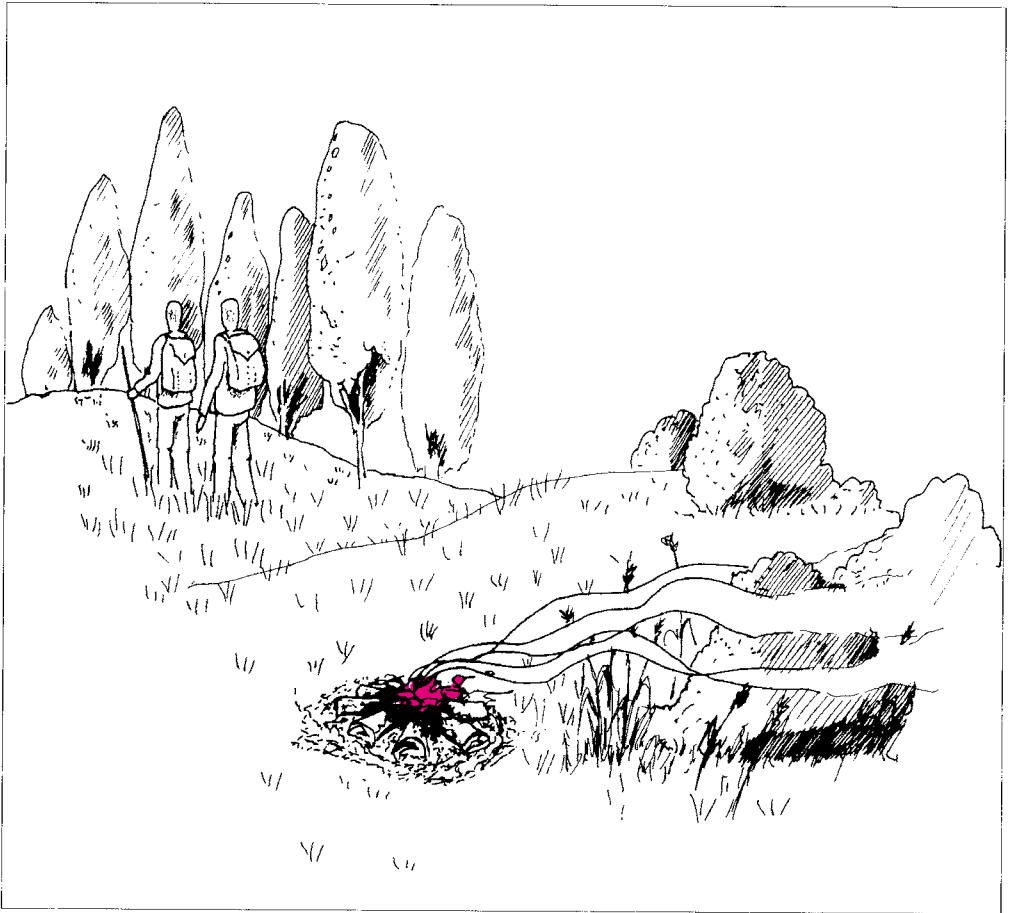
For instance, some very simple basic rules for smoking could be:

- (i) During the fire danger season, smoking while walking or working in a forest area is prohibited.
- (ii) Smoke only in designated safe places where there is no hazardous fuel. These areas could be next to a stream or lake, on sandy soil, or on a roadway.
- (iii) Crush the butt-end of the cigarette against a bare rock, or into a sandy soil.
- (iv) Use a cigarette lighter or make sure that the match is extinguished.
- (v) Use the ashtray in the vehicle.

4.4.3

Campfires

Campfires are a frequent cause of wildfires in those areas where camping, hunting, hiking, fishing, and picnicking are popular.



The following information should be made known to people who go camping:

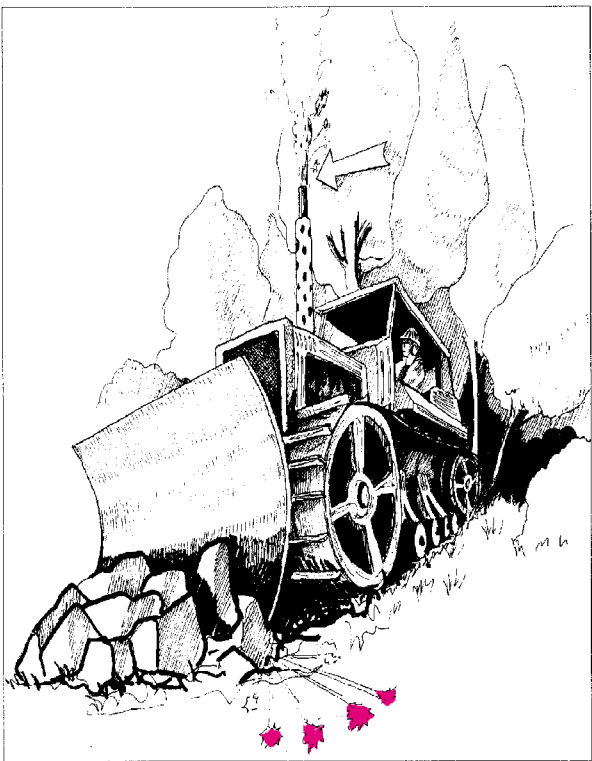
- (i) The campfire should be contained in a specially constructed fireplace which should be well away from overhead and surrounding hazardous fuels.
- (ii) The campfire should be kept small.
- (iii) The campfire should never be left unattended, as a wind could spread the fire into nearby fuels.
- (iv) Make sure that the fire is properly out before leaving the site. This can be done by pouring water or sand over the fire and stirring the embers with a stick. By feeling with your hand, check that no burning material remains.

To reduce the damage caused by campfires the public should be educated and informed about fire prevention methods. Signs and warning notice boards should be erected and information on how to prepare a safe camp site should be available at all public camping sites.

4.4.4 Logging and other forest operations

Very often, logging and other forestry operations cause wildfires. Careless employees and the use of different machines, such as power saws, tractors, and bulldozers in hazardous areas during the fire danger season can be the cause of fires.

When in the forest the use of approved spark arresters in tractors and other power driven equipment is one way to reduce the risk of fire. Welding operations should be restricted to designated safe areas and some of the more dangerous forestry operations should be restricted by local regulations. While working in the forest the employees should be trained in the use of, and have nearby, fire suppression equipment, such as fire extinguishers, shovels, and backpack pumps.



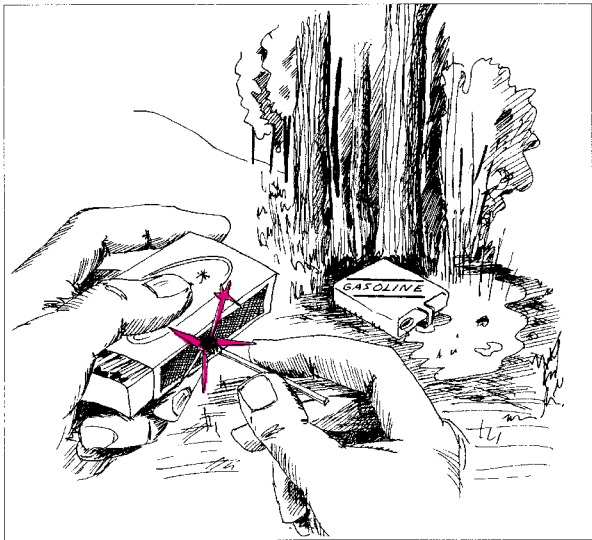
4.4.5 Arsonists

During the last few years arson has taken the top place in the causes of wildfires.

In many countries during this time the number of wildfires started by arsonists has increased at an alarming pace. It is difficult to prevent this new development.

Law enforcement is a general deterrent to arson.

It is very problematic to control and prevent arson.



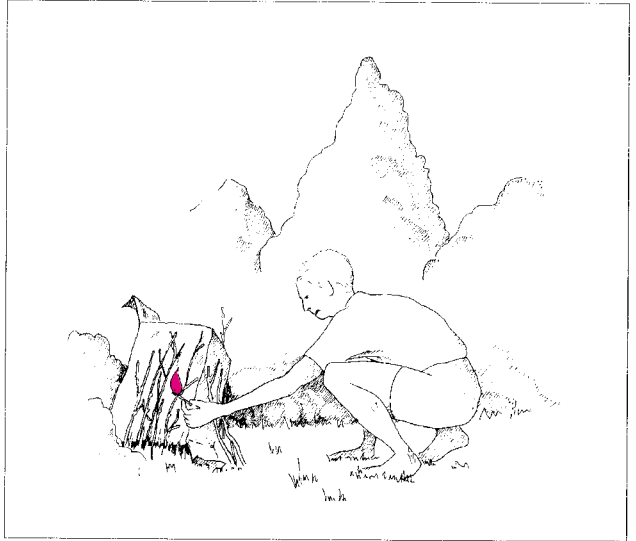
4.4.6

Children

Children playing with matches or with other sources of fire are causing an increasing number of wildfires each year.

Children are often too young to understand what is dangerous playing.

Training, relevant education, and proper parental supervision are necessary to prevent this cause of wildfires.



4.4.7

Lightning

Lightning is one cause of wildfire that is not preventable. Usually lightning is accompanied by rain, but occasionally a 'dry' lightning will start many fires. Fires started by lightning strikes may smoulder for days before conditions become favourable for the spread of the fires.

Constant detection is required to locate these dormant or sleeping fires. Lightning storms usually follow a definite path across the terrain. A map which shows the fires caused by lightning over a period of ten years will usually show the lightning fire pattern. Prompt detection is the best defence against fires caused by lightning.

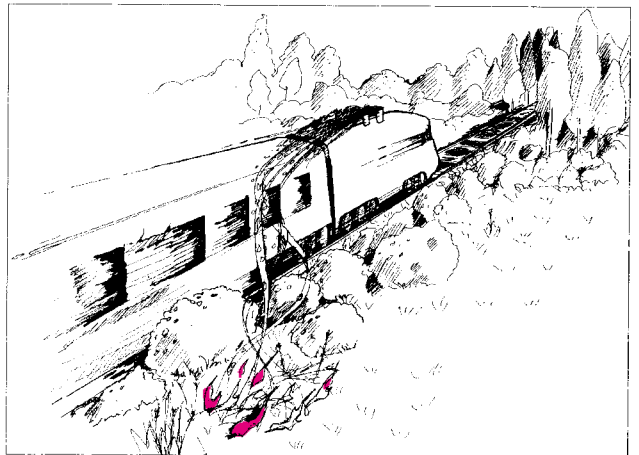


4.4.8

Railroads

The railway system of a country can also cause forest fires, especially where coal - burning engines are in use.

The engine driver should be made aware of the dangers and fire guards along the line are essential.



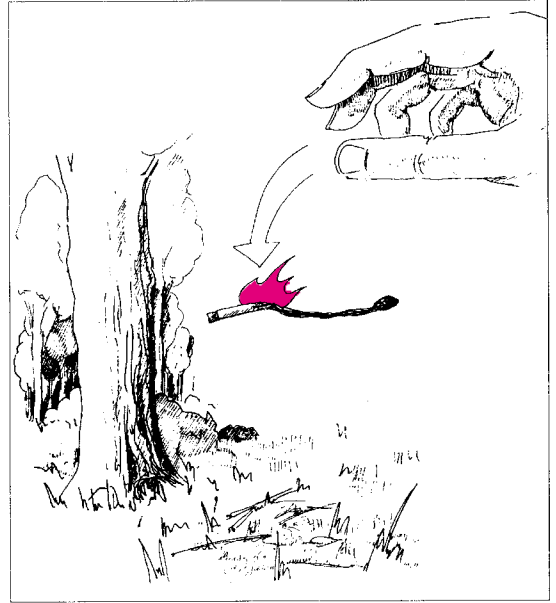
4.4.9 Secondary causes of wildfire

Carelessness of people is a major cause in most countries.

Secondary causes of wildfire include all the other causes that have not been previously listed. There may be many other causes, such as broken power lines, army training operations, negligent people, etc.

It is important to analyse these fires over a long period of time.

The wildfire prevention effort of the fire service must consider every possible type of fire that occurs in the protection area.



4.5 Prevention Methods

There are many different methods used to prevent wildfires; some need a lot of manpower, and some need much money. If satisfactory results are to be expected from the fire protection objectives some of these methods should be used in combination.

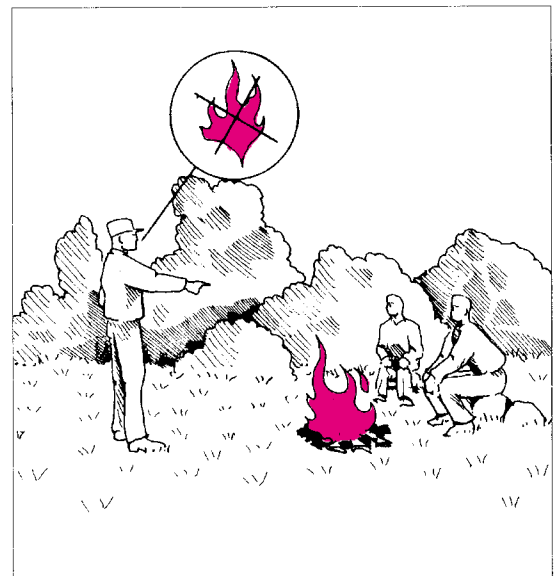
Therefore it is important that there is a fire prevention plan which estimates both the monetary resources and manpower requirements.

It is a normal situation that the results of the fire prevention activities are seen only after a long period of time. Fire prevention requires intensive and patient work from year to year.

4.5.1 Personal contact

Personal contact is probably the most effective method of fire prevention, if it is done correctly. The best place to demonstrate fire prevention techniques is at the site of a potential fire.

Here it can be demonstrated how to build a safe campfire, how to smoke cigarettes and tobacco carefully, and how to prevent the different types of fire from starting. The most far reaching results will be gained through public understanding and cooperation which will, in turn, depend on the awareness, interest, attitude, opinion, and beliefs of the individual person.



4.5.2 Associations and groups

In the work of fire prevention, useful co-operation could be gained from associations and special groups of people. These groups could be, for instance:

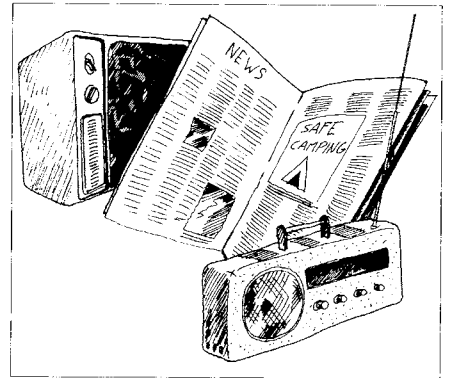
- wildlife clubs;
- environmental groups;
- Boy Scouts and Girl Guides;
- camping associations;
- holiday home owners; and
- caravan and motoring associations.

All these groups, and many others, can assist in the detection and prevention of fires. The more people you have on your side, the more effective will be the elimination of wildfires caused by human carelessness.

4.5.3 Mass media

Mass media includes radio, television, newspapers, and various other publications designed to reach the general public or specific groups.

The use of the mass media is one of the best means of public education in the prevention of wildfires. However, it must be sure that the method used is reaching the target audience. How many people can read and how many own a radio or a television set must be known.

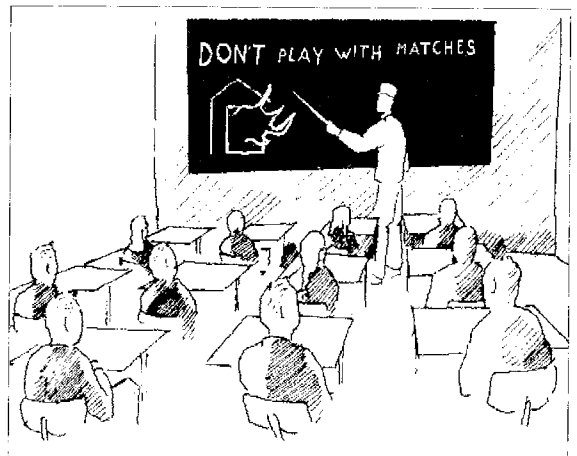


Provision for advertising over the radio, on television, and in the newspapers during the high and extreme fire danger periods for advising against any burning activity, will help to keep down the numbers of escaped fires. These warnings to the public should be arranged through the local weather forecasting service.

4.5.4 Schools

Fire prevention training in schools and colleges is an important part of any prevention effort. How to introduce the material will depend on the particular school or college system. The best approach is to first contact the Principal and find out the most suitable type of presentation.

Teachers can be involved by providing information and furnishing relevant material to them. The main benefit from school contacts is that not only the students are reached but also the parents through the message the students carry home.



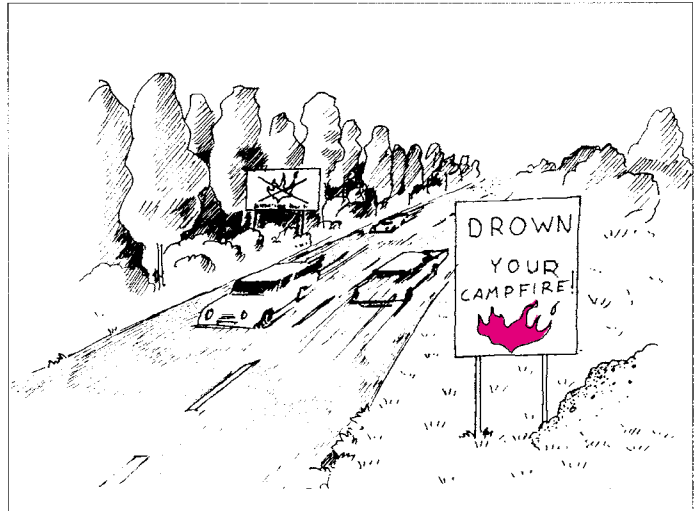
4.5.5 Signs and warning notice boards

Fire prevention signs can be used to inform the public of fire regulations, restrictions, and procedures to reduce fire. Signs should be erected in carefully selected places, where they will be most effective:

- along roadsides;
- at camping grounds;
- at petrol stations; and
- anywhere people congregate.

Timing is very important. A sign warning of extreme danger should be removed as soon as the danger has passed.

Place the sign so that it will be clearly seen. It should be neat, and not in conflict with other notices.



4.5.6 Posters

Posters can also be used in places where the public assemble, such as market places, bus and railway stations, public offices, and schools.

4.5.7 Other methods of fire prevention

There are a number of other different methods that have not been mentioned. One of them is a **Smokey Bear** programme as in Indonesia.

This means that a national animal is taken as a symbol for teaching fire prevention. The animal gives good advice and instructions on the proper way to use a fire in the forest.

This kind of programme is very effective, especially for children, when used in films, on television, in posters, cartoons, and in advertising.



Fire control logos

Thailand



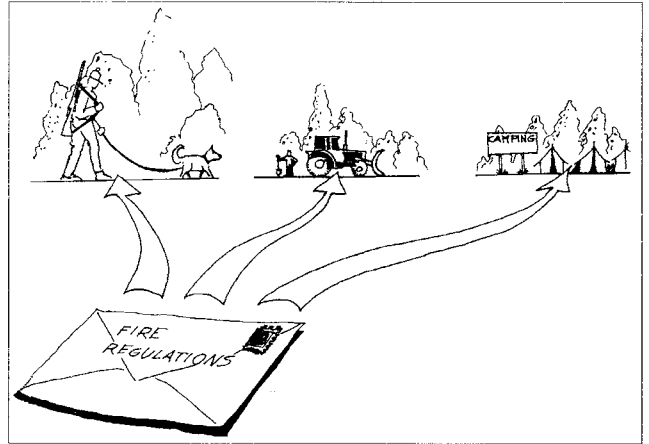
Namibia



Prevention letters

A well prepared letter aimed at a specific aspect of fire prevention and sent out with a personal message to a group is very effective.

For instance, a letter sent to local hunting associations just before the hunting season could produce favourable results.



Fire danger forecast

The national weather forecasting service should be able to send out a fire danger rating daily throughout the fire danger season.

Arrangements can be made with radio and television stations to include in their regular weather forecasts some fire danger warning, particularly when the rating is high or extreme. This is a very useful service both for fire prevention and for fire suppression. It is also a good means to make the general public more aware of the dangers of wildfires.

Firebreaks and fuelbreaks

Firebreaks or firelines may be either natural barriers, such as a road or a stream, or specially constructed barriers to limit the spread of fires and to provide an established control line in the case of a fire starting.

The usual firebreak is a strip of land that has been cleared of all trees and scrub growth.

The width of the strip will depend on the type of fuel, location, the topography of the land, and weather conditions. Usually, the width of the clearing will not be less than one half the height of the tallest tree which supplies the fuel.

A fuelbreak is a wide strip or block of land on which the natural vegetation has been permanently modified so that when a fire burns into it, it can be more readily extinguished with relative safety for the fire fighters. It may or may not have firelines built into it.

Fuelbreaks are generally placed strategically along ridges and in valleys. They also include any access roads.

Firebreaks and fuelbreaks should also be constructed to prevent wildfires from spreading from one area into another area.

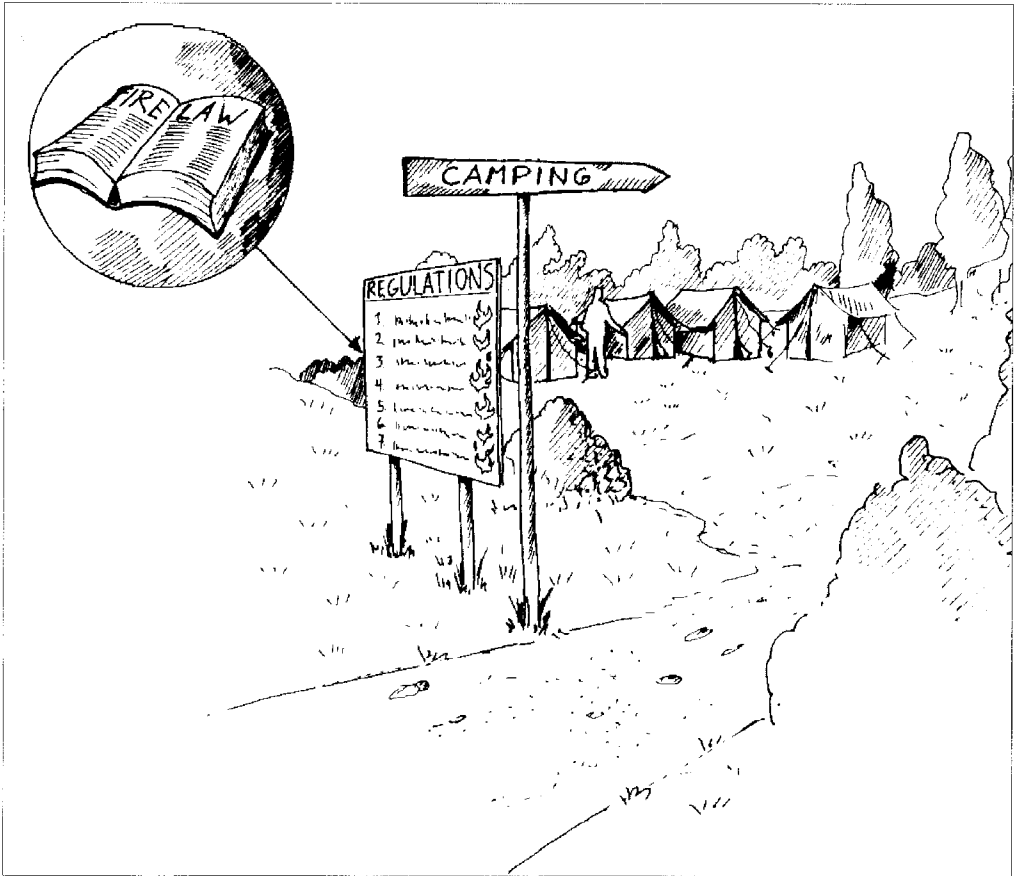
A greenbelt

A greenbelt is an adaptation of a fuelbreak in which the vegetation is kept green and living by irrigation.

4.6 Laws and Regulations

The basis for forest fire prevention will stem from the local laws and regulations against wildfires, and from knowing how to behave with outdoor fires.

National and local laws and regulations for smoking, campfires, and debris burning are important for forest fire prevention.



Laws and regulations should be impartial and aggressively enforced. Collection of the fire suppression costs from those who cause a fire is a good method of prevention. Cooperation with the police would be required in this activity.

4.7 Fire Investigation

Unknown fires comprise a too significant proportion of the wildfire statistics in many countries. As mentioned earlier, one basis for prevention is good statistics of fire causes. This needs reliable knowledge of how and by whom the fire had been caused at its starting place.

In every wildfire, immediate investigation of possible causes and protection of evidence at the fire site is necessary.

The first fireman arriving at the scene should be responsible for preservation the evidence. It is important that the scene be preserved in its original condition.

On the way to the fire and around the fire, the fire fighter should:

- (i) make notes of anyone or anything that could relate to the starting of the fire;
- (ii) observe vehicles, motorbikes and cars, and so on near the fire area and those moving away from it; and
- (iii) record licence plate numbers, descriptions of vehicles, numbers of people, personal descriptions, and the location or moving direction of the fire.

4.8 Fire Hazard and Hazard Reduction

Fire hazard (fuel) is one factor which can contribute to the starting of wild fires. There are both natural and man-made fire hazards. There are many types of fuels that create hazards, amongst others:

- fuels from brush, fields, and right-of-way clearings;
- slash accumulations in timber cutting;
- dryden grass and debris accumulation in fields, along fence rows, around buildings, and near roads and railroads;
- large accumulation in forests of flammable leaves, dead trees, dry bushes, etc;
- exceptionally dry fuels due to a prolonged dry spell;
- rubbish accumulations in or around residences, storage areas, and other buildings; and
- improper storage of inflammable gases and liquids in or near warehouse buildings and storage areas.

All potentially hazardous areas adjacent to the boundary of protected forest or plantation areas must be the prevention objective of the Fire Service. The only way to prevent fires starting in fire hazardous areas is to eliminate the hazard or the causes.

Total elimination is very seldom possible. That is why hazards should be reduced as much as possible, such as by:

- cleaning up litter and rubbish accumulations;
- storing inflammable gases and liquids in safety (in locked stores);
- cleaning up slashed timber, cutting or breaking it into smaller pieces;
- preventing large fire hazard areas by construction of fire-breaks or fuel-breaks;
- replacing some vegetative fuel hazards with less hazardous or more fire-resistant vegetation; and
- closing hazardous areas to use during periods of extreme fire weather conditions, which may be the only solution in some areas.

In summary, it can be said that the fewer hazardous areas there are in protected forest areas the smaller is the possibility for fires to start.

In plantation areas, a dense plantation is not so hazardous because these areas are normally also grass-free areas. Less dense plantation areas normally include a lot of grass, and are therefore very problematic to protect.

Controlled Burning of Fire Hazard Areas

The most effective fire hazard reduction is to eliminate most of the fuel from hazardous areas.

This can be done easily by burning off all hazardous fuel, which is called controlled burning (or prescribed burning). For instance, dryden grass along roads and railroad rights-of-way forms very hazardous fire risk areas. It is normal in many countries to burn off all hazardous grass along roads and railroads before fire seasons. In some countries, the Forest Service uses controlled burning of slash in areas after timber cutting, which reduces the hazard on these areas.

The technique of controlled burning needs knowledge and experience from the person doing it, otherwise the fire will escape very easily.

On the other hand, controlled burnings are useful for understanding fire behaviour and it is good training in the use of handtools and equipment. Also, it gives good practice for men to work with hot flames and inside smoke. Controlled burnings are usually done just before the fire season. Fuel in the control burning area should be dry enough for burning, but not too dry, because the fire will then escape easily.

Before controlled burning there should be consideration to the following points:

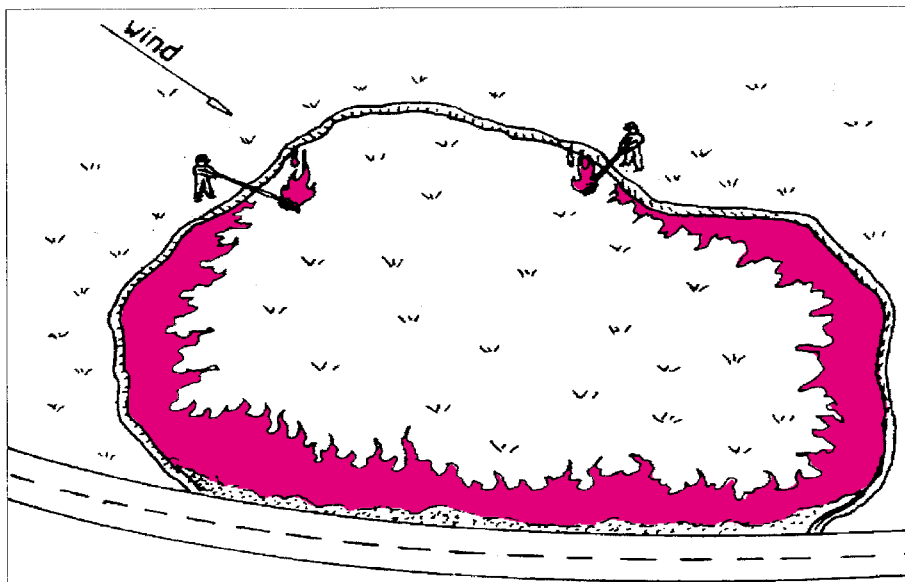
- (i) The fuel is dry enough, but not extremely dry. Relative humidity should be between 40-60 %. Below 30 % humidity, fire could become dangerous as the risk of spot fires grows.
- (ii) The weather conditions are favourable and safe for burning. Slow wind is good and its velocity is not allowed to be too much, because the risk of escaping fire and spot fires becomes too high.
- (iii) Before setting a fire the burning area must be surrounded by a wide enough fire-line. Safe width depends on the height and volume of fuel.
- (iv) There must be a sufficient amount of extinguishing equipment on the site, like swatters, backup-pumps, shovels, hooks, rakes, etc. Also, there should be enough fire men for patrolling and controlling the fire. If possible, there should be enough water for backpack pumps and / or fire pumps.
- (v) There must be only one fire boss as the leader of the controlled burning, who should have enough knowledge and experience of the controlled burning-technique.
- (vi) Before starting, the fire boss must report the plan of the burning to the local fire chief and / or fire headquarters, village chief, and neighbours.
- (vii) The best time to start firing is afternoon, because humidity is at its lowest by day and the wind is stable.

Before controlled burning can be started it must be checked that the fuel moisture and conditions are favourable for burning. This can be done by using small test fires.

The firing technique in control burning, for dry and humid fuels, is basically as follows.

Dry fuel - the fire starts and spreads easily:

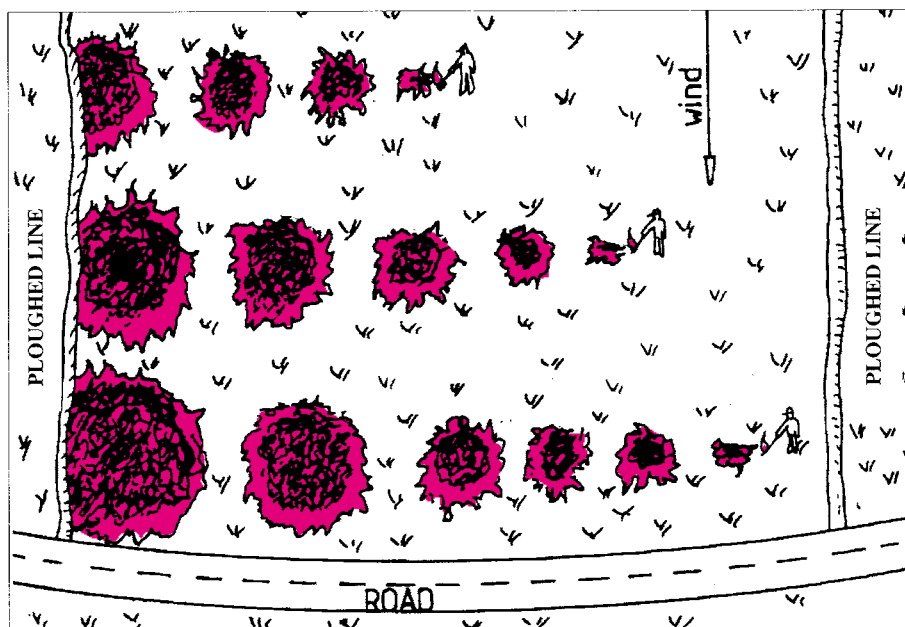
- (i) The fire is started beside the control / fireline, from the downwind side to the upwind side. The control line surrounds the area (on flat land).
- (ii) On slopes, fire starts from the upslope and spreads to the downslope.
- (iii) Firing should continue on both sides from the starting place, so that the fire's edge becomes like a horse shoe.



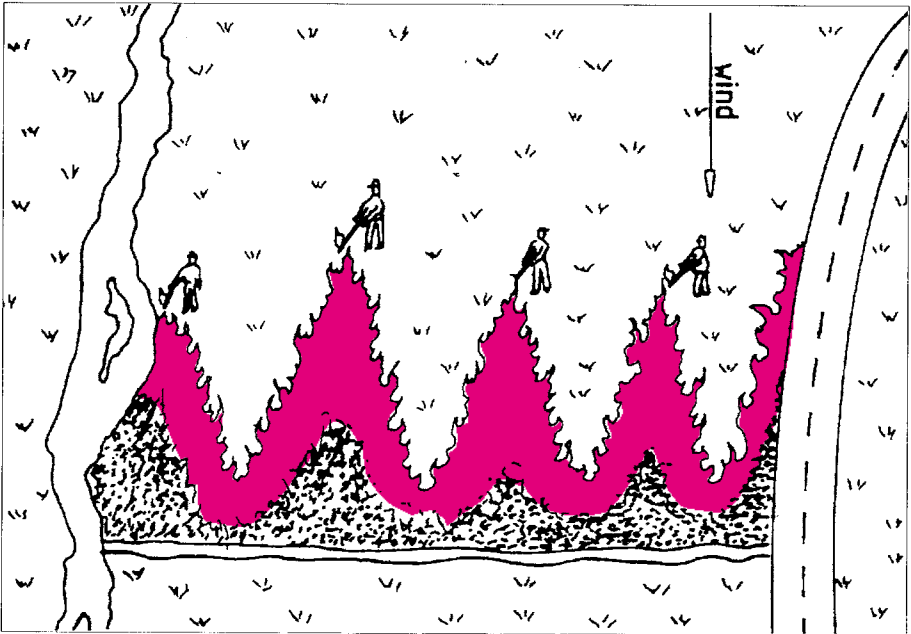
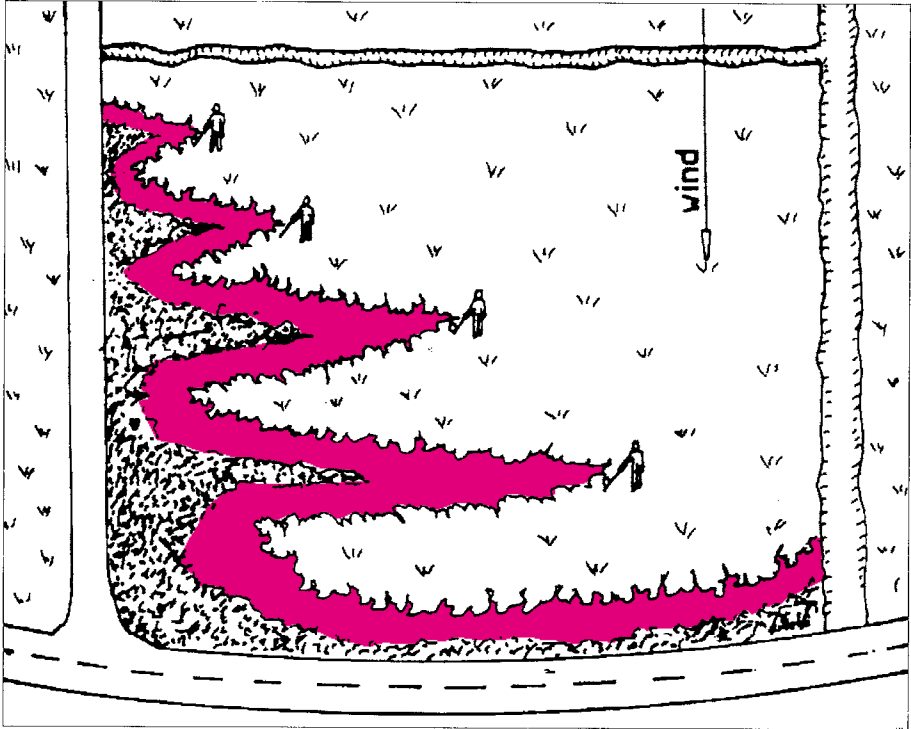
- (iv) Later on, spotfires can be made inside the area, which creates suction to the central direction and all flames move towards the centre.
- (v) After more than half of the area has been burnt, firing can be started on the upwind side of the area's edge (backfiring).
- (vi) The fire's own suction helps to keep flames inside the area. When the main fire and backfiring meet in the centre of the area they become a torch.

Humid fuel - fires will not start and spread easily:

- (i) Firing can be started from the upwind side to the downwind side (on flat land).
- (ii) For effective burning, spotfiring should be used inside the area.



(iii) For effective burning, fingers should be used inside the area.



(iv) On slopes, firing can be started from the downslope to the upslope.



FOREST FIRE BEHAVIOUR

5. FOREST FIRE BEHAVIOUR

5.1 General - Forest Fire Behaviour

The first step in every forest fire fighter's training is a knowledge of forest fire behaviour. There is no chance of being successful in the management of suppression activities without the knowledge of how a forest fire behaves.

Fire behaviour can be defined as the manner in which fuels ignite, flames develop, and the fire spreads and exhibits other phenomena.

How and why forest fire spreads is determined by a number of interrelated factors.

In order to predict fire behaviour it must be understood and known:

- (i) what causes a fire;
- (ii) how it will start;
- (iii) will it continue burning;
- (iv) in what direction and how fast will it spread;
- (v) why will it burn the way it does; and
- (vi) how frequently does it burn, and when does it burn.

This knowledge will enable fire fighters and managers to:

- (i) develop a more effective and efficient forest fire pre-suppression and suppression plan, helping in the decision of when, where, and how to control a fire;
- (ii) work safely; if dangerous situations can be recognised and avoided; and
- (iii) train more efficient fire fighters in forest fire control.

5.2 Principles of Combustion

5.2.1 Fire triangle

All fires are the result of a chemical process that occurs when three essential elements

- FUEL, HEAT and OXYGEN -

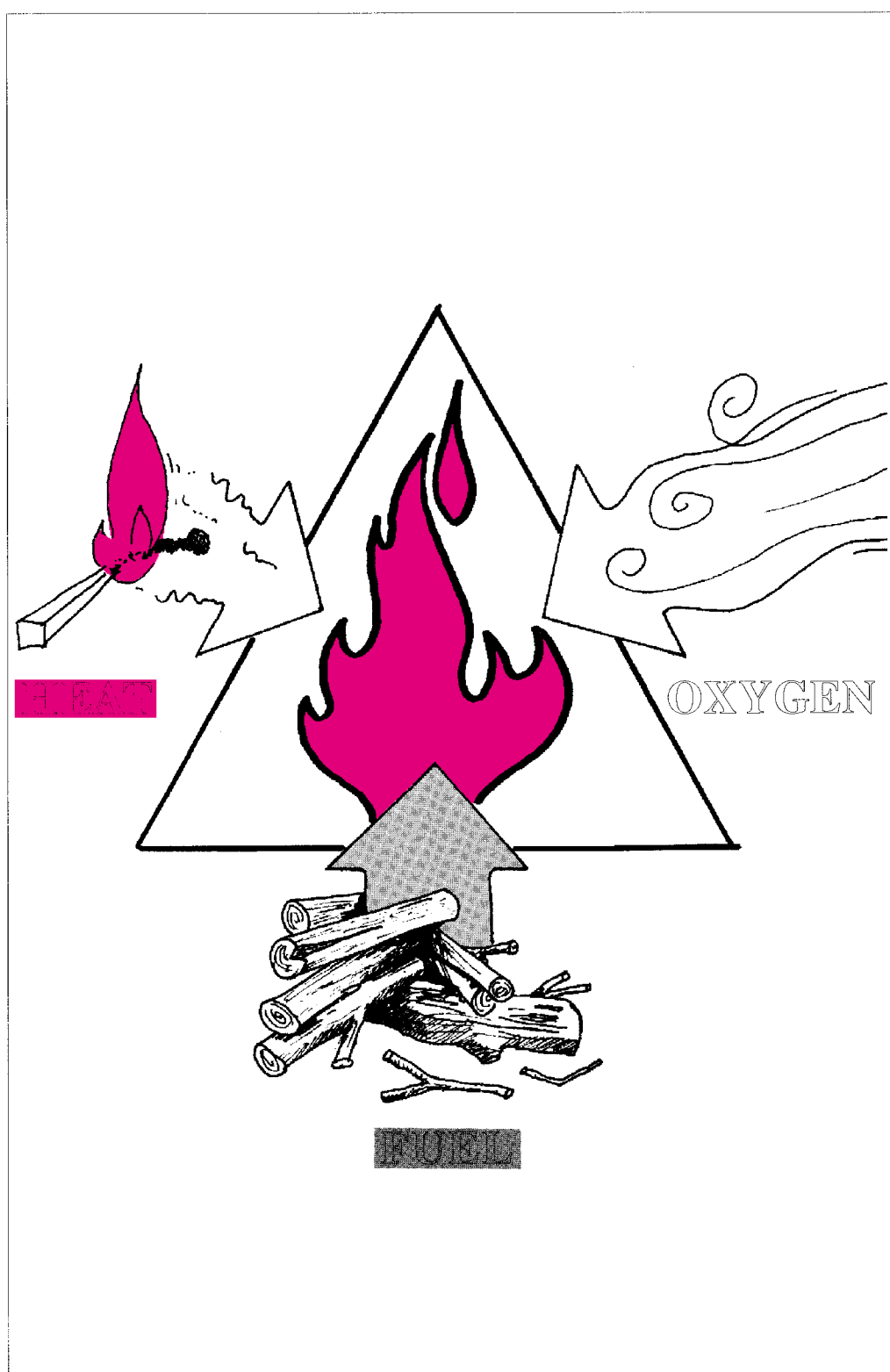
are brought together in the necessary combination to support combustion. This combination of the three elements of fire is called the:

"FIRE TRIANGLE".

In a forest there is an abundance of fuel and air (oxygen) always present. To complete the triangle (= fire) only an addition of sufficient heat or a source of ignition is required.

If any one of these three elements can be eliminated, the fire can be put out. In forest fuels, the principal inflammable component is carbon. The reaction is very simply expressed : carbon plus oxygen gives carbon dioxide plus energy ($C + O_2 = CO_2 + \text{heat energy}$).

THE FIRE TRIANGLE



The three elements of **the fire triangle** are:

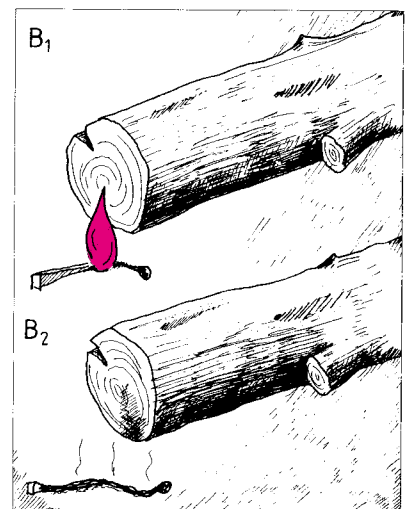
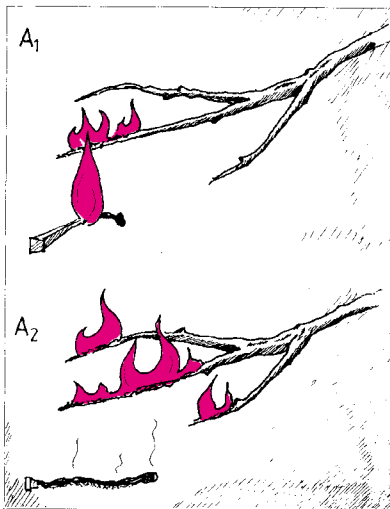
Oxygen - 21 percent of the air is oxygen. A reduction in oxygen to 15 percent extinguishes the fire. This can be done by smothering or covering - usually with sand (soil material) in the case of a wildfire, or swatters, sacks, branches, etc.

Fuel - wildfires are primarily controlled by working on the fuel side of the fire triangle. This is done by confining the fire to a definite amount of fuel by means of a fire line and natural barriers if they are available. By keeping all fire inside the line it is confined and controlled. The line is usually made by removing the surface fuel with tools or equipment so that the mineral soil is exposed, or by wetting down the width of the line with water.

Heat - in order to start a fire, fuel must be brought to the ignition temperature. If the heat drops below the ignition temperature, the fire goes out. Water is the most effective agent for this reduction of heat. Application of sandy soil also helps to reduce the heat.

5.2.2 Ignition temperature

Ignition temperature may be defined as the temperature of a substance at which it will ignite and continue to burn without any additional heat from another source. If a fuel stops burning when the heat which caused it to burn is removed from it, then the fuel has not reached its ignition temperature. The ignition point, or phase, when rapid combustion takes place varies with the type and condition of the fuel. The ignition temperature ranges from between 220 - 250°C depending on the particular fuel. For example:



A. A match is applied to a small twig. The twig begins to burn and continues burning after the match is taken away from it.

B. A match is held under a dry log. The log begins to burn but stops burning as soon as the match is removed from it. In these two examples it can be seen that one match would raise the temperature of a small twig to its ignition point, but one match could not cause a log to reach its ignition temperature. The size of the fuel in relation to the heat applied is important in determining whether or not the fuel will reach its ignition temperature.

More units of heat must be applied to a large size fuel than to a small size fuel in order to make it reach its ignition temperature. Another factor which determines whether or not a fuel will reach its ignition temperature is the moisture content of the fuel. A wet log will take longer to reach the ignition temperature than a dry log.

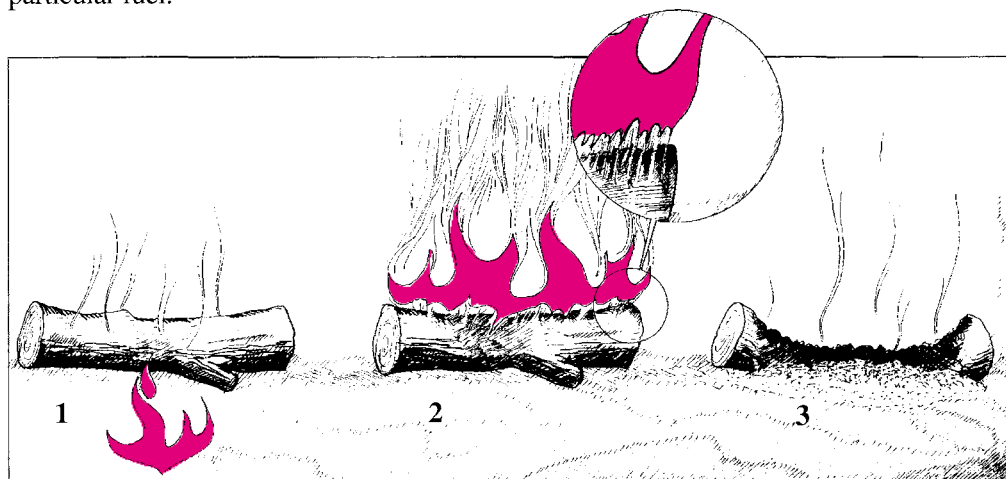
Some of the sources of heat which cause forest or grass fires are:

- (i) flames (e.g. match);
- (ii) embers (e.g. cigar);
- (iii) electrical sparks from man made sources;
- (iv) lightning; and
- (v) friction (forest machines, trains, etc.).

5.2.3

Phases of combustion

Combustion is possible if sufficient heat is present to attain the ignition temperature of the particular fuel.



In forest fires, all fuels undergo the following three phases of burning. The completion of these three phases will only occur if all three elements of the fire triangle are present, and if enough heat is applied.

Phase 1 - Pre-heating

This is the phase where fuels are dried, heated, and partially distilled, but where no flame exists. In this phase the temperature of the fuel is being raised to the ignition point (temperature), which is roughly 220 - 250°C for most wildfire fuels.

Phase 2 - Fuel breakdown (gaseous phase)

This is the phase where the pre-heated fuel breaks down into two fuels; gases and charcoal. The fuel has been brought to its ignition temperature and if an ignition source is present, flames appear above the fuel. At this phase the gases are burning, but the fuel itself is not yet glowing.

Phase 3 - Combustion (charcoal phase)

This is the third and last phase of burning. Before this phase, the fuel has already been broken down into two fuels, gases and charcoal, by the process of fuel breakdown. During the phase of combustion the gases from the fuel burn off with a flame, which is clearly visible, and the charcoal burns without a flame. The fuel is consumed and ashes are left. Wildfire fuels in this phase can cause spotfires if a wind causes mass transport, or if the burning fuels break apart and roll downhill.

5.2.4 Heat transfer

Heat is a form of energy that can be moved or transferred from one substance to another. Heat transfer influences the fire to behave the way it does. Fires spread by different methods of heat transfer.

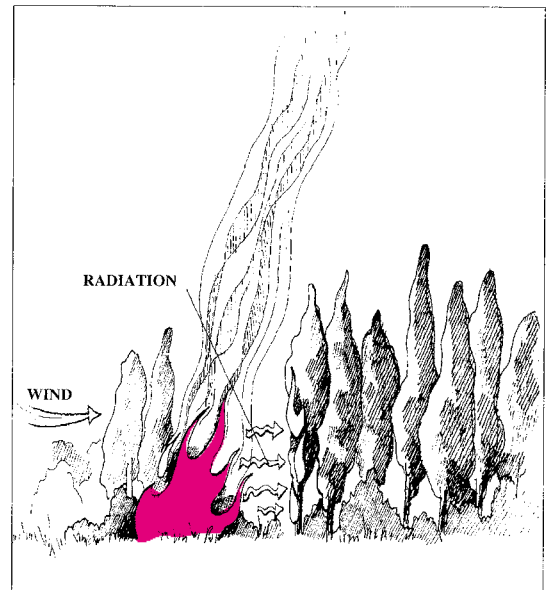
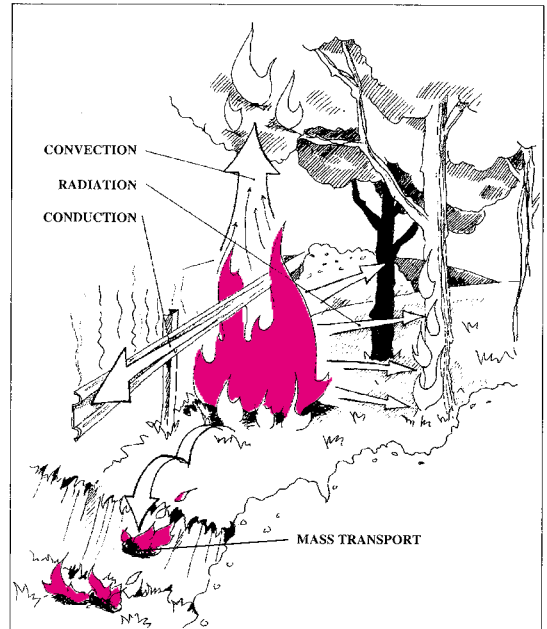
Four different methods of heat transfer can be discussed:

- (i) Radiation.
- (ii) Convection.
- (iii) Conduction.
- (iv) Mass transport.

Radiation is the transfer of heat through space, in any direction, at the speed of light. It does not need the movement of hot air. The intensity of the heat, however, decreases by the square of the distance from the object to the source.

Radiation is the main means by which fuels ahead of a "flame front" are pre-heated. That is, the heat radiated from the flames pre-heats the unburnt fuel to its ignition temperature and causes it to burn.

A large fire (with high flames) will pre-heat and ignite fuels faster than a small one. Since radiation causes the pre-heating of new fuel, it is an important cause of the spreading of surface fires. Radiation may pre-heat fuels across a fuel break and contribute to the fire jumping the fuel break.



Radiation is important to fire behaviour since it:

- (i) enables a surface fire to spread; and
- (ii) may contribute to a fire jumping a fuel break.

The term **convection** refers to the transfer of heat by the movement of hot air and other heated gases. The smoke rising above a fire is evidence of the upward movement of hot air and gases. A fast rising convection column indicates that the fire is burning intensely.

Convection forms heated air and smoke gases that spread heat in any direction, depending on the movement of the air. In a forest fire, fuels are pre-heated when they come into contact with this hot air and smoke gases. Convection contributes to the spread of fire.

A rising convection column may carry hot embers and fire brands from an existing fire aloft. These heat sources drop back to the ground and may cause spot fires should they land on a suitable fuel.

Convection also causes "torching" and contributes to the start of a crown fire, although this is a rare occurrence in tropical forests.

To summarise, convection is important to fire behaviour because it contributes to:

- (i) the spread of fires;
- (ii) spot fires;
- (iii) torching;
- (iv) the starting of crown fires; and
- (v) the rapid spread of fires up a slope.

Conduction refers to the transfer of heat within a fuel or from one fuel to another by direct contact. Wood is originally a poor conductor of heat, but metal is a good conductor. Although this method of heat transfer is important in building structures, it has little relation to wildfires.

Mass transport is a principal method of heat transfer in wildfires. It is primarily related to contact and it may be caused by the rolling, or falling, of ignited fuels and embers. Mass transport can occur when burning fuels roll down a slope into a new fuel, or when burning fuels (embers, branches, etc.) drop from above to ignite ground fuels.

Main Factors Influencing Fire Behaviour

There are three main factors which influence fire behaviour:

- (i) Fuel.
- (ii) Weather.
- (iii) Topography.

5.3.1

Fuel

Fuel is any organic material that will ignite and burn, either living or dead, in the ground, on the ground, or in the air. It must be remembered that fuel forms one side of the fire triangle. It is important to be familiar with certain properties and characteristics of the fuel, which can include the:

- (i) size of fuel;
- (ii) fuel arrangement;
- (iii) volume of fuel;
- (iv) fuel type and fuel type pattern; and
- (v) fuel condition.

In analysing any fire situation, all five of the above fuel factors must be taken into account.

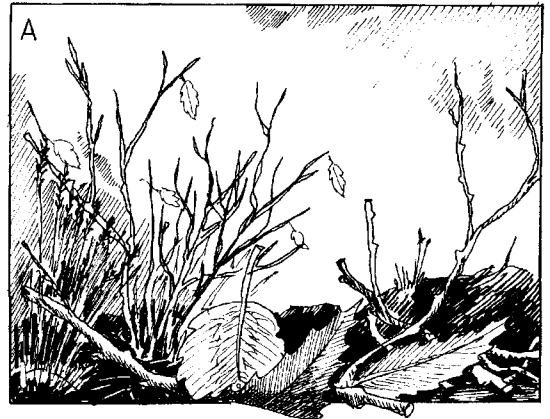
Size of fuel

The size of a fuel is an important factor in determining the rate of combustion of the fuel. If the pieces of fuel have a large surface area exposed per unit volume, the rate of combustion is less than that of small pieces.

A. Light (fine) fuels are twigs, leaves, grass, small branches, pine needles, etc.

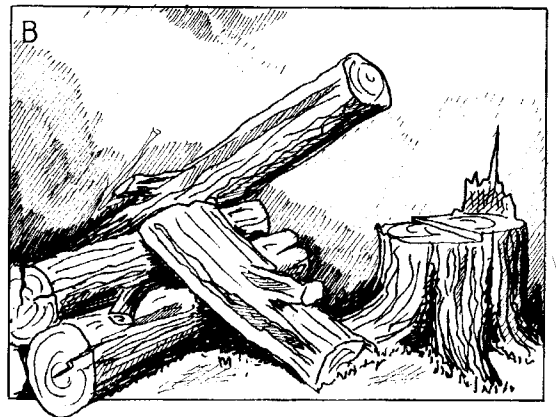
Light fuels pick up moisture quickly and give it off quickly. Light fuels, such as dry grass, need very little heat to reach ignition temperature. Once the grass begins to burn it will burn very quickly.

Therefore, light fuels are referred to as being fast-burning fuels.



B. Heavy (coarse) fuels are large fuels such as logs, stumps, standing trees, etc. In comparison, a heavy fuel takes in moisture slowly and gives it up slowly. Large fuels need much more heat to reach ignition temperature than a light fuel.

Heavy fuels are therefore referred to as being slow-burning fuels. Heavy fuels continue to burn for a much longer time.



FIRE SPREADS FASTER IN FINE FUELS THAN IN HEAVY FUELS.

Fuel arrangement

The type and size of the fuel determines, in part, how a fire burns. The way in which the fuel is arranged also has an important influence on fire behaviour.

To a large extent, fuel arrangement determines the:

- (i) rate of fire spread and burning;
- (ii) direction of the fire spread;
- (iii) rate of evaporation of moisture; and
- (iv) rate of oxygen supply for burning.

Fuel arrangement is the relationship of all the combustible materials in the horizontal and vertical planes from mineral soil to the ground layer. The arrangement of fuel affects the rate of evaporation of moisture, the rate of oxygen supply and burning, and the rate and manner in which fire will spread. The arrangement of fuel affects the amount of air that can pass around it.

The horizontal arrangement of individual pieces of fuel affects the rate of the fire spread, and its intensity. Fuels which are far apart burn slowly and the fire spreads slowly from one piece of fuel to another. If the pieces are close together, they will burn with great intensity and the heat produced will cause the fire to spread more rapidly. Fine fuels which are closely arranged, such as grasses, are easily ignited because very little heat is lost by conduction. Each piece is small and more or less independent, thus it will heat up and dry out rapidly.

The vertical arrangement of fuels affects the rate of spread and the type of fire which results. Combustible fuels that are continuous from the ground to the tops of the trees may "torch". That is, they may burn individually from the ground to the tree top (or crown) and may then spread through the tree tops in advance of the surface fire. The continuity and density of the crowns will have a strong bearing on whether a crown fire will continue or drop down to become a surface fire. Where there is a definite separation between the surface fuels and the crowns the possibility of a fire climbing to the tree tops is minimised.

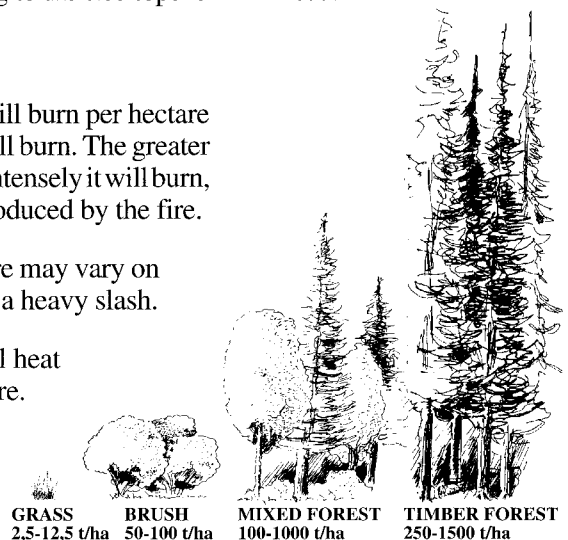
Volume

The volume of the available fuel that will burn per hectare affects the intensity with which a fire will burn. The greater the volume of fuel per hectare the more intensely it will burn, and the greater will be the total heat produced by the fire.

The amount (volume) of fuel per hectare may vary on a wide scale, between a light grass and a heavy slash.

The volume of fuel determines the total heat that can be developed during a given fire.

The total heat volume plays a big part in the spread of the fire.



THE VOLUME OF FUEL REFERS TO THE AMOUNT OF FUEL PER HECTARE

High volumes of fuel usually require more work in line construction than low volumes.

If a fire were burning in a light accumulation of surface fuel it would be relatively easy to control. A fire burning in a heavy accumulation of surface fuel would be fairly hot. This fire would be intense fire, and much more difficult to control.

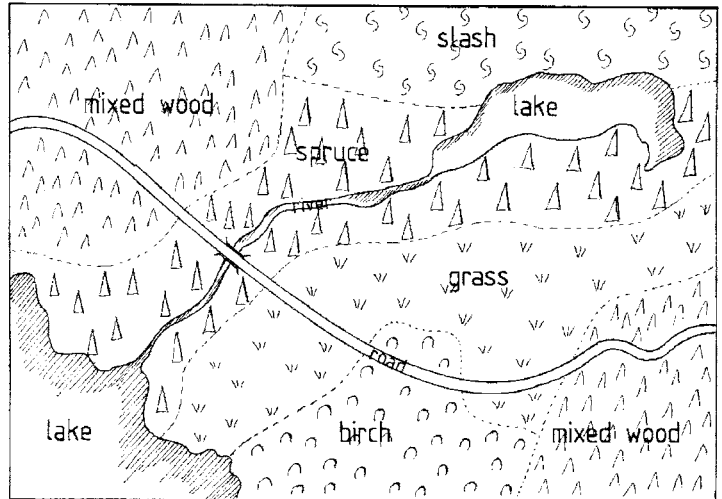
Fuel type and fuel type pattern

Fuel type refers to the general classification of forest cover type, i.e. grass, bush, mixed forest, conifer, hardwood, slash, etc.

Fuel type pattern refers to the arrangement of barriers and the different types of fuel.

Fire spreads more rapidly in certain types than in others, depending on the season.

For example, poplar stands and other hardwoods usually form good barriers, but pine and other conifer barriers seldom do.



The fuel type pattern shows where the different types of fuel and barriers are located in an area.

Fuel condition

Fuel moisture is a prime factor in judging the burning capability of fuel. It is a product of past and present weather events. Forest fuels obtain their moisture from:

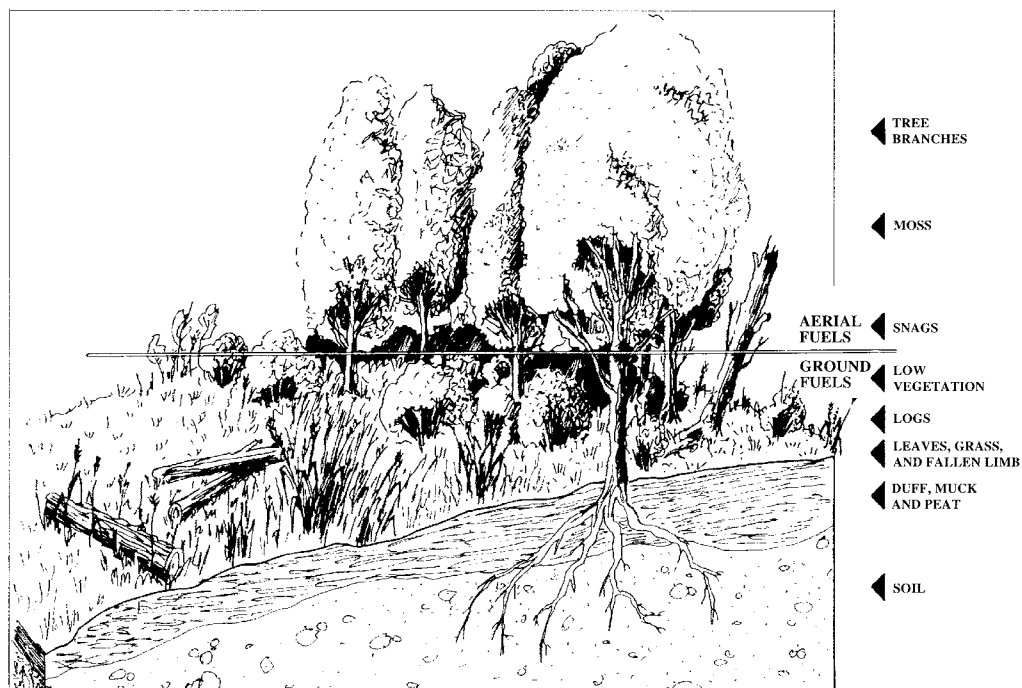
- (i) the atmosphere;
- (ii) precipitation; and
- (iii) the ground.

There is a relationship between the relative humidity and the moisture in fuels. When the relative humidity is high the moisture in forest fuels tends to be high, and when the relative humidity is low the moisture content is low. Precipitation, or rain, has an obvious effect on the moisture content of forest fuels.

When the fuel moisture is high fires are difficult to start, and when the fuel moisture is low fires start easily and spread rapidly. Temperature, humidity, wind, the precipitation season, the time of day, and the topographic location all have either a direct or an indirect bearing on the fuel moisture at a given time. Fuel moisture changes more rapidly in dead fuels than in living fuels.

Ground and aerial fuels

Fuels are classified by location as ground or aerial fuels. Each of these classes is then evaluated for arrangement, size, volume, and moisture content.



Ground fuels are those lying on, immediately above, or in the ground. They may be either dead or living materials, including duff, roots, branches, dead leaves and needles, grass, fine deadwood, logs, slash, brush, and small trees.

Duff is the partially decayed vegetative matter lying on the soil. In a forest it may be several centimetres to one metre deep and it creates the humus soil beneath it. It may be only a light layer of decaying vegetable matter, such as grass. Usually duff is inflammable, but burns slowly. Dead leaves and needles that are loosely arranged and not in contact with the ground are most inflammable. If they are still attached to the branch and freely exposed to the air they are especially inflammable.

With grass, weeds, and maize the key factor is the stage of drying. Succulent green grass is a good fire barrier, but as it gradually dries it becomes increasingly inflammable. Twigs, dead needles, leaves, small branches, bark, and rotting materials are classed as fine deadwood. It is ignited easily and provides the kindling for larger fuels.

Logs, stumps, and large branches are heavy fuels which require long periods of dry conditions before they become highly inflammable. When they do become dry, they can develop very hot fires. Low brush and small trees may either slow down or accelerate the spread of fire, depending on the species and its drying stage.

Peat fires are a hazard in certain areas. Peat contains oxygen and supports slow-burning fires when it becomes dry enough to kindle. It burns down to the depth at which moisture is found.

Aerial fuels consist of tree branches, crowns, snags, and high brush. They are physically separated from the earth and from each other and air can circulate around the fuel particles. They may be green or dead and they form the canopy of the forest or tall brush.

The live needles of evergreen trees are highly inflammable because their arrangement on the branches allows for the free circulation of air and they contain oil and resins susceptible to ignition.

Tree crowns react quickly to the relative humidity, and it is rare for a crown fire to occur with a high relative humidity. Crown fires do not occur unless sufficient ground fuels are underneath to trigger the action or unless the area is close enough to another fuel type that can furnish enough heat to start combustion. There must also be sufficient wind to maintain a crown fire.

In some stands, a sufficient amount of dead stems and branches may be present to allow for a fast spreading crown fire.

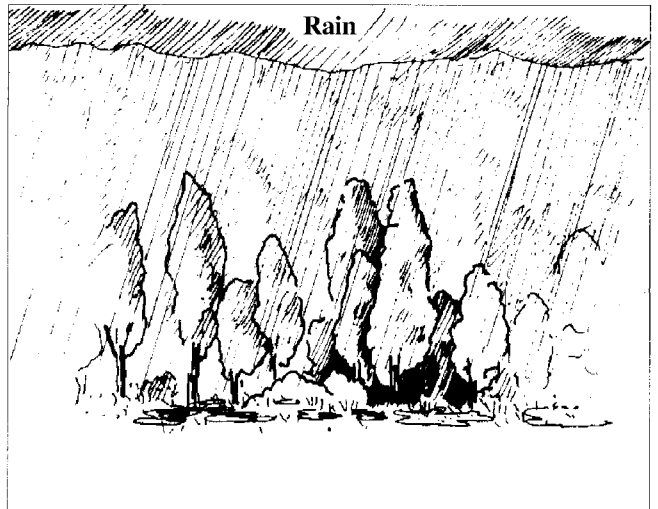
5.3.2 Basic weather factors

A true analysis of fire behaviour cannot be made on the basis of one weather factor alone. Actual fire behaviour is the result of many factors acting together in various ways. The basic weather factors which we should take into account in wildfires are:

- (i) precipitation;
- (ii) wind;
- (iii) temperature; and
- (iv) relative humidity.

Precipitation in the form of rain, dew, or heavy fog must be taken into account. All these factors may be referred to as precipitation.

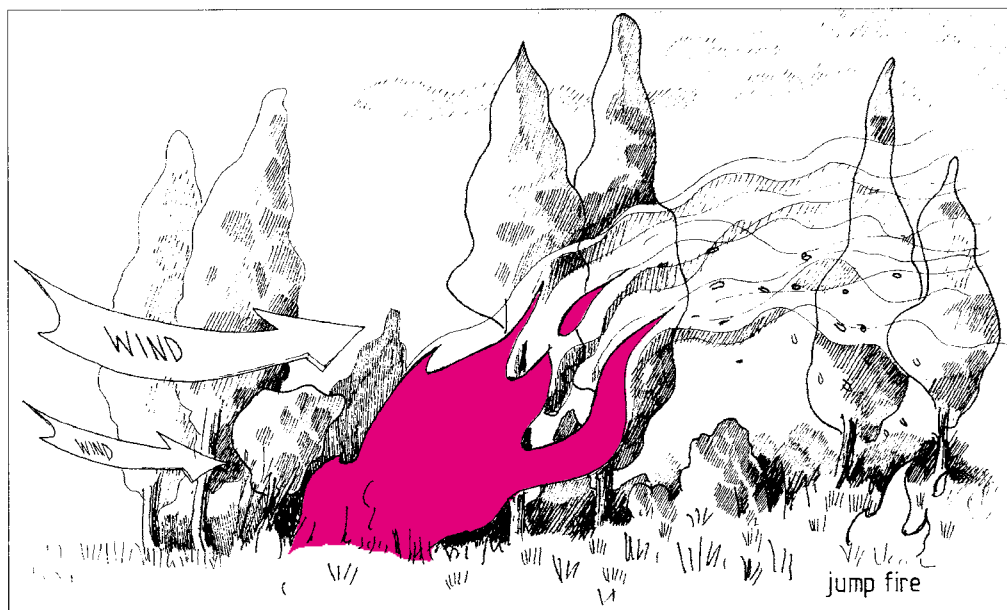
Like relative humidity, rain influences the moisture content of the fuels. The large or heavy fuels are more likely to hold their moisture content longer.



Suppose that two days ago, 10-20 mm of rain fell on the region. Humidity is now 30% and wind speed is high. In the case of a fire, the fine (light) fuels will most likely burn completely. Heavy fuels may char but will not burn very easily with a flame. The fire will die down at night when the relative humidity rises and the wind speed drops.

This is because the recent rainfall contributed to the difference in the forest fire behaviour between the heavy and light fuels. Fine fuels lose their moisture more rapidly. The heavy fuel will not burn easily because it contains a lot of moisture. The increased relative humidity at night increases the moisture content of the fine fuels, thus causing the fire to die down. This is also the reason why very few fires occur early in the morning.

Wind is a major factor in determining fire behaviour. It affects the rate at which a fuel dries, it increases the supply of oxygen, influences the pre-heating of fuels, and may carry burning brands or embers forward, causing jump fires or spot fires. The pressure of heavy wind may bend the convection column towards the ground, permitting rapid pre-heating and drying of the fuels ahead of the fire and allowing the fire to spread rapidly in that direction. Wind also influences the moisture content of the fuel (fuel condition). If the wind speed is high, a forest fuel will dry out much faster than it would if the speed were low. The principal result of wind is that it influences both the rate and the direction of fire spread.



Wind speed is at its maximum during the day, or in the afternoon, and will drop down in the evening. That is why fire fighting is most difficult during daytime, as a fire can spread very quickly. It is always safe to assume that if the wind speed doubles, the speed of a fire's spread in the direction of the wind will more than double.

In addition to carrying fire brands to a new fuel where they can start spot fires, the wind has two other important and direct effects on fire behaviour, it:

- (i) influences direction of spread; and
- (ii) influences rate of spread.

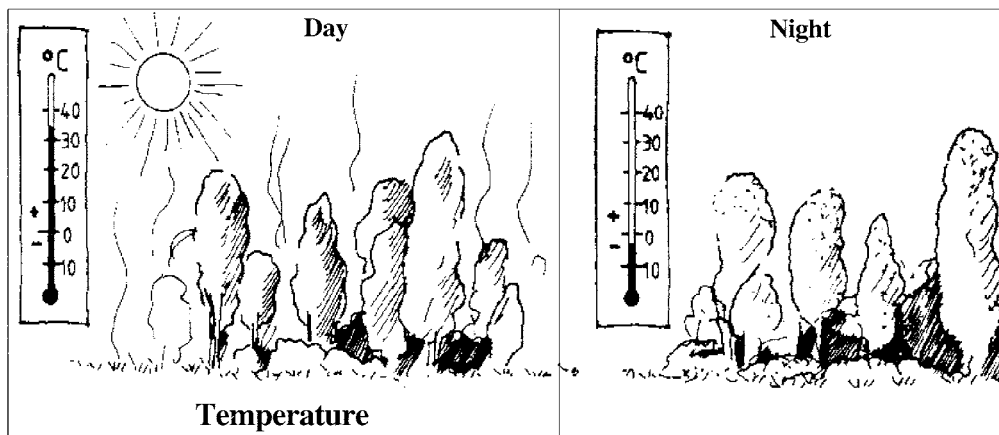
This is because the wind bends the convection column and the flame from the fire and increases the oxygen supply.

Wind can carry burning embers across a narrow fuel break, thereby causing the fire to jump the fuel break. This is not however the only way that a surface fire can jump a narrow fuel break. If the fuel is relatively dry it could occur due to radiation, to spot fires, or to direct contact of flames with the fuel on the other side if the wind bends the flames and convection column.

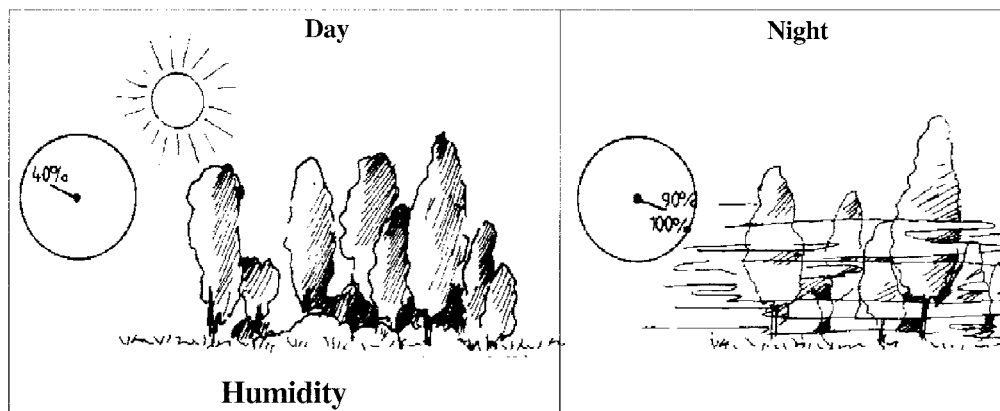
The fire fighter should be constantly aware of the winds in the vicinity of fire.

If an anemometer is not available, wind velocity in the forest can be estimated by observing the surroundings, as shown in the following table.

Modified Beaufort scale for estimating wind speed		
Wind class	Range of speed m/s	Nomenclature
1	0 - 1.5	Very light - smoke rises nearly vertically. Leaves of quaking aspen in constant motion; small branches of bushes sway; slender branchlets and twigs of trees move gently; tall grasses and reeds sway and bend with wind; wind vane barely moves.
2	1.5 - 3	Light - trees of pole size in the open sway gently; wind felt distinctly on face; loose scraps of paper move; wind flutters small flags.
3	3 - 5	Gentle breeze - trees of pole size in open sway very noticeably; large branches of pole size trees in the open toss; tops of trees in dense stands sway; wind extends small flags; a few crested waves form on lakes.
4	5 - 8	Moderate breeze - trees of pole size in open sway violently; whole trees in dense stands sway noticeably; dust is raised in the road.
5	8 - 11	Fresh - branchlets are broken from trees; inconvenience is felt in walking against wind.
6	11 - 14	Strong - tree damage increases with occasional breaking of exposed tops and branches; progress impeded when walking against wind; light structural damage to buildings.
7	14 - 17	Moderate gale - severe damage to tree tops; very difficult to walk into wind; significant structural damage occurs.
8	17	Fresh gale - intense stress on all exposed objects, vegetation, buildings; canopy offers virtually no protection; wind flow is systematic in disturbing everything in its path.



Temperature is the third basic weather factor which should be taken into account. The temperature influences the condition of forest fuel, as its main effect is to dry the fuel. Temperature also has a very direct affect upon the fire fighters themselves. It is more uncomfortable and tiring to fight fires in excessive heat.



Relative humidity is an indicator of the percentage saturation of the air at the prevailing temperature. Therefore, if the relative humidity is high it means there is a high amount of moisture in the air. The amount of moisture in the air affects the amount that is in the fuel.

Wet fuels, and most green fuels, do not burn freely. If, for instance, the relative humidity is 80%, the fuel is less inflammable than it would be if the relative humidity were, for instance, 20%.

Some rules of thumb

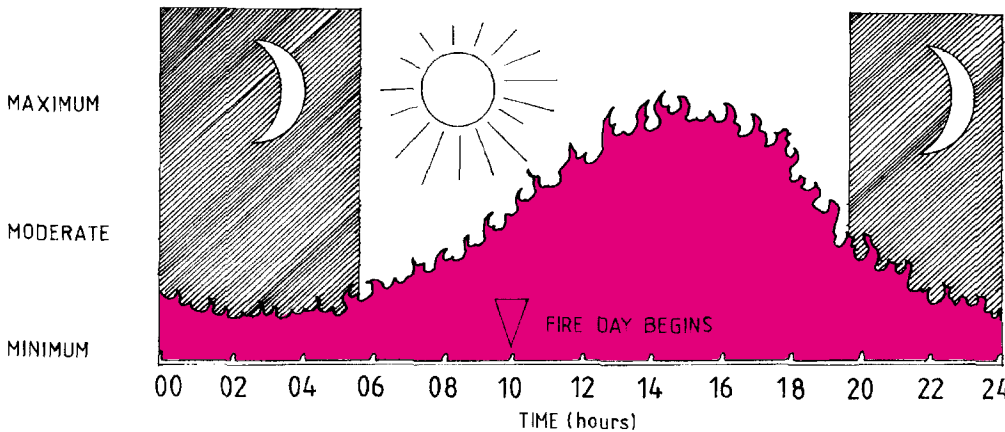
- (i) For every 20°C decrease in temperature the relative humidity is doubled, and for every 20°C increase in temperature the relative humidity is lowered by one half.
- (ii) Around 30 % relative humidity is the ordinary danger point for wildfires.
- (iii) When the relative humidity is above 30 % fires are not too difficult to handle, but below 30 % wildfires are generally more difficult to control.
- (iv) Relative humidity varies according to the time of day, it is highest in the morning, around dawn, and lowest in the afternoon.

5.3.3 The changing influences of weather

Two natural conditions influence the weather which, in turn, influences fire behaviour. These are:

- (i) time of day; and
- (ii) seasonal changes.

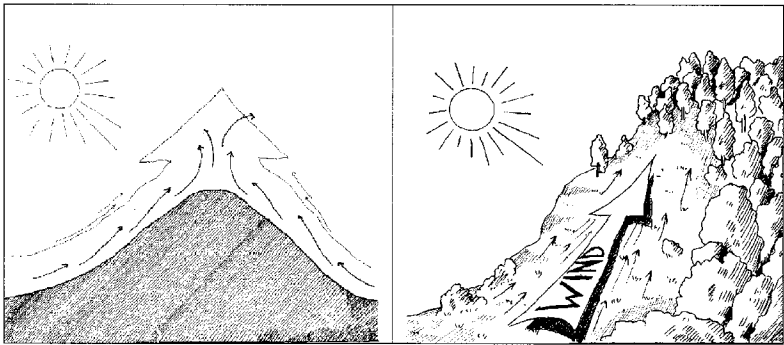
Time of Day



The same fire may burn very differently at different times of the day. The time of day influences wind, relative humidity, and temperature. We have seen that the greatest fire danger exists when the wind speed is high, relative humidity is low, and the temperature is high.

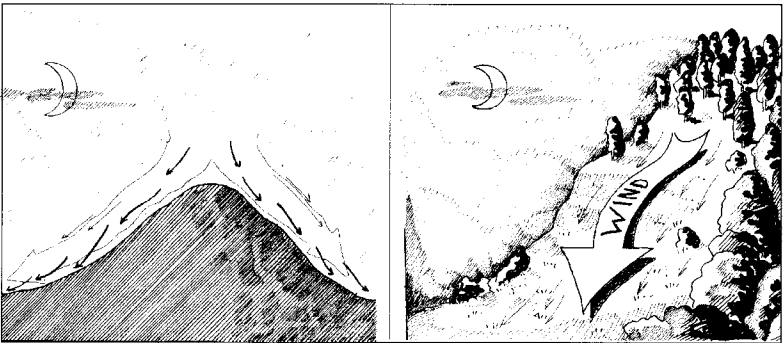
The greatest fire danger during the day is roughly between 10 a.m. and 6 p.m.

The wind speed is high, relative humidity is low and the temperature is high.



The lowest fire danger exists between about 2 a.m. and 6 a.m.

The relative humidity is high, the wind speed is low and the temperature is low.



Seasonal changes

The natural cycle of the season also influences fire behaviour. Each season has a different effect on the available moisture and the condition of forest fuels.

In a tropical forest, the fuels dry out during the dry season and are green during the rainy season. Dead fuels are more inflammable than green ones and thus form a high hazard condition. The season affects the drying time of the fuels, the temperature, and the relative humidity of the air.

5.3.4 Topography

A knowledge of topography is important to understanding fire behaviour. Topography is the third major factor which determines how a fire will burn, where it will burn, and why it burns the way it does.

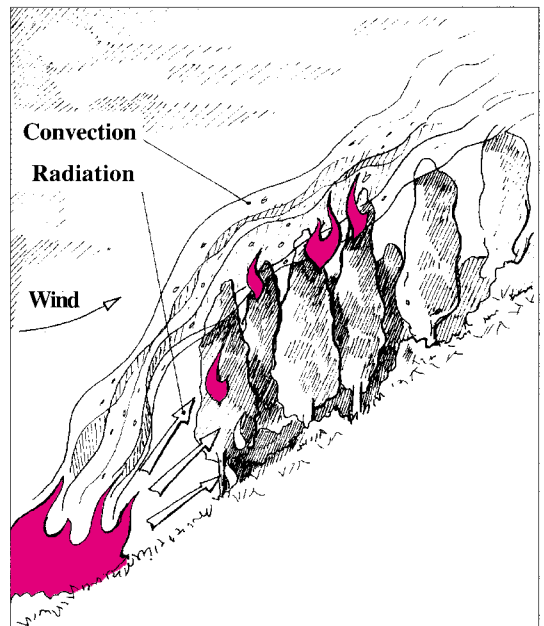
The term "topography" refers to the physical features of the earth's surface. Topographical information tells us whether the land is hilly or flat, whether there is a presence or absence of water (lakes, dams, rivers, streams, etc.), where there are cliffs, swamps, and so on.

Slope

Slope has a great influence on fire behaviour. A fire will burn much faster uphill than it will on a level surface or downhill. When the ground is sloping the convection column and the flame front is much closer to a new fuel. The convection column and the radiation of heat from the spread of the fire downhill is much slower than on a flat surface, but an uphill fire will always spread faster than on flat land. The speed of the fire spreading uphill will depend on the degree of the slope. The spreading is faster as the hill gets steeper.

The slope influences fire behaviour in two ways:

- (i) the rate of fire spread; and
- (ii) the direction of fire spread.



Natural barriers

Topography can be a natural barrier, and / or a hindrance to the fire. For example, a fire burning at ground level spreads to the shores of a large lake. The wind blows towards the lake. When the fire reaches the lake it will probably burn itself out.

As well as lakes, dams and rivers, roads, cliffs, and swamps may serve as effective natural fire barriers. The presence or absence of natural barriers is therefore an important topographical factor.

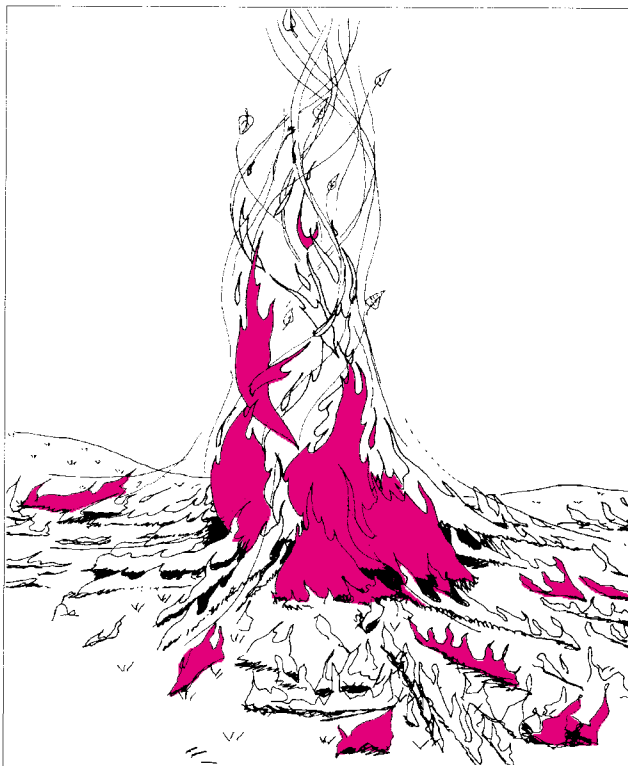
5.4 Rate of Spread

The rate of spread in forest fires is variable, and depends on the following interacting factors:

- (i) fuel quantity;
- (ii) fuel moisture content;
- (iii) fuel type and dispersal;
- (iv) wind direction and speed;
- (v) slope of ground; and
- (vi) weather conditions.

5.5 Torching

When the weather is dry enough for individual tree crowns to be easily ignited, but there is not sufficient wind to sustain a crown fire, the resulting phenomenon is called torching. Torching is always a danger signal to the firefighters as it means that any increase in wind may result in a crown fire, and also because needle clusters, small pieces of bark, and other material may be lifted above the burning tree and cause spot fires some distance away.

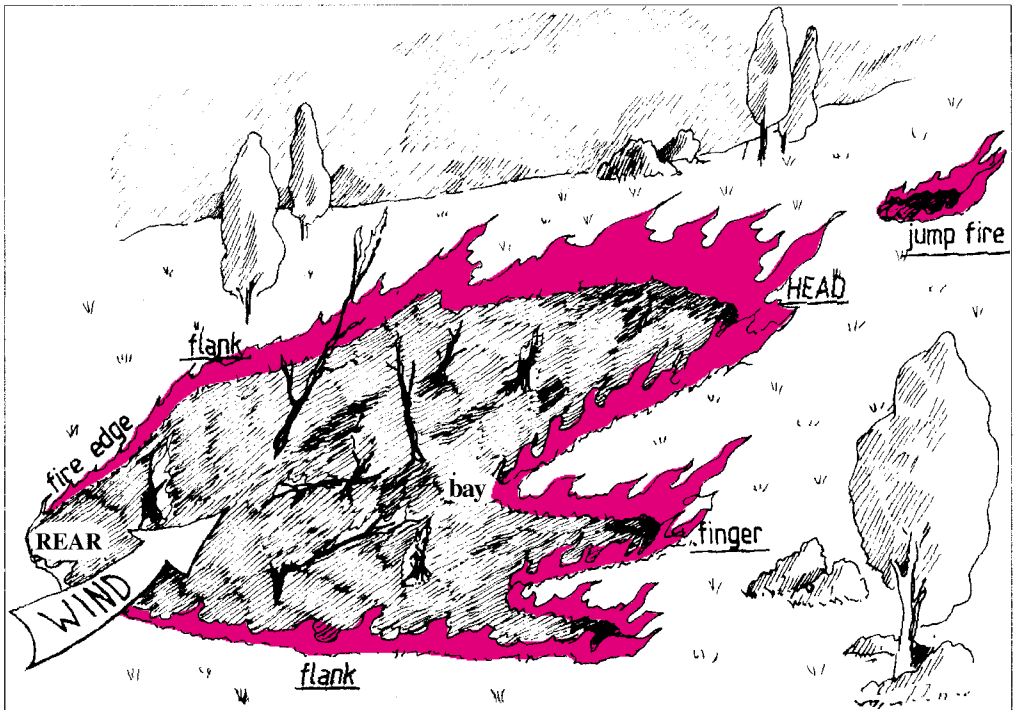


5.6 Large Fire Behaviour

On average, five to ten percent of all forest fires grow to a large size. These are the fires that cause the most damage, often reaching catastrophic proportions. Many large fires are the result of adverse conditions of weather and topography. "Adverse" may also include conditions too tough for the strength of the initial attack forces for the particular fire. The initial attack force is not usually strong enough to combat worse than average conditions.

The transition from a small fire to a large fire regime is typically sudden, sometimes only 15-30 minutes. This transition to convective dominance is marked by an increase in fire intensity (particularly by fuels burning well inside the fire edge), an increase in draught, the production of black smoke indicating incomplete combustion of the flame gases, and often an increase in the amount and distance of spot fires.

A blow-up is a sudden increase in fire intensity and an increase in the rate of spread, or both, that probably multiplies the existing control plans. Blow-ups are often the result of violent convection, and they may have some characteristics of a firestorm. When fires have reached extreme fire behaviour the combustion chain has usually become so strong that it cannot be broken by conventional fire-fighting methods. It is then necessary to plan the control for the changing conditions, and to try to anticipate the place and time at which the changes will occur. In the meantime, only part of the perimeter may be tenable for the fire control forces.



Head - The head is the most rapidly spreading part of a fire's perimeter. It is usually driven by the wind, the uphill effects of a slope, or is determined by the fuel arrangement or the fuel type pattern. The head often burns very intensely, and may move forward at a dangerously fast rate.

Finger - A finger is a long narrow tongue of fire projecting from the main fire body. Each finger has its individual "head" and "flanks". This fire pattern usually results from the fuel and slope conditions.

Bay - That part of a fire edge usually between two or more fingers, where fire spread is slower because of the fuel or slope conditions.

Rear - That part of the fire edge opposite to the fastest spreading side is referred to as the rear of the fire. It usually burns with a slow rate of spread, and is easier to handle than other parts of the fire.

Flanks - The sides, or parts, of the fire's perimeter roughly parallel to the main direction of spread are called the flanks. They are designated left or right as viewed facing the head of the fire from the rear. The flanks do not generally burn as intensely, nor spread as rapidly, as the head.

The edge - The fire edge is the boundary of a fire at any given moment. It can be active, burning with varying intensity, or completely extinguished. The fire edge must not be confused with a fire line, which is a natural or constructed line along which fire fighters undertake control action.

Other terms

Other terms commonly used to describe the conditions of a forest fire are "hot spot", "smudge", and "jump fire". Their definitions are as follows:

Hot spot - A very active part of a fire's edge is referred to as a hot spot. The fire burns more intensely and spreads more rapidly than the adjacent section of the fire's edge. It may constitute a local threat to fire line construction efforts.

Smudge - A spot in a fire, or along a fire's perimeter, which has not yet been extinguished, and which is producing smoke. A term commonly used during the patrol stage of a fire.

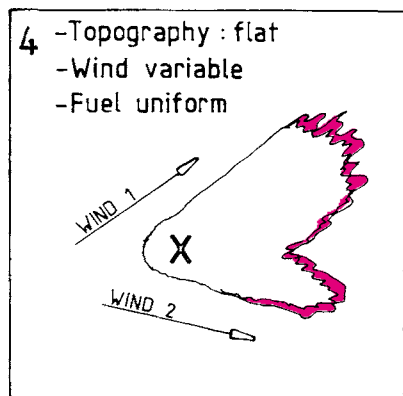
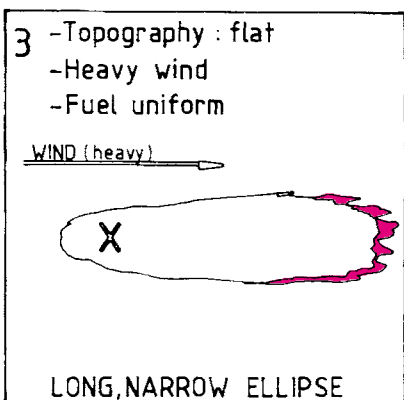
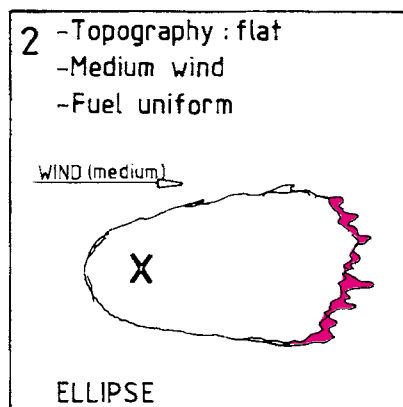
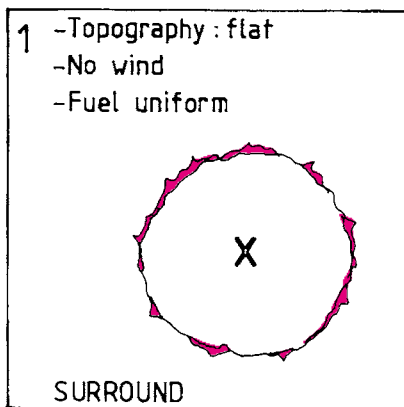
Jump fire - Jump fires occur in advance of the main fire and are started by burning sparks or embers carried from the main fire by air currents. They are also often referred to as spot fires. When a fire jumps immediately across an established fire line the new fire may also be referred to as a jump fire.

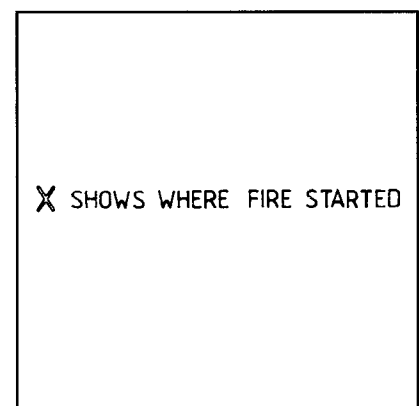
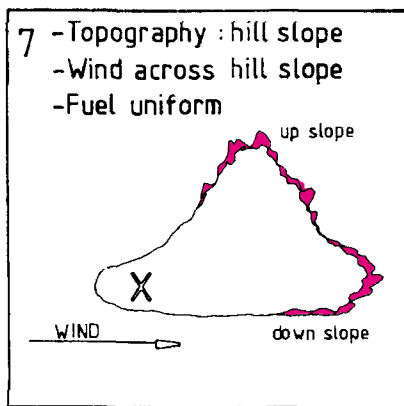
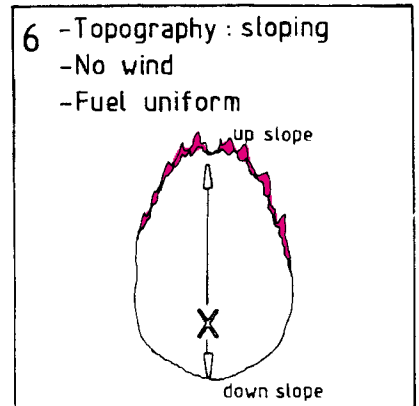
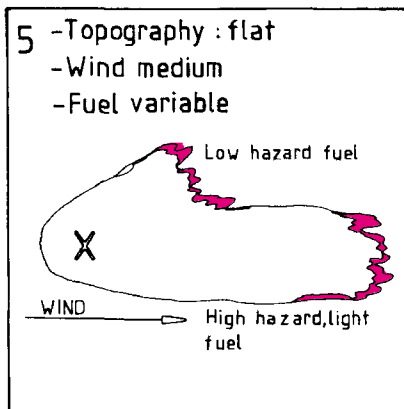
5.8

Form of Forest Fires

The factors which influence the form of a forest fire are:

- (i) wind, especially the speed of the wind;
- (ii) differences in fuel; and
- (iii) topography.





5.9 Types of Fire

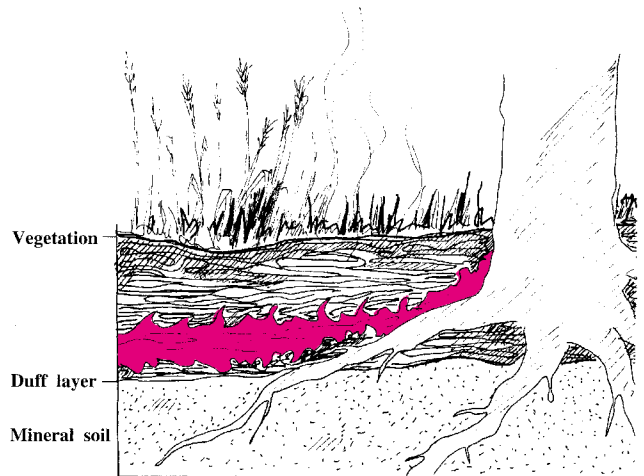
There are three fuel layers in the forest: the sub-surface, surface, and crown .

A forest fire can burn in one or any combination of these layers. However, most fires occur and burn in the surface fuel. Occasionally, surface fires, burning intensely, will spread to the crowns of the trees. Here, the fire will travel through the tree tops at a high rate of spread but will eventually return to the surface fuel layer. Under certain circumstances, the fire will burn beneath the surface fuels in the sub-surface layer. Here it can lie dormant, burning slowly, waiting to be fanned once again into a surface fire and, from there, leaping upwards to become a fast moving crown fire under favourable fuel and weather conditions.

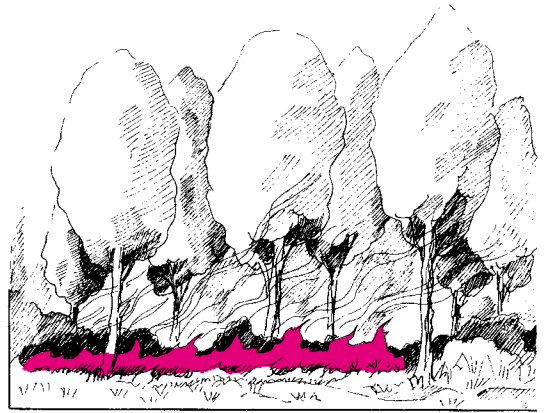
In this respect, the three main types of forest fires encountered are:

- (i) sub-surface fires;
- (ii) surface fires; and
- (iii) crown fires.

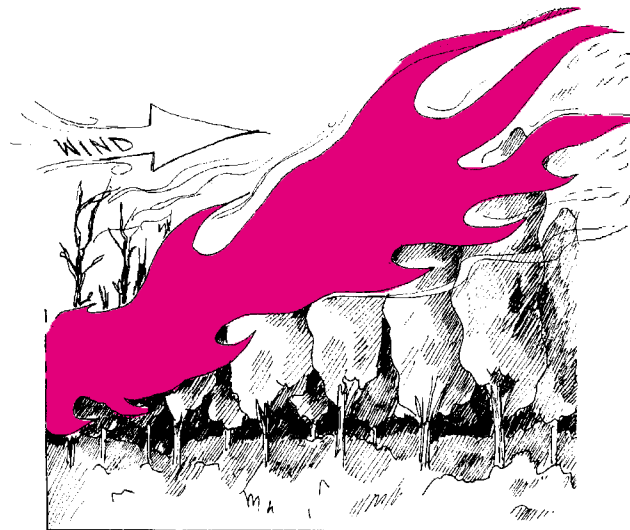
A sub-surface fire burns in the organic material under the surface litter and, by itself, will spread slowly. The depth to which it burns will vary with the depth of the decomposed and partially decomposed vegetation, and with the drought conditions. It may be from several centimetres to one metre deep. The sub-surface fire can present control problems because of the difficulty in locating the fire's edge and extinguishing it.



A surface fire is a fire which burns in the fuel on the surface of the ground. This category would include burning slash, brush, grass and surface litter (twigs, dry leaves, needles, and other undecomposed material), or anything which burns on the surface of the ground.



A crown fire develops from a surface fire where the type, volume, and vertical arrangement of fuels will carry the fire and gases from the surface into the crown fuel layer. Such an arrangement of fuels presents a "stepladder" effect. The crown fire burns independently of fire burning on the surface and advances from tree top to tree top with the leading edge outrunning the surface fire below. The crown fire usually occurs in conifer stands with a continuous crown cover. Fires burning in the crown layer are extremely difficult to control and spread quite rapidly.



However, in tropical forest, there is a very rare chance of a crown fire taking place. Crown fires are an indication of explosive fire conditions. A crown fire may start in the following manner:

- Currents of rising hot air and other gases from a surface fire produce a convection column.
- If this convection column touches the crowns, it will pre-heat them.
- The convection column may also carry burning leaves and branches up to the pre-heated crowns, setting them on fire.
- Once the crown of one tree begins to burn, it may set the crowns of trees next to it on fire. A wind will cause the spread of fire from crown to crown and the crown fire will spread ahead independently of the surface fire below.

5.10 Classification of Fires

Small fires

A "small" fire is one that has not yet built up to serious proportions of intensity and spread. It can be controlled with the forces of hand by initial or direct attack. Generally, small fires have a size from a few acres to ten hectares. Small fires are normally only surface fires.

Medium fires

Medium fires are of serious intensity, depending on the fire fuel and weather conditions. They can burn both as a surface and a crown fire. Suppression tactics can be by direct or indirect attack. A medium fire is about 40 hectares to 100 hectares in size.

Large fires

Five to ten percent of all wildfires in a given area grow to a large size. These are the fires that do the most damage, often reaching catastrophic proportions. Many large fires are a result of adverse conditions of weather and topography. In large fires, the size, distribution, and arrangement of the fuel particles are relatively unimportant, it is the total fuel volume that is important. The fighting tactic for large fires is mostly indirect, because there is no chance to make a direct attack.

5.11 Fire Behaviour Rules of Thumb

Both the rate of spread and the flame height will vary linearly with fuel loading in the same fuel type. For example, when fuel loading doubles, the rate of spread and flames will also double. This rule is strictly accurate only in fuelbeds that are near their optimum packing ratio and in which the degree of compaction is not greatly affected by loading.

For very fine fuels such as grasses and reeds the rate of spread increases more rapidly in relation to loading. For example, the spread rate triples when loading doubles, whereas in very large fuels or densely packed fuelbeds the spread rate is little affected by loading.

Fuel moisture content

At a fuel moisture content below 5 percent, fires in fine and large fuels tend to spread at an equal rate. At a fuel moisture content between 5 and 15 percent, fires in fine fuels spread more rapidly than those in large fuels. At a fuel moisture content above 15 percent, fires in heavy fuels will continue to burn and spread, whereas those in fine fuels will extinguish themselves.

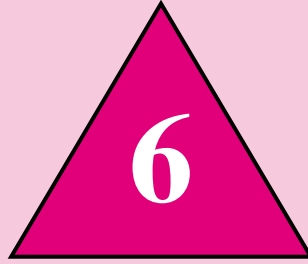
Wind

The rate of spread will double for each 4 metre per second increase in the wind speed. This rule is valid for fires in loosely compacted surface litter. Grass fires increase their rates of spread faster than this, particularly at higher wind speeds, whereas fires in heavy or compacted fuel are less affected.

Slope

- (i) The rate of spread doubles at 10 degrees increase in slope.
- (ii) The rate of spread doubles again at 15 degrees increase in slope up to 30 degrees and for every 10 degrees thereafter.
- (iii) The rate of spread can increase ten fold on slopes above 35 degrees.

Actually, the effect of the slope on the fire spread is a function of the packing ratio of the fuelbed. Consequently, fires in loosely packed fuels such as grass are affected more than those in dense duff.



PRE-SUPPRESSION ACTIVITIES

6. PRE-SUPPRESSION ACTIVITIES

6.1 Introduction

Pre-suppression includes all the actions that are required in fire fighting for the successful suppression of a fire, with the exception of fire prevention.

This includes all kinds of preparation, such as the development of the organisation, maintenance of equipment, planning, cooperation and mutual aid arrangements with other authorities, personnel recruitment, and training.

Fire suppression will only be as effective as the quality and the continuity of the pre-suppression operations. A lot of work is required in the area of pre-suppression. In this work it is well to remember an old proverb;

'good planning is the work half done'.

6.2 Planning

Pre-suppression planning is one of the most important duties of the responsible organisation for forest fire control. Planning should be done at local, regional, and government level. Most of the details must be included in the local or regional fire plan. Pre-suppression plans must cover all the required activities, from single fires outside the fire season to the most difficult situation when several large fires occur at the same time. The fire chief, or responsible authority for forest fire control is responsible for the preparation of the pre-suppression plan.

Regional and local fire plans should include all the recruitment of personnel, the purchase of equipment, and all the activities needed in forest fire suppression.

A forest fire control plan should cover the following:

- (i) The organisation of suppression activities.
- (ii) Cooperation with other authorities, their crews, and equipment.
- (iii) Equipment, tools, machines, and transport.
- (iv) Supplies for personnel and machines.
- (v) Recruiting and payment of personnel.
- (vi) Fire detection.
- (vii) Communication.
- (viii) Identification and maps.
- (ix) Reporting and alarm systems.
- (x) General suppression plan for different types and sizes of fire.
- (xi) Management instructions.
- (xii) Fire danger measuring and rating system.
- (xiii) Closing high hazard areas to the public.
- (xiv) Training programmes.
- (xv) Issuing special radio and television messages or newspaper articles.

The general plan requires different maps and background data, such as:

- (i) a map of protection areas (forests, plantations);

- (ii) a map of hazard areas;
- (iii) a map of forest roads and paths;
- (iv) a map of the organisation for forest fire control, showing the location of headquarters, district boundaries, lookout towers, weather stations, equipment stores, telephones, etc;
- (v) a map showing water supplies, firebreaks, natural barriers, and firelines;
- (vi) annual statistics of fire occurrences by causes; and
- (vii) lists and records of senior management, personnel, units, and equipment.

Most of this background information can be on one map which is called the **REGIONAL FIRE PLANNING MAP**, or in short, the fire map.

This special forest fire map should be in every headquarters and every alarm centre. The fire map, together with all records and lists, must be checked and brought up-to-date before every fire season.

Government may also prepare a long-term fire plan, for a five year period for instance. This long-term plan should include the objectives for developing forest fire control, finance for forest protection, care of equipment, and any other duties.

Background data and records are useful to the fire service authorities in order for them to evaluate resources and the personnel of the organisation.

6.3 Lists and Records

It is important for the fire headquarters and alarm centre to have accurate detailed lists and records of all the usable resources for fire suppression.

Using these lists and records, the fire chief can quickly alert all kinds of assistance, crews, and equipment that are needed in the fire suppression operations.

6.3.1 A list of senior management

One of the most important lists is one giving the names of the senior managers in the organisation. The list should include supervisory staff, and other heads of the fire suppression organisation, for example the:

- (i) fire chief;
- (ii) deputy fire chief;
- (iii) service heads;
- (iv) head of fire suppression;
- (v) head of supplies;
- (vi) head of communications;
- (vii) head of transport;
- (viii) line management (divisions, sections, crews);
- (ix) head of air attack;
- (x) head of first aid and safety; and
- (xi) heads of village fire units.

It is also important that those in control have agreed to their duties and know what they must do if a forest fire occurs.

6.3.2 A list of fire crews

A list of the crews and personnel, as included in the fire suppression plan, must also be included in the fire plan. This record must list all the professional and voluntary fire crews and the personnel and crew heads in every village and in every fire district.

Village fire crews		_____ municipal fire plan	
Crew from _____		fire region _____	
Fire chief	_____	add. _____	tel. _____
1 deputy	_____	_____	_____
2 deputy	_____	_____	_____
Crew boss	_____	_____	_____
1 deputy	_____	_____	_____
2 deputy	_____	_____	_____
Firemen			
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
Alerting :	_____	_____	_____
Transportation:	_____	_____	_____
Equipment:	_____	_____	_____
Person responsible	_____	_____	_____
to collect the crew:	_____	_____	_____
Place to arrive:	_____	_____	_____

In general, many countries have a law that enables the fire chief to recruit civilian personnel for wildfire suppression work.

Both the crews and the civilian personnel should have the physical ability for wildfire suppression work. Payment of the crews for fire suppression work should be decided before the start of the fire season.

6.3.3 Lists of tools, equipment, machines, and transport

All tools, equipment, machines, tractors, and other vehicles which belong to the fire organisation should be listed and recorded at the fire headquarters or the alarm centre.

These lists must include the type, kind, and numbers. They must be compiled by the fire headquarters and by the section in charge of stores.

These lists must also name all the headquarters and stores staff who are responsible for the care and maintenance of the equipment. The drivers and the transport service must also be named.

6.3.4 Cooperation with other authorities

Very few forest fire service organisations can clear up unusual fires, serious fires, or very large fires on their own. It is also normal for the fire service not to have sufficient funds with which to purchase equipment, special machines, and vehicles to cover these circumstances. Therefore, the necessary arrangements with other organisations for help and cooperation in forest fire suppression must be planned and made.

These other organisations may have special machines and equipment which would be very useful in fire suppression, for example, the Air Force will have aeroplanes and helicopters.

The degree of co-operation and the arrangements will depend on the local situation and the resources of the fire service. National agencies can assist in the development of cooperation and agreements in accordance with local laws.

In many countries the forest fire services have reciprocal cooperation agreements with other governments or local authorities, such as the:

- Fire Department;
- Police;
- Army and Air Force;
- civil defence;
- rescue services;
- road construction units; and
- Red Cross.

All the special equipment, machines, and crews of these other authorities and organisations should be listed at the headquarters.

These lists must point out how to alert and who is responsible for sending help and resources to the other organisations.

6.4 Supply Service for Personnel and Equipment

Fire suppression activities will need food and water supplies. The longer the fire suppression takes, the more supplies will be required. If there are not supplies for the fire fighters, the manpower is quickly lost. During the first hours of fire fighting they will require drinking water, and after two or three hours of work they will require some kind of food. Therefore, for long and continuous work it is important to plan the supplies of water and food before the fire occurs. It must be known from where to obtain drinking water and food at any time of the day or night, and how to bring these supplies to the fire site.

There must also be a plan for the fire fighting machines to have a regular supply of their essential needs, such as petrol, diesel, and maintenance.

The person responsible for these supplies is called the head of supplies.

6.5 Forest Fire Detection

6.5.1 General

An essential part of forest fire suppression is the detection of the fire. The capability of discovering and locating the fire starts in the protection section of the forest fire service and is the basis of effective fire suppression.

The occurrence of a wildfire must be observed and reported as soon as possible in order to start the suppression activities while the fire is still small.

A certain part of the detection will be done by people who are living and working in the area, by travellers passing through the area, or by aircraft passing over the area. This type of detection is referred to as 'general detection' and it works if people are active and interested in reporting fires.

Although this general detection is effective in small sections of the protection area, a specific system of detection for the fire danger season must be planned and organised. This is referred to as 'organised detection'.



Most of the forest fires are detected by the public. However, in many countries forest fire detection still falls to the patrolman, ranger, observers in fixed lookout towers, or to aircraft.

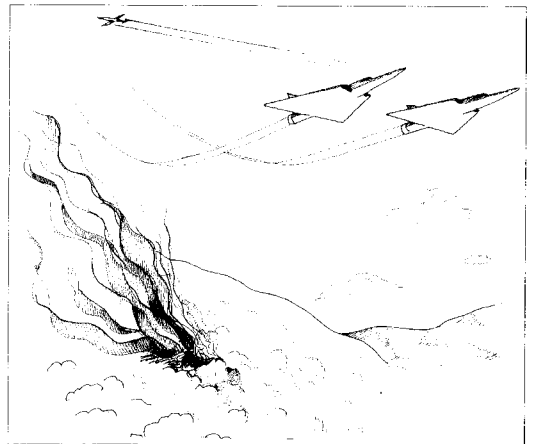
Experience shows that fires near a village forest area, particularly those having a high population, have the largest proportion of fires detected by the public.

6.5.2 Detection planning

The discovery and reporting of uncontrolled fires can be accomplished in a number of ways.

The first step in fire detection planning is to find out where and how effectively the fire is discovered by general detection. Statistically, fifty to eighty percent of wildfires are reported by residents of the populated areas (in Europe).

It may be necessary for government to order the obligatory reporting of all forest fires to be a civic duty.



For fire detection to be effective everyone must know where and how to report a fire. It is also imperative that the reporting person gives an estimate of the size and location of the fire as accurately as possible.

If the general detection in some areas is active and effective the organised detection can be reduced or left out altogether.

It is unnecessary to support organised fire detection in areas where the fires are discovered by general detection, as in:

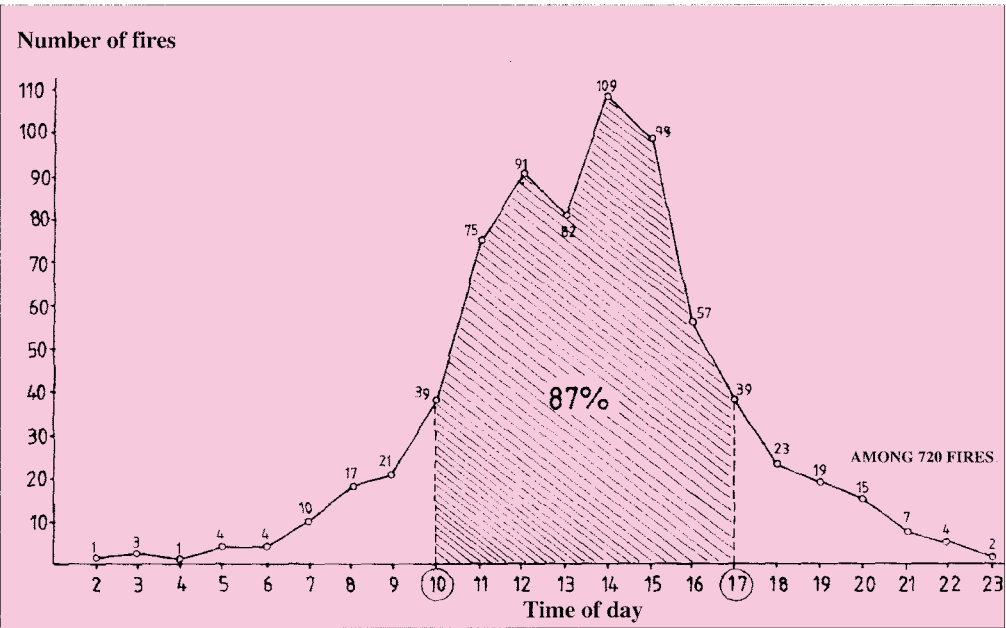
- densely populated areas;
- areas of little fire occurrence;
- areas where the fire risk is very low;
- areas which have no significant value.

It is also unnecessary to support fire detection during those seasons when the possibility of a forest fire occurring is minimal.



As mentioned above, organised detection should be flexible, and it must relate to the actual fire risk. This is the way to keep the costs as low as possible.

The authority responsible for fire detection must have the means to follow the daily fire danger variations, as the effectiveness of the detection will be correlated to the actual fire danger.



Long-term statistics for fire occurrence may help in detection planning

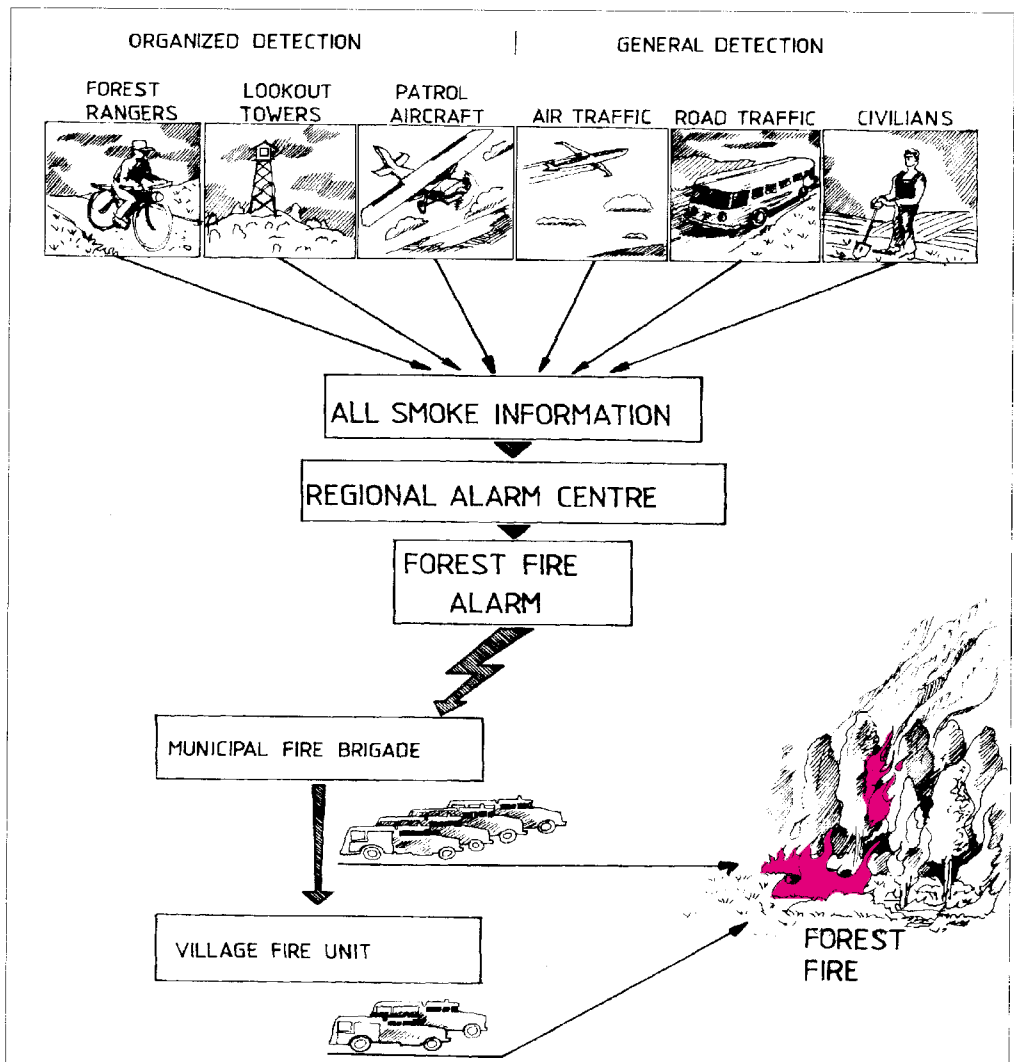
The accurate location of the fire requires good, identical maps in the fire towers, fire alarm centre, patrol aircraft, etc.

All fire and smoke reports should be concentrated in one place, the district fire alarm centre. This centre must be on continuous duty and be provided with good communications, maps, and information about fire crews and other units. The district fire alarm centre is also responsible for dispatching the fire crews.

The main methods of organised fire detection activities are:

- (i) ground patrolling;
- (ii) lookout towers, points, and stations; and
- (iii) air patrols and satellite.

A combination of these methods may be the most appropriate, and the most effective. Air patrolling is very effective, but at the same time an expensive method.



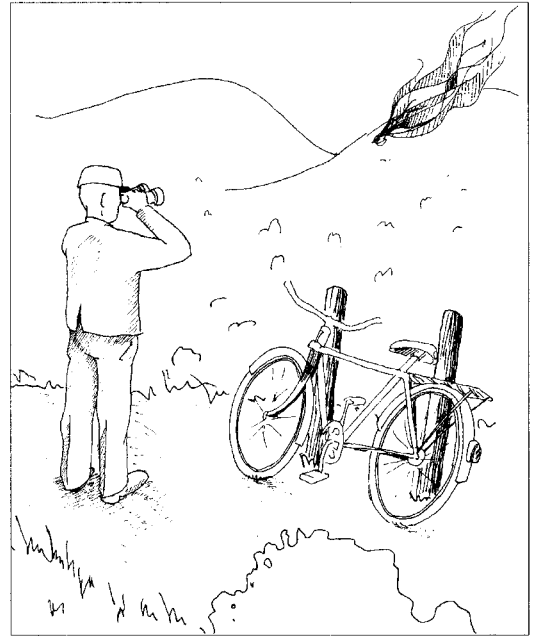
6.5.3 Ground patrolling

Ground patrolling can be carried out by using patrolmen who patrol the area around the forests for which they are responsible. They move along appointed routes, forest roads, forest paths, etc.

Patrolmen, or rangers, can travel in the forest on foot, bicycles, by canoe, or on horseback, and should be equipped to take initial attack against any small fire that may be found.

Patrolmen can also use motor vehicles, motorcycles, or mopeds. Forest fire patrols are often combined with general forest patrolling.

Ground patrols must have some kind of communication or alarm system and good maps to report the location of the fire.



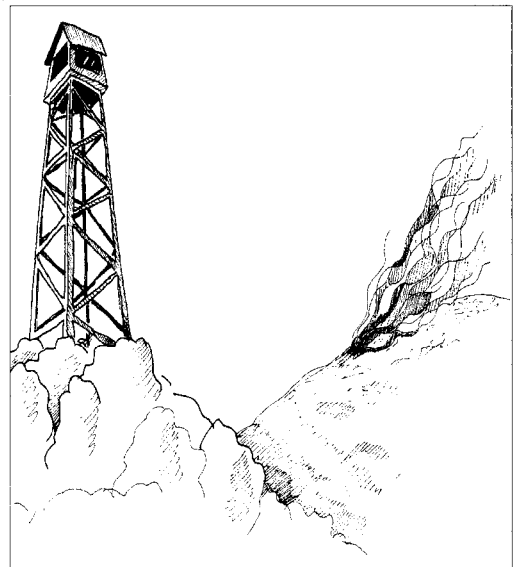
6.5.4 Fixed lookout stations

Fixed lookouts can be fire lookout towers, or lookout points. Lookout towers are appropriate on flat terrain. Lookout points are normally built on the top of high hills. The effective detection range of the lookouts is approximately 30 - 40 km around the tower or point. There are a number of factors that have a strong influence on the visibility, such as time of day, haze or smoke, and the position of the sun.

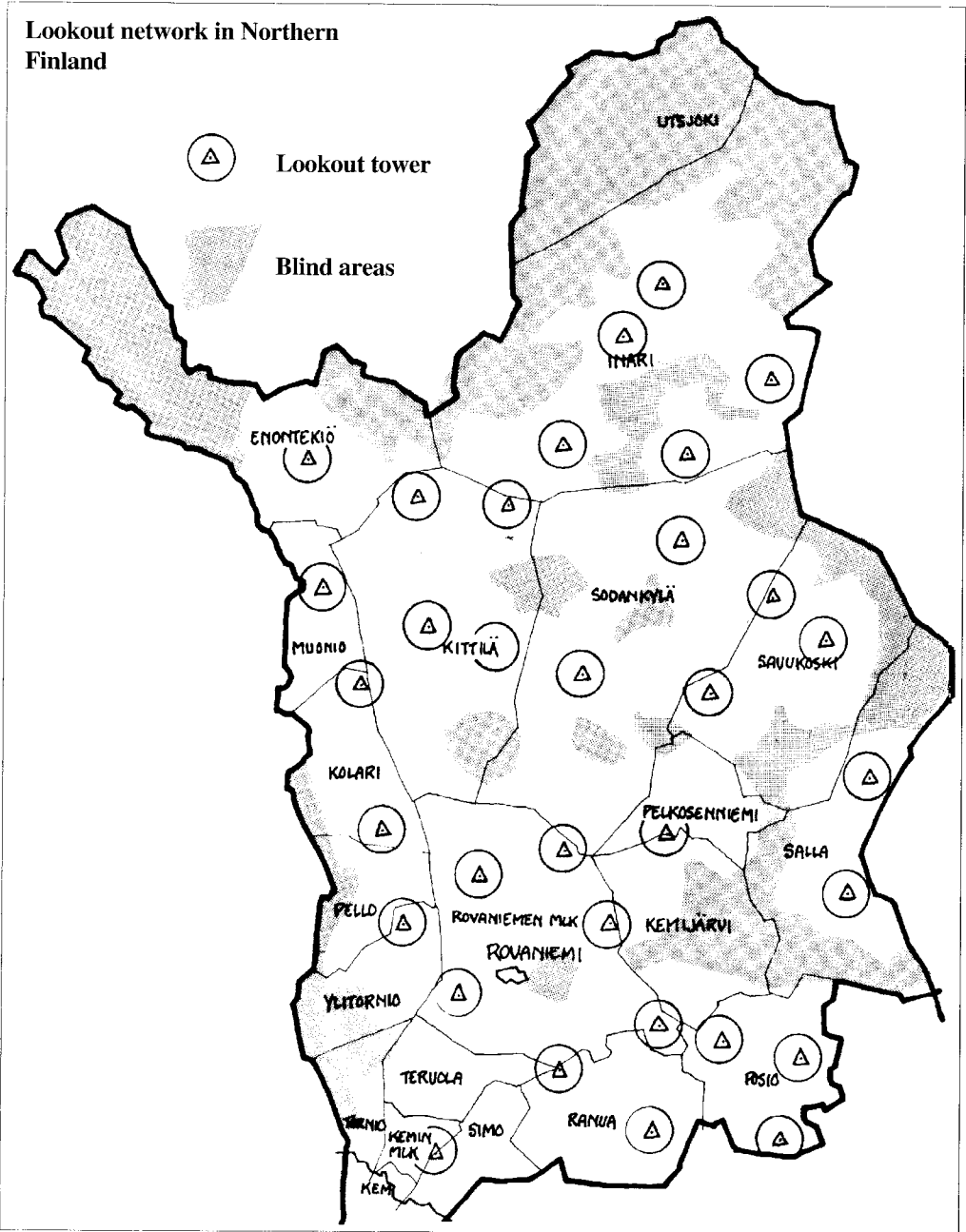
Lookout towers are normally built of wood or steel, and are from 5 - 25m in height, depending on the height of the surrounding forest and any visual obstructions.

If the fire detection is organised through the use of lookout towers, they must be built sufficiently close to each other, as it is essential to locate the same smoke from two towers at the same time. It is also essential for the lookout towers to have some way to send information, and to receive notification of every other observation from the fire alarm centre.

Normally, the fire towers are supplied with some form of communication system, such as telephones or radio-telephones.



It is necessary to keep a day book in every tower, in which the observer has to note down reports of fire and other things that happen during the day. The other essential items of equipment for the towers are binoculars, maps, an angle bearing indicator and compass.



The responsible authority for forest fire suppression should agree on some sort of arrangement for observing with the local people before the start of the fire season.

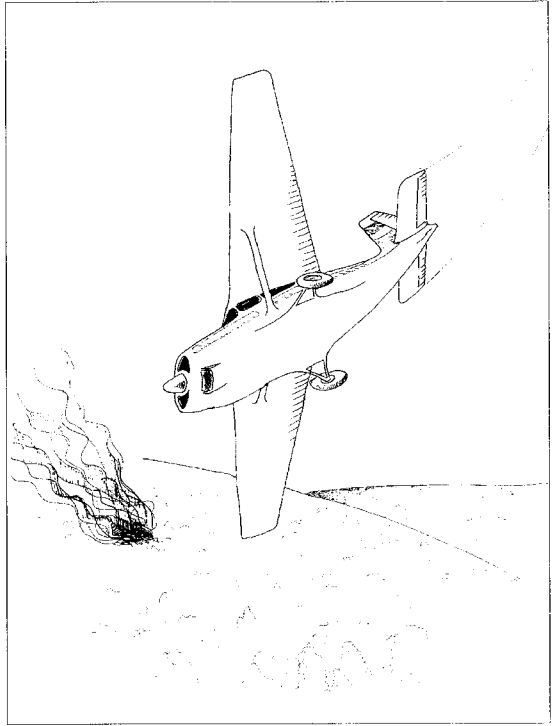
6.5.5 Air patrols

Air patrolling is an appropriate method of fire detection in extensive, sparsely populated areas.

The great advantage of air patrolling is that the forest fire service can give prompt and reliable information, and an accurate location of the fire. Patrol aircraft can also guide the fire attack crews by the fastest and easiest route to the fire.

One other good aspect of air patrol is that it is flexible. The area to be covered and the frequency of flights can be changed daily or they can be cancelled, depending on the actual fire danger and risk.

In addition, an experienced pilot and observer in the detection aircraft can continue with the fire scouting if the smoke turns out to be a fire.



The number of daily patrol flights and the patrol routes will depend on the actual fire risk. For this reason the supervisor of the air detection unit needs to know the rating of the fire risk in the area.

Normally, the distance between the air patrol route lines is approximately 50 - 60 km.

It should be possible to report all fire discoveries directly from the patrol aircraft to the district fire alarm centre.

The fire detection aircraft must be supplied with fire service maps.

6.6 Communication

6.6.1 General

Since the beginning of organised fire protection, the need for reliable communication has been recognised as vital. More than any other support activity, the successful control of forest, brush, and grass fires depends on communication.

Adequate and reliable communication will mean less loss, because with good communication all the different activities can be quick and effective. Effective communication could, for instance, provide a successful conclusion to most fire fighting operations.

The fire service should consider the various requirements for communication in the following principal fire control duties:

- (i) detection activities;
- (ii) reporting activities and alarm systems;
- (iii) fire suppression activities; and
- (iv) cooperation with other organisations, authorities, and their units.

Some available systems and methods of communication are:

- (i) fixed lines, such as telephone and telex;
- (ii) wireless communication networks (radio-telephone);
- (iii) written messages (messenger on foot, on bicycle, etc.); and
- (iv) visual or voice signals.

The most popular and the most effective method of communication in use today is the radio network, or radio-telephones. Written messages and visual signals should not be ignored however. Radio-telephones are very expensive compared to these.

The efficient and appropriate use of any of the available technical communication systems requires experienced specialists and trained personnel.

In addition, good communication during fire suppression operations is important for the safety of the fire crews.

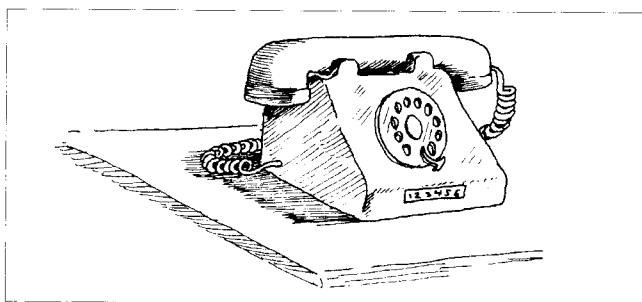
6.6.2 Communication equipment and methods

The different activities of forest fire control require different types of communication systems and equipment.

The following communication systems and methods are in common use.

(i) Telephone

This is very useful for fixed lookouts and towers to report the discovery of a fire, and for general fire reporting.

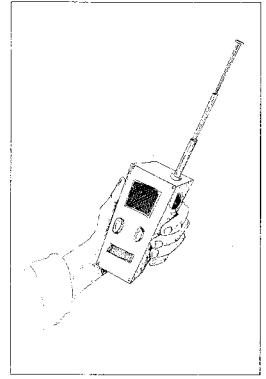


(ii) Radio-telephone (radio networks)

This is very useful for all forest fire control duties. In addition to the fire service communication network, the networks of the police, army, air traffic control, etc. can be used for forest fire suppression operations.

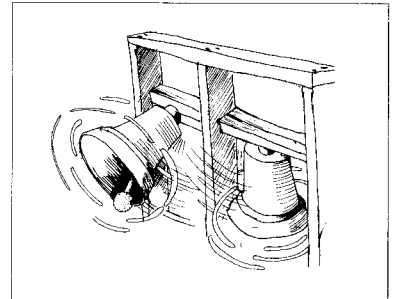
Radio-telephone networks can work on:

- (a) LF-frequencies - these radio-telephones can be used only over very short distances, for instance, between section and crew leaders on the fire line.
- (b) HF-frequencies - these radio-telephones can be used over a long distance, for instance between district headquarters and the alarm centre.
- (c) VHF-frequencies - these radio-telephones can be used over a short distance, but are very useful in many different forest fire control activities, such as patrolling and fire suppression.



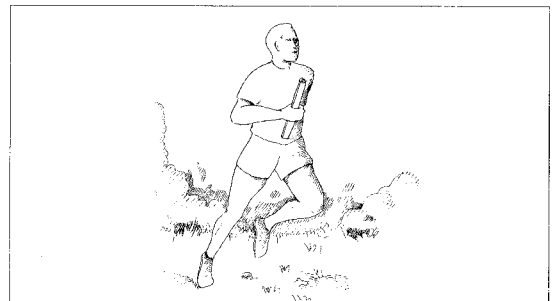
(iii) **Visual or sound signals**

These are used mainly during fire suppression operations, and for reporting fire alarms to the people of the villages. If visual or sound signals are used they must be clear and direct, in order to be fully understood by both parties.



(iv) **Messengers**

Messengers can be used, on the fire line for instance. The bicycle and the moped are suitable vehicles for the messengers, because they can be used on forest paths.



Primary communication needs in a fire attack operation are:

- (i) between the fire chief and the site of the fire, and between the fire chief, division heads, and sector heads in a large fire;
- (ii) between the fire chief and headquarters, or the alarm centre; and
- (iii) between the fire chief and aircraft, and heads of other authorities if they are used.

6.6.3

General directives for organising communication systems

All detection units such as fixed lookouts, towers, watchmen, and patrol aircraft must have some communication system for reporting fires to the district fire alarm centre.

The primary network in fire attack is the network of the forest fire authority, if they have one in use. Communication in fire attack situations must primarily be organised through management.

Communication in fire attack will depend on:

- (i) the size of the fire and conditions at the fire site; topography, distance, etc;
- (ii) the number of fire crews and units (size of fire); and
- (iii) organising management in fire attack operations.

Radio operators for fire action should be selected and trained with care, and the head of communications should have a lot of experience in radio networks.

The maintenance of the communication equipment must not be neglected. For example, during fire attack operations there must be a reserve supply of batteries for the hand-portable radios.

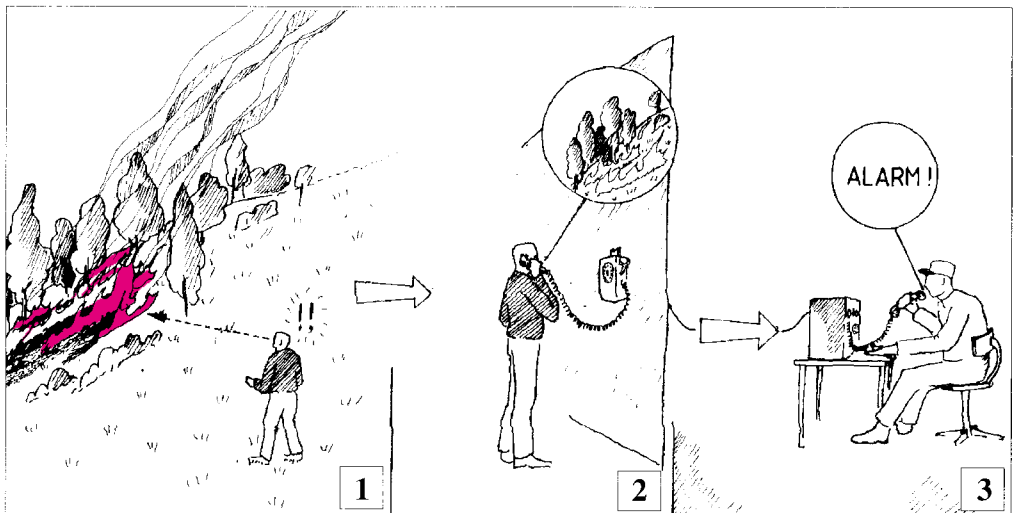
6.7 Fire Reporting and Alarm Systems

6.7.1 Reporting and analysis of smoke and fire

One essential part of forest fire control is the checking of all detected smoke, and finding out which of them are in fact forest fires.

If the fire service has done a successful prevention job the general public will, during the fire danger season report to the fire service any planned agricultural and other outdoor fires before they start to burn.

If the local people are concerned about wildfires and they are interested in fire prevention they will report all detected smoke seen in the forest areas, as this could be a forest fire. This assumes that the public know how to report fires and the telephone number or address of the fire report centres. This is also why the fire service must have a well known fire centre office where all reports of smoke and fire information will be collected.



This local fire centre is responsible for analysing and checking all the smoke reports to see if they are planned fires or real forest fires. One centre can be used to collect all the forest fire reports.

One suitable system could be that all smoke and fire reports are first collected at an appropriate centre in the village. This centre could be, for example, the local forest office, police station, telephone exchange, or any other government office which should be on duty 24 hours a day during the fire danger season.

The most common method for reporting fires is by telephone. That is why a local telephone number for reporting fires should be made widely known to the general public.

The local village fire centre should also be responsible for dispatching the local fire unit to the initial attack site.

All the smoke and forest fire reports received at village level must be sent to the regional forest headquarters, or to the regional fire alarm centre.

Reports from the lookout towers, patrolmen, and other detection organisations must be collected at the local fire centre, or the regional headquarters or alarm centre.

If there are too many places, or too many people handling and analysing the reported information, this might cause confusion and false alarms.

6.7.2 Regional fire alarm centre system

Experience has shown that it is advisable to concentrate all information and reports of smoke, fires, and the dispatching and alerting of crews to some regional fire alarm centre. This centre could be a regional forest headquarters. The regional fire alarm centre may cover many villages and municipalities.

One appropriate system for report analysis and alarm duties could be a combination of the village fire centre and the regional fire headquarters.

The principal duties of the alarm centre may be alternated, depending on the fire service organisation. The fire alarm centre can for instance:

- (i) receive and record all smoke reports from the general public and detection organisations;
- (ii) analyse and check all smoke reports as soon as possible, to confirm whether or not they are permitted forest fires;
- (iii) give permission for outdoor fires, such as agricultural fires and prescribed burnings;
- (iv) receive and record all reports of forest fires;
- (v) coordinate and lead forest fire detection activities, ground and air patrols, lookout towers, and their times of duty;
- (vi) alert the fire crews and dispatch any help and equipment required by the fire chief;
- (vii) coordinate and guide all fire suppression activities;
- (viii) alert other authorities and their crews to assist the fire service in suppression operations;
- (ix) lead all the communication activities in the forest fire service; and
- (x) keep up-to-date the lists and records of fire crews and all the equipment in use.

The alarm centre could also serve as a supply store for fire tools and equipment.

The effective and successful working of the fire alarm centre assumes among other things:

- good communication networks, radio-telephones, telephone connections, and other communication equipment as required;
- sufficient supplies of appropriate and accurate maps, which should cover the entire district;
- exact and up-to-date information and records of fire crews, equipment, available aircraft, etc;
- alarm systems to alert fire crews, and other units for fire suppression; and
- trained personnel who are on duty 24 hours a day during the fire danger season.

6.7.3

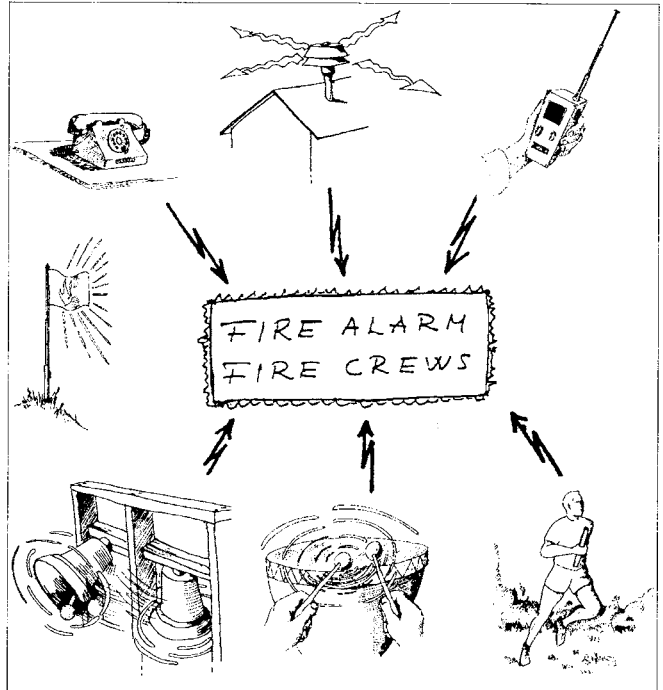
Methods to alert fire crews and other units

New technology offers many alternative means for alarm systems.

The simple, tried and tested methods for fire alerting are still in use today.

Some of these methods are:

- telephone;
- radio-telephone;
- fire sirens;
- church, or other loud bells;
- drums;
- messengers (by foot, by moped, etc.); and
- flags.



6.8 Location and Maps

6.8.1 Location

The dispatcher or person on duty in the fire alarm centre is responsible for requesting from persons reporting a fire as much accurate information as possible, such as the location, access routes, etc.

Before any fire crew can be dispatched to the fire it is necessary to locate the fire on the map and in the field. Suitable maps are needed for this purpose.

Location can be reported by using symbols and marks on the map in use. It is easier and more accurate to report a fire if we have a method for location. There are three general and appropriate position definition systems used in the forest fire service, as described in the following pages.

Definition by map names and distance

With an accurate map, the fire location can be specified by using information obtained from the map, for instance:

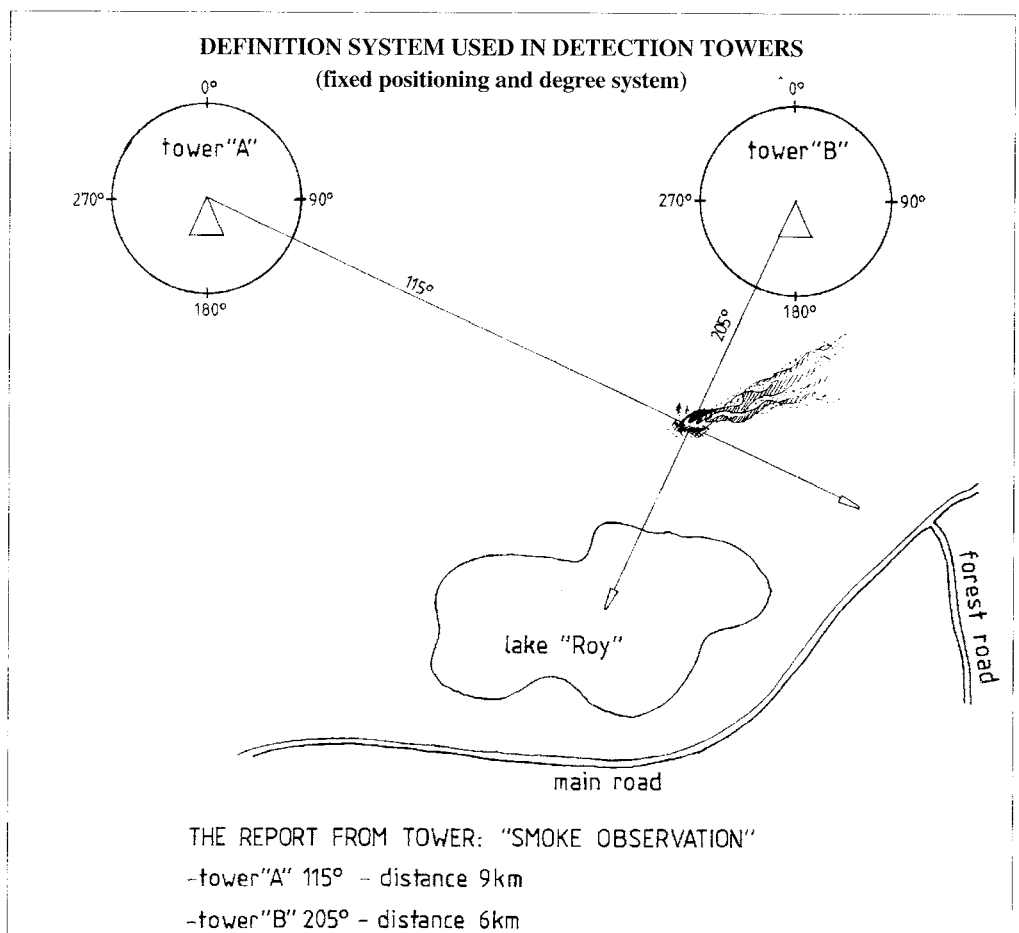
- '2,5 km north of a lake called Long Lake'.
- '5,5 km west along road number 57 from the village of St. Caulle, and then to the right for approximately 500 metres'.

DEFINITION BY MAP'S NAME

- 1/2 km north of lake "Roy"
- 3-4 km north-west of road block main road/forest road

In this system no equipment is needed, but it must be sure that the other operator has the same map, can read the map, and can understand the directions given.

Fixed position and degree system

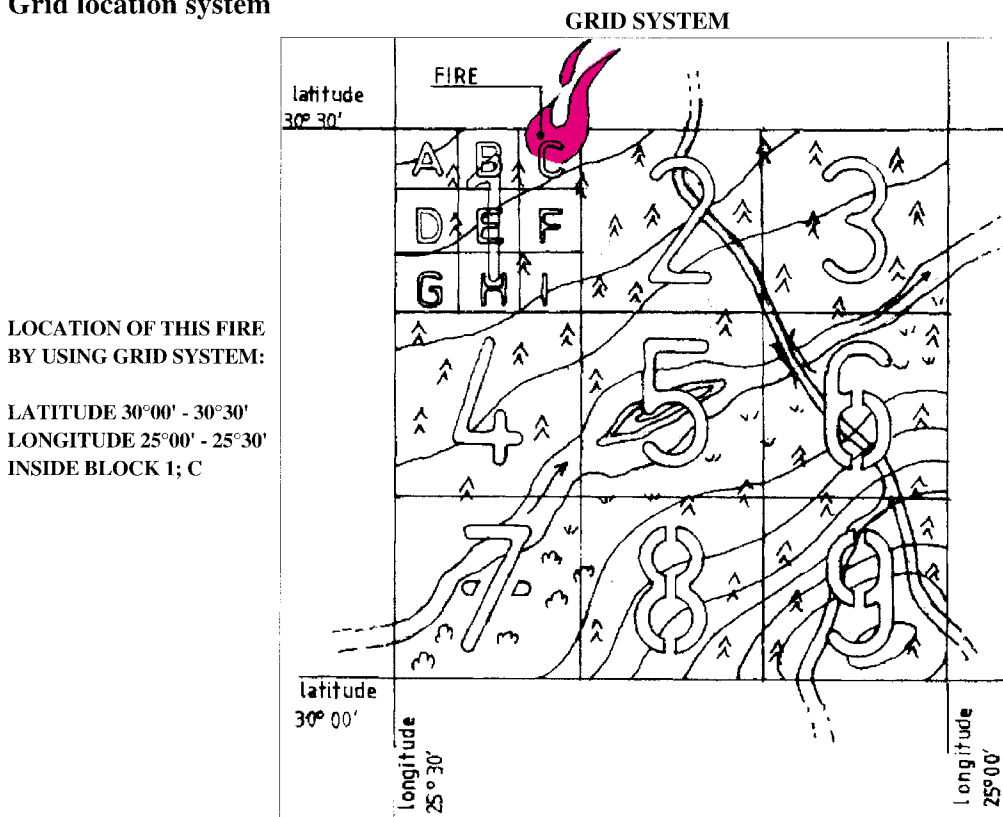


This is a very useful position definition system for fire towers and fixed lookout points. In this method the direction of any smoke that can be seen from a fixed point is read, in degrees (0 - 360), from a fire tower for example.

If smoke and fire can be seen simultaneously from two towers two bearings can be given and the fire can be found on the intersection of those bearings. The use of this system requires a compass and a special 'bearing indicator'. The regional fire alarm centre must have the 'bearing plastic' for location.

Remember that 'north' is not accurately given on a compass. It varies depending on the geographical situation (variation).

Grid location system



Many countries have developed a position definition system of their own for forest fire control. In addition to forest fire location, this system is in general use by other rescue services. In this system, the location of the fire is reported as the numerical co-ordinate.

Location systems could be developed as follows:

- (i) A special local grid system, developed for a particular country.

Usually, the local grid system requires a 'plastic roamer grid'. By using this instrument the co-ordinates of the fire site can be read. It should be remembered that senior staff must be trained to use the position definition system before prompt and accurate fire locations can be expected.

- (ii) A grid system related to longitudes and latitudes which is known as the international method. This system does not require any plastic roamer grid.

6.8.2 Maps

Basically, only two types of maps are needed for forest fire control: regional maps and local maps.

Regional maps

The primary use of these regional maps is for:

- fire location;
- guiding the units to the fire site;
- cooperation with the units; and
- pre-suppression information, which must be added to the map in conjunction with the fire service.

The appropriate scale of these maps is between 1: 100 000 and 1: 500 000. These large scale maps must be in use in every fire alarm centre or headquarters, and in every fire unit. Regional maps must contain information about main roads, forest roads, natural water supplies, contours of the forest areas, and district and provincial boundaries.

These maps should also contain a position definition system.

Local maps

For large fires, a local map surrounding the actual fire site is required. The primary use of this map is for the management of fire suppression by the fire chief, section heads, etc. A good scale for these maps is between 1:10 000 and 1:50 000. Local maps must contain exact information of the local wilderness, villages, roads, forest roads, paths, natural water supplies, contours, electric power lines, fields, types of forest or vegetation, etc. A local map is a very important 'tool' for the fire chief, especially in large fires.

All senior personnel in the fire suppression organisation and the fire service should be trained in the use of maps.

6.9 Fire Weather Services

6.9.1 General

In most countries the weather forecast for the general public is not accurate enough for the forest fire service. For this reason many countries have developed their own specialised meteorological service to assist the forest fire service.

The responsible authority for forest fire suppression must have their own system of measuring and rating the daily fire danger.

For forest fire control a daily fire danger rating is needed for:

- pre-suppression planning;
- detection action;
- planning of suppression tactics; and
- alerting the general public of fire danger situations.

For the fire danger rating a weather index scale is needed and daily weather observations around the protected areas must be taken.

This information requires basic meteorological observations from around the country. This service can be organised by meteorological stations at airports, harbours, forest stations, etc.

6.9.2 Fire weather index

The fire weather index (FWI) is an important indicator of the burning conditions, because each day it indicates the expected fire behaviour situation in the forest fuels.

The fire weather index is calculated on the basis of relative humidity, wind speed, rainfall, and temperature.

A very high fire weather index indicates that the forest fuels are dry, and very inflammable. A low fire weather index indicates that the forest fuels are not very inflammable, and that there is no danger of a serious forest fire.

The fire weather index can be divided, for instance, into four index classes. Examples of these index classes are:

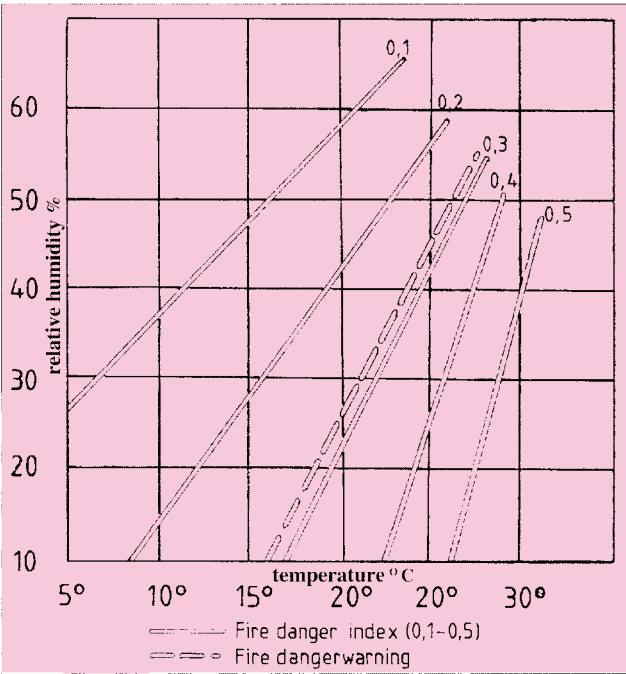
Numerical scale (Used in Canadian FWI)	Index class	Fire behaviour
0 - 3	Low	Creeping fire only
4 - 10	Moderate	Surface fire only
11 - 22	High	Running fire occasional crown fire
23 +	Extreme	Crown fires likely

6.9.3 Measuring fire danger

The realistic measurement of fire danger is difficult because there are many contributing factors to consider. Some of them are fire weather factors. Other factors that must be considered are fuel type, hazard, fire risk, and the probability of lightning.

Fire danger is also a related measure of the expected fire behaviour, and of the daily fire control requirements.

All personnel responsible for the suppression of forest fires and grass fires must be aware of the daily fire danger and fire weather index.




6.9.4

A practical example of assessing fuel dryness and flammability for controlled burning

The moisture of fuel affects its flammability and so has a major effect on fire behaviour. The single leaf test described below gives a direct indication of how a burn will behave.

Single leaf test

Sheltered from any wind, light the end of a dead leaf and, once lit, take the ignition source away. The aim is to discover the angle at which a small flame either goes out or flares up.

 <p>wet</p>	<p>LEAF BURNS ONLY IF STRAIGHT DOWN (OR NOT AT ALL)</p> <p>All fuels too wet if this leaf in area to be burnt. O.K. if only wet types not to be burnt.</p>
 <p>moist</p>	<p>LEAF BURNS IF ANGLED DOWNWARDS BUT NOT IF LEVEL</p> <p>Fine fuels in this leaf's position will only burn if on slope or in wind.</p>
 <p>borderline</p>	<p>LEAF BURNS IF LEVEL BUT NOT ANGLED UPWARDS</p> <p>Fine fuels in this leaf's position will burn but very slowly unless helped by wind, slope, and fuel continuity. If on top of litter layer, wait another day.</p>
 <p>dry</p>	<p>LEAF CAN BE ANGLED UPWARDS AND STILL BURN</p> <p>Fine fuels in the same positions as this leaf are dry enough to burn. O.K. if this leaf is from top of litter. RISKY if from BOTTOM.</p>
 <p>too dry</p>	<p>LEAF BURNS IF HELD STRAIGHT UP</p> <p>All fine fuels very dry and flammable. Fire will run up stringy bark trees. Spotting likely, especially if windy.</p> <p>DON'T BURN!</p>

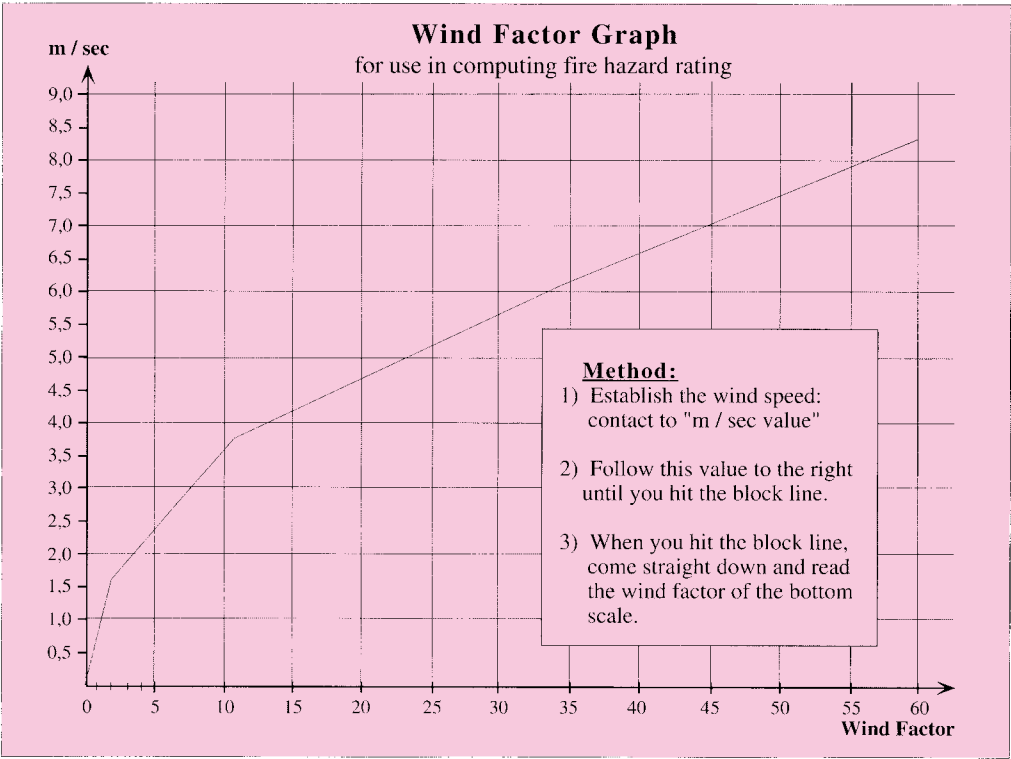
6.9.5 To compute a fire hazard index

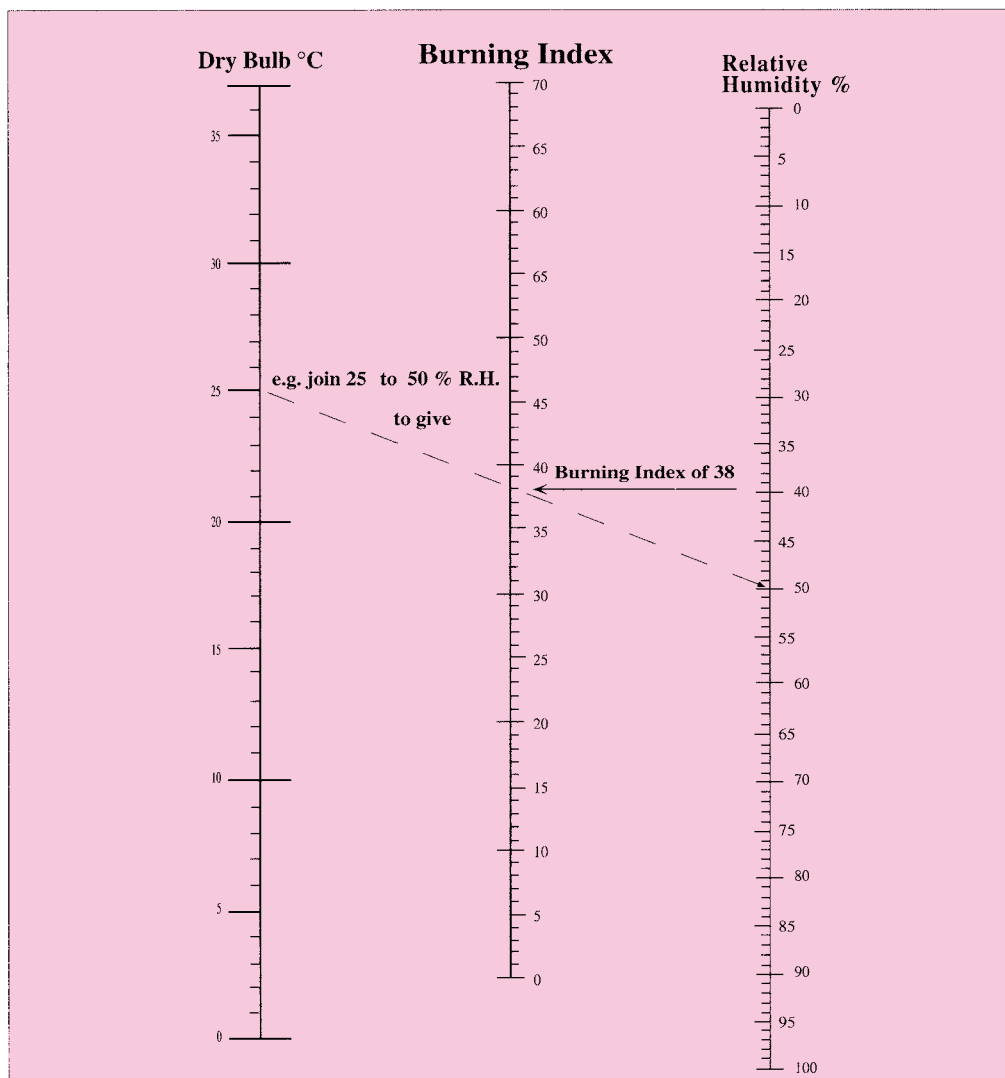
- (i) Establish the relative humidity
- (ii) Establish the dry bulb temperature (°C)
- (iii) Using a straight edge, join dry bulb temperature to relative humidity on the alignment chart (next page); this gives the basic burning index.
- (iv) Multiply by the appropriate “rainfall correction factor”
- (v) Add the “wind factor” to the product of the rainfall correction factor

To calculate the rainfall correction factor, multiply the basic burning index by the appropriate value from the following chart:

Rainfall mm	Number of days since last rain							
	1	2	3	4	5	6	7	10
12.0 - 15.0 mm	0,2	0,3	0,4	0,5	0,6	0,7	0,8	
15.1 - 20.0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	
20.1 - 25.0		0,1	0,2	0,3	0,4	0,5	0,6	
25.1 - 38.0			0,1	0,2	0,3	0,4	0,5	
38.1 - 50.0				0,1	0,2	0,3	0,4	
50.1 - 65.0					0,1	0,2	0,3	
65.1 - 75.0						0,1	0,2	

Rainfall correction factor is of doubtful worth if variables of potential fuel are considered. However, an arbitrary and subjective value could help in the computing of an otherwise difficult rating exercise. Because of changing climate patterns (hotter and drier) the influence of unexhausted moisture values is lessened when compared with a decade ago. Precipitation of less than 12mm is discounted, as are falls of more than 10 days ago.





Burning Index Alignment Chart

Example from Zimbabwe - Fire Hazard Index (0-39 = green, 39-59 = orange, over 59 = red, do not burn)

Data:

Dry bulb temperature:	25°C
Relative humidity:	50%
Rainfall:	15 mm 3 days ago
Windspeed:	5m / sec

Method:

Basic burning index of	38
Rainfall correction	$0.4 \times 38 = 15.2$
Add wind factor of	25.0
Fire hazard index	= 40.2

6.9.6 Fire danger conditions in different scales

The following conditions will generally apply under the different index classes.

Low fire danger (FWI 0 to 3)

Fires spread slowly from slash piles, campfires, and other sources of heat, and are easily controlled. Lightning fires may start. On windy days the detection system covering high hazard and special risk areas should be in operation. The regular suppression crew should be on call.

Moderate fire danger (FWI 4 to 10)

Fires start readily from an open flame, burn briskly, and tend to spread rapidly as they increase in size. The detection system should be in operation, and the regular suppression crews ready for immediate action. A secondary force should be on call.

High fire danger (FWI 11 to 22)

Fires start readily from flame, glowing cinders, cigarette butts, and so on, spread rapidly and tend to grow in suitable fuels. Regular suppression crews should be completely mobilised and on stand-by for immediate action. Reserve forces should be on call.

Extreme fire danger (FWI 23 and over)

Explosive conditions. Fires start immediately from sparks and burn fiercely. Crown and spot fires are often uncontrollable during the afternoon heat. Relief supplies should be arranged. Relief crews should be available on call and emergency action should be taken as required.

6.9.7 Definition of terms

Duff - The layer of decomposed and partly decomposed dead vegetation forming a mat covering the ground. In this layer the unit structures have not decayed to the stage where their original form cannot be recognised.

Top-layer duff - The upper horizon of duff consisting of loosely compacted, undecayed leaves or needles. This is the layer which dries out first and in which fires start or spread.

Litter - The loose debris of dead sticks, branches, and twigs lying on top of the duff.

Humus - The layer of decomposed organic material found between the mineral soil and the duff. Owing to the decomposition, unit structures cannot be readily recognised in this layer.

Fuel - Any material which supplies a medium to support combustion.

Hazard - The relative amount, character, arrangement, and moisture condition of the fuels.

Risk - The relative chance, or probability, of fire starting, determined by the presence or absence of causative agencies. Risk refers only to the agencies which cause fires.

Inflammability - The susceptibility of the fuels to ignition.

Danger - The sum of risk, inflammability, and hazard, together with damage probability and the degree of difficulty with which a fire can be put out.

6.10 Training

Specific training programmes must be provided for the fire service organisation. The section on training in this chapter outlines the background, problem areas, and practice in training.

6.10.1 Background and problem areas

The problems of forest fire prevention in the tropical, sub-tropical and temperate regions of the developing world are in many respects very different from the problems in the so called western world. One very big difference lies in the occurrences of fires. Natural fire incidents frequently occur in North America and Europe where lightning and other natural incidents very often causes wild fires.

In the Tropical Regions, most fires (90 % or more) are caused by man. Thereby the bias towards fire prevention (work to prevent fires from happening) rather than towards fire suppression (actual fire fighting) is quite understandable in the countries in the tropics.

The forest fire control work in industrialised countries therefore differs quite a lot from the work to be prioritised when planning to prevent natural fire disasters in developing countries. The differences are:

- (i) the basic educational level of the people;
- (ii) the literacy rate;
- (iii) the agricultural traditions, i.e. the practice of using fire for clearing agricultural land; and
- (iv) the attitude of people towards the environment, which is unfortunately tied up with the living standards of the local population.

It is said that only rich people can afford to protect the environment. Therefore, it is also known that Canada, the USA, Germany, the Scandinavian countries and Japan at present have the strongest environmental movements.

If natural disasters are excluded, such as the Mt. Pinatubo eruption in the Philippines, then forest fires come close to being the worst kind of all known disasters, in that their ecological destruction usually has a very long lasting effect, in some known cases from 40-80 years.

Strong winds, such as typhoons, may have a heavy toll on human life and massive material damage, but the ecological damage is generally short, 1-5 years. The ecological effects of floods are similar to those of strong winds, except that floods are always related to the destruction of forest cover, and thus to forest fires, which destroy the forest vegetation and the soil texture of the forest floor, i.e. the water retaining capacity of the top soil.

When the microfauna of the soil is destroyed by repeated forest fires, the water absorbing cavities (created by the micro-organisms) in the soil also become compacted, and when tropical rain occurs the water seepage into the soil is minimal, leading to high speed run-off

of water. Since the curve of the soil eroding effect of running water is almost logarithmic, the importance of not allowing large scale burning of the forest floor in flood-prone areas is obvious, such as in Nepal (which is the primary reason for the flooding in Bangladesh).

The involvement of FTP/Finland in international training in Forest Fire Control was started in 1981. In the initial stage FTP tried to implement the philosophy of providing information in the form of lectures, training material, and case studies.

This approach was found weak because the key points of information were already found to be available in most developing countries.

A second approach was to focus on European or North American sophisticated technology (satellite and computers) in combination with a heavy bias towards actual fire fighting (suppression).

This approach also failed, because it soon was found out that:

- (i) The main problem in fire control in developing countries is human attitudes towards forests and fires.
- (ii) Another problem is how to reach and educate the tens of millions of shifting cultivators in upland forests living “outside the society”.
- (iii) There was a strong need to develop fire suppression with the minimum use of water, and to find ways of how best to start up the manufacturing of local quality fire control tools.

The main areas of insufficient knowledge found out in the process of developing training methodologies in forest fire control were the:

- (i) lack of knowledge on efficient application handtools in forest fire control;
- (ii) lack of knowledge in how to plan and implement forest fire control; and
- (iii) lack of knowledge in how to mobilise fire fighters.

The early training experience of FTP thus led to the revision in thinking, regarding the most efficient methods and techniques in forest fire control. The present training procedures are now concentrating on developing the skills and the planning capabilities of the participants.

6.10.2 Overall training strategy

All training has to be based on the collection of reliable or realistic estimates of fire damage in each country.

Even here, FTP has met a lot of resistance, because fire statistics form a part of national policies and politics. A regional natural resources officer could lose his job if the fire statistics he produced showed too many burnt areas. Thereby, many authorities concerned (district/ regional) have been forced to annually “clean” and trim their fire statistics to look more favourable.

The Thai authorities (Forest Fire Control & Rescue of the Royal Forest Department) selected an opposite approach to the one mentioned above, namely to put a concrete price tag on the trees lost through fire every year.

When a true figure for the annual burning is achieved, the politicians will have to react, as was the case in Thailand. This may be the only way for the local authorities responsible for forest fire control to obtain funds for training.

His Majesty the King of Thailand, who himself is a nature preservationist, has now given a directive to the Cabinet to urgently start the training of 4000 villages of shifting cultivators.

Tanzania may in many respects be one of the few African countries where good results have already been achieved in long term education and training of people in the negative effects of forest/biomass burning. In 1992 14,000 fire volunteers (villagers) turned up on a radio call to fight a forest fire on Mt. Meru in the Arusha Region in Tanzania, this is the only region that has been able to reduce 1 million hectares of unnecessary savannah burning per year.

On a global scale it is therefore quite clear that the fire risks have to be minimised as much as possible. FTP/Finland considers that the best way to tackle this problem is by providing specialised training in the:

- building of an institution responsible for forest fire control for each country;
- creating reliable national fire statistics for each country;
- providing pedagogical and technical training in forest fire control and in networking high risk countries (such as in Indonesia, Brazil, the Philippines, India, and Nepal);
- creating regional training centres for the training of forest fire extension workers (forest fire instructors);
- the start-up of the manufacturing of ergonomically sound high quality forest fire control tools in each country. At the present time only the Philippines qualifies, these high quality tools having been developed under an ILO/Finland project in the Philippines between 1976-1982;
- training in the skills of using manual (labour intensive) tools and their maintenance; and
- the forming of voluntary village fire brigades.

In the following section a typical lay-out of a course on forest fire control is presented.

6.10.3 Example of a course on forest fire control (3 weeks)

Objective

The objective of the course is to train the participants in theoretical and practical aspects of forest fire prevention and fire fighting and to demonstrate the use of manual and light motorised forest fire fighting equipment so that they can better plan, organise, and implement forest fire prevention, control, and safety measures.

After completing the course the participants should:

- be familiar with the measures taken to prevent forest fires;
- be familiar with organisational, technical, and tactical aspects of forest fire fighting;
- be familiar with methods to control different types of forest fires using manual or light fire fighting equipment;
- be able to draw up fire fighting plans and advise the responsible regional authorities on fire fighting measures.

Course background

Forest fires have become an increasingly serious problem in developing countries. This is especially disastrous in the present situation, with the area of natural forests having rapidly decreased and forest fires often destroying tree plantations. The situation is even more alarming since these plantations have been established to compensate for the disappearance of natural forests.

There are a variety of reasons for the extent of forest fires today, and aside from those caused by slash and burn cultures one main problem is the lack of expertise and equipment in actual forest fire fighting. The main emphasis in the course programme will be on finding proper solutions for both problem areas; social and technical.

The course will last three weeks and will consist of lectures and discussions, group work, case studies, and study visits. The participants will be required to prepare beforehand a report on fire fighting organisation and methods in their respective home areas. The following main topics will be discussed during the course:

- general organisation of forest fire fighting authorities and their respective responsibilities, etc;
- forest fire prevention, control, and communication systems;
- identification of forest fires;
- the behaviour of forest fires in various types of forests, different climatic conditions, etc;
- forest fire equipment and its use;
- forest fire fighting tactics and techniques for different types of forest fires;
- management of forest fires; and
- safety hazards planning for fire protection.

Theoretical part

Forest fire prevention; methods and possibilities.

Preparation of a fire plan.

Fire suppression organisation.

Fire service organisation.

Mobilisation and management of personnel.

Leadership during the fire.

Control and maintenance after the fire.

Reporting the fire.

Equipment care.

Practical part

Leadership in forest fire fighting.

Use of various methods and tactics in fire fighting.

Use of various types of equipment and handtools.

Maintenance and control of fire fighting equipment and handtools.

6.10.4 Training of personnel

Training of the firemen must be carried out before the start of the fire season. Training includes

both the practice required to perform operations efficiently, and the learning of all the necessary background information. The objective of the training is to develop each fireman in fire prevention methods to be able to control fire with minimum loss of life and property. Training is also necessary in safety measures for the use of hand tools and equipment. The training of firemen must be continuous, and be repeated at least once a year, before the fire danger season.

6.11 Public Awareness of Large Fires

In many countries, fifty to eighty percent of wildfires are reported by the general public. It is important for the fire service to have close cooperation with the general public, because both may need help in the case of a large fire.

During high and extreme fire hazard situations, when there should be no permission given for outdoor fires and some forest areas may be closed, the fire service must be able to inform the public by radio, television, or other means.

In the case of large, serious fires the fire service should have plans to warn and evacuate any person from the area where the fire is spreading.

6.12 Field Preparation Prior to the Fire Season

It is necessary for the field manager, together with the local fire chief, to check the responsible organisations and prepare all the necessary duties for fire protection. There are a number of checks and preparations to be done before the start of the fire season. Some of the most important preparation duties are given in the following sections.

6.12.1 Forest roads

Most of the protected forest areas should be accessible by forest roads. It is important therefore to consider the aspects and requirements of fire protection when planning these forest roads.

Before the start of the fire danger season, all forest roads should be made ready to take fire trucks and other vehicles.

6.12.2 Lookout towers

Lookout towers must also be checked before the start of the fire danger season, to see if they are safe or in need of repair. Lookout points should have in place all the equipment needed for fire detection and reporting. Communication systems must be checked and confirmed to be in working order.

6.12.3 Warning signs and boards

In order to prevent fires, all notice boards should be along the main roads and in the protected forest areas. In some countries the warning boards are collected and put into store after the fire danger season is over.

The field manager, together with the local fire chief, should carefully consider the sites for the warning signs.

6.12.4 Firebreaks and fire lines

One of the most important operations is to check and prepare adequate firebreaks and firelines in the protected areas. If they are old they must be cleared of all fuel. They must also be wide enough to prevent a fire from spreading.

6.12.5 Hazard reduction (Fuel management)

All high hazard areas which may become risk areas within the forest or plantation should be eliminated before the start of the fire danger season.

Typical hazard and risk areas are, for example, dry grass along the roadside and large dry grass areas inside, or nearby, the plantations.

These areas can be reduced by cutting and collecting the grass before the start of the fire danger season, or by controlled burning.

With adequate equipment and trained fire crews, controlled burning is easy to carry out, and at little cost. At the same time, controlled burning is good practice for the fire suppression crews.



FOREST FIRE EQUIPMENT

7. FOREST FIRE EQUIPMENT

7.1 Forest Fire Hand Tools

Successful forest fire suppression depends on a well balanced combination of people, equipment, tools, and training. For any forest fire control organisation to be effective it is important that they are provided with appropriate fire control tools and equipment. These are necessary in the prevention and suppression of any forest fires.

There are five basic work functions in forest fire control where hand tools are used. These are:

- (i) line location;
- (ii) clearing and construction of trails;
- (iii) grubbing, trimming, trenching;
- (iv) burning off; and
- (v) suppression / mop-up.

In fire suppression the purpose of using the tool is to reduce combustion, in any one of several ways or combinations of ways.

Firstly, the person / tool combination may reduce combustion by removing potential fuel from the path of the fire. For example, the use of a fire rake to remove forest litter of dry leaves.

Secondly, a tool can be used to cool the burning fuels directly in front of the fire to a temperature that will no longer support combustion. An example of this is the application of water or sand to the burning fuel.

Thirdly, a tool can be used to smother a fire to prevent it from obtaining the amount of oxygen it needs to sustain combustion. Fire swatters of various kinds are used in this way.

In the course of fighting a fire a good fire fighter uses a fire shovel, for instance, in three ways: to remove the fuel, to cool-off the burning flaming fuel, and to smother a fire to prevent it from getting the oxygen it needs to sustain combustion.

7.1.1 Basic considerations in choosing fire accessories and tools

Since the firefighting job varies, there is considerable variation in the relative importance of each criterion in a particular environment.

- (i) **Effectiveness** - This is the capability of the accessories and tools to accomplish a desired task to an acceptable standard. The emphasis is on the quality of the result.
- (ii) **Efficiency or Productivity** - Whether hand or motor-driven, an item of equipment should permit or produce a maximum amount of effective work of a given kind for a minimum energy requirement. For hand tools this is strongly influenced by the experience and training of the individual worker.
- (iii) **Versatility** - The wider the range of use of a specific piece of equipment or tool the better, although efficiency also has to be considered.
- (iv) **Portability** - Some fire equipment must be transported over long distances under difficult conditions, sometimes by aircraft. Under these conditions, heavy or bulky

- equipment will increase transport difficulty and increase the frustration level of those responsible for forest fire control. Especially for fires in high altitudes (and in ecologically sensitive areas such as Mt. Kilimanjaro in Tanzania) light, portable tools are required.
- (v) **Durability** - Fire tools must be strong and not prone to breaking when most needed. The breakage of a personal tool may even result in the death of the fire fighter, such as in the event of a sudden change in wind direction.
 - (vi) **Maintenance and replaceability** - Minimum maintenance requirements are essential. Also essential is that key parts and assemblies can be readily detached and replaced (e.g. blades, flaps, and handles).
 - (vii) **Standardization** - It is desirable to use the same items as widely as possible, both within and between protection organisations. Standardized tools can be readily pooled, traded, and effectively used, with less time consumed on servicing and maintenance.

The conditions under which wildfires are often fought will place a heavy strain on both the equipment and the firefighter. Failure of accessories and tools at crucial times during suppression operations can have disastrous effects on the success of the effort and the safety of firefighters.

7.1.2 Availability of fire control tools

The availability of fire control tools is an obvious pre-requisite for any successful forest fire control work. Some possibilities need to be explored however when ensuring the supply and availability of tools and equipment. The ideal condition prescribes the concept of local tool manufacture. It is recognized that through the local production of tools in a certain country, their supply and availability is assured. Besides this, local manufacture will help promote employment opportunities, create new skills, and finally, reduce the outflow of foreign exchange associated with the tools' importation.

7.1.3 Local tool manufacture

The development of appropriate hand tools takes several years. It takes many years before any tool manufacturer can produce tools of good quality. The process involves the reproduction of imported tools in workshops and small factories on a trial basis. The aim includes the assessment of existing technical expertise and the assumed costs of the local tool manufacturer. The findings of the Forest Management Bureau / ILO project in the Philippines were as follows:

- (i) Most of the deficiencies of locally-made hand tools are related to insufficient uniformity, occasional unsuitability of the raw material, and the lack of facilities, particularly in the process of heat treatment.
- (ii) Discarded motor-vehicle leaf springs, which constitute the principal raw material in the manufacture of various hand tools, coming from different and often metallurgically unknown sources.
- (iii) In manufacturing edge tools, tempering (heating of forged sections and subsequent quenching) is a vital process affecting the tools' quality. At present, most makers rely entirely on blacksmiths' experience. Though valuable, the experience alone cannot match the results attainable under methods utilizing measuring gauges.
- (iv) Some of the deficiencies of tempering in small scale workshops are due to the overly simple type of heat furnace used. A muffle furnace, preferably equipped with a

pyrometer allowing for a more uniform heating, would considerably improve the degree of control of the tempering process.

- (v) Manufacture of most forestry tools involves welding. Welders typically have a scant knowledge of the composition and properties of the metal to be welded. Consequently, they often choose an incorrect voltage, electrode, or welding rod, altering in the process the properties of the material and adversely affecting the tool's quality.

Most workshops however, not only do not possess, but cannot possibly contemplate investment in metal-testing facilities and the equipment designed for final controlled steel hardening, which is essential for the production of tools of more advanced design.

Two types of remedial action suggest themselves:

- (i) uniform batches of steel having known compositions and specification suitable for the intended purpose could be purchased; and
- (ii) final heat treatment of the pieces, using more advanced facilities, could be done on a cooperative or a sub-contracting basis.

There are other ways of improving the quality.

Firstly, in the arrangement of cooperation between the selected tool makers and the concerned institutions or agencies in matters of metal testing, quality improvement, and a contract-based heat treatment.

Secondly, there is also a possibility worth exploring of setting up a joint venture with foreign tool makers, whereby the local firm would start by assembling imported tool parts and gradually increase the domestic content.

7.1.4 Training

Tool supply and training in proper use and maintenance must go hand in hand. The training of workers in the efficient handling of tools is of no use if such tools are not available or not properly maintained once training is completed. Supplying tools to untrained workers is just as useless if the worker is not instructed in proper maintenance and efficient working techniques.

Effective use of fire control hand tools requires several weeks of practice before the proper working techniques are fully adopted. On-the-spot training with frequent follow-up is required to secure good results.

7.1.5 Tool maintenance, use, and storage

Fire tools and equipment should be stored in an adequately lit and well ventilated store room. The room should be large enough for tools and equipment to be stored in racks and bins, so that they are readily available when needed. It is desirable to have a room large enough for a work bench on which tools can be repaired and maintained. The wooden tool handles should also be protected from termites and other insects during storage, and the use of some wood preservative may be necessary. It would also be advantageous if the store room has an outside door which provides direct and easy access to vehicles for loading and unloading.

Fire tools should be identified with prominent and distinctive marks of some kind, such as a red band of paint 5 to 10 centimetres wide on the handle next to the head of the tool, or they may be stamped with an appropriate initial. Tools marked as such can be identified at a glance as fire tools. They are less likely to be misused on other projects if they are conspicuously marked as fire tools. Marked hand tools and equipment owned by the district or department can be easily be identified, especially if they may be used on fires where other units are also employed. Whatever identification is chosen should be used consistently throughout on all fire tools.

7.1.6 Description of hand tools

For the purpose of discussion, this book will limit itself to some of the important tools for use in the construction and maintenance of firebreaks and in fire suppression.

Hand tools used for fuel separation

Hand tools are frequently used for separating fuels when constructing firebreaks before the beginning of fire seasons.

During fire fighting they are used to construct a base line for back burning, or to separate burning fuel from unburnt material at the perimeter of a fire.

The main tasks are:

- to cut trees, logs, and shrubs;
- to chop grass and other low vegetation;
- to dig out half-buried fuel; and
- to remove surface litter so that the ground can be cleared of inflammable fuel.

The hand tools commonly used are:

- axes;
- saws;
- brush hooks;
- shovels;
- rakes; and
- rake-hoes; although
- spades, forks, and road brooms may be used in emergency.

None of these tools completely satisfies the main functions of cutting, chopping, dipping, and raking, but the uses of several are sufficiently versatile for the requirements of a fire crew. There has been a gradual move to develop standard equipment with a reduction in weight appropriate for working under conditions of heat stress, which is as important as strength and reliability.

Hand tools for smothering fire - swatters or beaters

However primitive they may seem, and however unpleasant and exhausting they are to use, swatters or beaters are useful for smothering flames. They come in all shapes and sizes. Whether green branches and wet bags or leather flappers and thonged beaters are

used, the main point is that sparks should be swept towards a fire, not scattered in all directions.

Shovels also have a place for beating out flames; for smothering burning fuel with earth and for burying smouldering material.

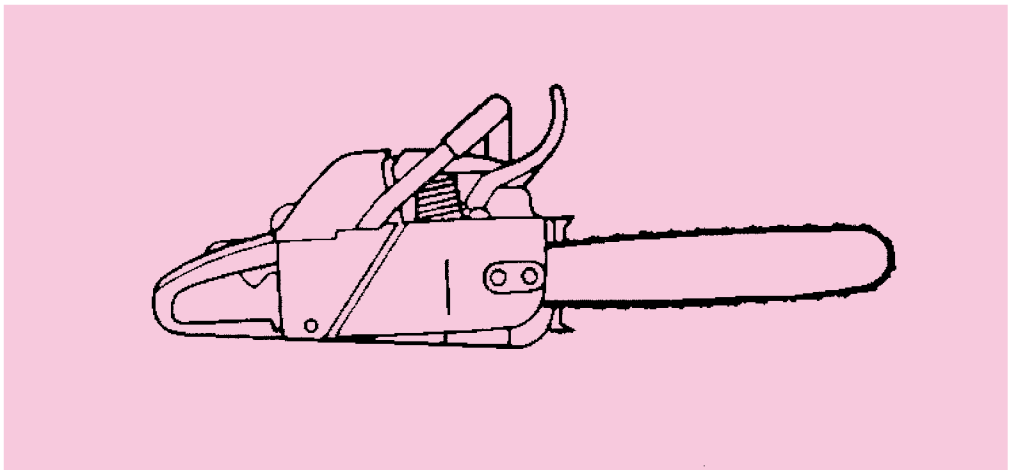
Hand tools for burning out fuel

It is not always possible to separate burnt fuels completely from unburnt fuels. It may be desirable to back burn so that unburnt fuel between a cleared control line and the main fire is disposed of under suitable weather conditions.

Torches made of bark or branches bearing dry leaves are often used. A rake may be used to spread burning material, although it may be necessary to use a more concentrated and reliable flame, especially if lighting up has to be done quickly.

Chain saws

Self-contained power saws are universally used and if they are maintained properly, they are the best means of cutting large material and felling timber and snags. Operators must have sufficient training and experience when they are felling trees. They should be required to observe the necessary safety precautions. Two men should work together.



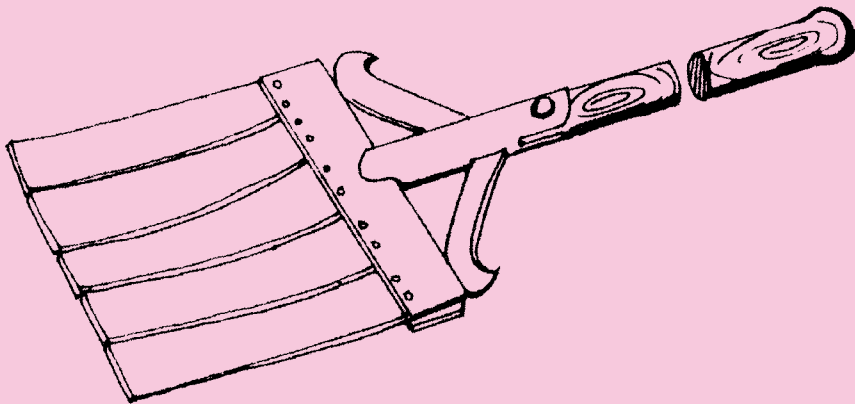
Use Cutting large material and felling timber and snags.

Maintenance Daily maintenance and regular sharpening essential.

Technical Specifications

Weight	: 5 kg.
Guide bar length	: 13".
Engine	: 49 cc, 2-stroke.
Special features	: Chain brake; handle guard.

Fire swatter



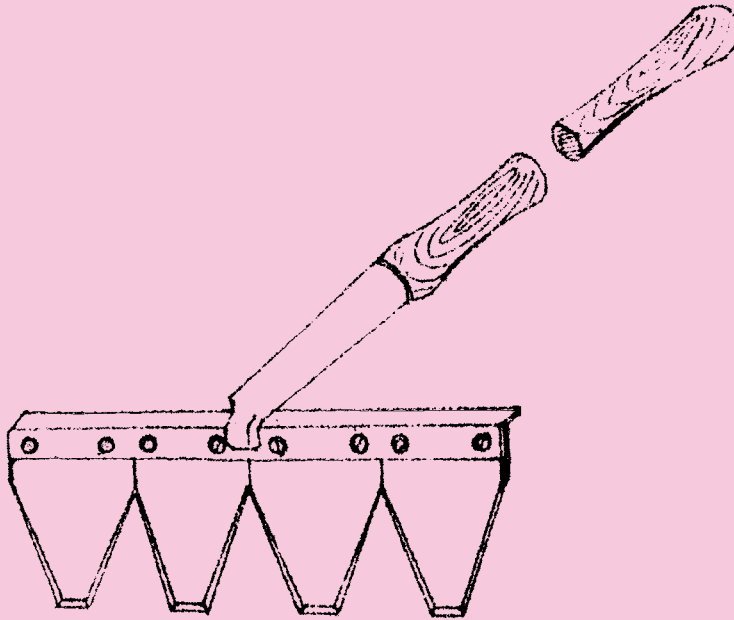
- Use**
1. To extinguish the flames in grass fire suppression.
 2. The hooks are designed for rolling of obstacles or burning debris.

- Maintenance**
1. Tightening of the nuts and bolts with the an adjustable wrench.
 2. Replacement of flaps when worn-out.
 3. Replacement of handles, if damaged.

Technical Specifications

Weight	: 2.70 kg.
Length of handle	: 1520 mm.
Length of flaps	: 300 mm.
Width of flaps	: 50 mm.
Material	: Conveyor belt for flaps, mild steel; tough wooden handle, e.g. <i>Parashorea</i> .
Function	: Grass fire suppression.
Special features	: Flaps can be replaced; safety grip (knob).

Fire rake



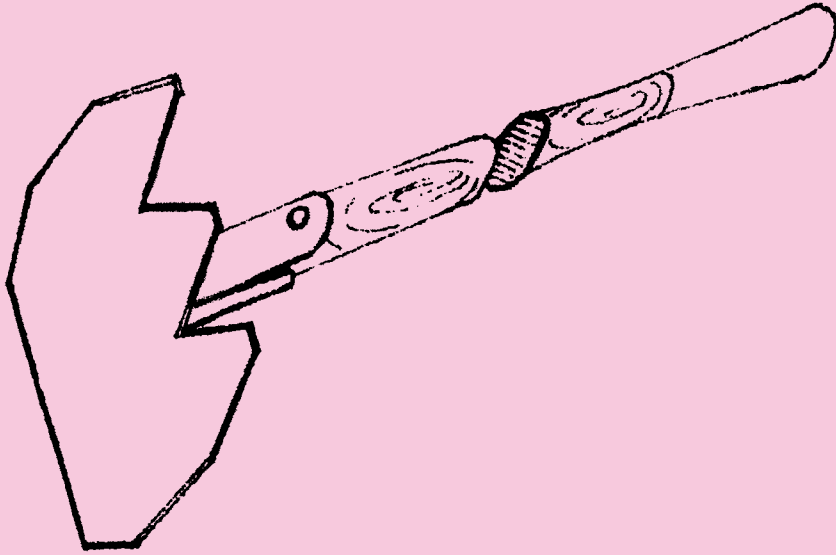
Use 1. For fireline construction.

Maintenance 1. Tighten all nuts and bolts using an adjustable wrench.
2. Sharpen blades with a file.
3. Replace either the blades or handle when necessary.
4. Clean with water and wipe with oil after use.

Technical Specifications

Weight	:	2.20 kg.
Length of handle	:	1200 mm.
Width of metal head	:	305 mm.
Material	:	Mild steel; tough wooden handle, e.g. <i>Parashorea</i> or similar.
Function	:	For fireline construction.
Special features	:	Replaceable blades; safety grip.

Rake-hoe



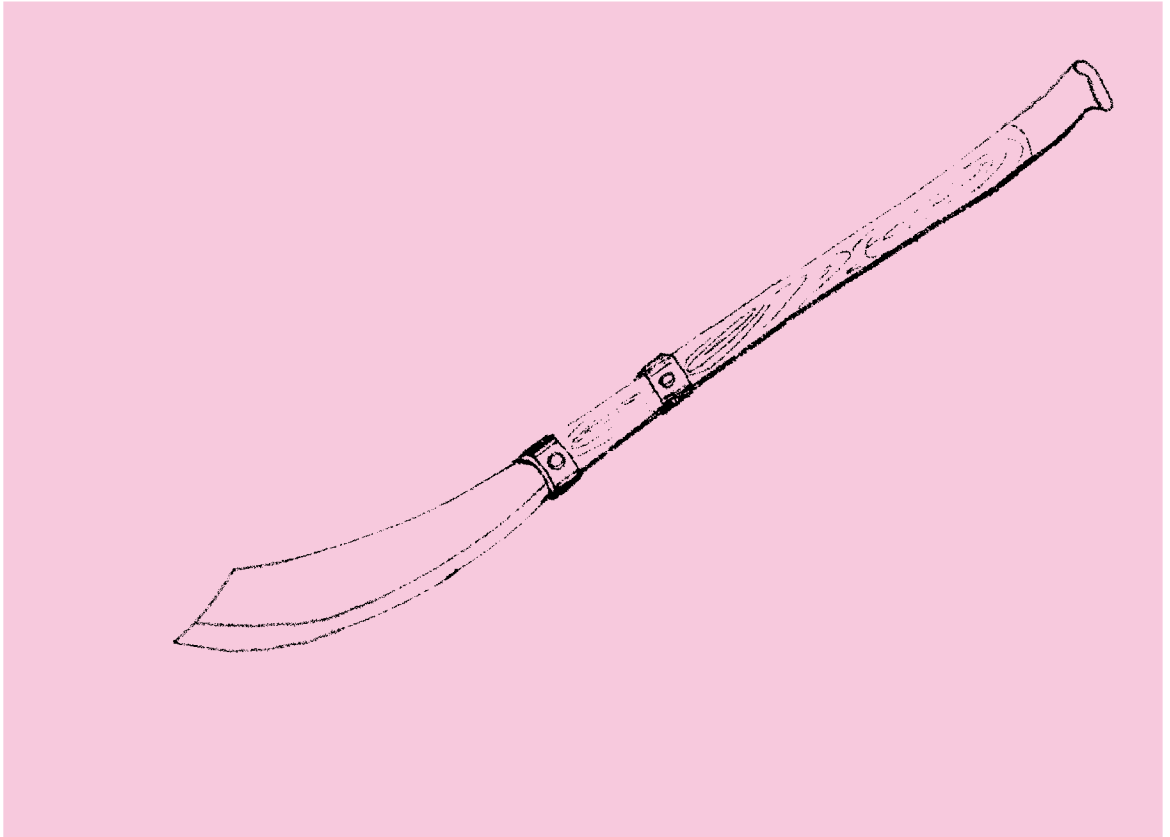
Use 1. Used to rip up and remove the vegetative cover from the area of a fire break under construction.

Maintenance 1. Sharpening on all four sides of the blade with a file or grindstone.
2. Tighten the nuts and bolts with an adjustable wrench.
3. Replace either the blade or handle when necessary.
4. Clean with water and wipe with oil after using.

Technical Specifications

Weight	: 1.80 kg.
Length of handle	: 920 mm.
Width	: 230 mm.
Material	: Mild steel; tough wooden handle, e.g. <i>Parashorea</i> or similar.
Special features	: Flat handle; safety grip; sharpening on all four sides of the blade.

Improved grass-cutting bolo



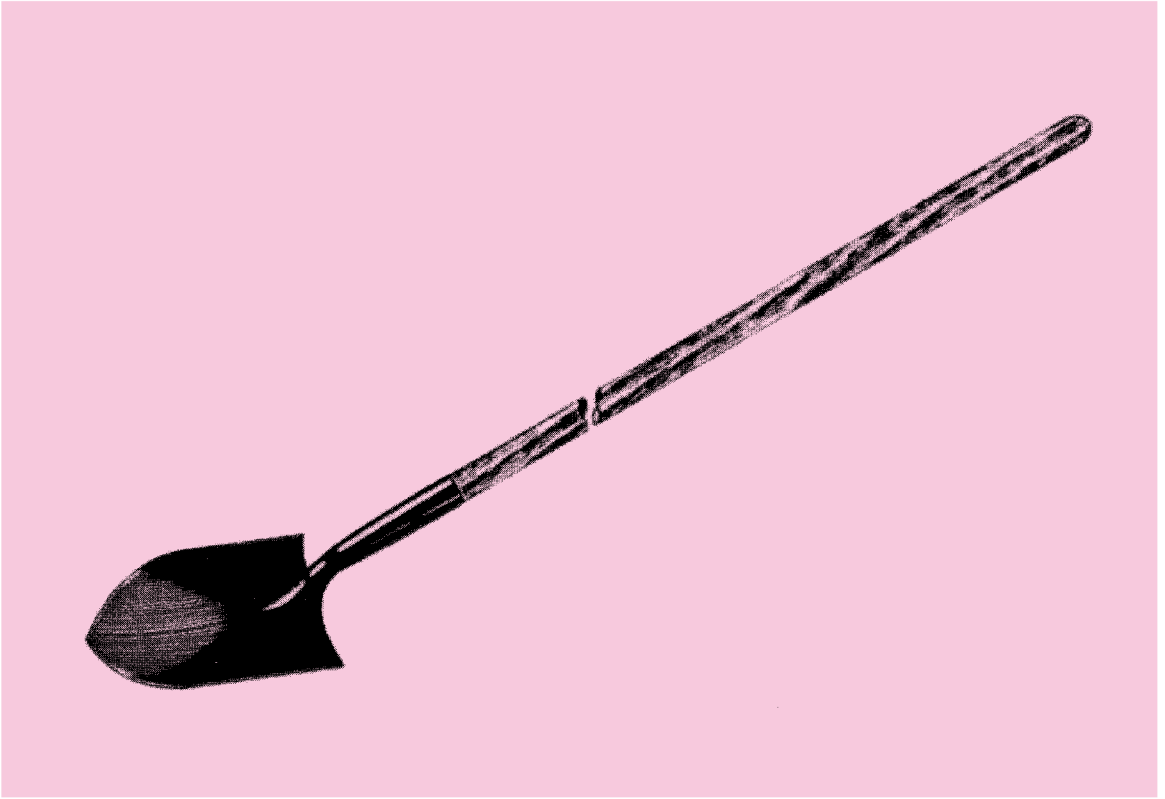
Use 1. Cutting of grass.

Maintenance 1. Sharpen the blade using a file and whetstone.
2. Wipe the blade with oil to prevent rusting.

Technical Specifications

Weight	: 0.5 kg.
Length of blade	: 300 mm.
Length of handle	: 560 mm.
Material	: Discarded bandsaw blade and very light wood handle (such as <i>Shorea</i> spp.).
Special features	: One or two reinforcing segments preventing splitting of handle; replaceable handle and blade; washer between nut and bolt.

Fire-fighting shovel



Use

1. It is mainly used for throwing soil to extinguish flames.
2. It can also be used to scrape firelines and to swat flames.

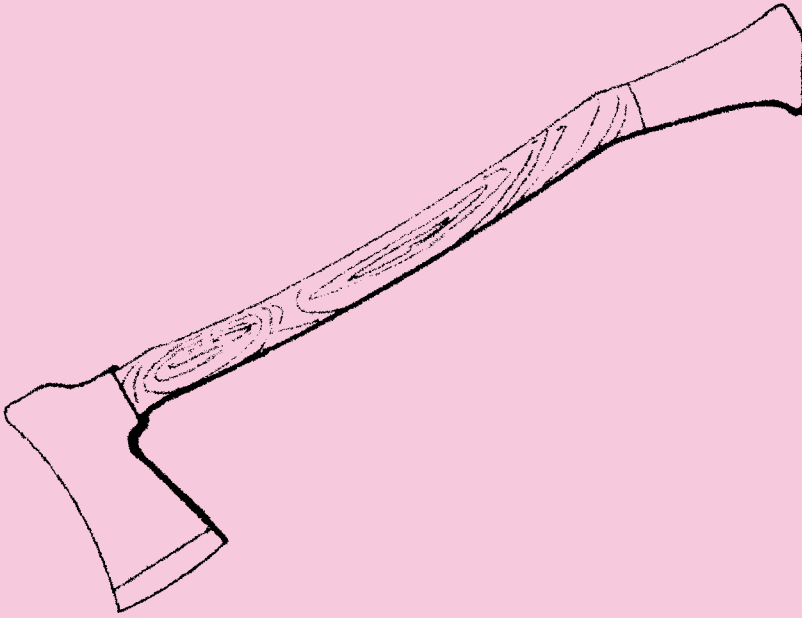
Maintenance

1. Shovels must always be kept in optimum condition by sharpening with a file or a grinding stone.
2. Replacement of handle, if damaged.
3. After use, clean with water and apply oil using cotton rag moistened with oil.

Technical Specifications

Weight	: 3.20 kg.
Length (handle)	: 1500 mm.
Length of blade	: 300 mm.
Width of blade	: 220 mm.
Material	: Mild steel; tough wooden handle, e.g. <i>Parashorea</i> or similar.
Function	: To scoop up top soil or double as fire swatter.
Special features	: Cross grip; concave blade for structural strength.

Axe



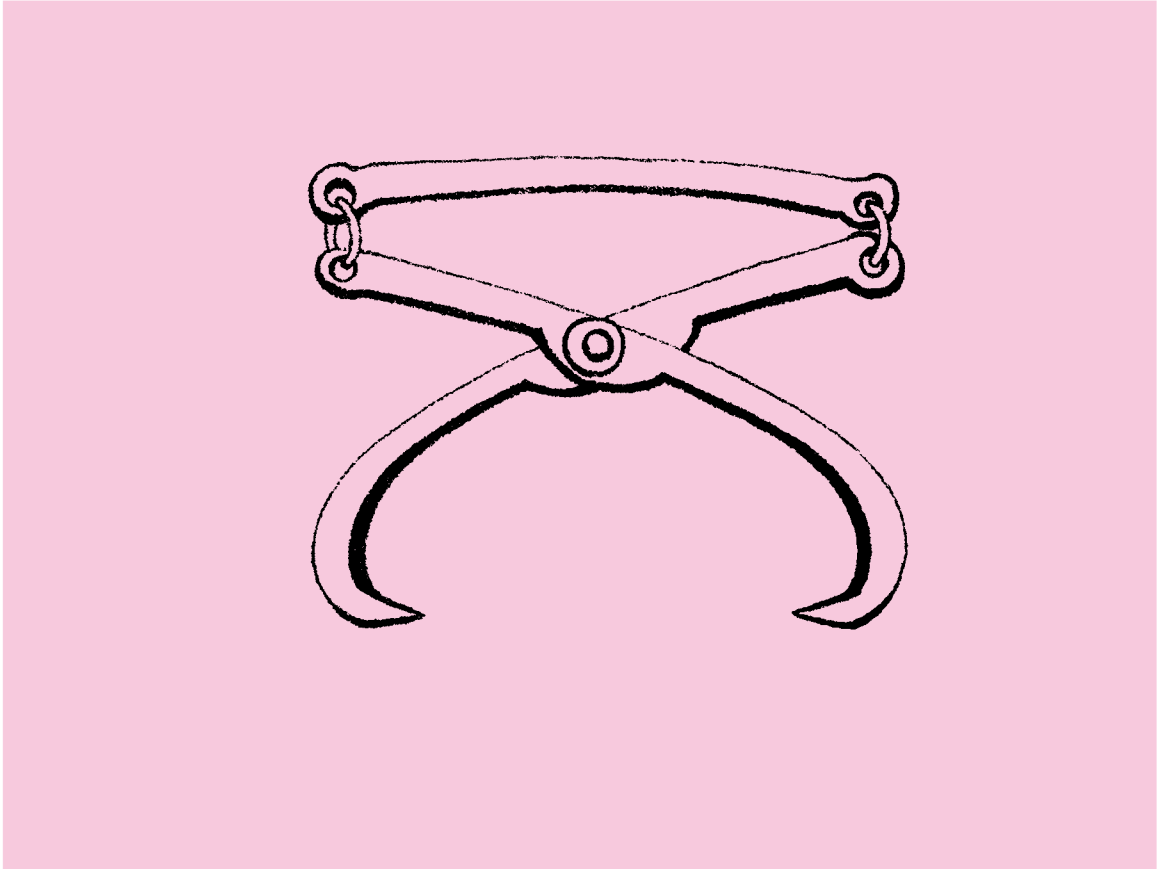
Use 1. For blazing and brushing.

Maintenance 1. Sharpen the blade using of file and whetstone, or a grindstone.
2. Replace handle if damaged.
3. Clean the tool and wipe the blade with oil before it is stored.

Technical Specifications

Weight	: 2.40 kg.
Length of axe	: 650 mm.
Width of head	: 93 mm.
Material	: Handle - tough hardwood.
	: Blade - high quality steel.
Special features	: Hammer design of axe head for pounding tree felling wedge.

Teamwork tong



Use 1. For fire trail / line construction.

Maintenance 1. Sharpening of tips, lubrication of central joint.

Technical Specifications

Weight	: 2.30 kg.
Length, closed	: 590 mm.
Maximum grasp width	: 315mm.
Material	: Leaf spring
Special features	: Reinforced portions around the central rivet.

7.2 Fire Pumps

7.2.1 General

The engine driven firepump, or so called fire-engine or pumper, is the most important piece of equipment for the modern fire brigade at the scene of the fire. That is why fire-engines used to be called “the heart of fire fighting works”, and fire hoses “the blood veins”.

The target of the firepump is to give pressure and momentum to water at the scene of the fire. The firepump itself is driven by a gasoline or electrical engine or by human power.

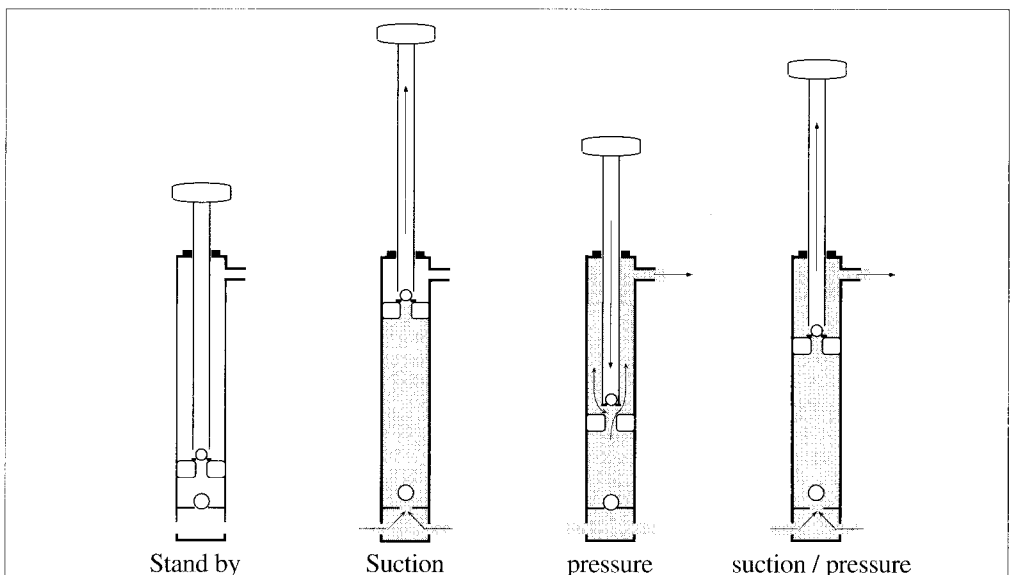
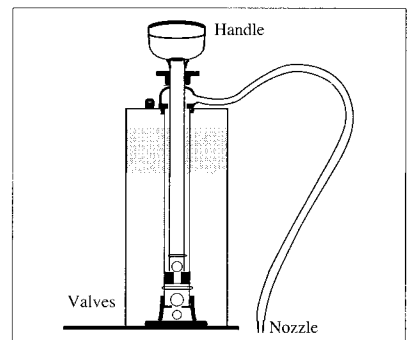
7.2.2 Backpack pump

Backpack sprayers should be included in the fire fighting equipment because of their extreme portability and effective use of small quantities of water. The use of water in the forest fire should be limited by using the fog stream nozzle as much as possible. With the fog stream nozzle the heat of a fire can be cooled 4-5 times more effectively than with the straight nozzle spray. The fog stream nozzle spray is excellent for wetting down unburnt fuel and for building a narrow but effective break in the fuel. The length of the straight stream can be more than 10 metres and the maximum water use can be 10 l/min.

When a backpack pump is used the following must be remembered:

- keep the pump full of clean water;
- keep the lid closed;
- check that the tube and nozzle are not blocked; and
- check and oil the pump regularly.

Typical backpack pump



Action of the backpack pump

7.2.3 Centrifugal pump

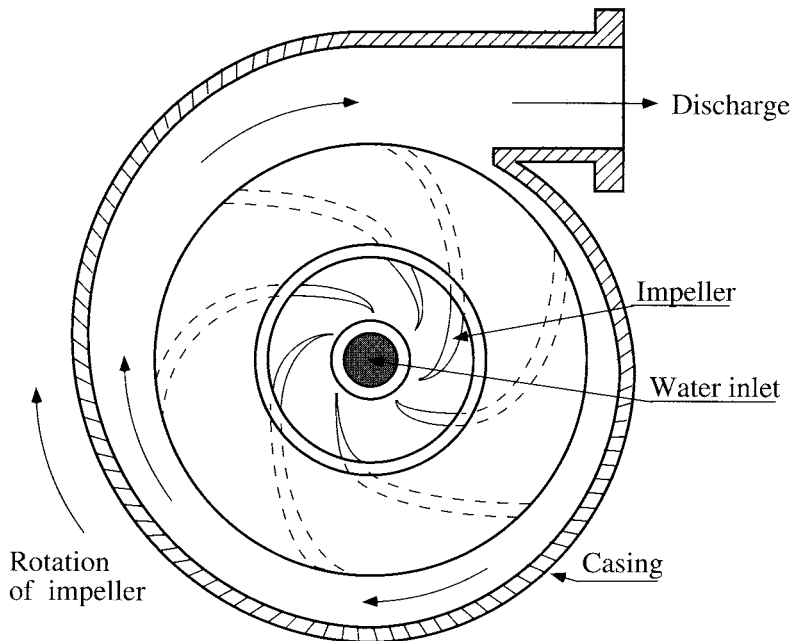
Pressure to pump water can be produced by a centrifugal pump. Such a pump consists of a casing within which there is an inner nest containing one or more impeller plates. The impeller plates are formed of two round discs held apart by the impeller blades. A pump with one impeller plate is known as a one-graded pump, with two plates as a two-graded pump, and so on.

Both the pump nest and casing are equipped with valves to empty the pump of water. The pump should also be equipped with pressure and vacuum gauges.

Use and characteristics of the centrifugal pump

Water may be raised to the pump through vacuum by using a suction pump. When the water reaches the impeller plates it is thrown with great force against the casing, on its way to being discharged. If a one-graded pump gives a discharge pressure of four atmospheres, a two graded pump will give up to eight atmospheres, and so on. However, if water is taken from a pipe, with a pressure of three bars for instance, the pressure at discharge from a two-graded pump will be eleven atmospheres (8+3).

A higher rotation speed in the pump will give a greater water pressure and volume. Higher rpm will increase the rotation speed, the water pressure growing with the revolutions.



The water capacity of the pump is calculated as follows:

$$W_1 = W \frac{r_1}{r}$$

where: W = Water capacity in litres/minute.

W_1 = Increased water capacity in litres/minute for rpm (r_1) of the pump.

r = Standard rpm in the pump.

r_1 = Estimated increased rpm in the pump.

The pump's water pressure is calculated as follows:

$$P_1 = P \frac{r_1^2}{r^2}$$

where: P = Standard water pressure in bars.

P_1 = Increased water pressure in bars when using increased rpm (r_1) in the pump.

r = Standard rpm in the pump.

r_1 = Estimated increase in pump rpm.

The energy requirements of the pump can be calculated as follows:

$$E = \frac{W \times H}{4500 \times \eta}$$

where: E = Energy requirement in kilowatts.

W = Water in litres / minute

H = Static pressure height of water in metres.

η = Efficiency coefficient (0,5 - 0,8)

The pump efficiency at different water capacities can also be calculated by modifying this formula and using the known energy of the pump (kW) for value E.

The suction pump

The centrifugal pump (which is nowadays the most common firepump) cannot by itself take water from the water source. It has to be equipped with a suction pump or vacuum pump.

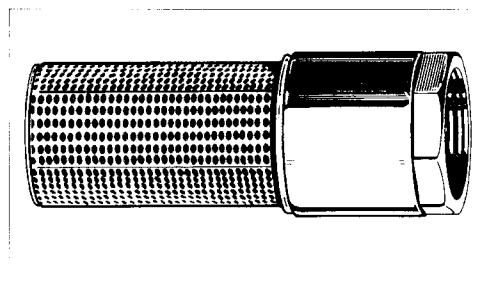
The suction pump is placed by the water source to suck water into the centrifugal pump. The highest theoretical suction height from the water to the suction pump is 10,3 metres, although in practice the maximum suction height is normally 4 - 6 metres. If warm water is being drawn the suction height decreases with the increase in temperature, as shown in the following table:

Water temperature		Loss of suction height (approx.)
(Centigrade)	(Fahrenheit)	(metres)
30°	86°	0,5
45°	113°	1,0
60°	140°	2,0
75°	167°	4,0
80°	176°	5,0
90°	194°	7,0
100°	212°	10,3

Suction height is also lower if the air pressure is lower, as at high altitudes.

When placing the suction pump at the water source one of the most important considerations is obtaining good strong suction. The pump should be placed as near to the water as possible, with the suction height remaining less than six metres. For uphill pumping, the hose between the pumps should be constantly rising upwards, with no downward sections. For example, always under an obstructing fence and not over it; since going over the fence would cause a downward section when coming off it.

The suction strainer should be placed deep enough into the water to prevent any air being drawn into it. It should be more than 20 centimetres below the water level. The suction strainer must be hung in a fire bucket to prevent sand and dirt entering the line and reaching the pump. It must also be equipped with a return valve in order to constantly hold the water in the suction hose.



7.2.4 Use of fire pumps and hose lines

Friction loss

Friction loss is a loss of pressure in the fire hose due to the turbulence created by the interior surfaces of the hose. Additional pressure is needed at the pump to overcome this loss and maintain the desired pressure at the nozzle.

Friction loss increases if water flow is increased or if the hose diameter is reduced. It is also affected by the roughness of the interior hose surface. To decrease friction loss, bigger diameter hoses and/or lower pressure must be used, or there should be a shorter hose line between pump and nozzle. Also, hose should be laid as straight as possible.

Elevation loss

Elevation loss is the pressure drop caused by raising water to higher elevations. To obtain the same pressure at the nozzle as at the pump, the calculated elevation loss must be added to the pump pressure.

Friction loss and elevation loss must be calculated for any type of hose operation.

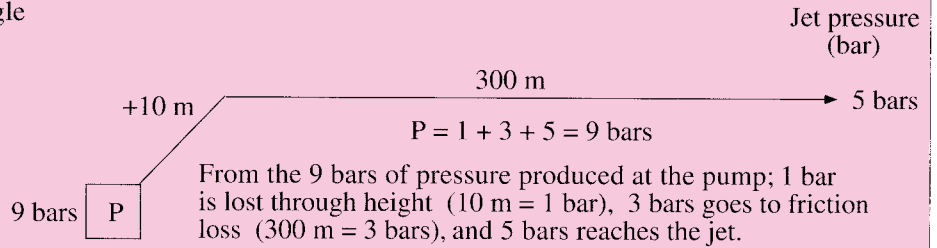
Rule of thumb

Friction loss is about 1 bar / 100 m of hose
and elevation loss is 1 bar / 10 m of elevation.

Friction loss and elevation loss can be calculated for several different situations as follows:

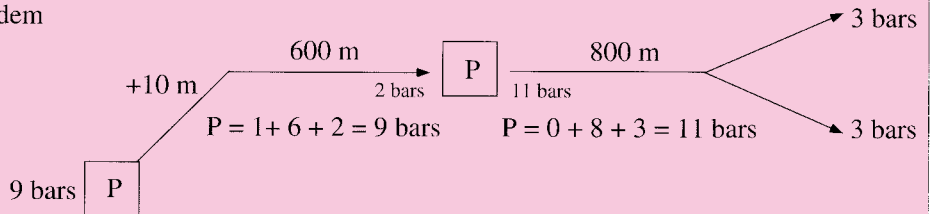
Example 1

Single



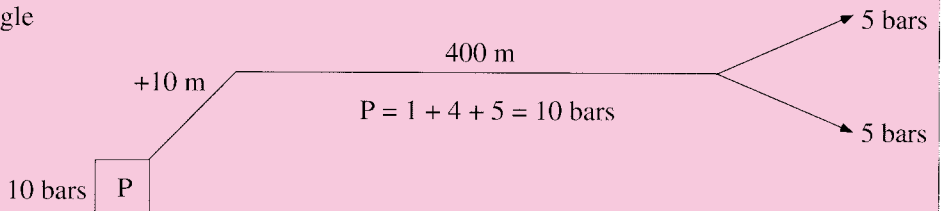
Example 2

Tandem



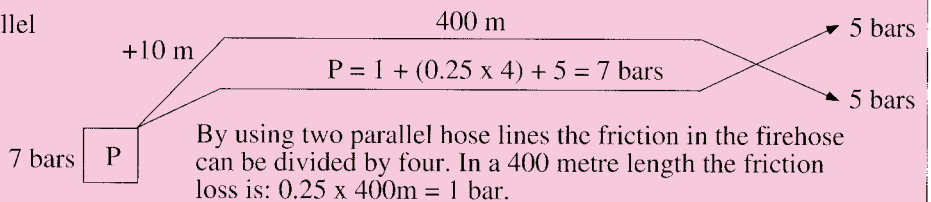
Example 3

Single



Example 4

Parallel



7.2.5 Main categories of pumps

The pumps that are normally used at forest fires can be divided into two categories:

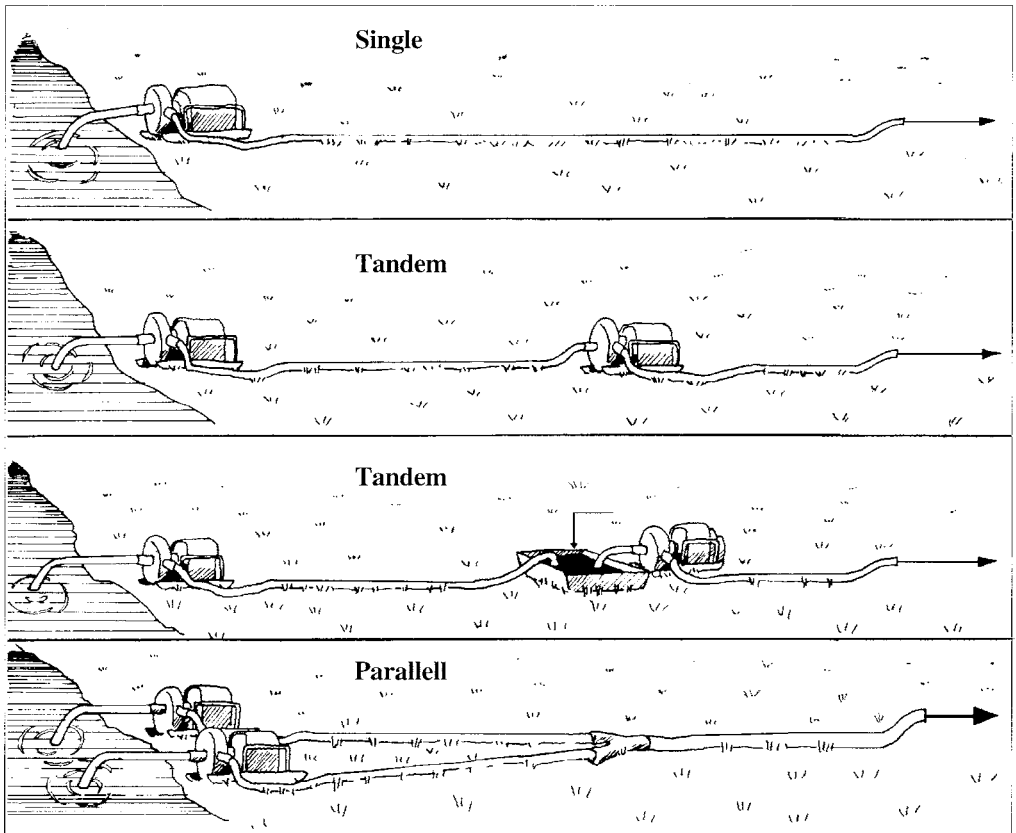
Fire-engine pumps - connected to a fire-engine and getting their power directly from its engine. The capacity of these pumps is normally very high, on average 10-20 bars pressure and 1000-3000 l/min. In addition to the pump, many fire engines are also equipped with an extra water tank.

Portable pumps - as used in forest fires must be of light weight because these will be easier to carry for long journeys in the forest. The capacity of portable lightweight pumps is usually 300 - 1000 l/min with a pressure of 5 - 15 bars. Portable pumps are useful if the water source is not accessible to fire-engines and if the water is close enough to the place of fire.

In addition, there are high pressure pumps used for fog spraying in an initial attack. These pumps are normally connected to fire engines.

7.2.6 The main pump hook-ups, booster pumps, and tanks

There are several ways to apply the water equipment supplying water in fire suppression. The crew boss, who is responsible for water supply, must know all the main applications and the advantages and disadvantages of each one.



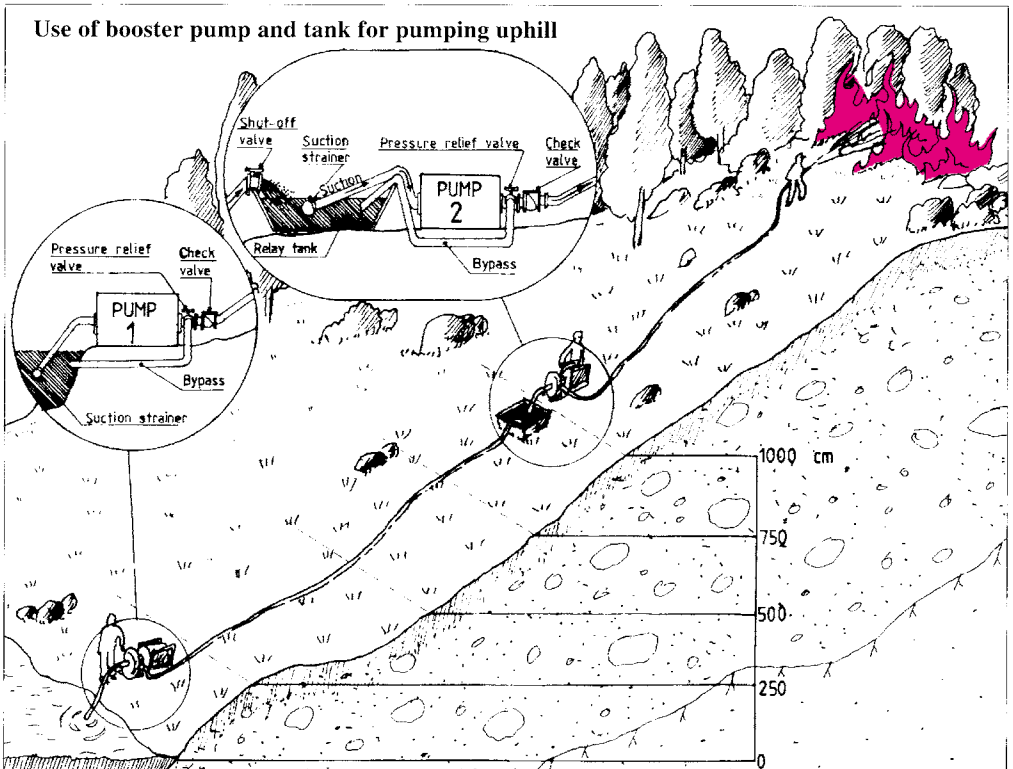
Selection of the application is affected by the:

- method of attack;
- fire intensity and fuel type;
- topography;
- water source and its quantity;
- fire fighting equipment in use; and
- the distance between the fire and water source.

If elevation or distance reduces water pressure below effective nozzle pressure an extra portable pump, preferably with a relay tank, should be installed between the nozzle and the main pump. The main objective with booster pumps is to raise the water pressure and capacity at the nozzle. The booster pump normally has a lower pressure capacity than the main pump.

Booster pumps can be set up in tandem or parallel fashion. When the booster pump is installed directly in the line, careful coordination is required and the pumps should be constantly attended. Communication between the pumps is highly desirable. Several booster pumps may be employed in one line, the only limitation being the suitability of equipment. It is usually impractical to connect more than three pumps directly (in tandem), but with relay tanks there are no limits except time and distance.

If the booster pump is only connected between the source and the final hose line an adapter coupling will be needed for the different diameter hoses. A special divider coupling will also be required for parallel operation.



7.2.7 Firepumps used in forest fires

Mako backpack pump

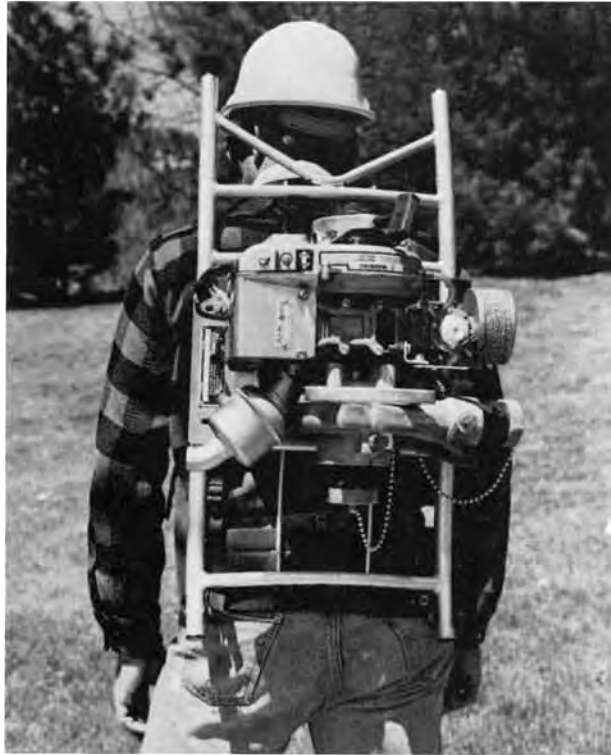


Construction: The pump has a light and very sturdy container made of polyethylene and is designed for easy carrying. The detachable lid is waterproof. The filling hole is equipped with threads and is amply dimensioned to make filling the container quick and easy. The pump is supplied with a metal foot brace. This efficient pump is double-acting and gives an even and long spray. The cylinder and pistons are made of seamless drawn brass tube and the other parts are of cast brass. The spray is furnished with a flexible rubber hose as well as nozzles for straight and fog stream.

Technical Data

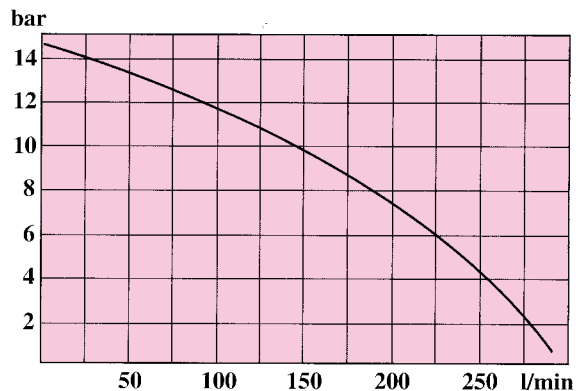
Fire type:	A (fibre fires).
Fire agent:	Water.
Capacity:	22 litres.
Weight:	5 kg.
Diameters:	Length / width / height: 25 / 37 / 67 cm.
Hose length:	700 mm.
Hose diameter:	½".
Effective time of use:	Straight stream 5 - 7 minutes, fog stream 10 - 15 minutes.

Hale fyr pak

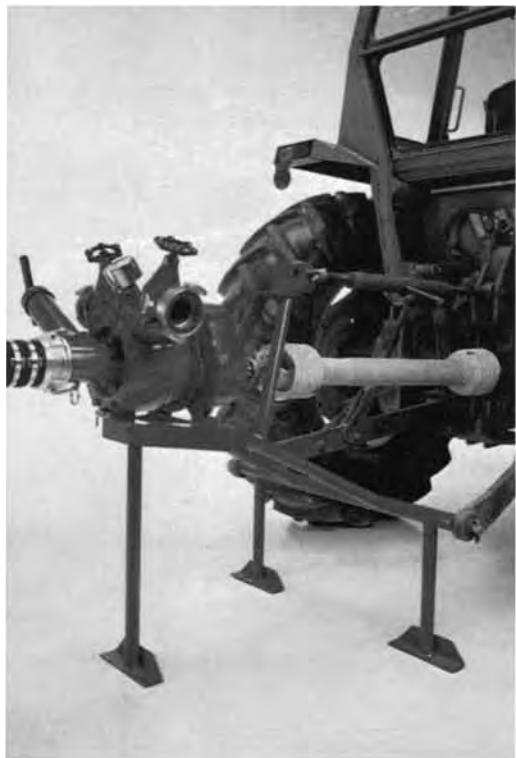


Technical Data

Motor:	U.S. Marine Co., air cooled, lubricated by oil/gas mix, features solid state ignition for easy starts and electrical overspeed protection. Spark-arresting muffler, standard.
Power:	8 HP at 7000 RPM
Weight:	15,4 kg.
Dimensions:	Length / width / height: 81 / 42 / 33 cm.
Ignition system:	Electronic.
Fuel:	Gasoline / oil 50:1 (2%).
Pump:	Centrifugal type bolted directly to engine.
Closed pressure:	14 bars.
Water capacity:	250 l/min.
Suction height:	2 m.
Suction equipment:	1½ -inch NPT.

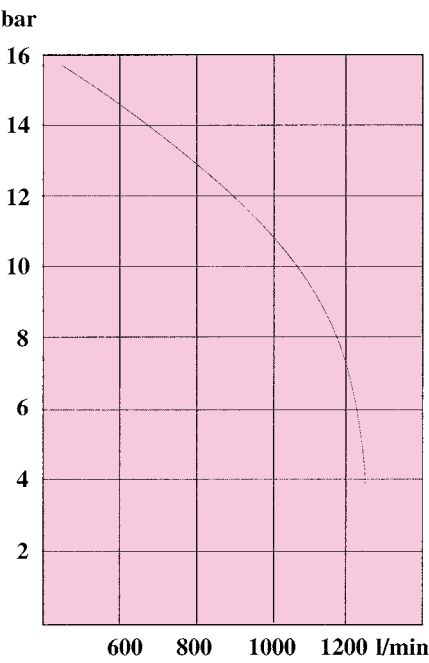


Tractor Esa



Technical Data

- Construction:** Motor pump for tractor installation.
- Pump:** 1-stage centrifugal pump cast in anodized light metal with 1:10.8 gear box, suction inlet 3 ¼" and two 3" pressure outlets, regular pressure 17 bars.
- Standard equipment:** 4 x 2 m of 3 ¼" suction hose with automatic couplings, suction filter with bottom valve, intermediate and recouplings, suction inlet cover, power transmission shaft, installation equipment.
- Weight:** Weight 76 kg with shaft and couplings.
- Dimensions:** Length/width/height: 90/95/98 cm.
- Water capacity:** 1200 l/min at 8 bars.
- Suction equipments:** Suction inlet screw R 3", pressure outlet screw R 2 ½".

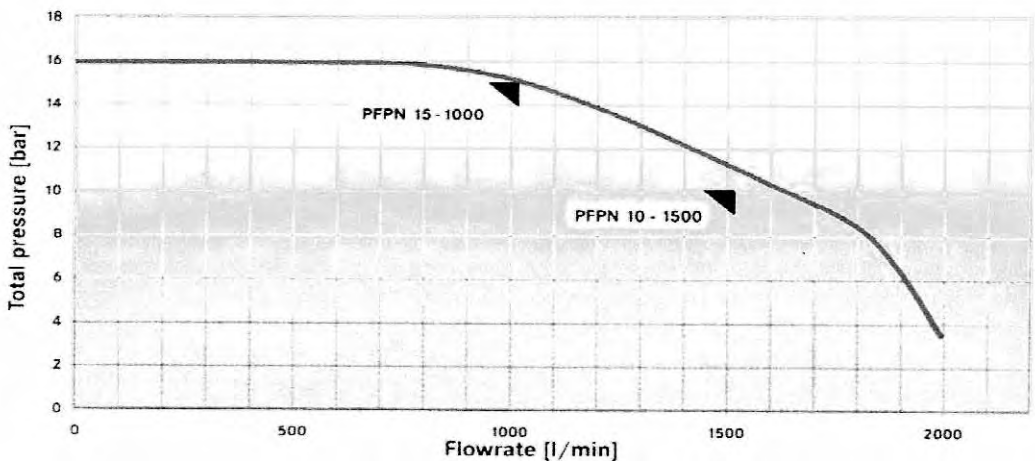


Rosenbauer Fox III



Technical Data:

Motor:	BMW A 67 boxer 1170 cc.
Fuel tank:	20 litres (will last for 90 minutes at full speed)
Power:	55 kW (77 hp) 5200 rpm
Weight:	Between 160-167 kg with fuel added
Dimensions:	L/WH = 947 x 740 x 840mm
Pump:	One-stage Centrifugal pump with single plate release clutch
Closed pressure:	17, 5 bar
Water capacity:	1000-2000l/min (from 4-15 bar)
Suction equipment:	4 pieces of Storz DS 110 4" suction hoses á 2 metres.



Hale Pump



Technical Data

- Motor:** Chrysler 2 stroke Power Bee air-cooled 8.2 cubic inch (131 cm³) displacement and solid-state ignition. Die cast aluminium cylinder and crankcase. Hardened forged steel connecting rod and crankshaft. Self-lubricated with oil and gasoline mixture. Spark-arresting muffler, standard.
- Power:** 8 hp at 7000 rpm.
- Weight:** 22 kg.
- Pump:** Centrifugal pump bolted directly to engine.
- Suction:** 2 inch (non-threaded) with easily removable oversize screen.
- Discharge:** 1,5 inch NST male with cap and chain
- Body:** Light weight, high strength, corrosion resistant aluminium alloy with smooth waterways for maximum performance.

7.3 Fire Armature

7.3.1 Fire hoses

Discharge hose

These hoses are divided into three groups:

- (i) linen hoses;
- (ii) rubber-linen hoses; and
- (iii) rubber-covered hoses.

The size of the discharge hose used on wildfire control varies from a 1 inch garden hose to a 3 inch rubber-lined hose. The most frequently used sizes are the 1 inch booster hose and the 1 inch woven jacket rubber-lined hose.

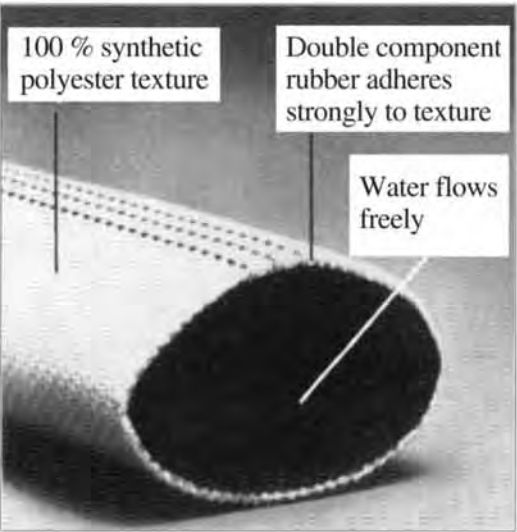
Linen hose is woven of flax fibres and synthetics. There is some leakage until the fibres swell and seal the tube. Minor sweating occurs during use, but this keeps the surface damp and resists burning. Linen hose is generally used in forest fire fighting

In general, hoses can be divided into two categories:

- (i) small diameter hoses (1" - 1 ½"); and
- (ii) large diameter hoses (2" - 3").

Large diameter hoses are used on main lines and small diameter hoses (or work line hoses) are used with nozzles.

Structure and test output of firehoses

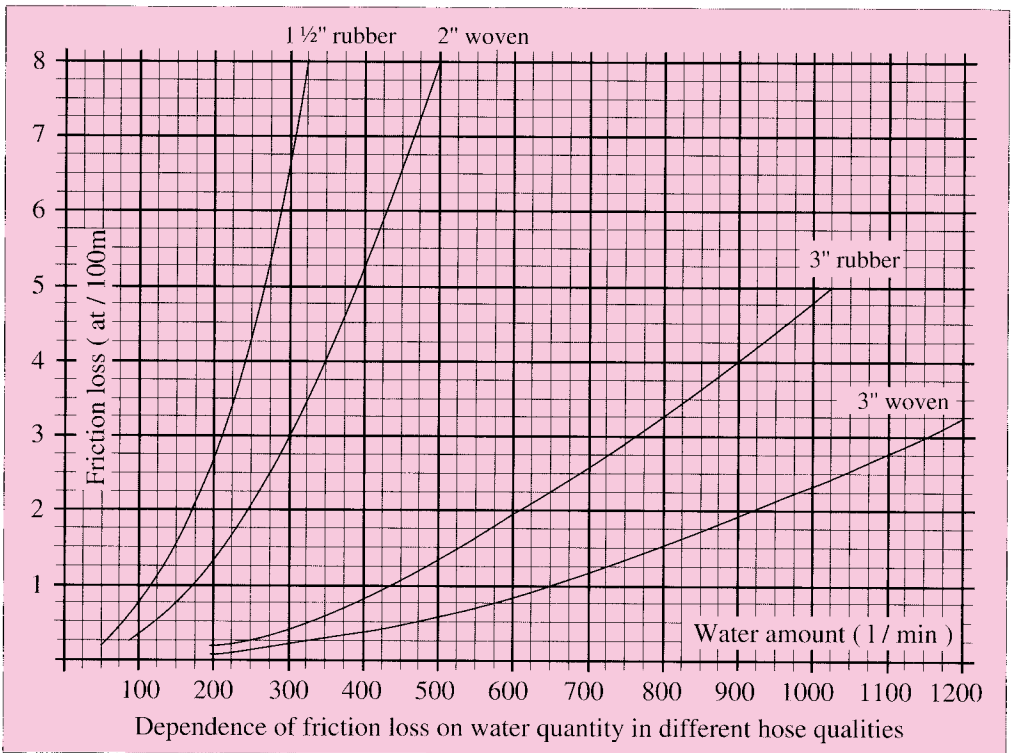


			break	work	test
ø"	ø mm	weight g/m	pressure bar	pressure bar	pressure bar
1½"	39	221	50	17	25
2"	57	294	50	17	25
2½"	63	388	50	17	25
3"	76	496	50	17	25
4"	102	633	35	12	17
4⅓"	110	750	35	12	17
6"	150	1066	20	7	10

Friction loss in fire hoses

Water input l/min	Friction loss in fire hoses / 100 m (bars)			
	3" rubber	3" woven	2" woven	1 ½" rubber
100			0.3	0.7
150		0.1	0.8	1.7
200	0.1	0.2	1.4	2.8
250	0.15	0.3	2.1	4.6
300	0.2	0.4	3.0	6.6
400	0.4	0.8	5.0	11.4
500	0.6	1.3	8.0	
600	0.9	1.9	11.0	
700	1.2	2.6		
800	1.5	3.3		
900	1.9	4.1		
1000	2.3	5.0		
1200	3.3			

Friction loss and water quantity in different hose qualities (bars)



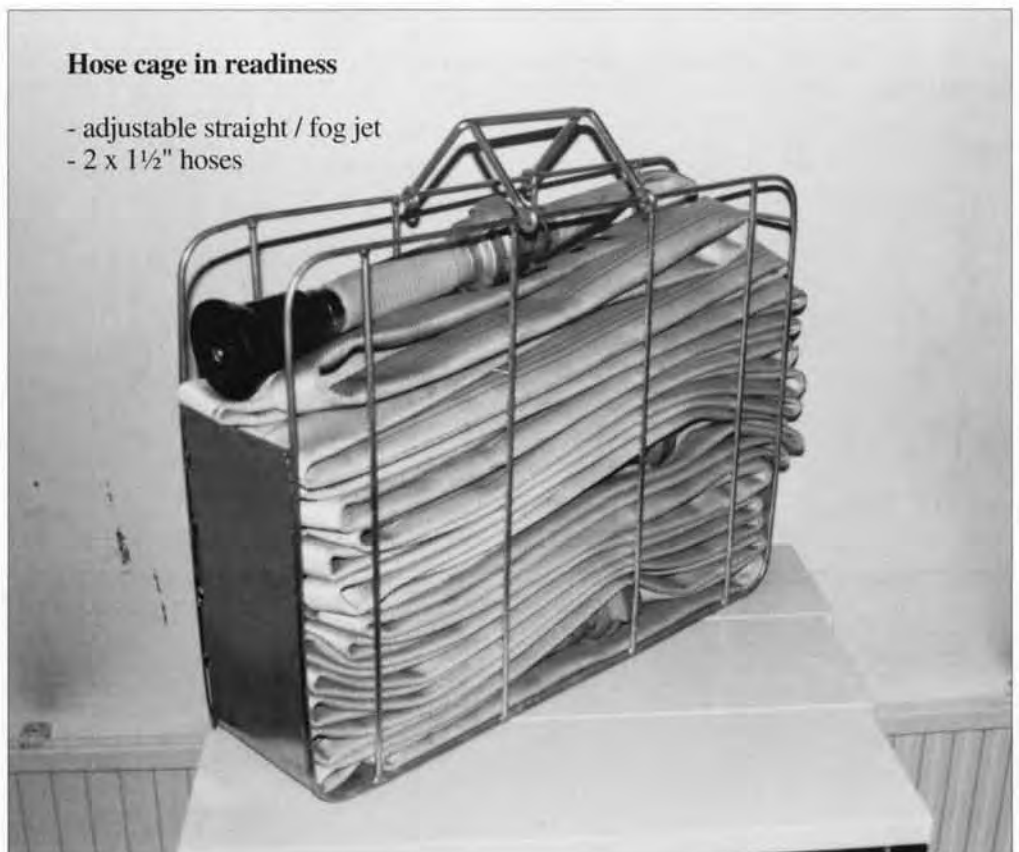
Hose lays

Often, the fire engine (pumper) can only reach one point at or close to the edge of the fire. In this situation the only way to supply water to the fire area is to lay lines of hose from the pump to the nozzleman. A simple way to lay the hose is to add hoses to the end of the line where they are needed. Gated wyes (dividing couplings) may be used at the intervals in the line.

Generally, the water supply line to the fire edge should be built starting from the pump to the main hose line, then dividing the main line with couplings, and finally adding two or three small hose lines at the edge of the fire to use as work lines. Three different hose lays can be defined.

- (i) progressive high pressure hose lines (1" - 1½");
- (ii) simple hose lays, or low pressure work hose lines (1½" - 2"); and
- (iii) main hose and low pressure work hose lines (2" - 3").

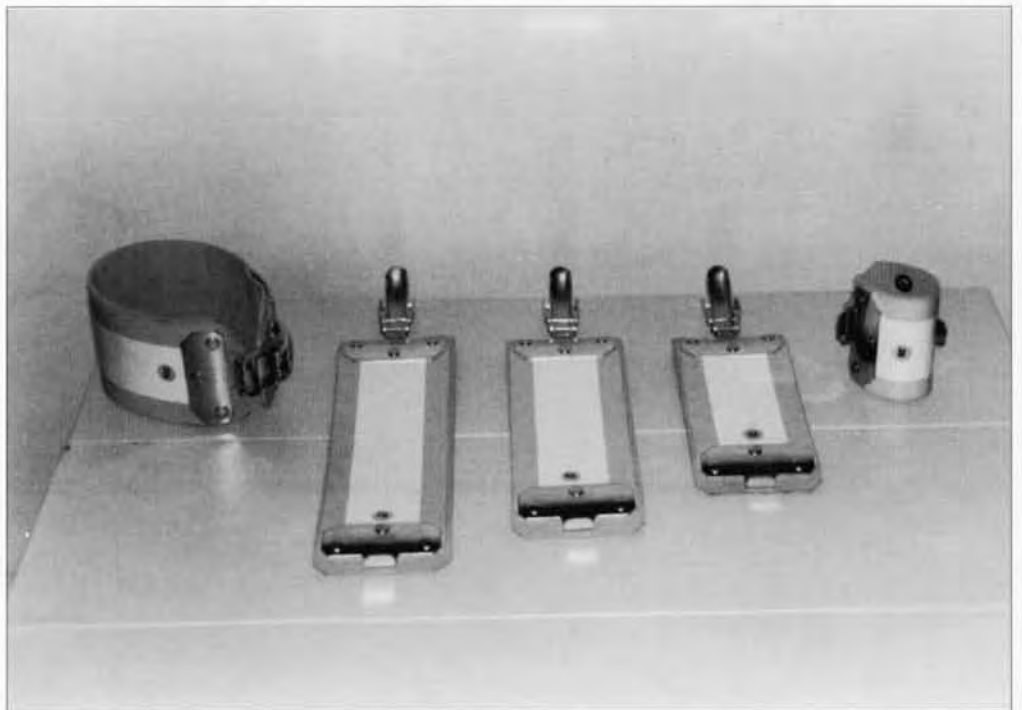
In any hose lay much will depend upon how much speed is required in applying water to the fire. If the forward speed of the fire is slow, one or two nozzle men are enough to stop it by spraying their way up both flanks at one time. Hoses can be added to the line until a booster pump and / or portable tank is needed to obtain sufficient pressure for satisfactory nozzle performance.



Hose handling techniques

When handling hose, several important points should be observed.

- (i) Do not drag the hose over rough surfaces or sharp rocks as the outside surface may become frayed and pinhole leaks may develop. Avoid hose lays over sharp objects as the vibration causes wear.
- (ii) Use the best hose next to the pump where the pressure is greatest, and the poorer ones nearest the nozzle.
- (ii) Lay hose in the most direct route from the pump to the point of use. Lay with a few short shallow curves on steep slopes and around trees and heavy brush so that the hose can be tied at intervals to keep it from slipping. When the hose is full of water its weight is enough to pull the line downhill unless anchored.
- (iv) Never drop couplings to the ground or on stones: take care of care of them. Never use oil or grease in hoses. Handle hose threads carefully and keep hoses and couplings clean, maintaining and repairing them directly after use.
- (v) Coiled hose is very easy to carry on backboards or in backpacks. Coiled hose is also very good when it comes to distributing the hose at a wildfire.

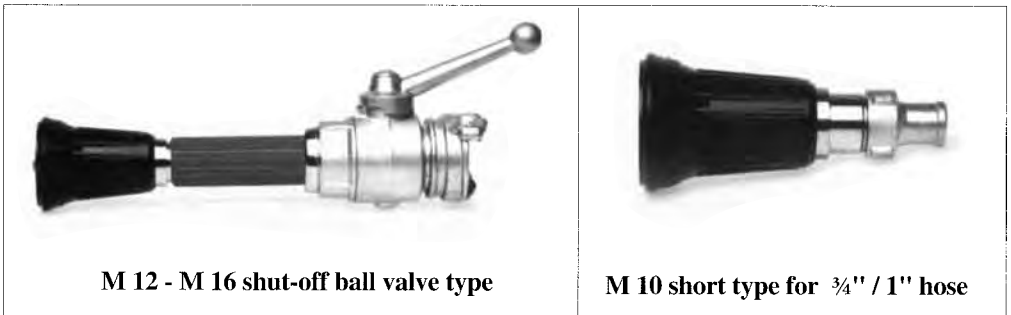


Repairing equipment for 3" - 2" and 1½" hoses used while fighting the fire.

7.3.2

Nozzles

Typical high quality nozzles (e.g. Sisu fogjet) for quick shut-off and stepless adjustment from straight stream to 90° fog and flush position are as follows.



Standard type:

- M 12/M 16 with coupling
- length 300 mm
- weight 1,5 kg

Can be equipped with a separate shut off ball valve:

- length 400 mm
- weight 2,6 kg

Material:

- body of chrome plated brass, top coated with weatherproof EPDM rubber bumper

Short type:

- M 10 with nipple for 3/4\" or 1\" hose
- length 150 mm
- weight 0,9 kg

Function:

By turning the bumper round the stops the following functions can be obtained:

- shut-off
- straight stream
- stepless adjustment for up to 90° fog
- row of teeth for superior fog cone
- can be easily cleaned in a flush position (i.e. fully open)

The use of water is always limited in forest fires. That is why fog nozzles should be used as often as possible. When using a straight stream the diameter of the nozzle should be checked.

Water outputs in different Sisu jets with different pressures and options when producing straight stream and fog are given in the following table.

	Bars	Spray angle (degrees)	M 10		M 12		M 16	
			l/min	Reach (m)	l/min	Reach (m)	l/min	Reach (m)
Straight stream	2	-	90	18	135	23	200	25
	4	-	130	25	190	30	285	32
	6	-	165	30	240	33	360	35
	8	-	185	35	270	35	420	37
	10	-	210	37	300	38	465	40
Fog	5	30	130	12	185	15	290	15
		60	180	11	240	14	320	14
		90	320	10	320	13	390	13
	8	30	175	15	275	16	430	19
		60	250	14	350	15	490	18
		90	410	13	460	14	620	17

The general water output table for a straight stream is given in the table below.

Jet pre- sure (bars)	Jet diameter (mm)																
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
	Quantity of water (l / min)																
1.0	41	65	94	128	167	212	262	317	378	444	515	592	673	760	852	949	1052
1.5	50	80	115	157	205	260	321	389	463	544	631	725	825	931	1044	1163	1289
2.0	58	92	132	181	235	300	370	449	535	628	729	837	952	1075	1205	1343	1488
2.5	65	103	148	202	264	335	414	502	598	703	815	936	1064	1202	1348	1502	1664
3.0	71	113	162	221	290	367	454	550	655	770	893	1025	1167	1317	1477	1645	1823
3.5	77	122	175	239	313	397	490	594	708	832	965	1107	1260	1423	1594	1777	1969
4.0	82	130	188	256	335	424	524	636	757	889	1031	1184	1347	1521	1706	1900	2105
4.5	87	138	199	271	355	450	556	674	803	943	1094	1256	1429	1613	1809	2015	2233
5.0	92	145	210	286	374	474	586	711	846	994	1153	1324	1506	1701	1908	2124	2354
5.5	97	152	220	300	392	497	615	745	888	1043	1209	1388	1579	1783	1999	2227	2468
6.0	101	159	230	313	410	519	642	778	927	1089	1263	1450	1650	1863	2089	2327	2578
7.0	109	172	248	338	443	561	694	841	1001	1176	1366	1566	1782	2012	2256	2513	2784
8.0	116	184	265	362	473	600	741	899	1071	1258	1460	1675	1905	2151	2411	2697	2977
9.0	124	195	273	384	502	636	787	953	1136	1335	1549	1777	2021	2282	2558	2850	3158
10.0	130	206	294	404	529	670	829	1005	1197	1408	1632	1872	2130	2405	2696	3004	3328
11.0	137	216	311	424	555	703	870	1054	1256	1475	1710	1964	2234	2522	2828	3151	3491
12.0	143	225	325	443	582	735	908	1101	1312	1541	1787	2051	2333	2635	2954	3291	3646
13.0						765	945	1146	1365	1603	1860	2135	2429	2742	3075	3426	3795
14.0						793	981	1189	1416	1664	1929	2215	2520	2845	3190	3554	3938
15.0						831	1015	1231	1466	1722	1997	2293	2609	2945	3302	3679	4076
16.0						848	1049	1271	1514	1779	2063	2368	2694	3042	3411	3800	4210

7.3.3

Couplings

Quick couplings: 2" and 3" for hoses



Dividing coupling: 3" - 3" + 2" - 2" quick couplings



Forest fire couplings: 3" - 2"



2" - 2" quick coupling



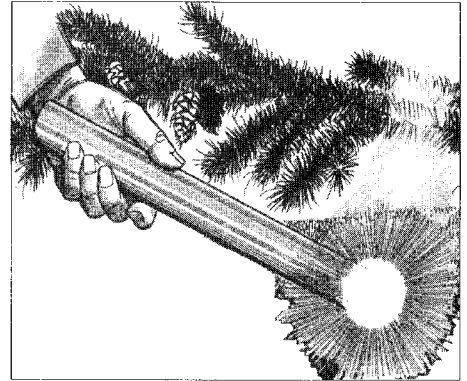
7.3.4 Firing devices

Fusees

Fusees are produced in three to ten and twenty minute burning periods. They are self-contained and are started by striking the primer against the safety cap. They should be stored in a metal container in humid climates, or otherwise they will become soft and mushy.

Dispose of the remains so that livestock cannot eat them; they are poisonous to livestock.

Fusees are good firing devices and require relatively small investment.

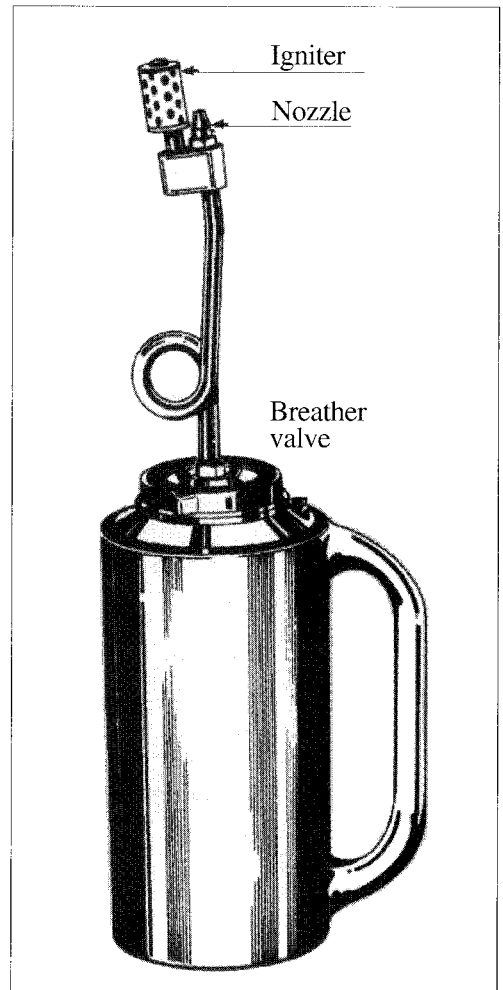


Drip torches

Sometimes referred to as a backfire pot, the drip torch is efficient, safe, and simple to operate. It is designed for firing semi-dry fuels that ignite slowly; when the burning oil is dripped onto the fuel, the operation can proceed without waiting for the fuel to ignite. Drip torches can fire a large area in a short time. These torches are equipped with a fuel trap on a spout to prevent flashback into the joint and a check valve in the cover to provide double protection against flashback. A breather valve, oilproof gasket, and sealed outlets prevent the slopping of fuel. They will operate best with a mixture of $\frac{1}{3}$ gasoline and $\frac{2}{3}$ diesel oil.

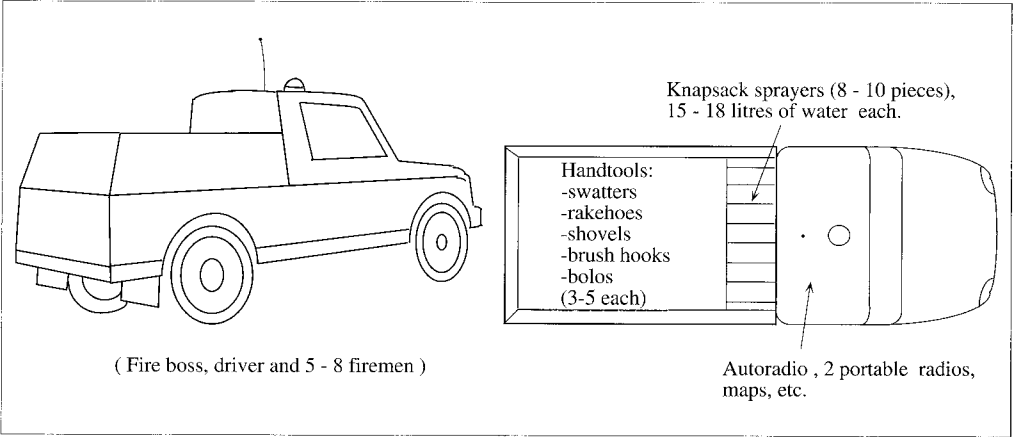
The torch should not be filled near an open flame or hot embers or while anyone is smoking, as the empty tank contains vapours that may explode. To operate, the torch is tilted forward until fuel flows over the burning igniter and the flaming oil is spread parallel to the direction of travel. To gain range, the torch is swung forwards and terminated with a snapping motion of the wrist. The igniter must have completely cooled before putting it out of service. Vehicle brackets are available for transport.

The drip torch is used to fire semi-dry fuels that are slow to ignite.



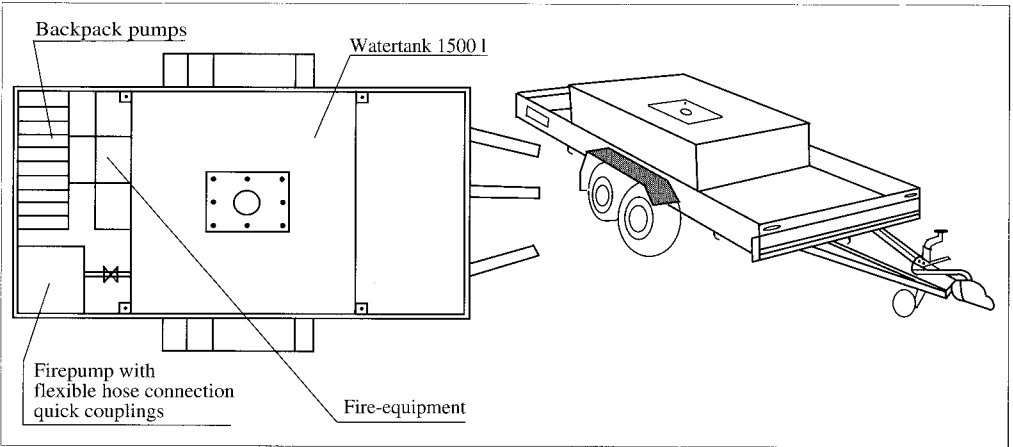
7.4 Fire Apparatus

7.4.1 Patrol or pick-up units



Tank-units designed for wildfire use are much less costly , better adapted to wildfire use, and more mobile than the standard fire department apparatus. Garden hose streams and adjustable garden hose nozzles or tips with quick shut-off are most often used on patrol tank units.

7.4.2 Fire trailer units



Fire trailer units consist of a trailer, watertank, portable fire pump, fire equipment, backpack pumps, and hand tools. Fire trailer units must be loaded and the water tank filled with water in high danger periods. Fire trailer units can be pulled with 4-wheel drive jeeps, trucks, or tractors.



4 x 4 bush fire vehicle used in NSW, Australia

Pumpers for wildfire use have needs and characteristics distinct from those used in the regular fire service. Municipal pumpers can be and are used on wildfires, but they are most effective on structural fires. Because of their cost and high-volume capability, they should not be used on wildfires except as a last resort or backup to wildfire-type pumpers. Use of high-cost pumpers in off-the-road service is seldom justified.

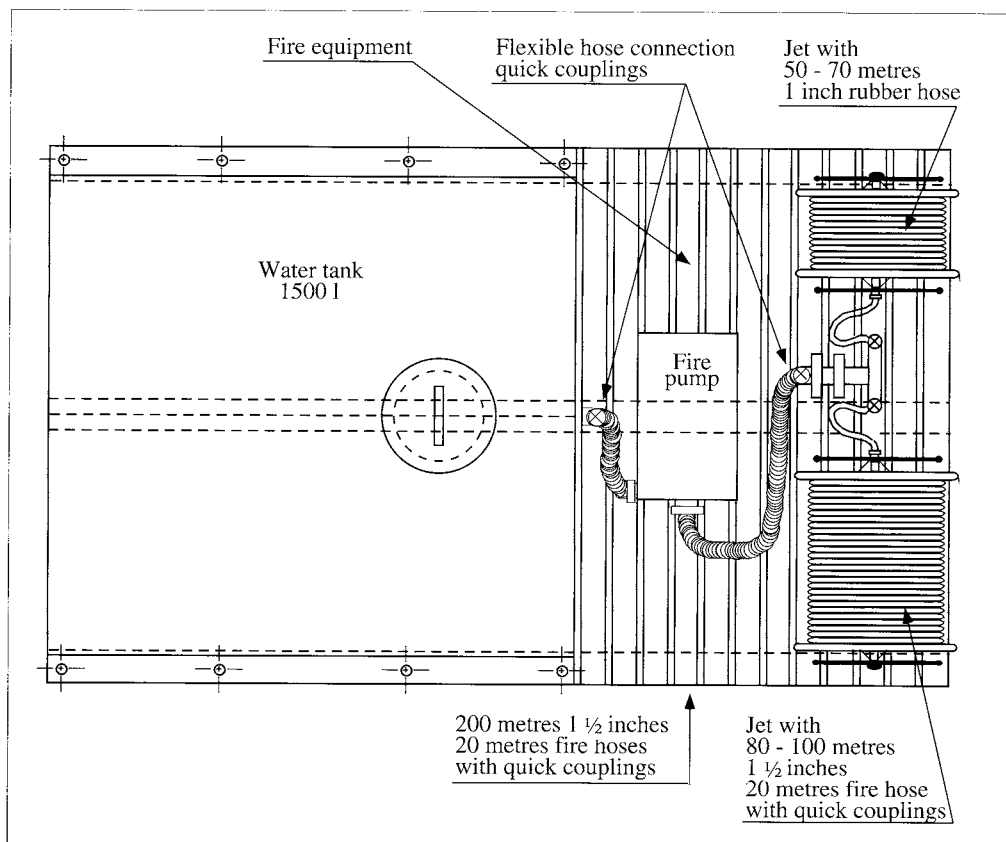
Wildfire pumpers need not discharge large volumes of water under most conditions. Volumes of 50 - 150 litres per minute are adequate for wildfires. However, the ability to produce larger volumes of 500 - 1000 litres per minute is also needed on structures exposed by wildfires.

Wildfire pumpers need not discharge large volumes of water under most conditions. Volumes of 6 to 30 gallons per minute (gpm) are adequate for wildfires. However, the ability to produce larger volumes up to 250 gpm is often needed on structures exposed by wildfire. The latter capability is desirable if it can be afforded, but would require a high-volume pump in addition to the wildfire pump.

Wildfire pumpers are operated off the road and must be constructed for this use. The all-wheel drive trucks are favourites for this reason. Excellent pumpers have been built on surplus military vehicles such as jeeps and four-by-four and 2 ½-ton six-by-six trucks. The commercial four-by-four trucks should be considered if the military vehicles are not available. A pumper designed for wildfire use is much less costly, better adapted to wildfire use, and more mobile than the standard fire department apparatus.

7.4.4

Slip-on units



Slip-on units are self-contained and can be removed from the truck chassis without disturbing the plumbing. The tank, pump, and plumbing can be either a slip on type or an integral unit. Usually, the removal of a few anchor bolts is all that is required. The usual size varies from 200 - 2000 litres. The tank capacity should be compatible with the size of the truck chassis. Overload should be avoided for safety as well as for maintenance reasons.

Slip-on units can be of any convenient size but the total weight with water, men, and equipment must not be more than the carrying capacity of the vehicle. Loading is from a ramp or gantry. This tank is useless without a vehicle so it must be kept loaded in high danger periods.

7.4.5

Tanker units

Tankers are primarily considered water supply vehicles for pumpers. They may or may not have a pump on board. The pump may be only capable of drawing and transferring the water, or it may have some capability of wildfire attack.

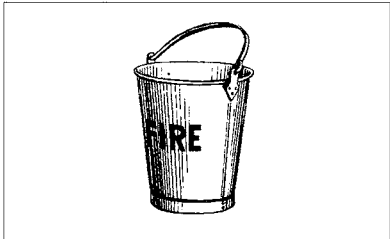
Tankers maintained for fire use only may vary in capacity from 2000 to 20000 litres. The larger semitrailer tankers are stationed in strategic locations where they can reinforce several fire control units.

7.4.6 Fire bucket and portable water bags

Fire buckets

Fire buckets can be made of textile, plastic, or metal, and be painted in a red colour and marked “FIRE” with black letters.

The capacity of a fire bucket is 15 litres.

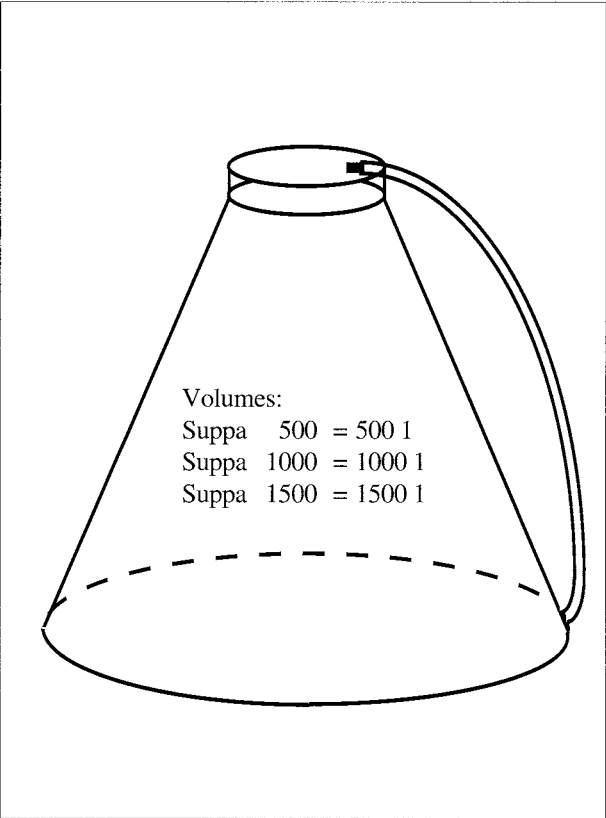


Portable water bags (Suppa bags)

Suppa bags are made of artificial fibre-reinforced, oil-resistant PVC fabric. When empty, the bags fold into a small space. Each bag has a discharge tube at the bottom (1" plastic tube) for filling backpacks with water and for other water supply.

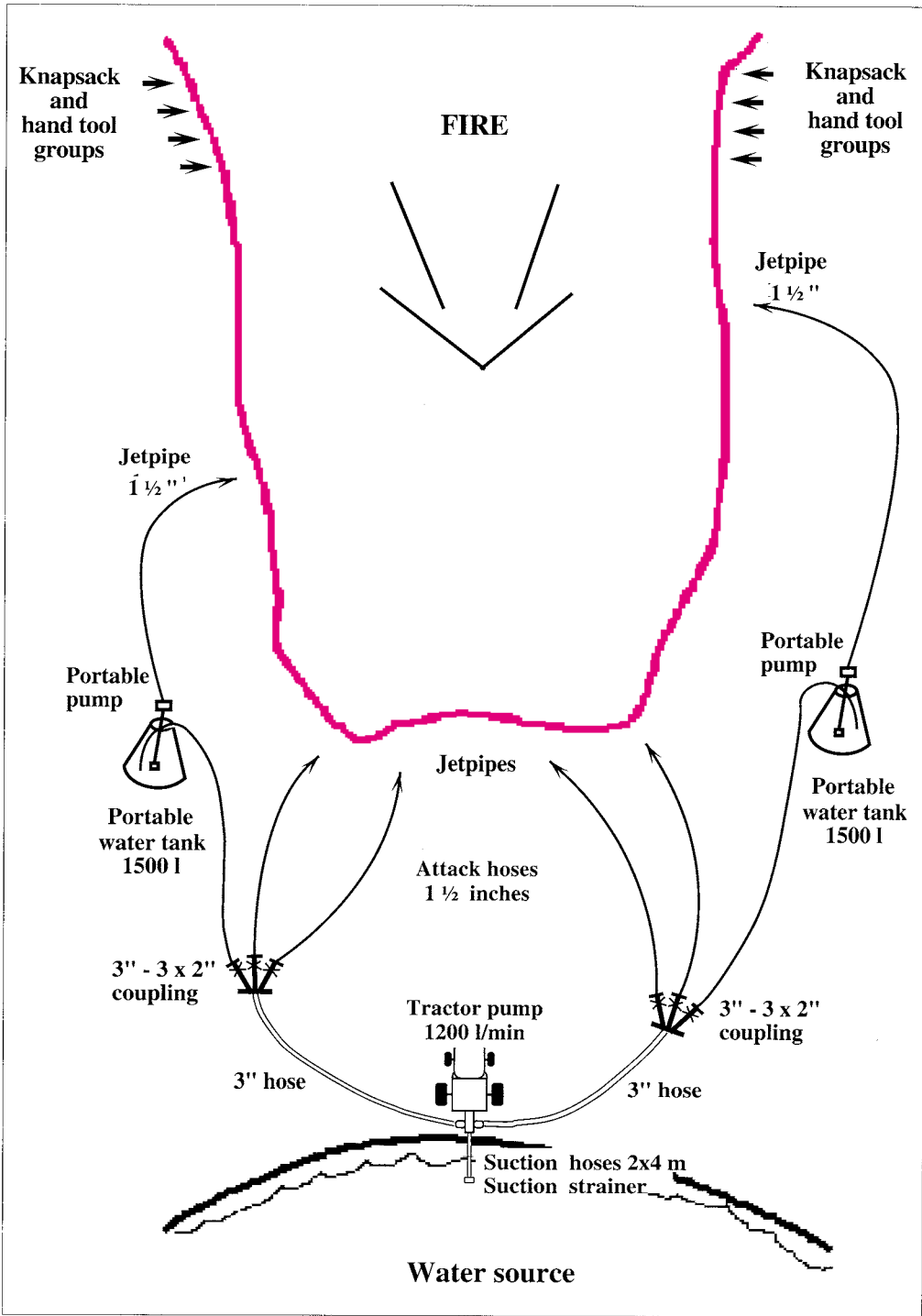
Portable water bags are used in forest fires and oil spills, irrigation work, and for temporary water storage. When used to collect oil from water, the bag is filled with the contaminated water and then allowed to stand until the liquid separates.

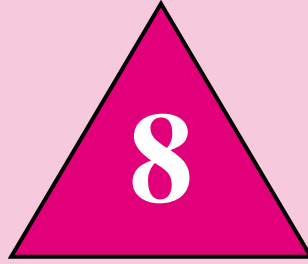
Suppa bags have a large capacity but are extremely lightweight and take up a minimum of space. The water is then released by means of the discharge tube. Thanks to their conical shape, Suppa bags require no supporting structures.



7.5 Coordination of forest fire equipment

An example for the coordination of handtools and light mechanized motor pump groups in grass or bush fires and in minor forest fires is given below. Water use is 500 - 1000 l/min.





SUPPRESSION TACTICS AND TECHNIQUES

8. SUPPRESSION TACTICS AND TECHNIQUES

8.1 General

Suppression means all the procedures which start on, or after the fire alarm. The main objective of the suppression activities is to extinguish the fire. Suppression procedures can be divided into two main parts, suppression tactics and suppression techniques. Sometimes it is difficult to separate these two main parts of the suppression procedures. In practice the tactics and the techniques must go 'hand in hand'.

Definition of terms

Tactics - A method of skilful procedure according to plans, using manpower and equipment in the right place and at the right time. Tactical ideas involve large forces. It is necessary for tactics to be flexible within the fire situation. Quick and effective use of information from fire scouting is the basis of tactics.

Technique - The knowledge of the technical methods used in different fire situations. Knowledge and use of the different tools, equipment, and extinguishing techniques.

Fireline - The line around an actual fire that is cleared by men or machines. It does not include live barriers. The fireline, or the line, is usually built by removing all the vegetation and burnable material from the top of the ground so that the mineral soil is exposed. The line may also be made by using a water spray to wet the fuel in a strip of adequate width in those areas such as grass, crops, short brush, leaves, needles, and weeds.

The required clearing width of the line will depend on the kind of vegetation, the topography, the burning conditions, and the location in relation to the spread; that is, along the flanks or in front of the fire. The line may vary in width from an ordinary narrow cattle trail in light grass, to several bulldozer blades wide in a tall timber forest.

The fireline (in the soil), normally about half a metre wide, is usually made with hand tools, unless bulldozers, scrapper blades, ploughs, or other suitable earth moving equipment is available. Water spraying is most effective in light flashy fuels where the topography is such that the pumps can be driven along the burning edge. In all these cases the main objective is to keep the fire inside the fireline until control is certain.

The main meaning of the term 'fireline' is - an obstruction line built during a fire in order to encircle it.

Sometimes, the fuelbreaks which are prepared inside the protected forest before the fire danger season are also called 'firelines'.

Natural barrier - Any area within a forest where a lack of non-flammable material obstructs the spread of forest fires.

Control line - A comprehensive term for all fire barriers and treated fire edges used to control a fire. It includes natural barriers and hand or machine built lines that totally encircle the fire area.

Fuelbreak - Generally a 20 - 300 m wide strip of land on which the natural vegetation has been permanently modified so that fires burning into it can be more readily controlled. Some fuelbreaks contain other narrow firebreaks such as roads or hand-constructed lines. During a fire these firebreaks can quickly be widened, either with hand tools or by firing-out. Fuelbreaks have the advantage of preventing soil erosion, offering a safe place for the firefighters to work from and giving low maintenance costs and a pleasing appearance. Preparing fuelbreaks is part of the pre-suppression operations.

Fire-break - Any natural or constructed line which removes the fuelbase in order to separate and stop the spread of the fire, or to provide a control line from which to suppress the fire.

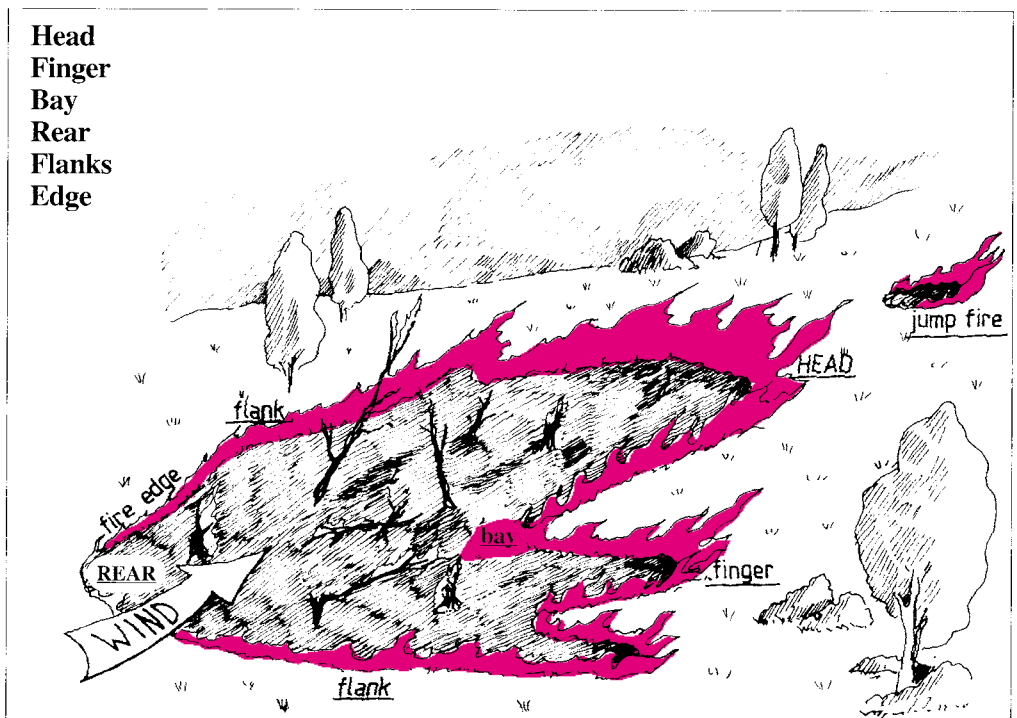
Backfire - A fire that is deliberately started along the inner edge of a control line in order to consume the fuels in the path of a forest fire, and/or to change the direction of the fire.

Burning-out - Also called firing-out, or clean burning. This means setting fire inside the control line to consume fuel between the edge of the fire and the control line.

Backburn - Any prescribed fire burning against the wind.

Backing fire - Generally a fire front spreading against the wind. A fire spreading on level or downward sloping ground with no wind is also called a backing fire. This process is called 'fighting fire with fire', and requires a control line around the intentionally burnt area so that the set fire can be controlled.

Parts of a wildfire - As illustrated in section 5.7 of this book the part of a wildfire are as follows:



8.2

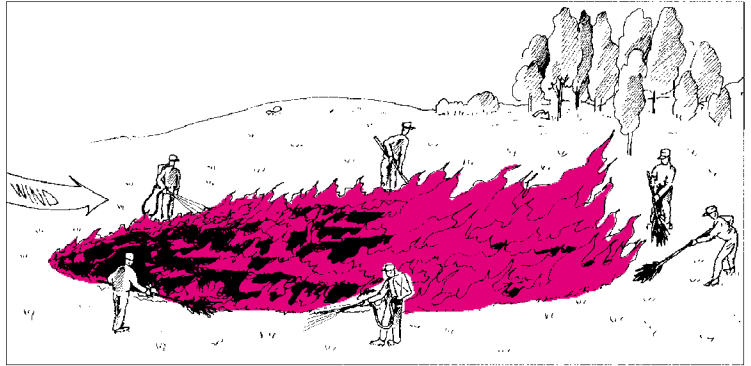
Phases of Wildfire Suppression

During every wildfire there are generally three phases of suppression action, especially in large fires. In small fires these three phases go on at the same time.

The three phases are:

Phase (i) - Attack

- Cut-off and / or restrict the fire.



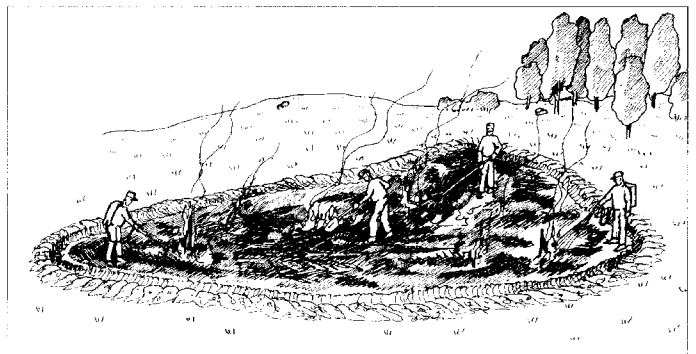
Phase (ii) - Encircle

- Surrounding the fire with the control line.



Phase (iii) - Mopping-up

- Mopping-up the fire.



In phase (i) a lot of knowledge is needed about fire suppression tactics.

In phases (ii) and (iii) a knowledge of fire suppression techniques is required.

In phase (iii) enough equipment and effective patrolling are required.

8.3 Tactics

8.3.1 Rule of thumb tactics

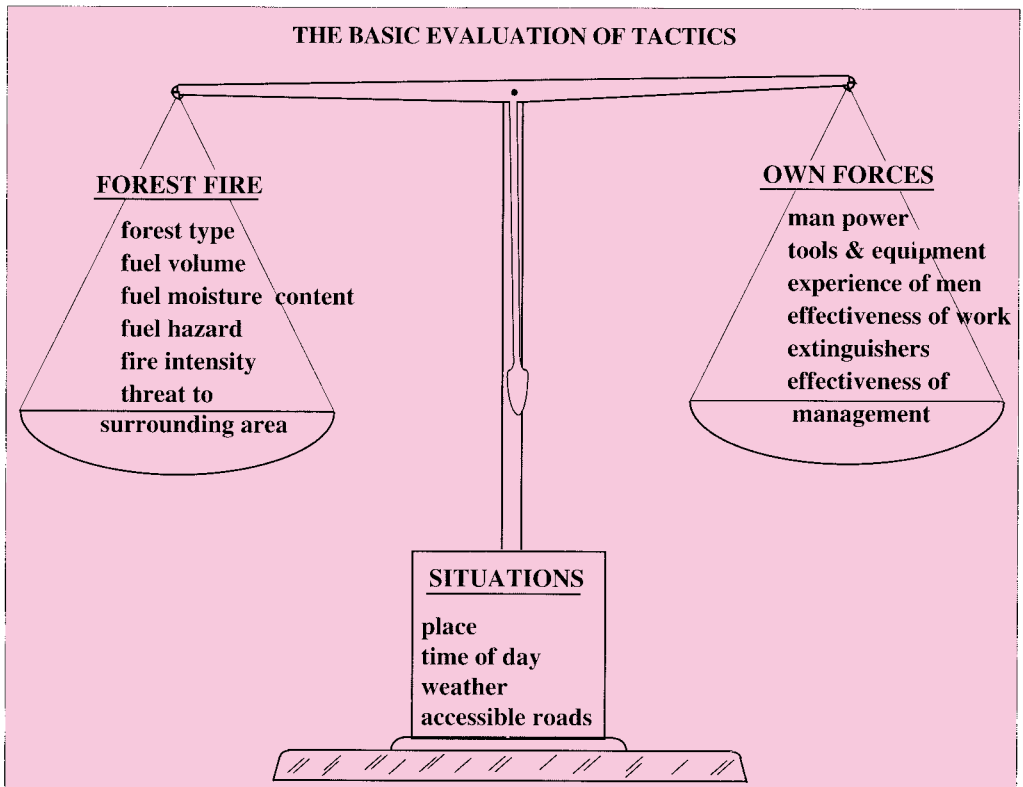
- Clear up all situations yourself.
- Use mainly simple methods.
- Try for the best results using the forces available at hand.
- The fire suppression forces should be concentrated on the most critical points.
- Continuous scouting and follow-up suppression work must be carried out.
- Prepare at all times for quick action on a critical area.
- Learn to use the weather and the terrain successfully.
- Management should continuously plan to prevent further outbreaks of fire.

8.3.2 Basic rules of fire suppression tactics

The basic rules for fire suppression tactics are:

- Ward off the greatest threats first.
- Cut off the fire at the place where the threat of spreading is greatest.
- Surround the fire area.
- Take care to avoid accidents.

In the basic plan for starting fire suppression tactics the fire chief should continually think of the tactics as being a balancing act.



8.3.3

Sizing-up

Size-up is the evaluation and estimation of a fire by the officer in charge to determine a course of action for suppression of the fire. It is the first action upon arrival at the fire.

Actually, the sizing-up begins on the way to the fire, as soon as the smoke is seen and the location determined.

Size-up is the estimation of the conditions so as to arrive at an opinion. It is a continuous action through an ever-changing situation. It is a constant process which starts from the time the alarm is received to the time the fire is completely under control. Wildfire control is largely a process of problem solving and decision making.

First of all, the problems must be analysed by taking into consideration all the facts and conditions that can be seen or determined.

Secondly, on the basis of the analysis and the expected fire behaviour, a course of action must be formed to control the fire.

Thirdly, instructions must be given to those who will do the control work.

Fourthly, follow-up operations are necessary to make sure that the correct action has been taken.

Scouting of the fire and its immediate surroundings is necessary in order to gain an appreciation of the situation. If the fire is relatively small the appraisal can be done in a short time, on the way to the fire or while the fire crews are unloading. Later on, as more information is gained it may be necessary to change the plan. If the fire is larger than the initial attack-crew can handle work must start on those locations where most loss can be avoided, or where the spread can be checked. If reinforcements are necessary, make the request as soon as possible so that they will arrive in time to be the most effective.

Sizing-up the situation is of great importance because it provides essential information and develops a definite plan of action for effective control. Without a reasonable size-up the attack may be completely ineffective.

Knowledge of fire behaviour is a basic requirement when sizing-up. If someone has a lot of experience of forest fires and fire behaviour they are able to make an accurate and prompt size-up. They must analyse the fuel, weather, and topography, and how they will affect the behaviour of the fire.

The following are important points when sizing-up the fire itself:

- (i) Analysis of the fire.
- (ii) Fire location.
- (iii) Safety (hazards to life).
- (iv) Resources available.
- (v) Calculation of probabilities.
- (vi) Plan and execution of control.

8.3.4 Analysis of the fire



The following questions on the behaviour of the fire should be answered:

- What is the direction of spread?
- Is the wind steady, or gusty and changeable?
- What is the shape of the fire area, its size, and its length?
- How intense is the burning and rate of spread?
- Are there fingers or danger spots that need immediate attention?
- Judging from the smoke, what is the direction and the speed of the wind?
- What is the fire weather forecast?
- Is the fire starting or slowing down? White or grey coloured smoke will indicate this.
- What kind of fuel is adjacent to the burning area, and ahead of it?
- Are sparks causing spot fires?
- Can anything be done to stop the spot fires?
- What is the main fuel and how does it burn?
- What is the topography?
- How will it affect the spread of the fire?
- Where is there access to the fire edge?
- How many natural barriers can be used?
- What length is the perimeter of the fire estimated to be?

8.3.5 Safety (hazards to life)

Hazards to life are the first priority in any fire. If buildings are threatened with fire, or if it can threaten to spread to buildings, they have to be evacuated. It must be checked whether there are any other areas where there could be a fire hazard, such as a camping site. Also, any hazards to the firemen, such as steep slopes, blind areas, rolling rocks, falling snags, and power lines must be checked for.

Furthermore, what additional information is needed? Where should scouting be carried out? What is the intensity and spreading speed of the fire?

8.3.6 Threatened property and some tactical advice

After the hazard to life has been determined, property, buildings, non-flammable storage, livestock, and so on have the next highest priority.

If the fire is beginning to start spot fires in the forest, extinguish them and then concentrate on the buildings. Keep a sharp look out for spot fires. If the wildfire is burning in a uniform fuel and at a constant speed towards the property, and if it is probable that it cannot be controlled before reaching the property, concentrate on saving the property.

Prepare a fireline around the buildings facing the fire. The distance will depend on the type of fuel and the effects of heat radiation. If possible, wet down the roof and walls of the buildings just before the first rush of heat reaches them. Consider burning back from the line towards the fire if circumstances are favourable and if the spot fires can be controlled.

8.3.6 Resources

The resources available to control the wildfire are an important factor in sizing-up the operation. Before a fire suppression tactical plan is made it must be known:

- How many firefighters are available for assignment?
- What kind and amount of equipment is in use, or can be assigned?
- Accessibility of the fire and the condition of the roads?
- How many and what type of reserves are available, and when can they be expected?
- What is the time of day and expected diurnal changes in relation to the size of the fire suppression work?
- What are the natural barriers and sources of water that can be used?
- What communications are available?
- Are maps or aerial photographs available on which to plot the fire and control strategy?
- What are the environmental considerations?

8.3.8 Situation evaluation (calculation of probability)

There are a variety of methods that can be employed to control a wildfire. To calculate which will be the most effective in a specific situation, the rate of spread must be determined, the type of the fuel must be classified, the size of the fire must be estimated, and the needs of the line control forces must be determined.

The weather, time of day, and time of year are also factors in control planning.

Water is of course the best and most effective control method if it is available and can be applied with reasonable efficiency. In the majority of locations, handtools are the most useful method of building the fireline. The use of handtools is best restricted to daytime use, while machines are best worked at night time. Earth-moving equipment, such as a bulldozer, is very productive, and usually efficient if available and possible to apply. However, earth-moving equipment still has to be followed-up by manual labour and may cause more damage than is justified. Normally, during the daytime, when the fire behaviour is difficult to assess and the fire is spreading rapidly, it is a risk to move any heavy machinery too near to the fire perimeter.

If possible, natural barriers should be used so that manpower and equipment can be applied to those sections where they can be most effective. Use all the forces available to get the situation under control quickly and efficiently.

The best advice for any particular area can be obtained from a local forester who is working in the area daily.

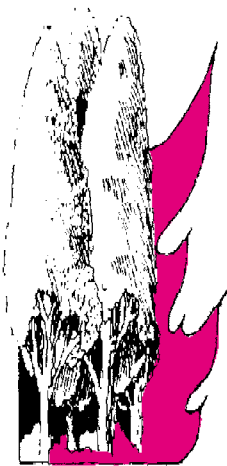
One of the most important factors in the evaluation is the estimation of time. At all times, estimations and calculations must be carried out in order to assess the fire fighting progress and the spread of the fire.

8.3.9 Rate of spread and height of flame

In some countries, the general rates of spread for different fuel types are classified as low, medium, and high. The rate of spread depends on the:

- quantity of fuel;
- type and dispersal of fuel;
- fuel moisture content;
- wind velocity;
- degree of slope; and
- weather conditions.

Timber



Brush



Grass



8.3.10 Size of the fire

If the fire is small, the perimeter can be walked around and an accurate estimate of the area can be made. If the fire is large, the sizing-up should be done by scouting. After the size-up operation you must be able to estimate any increase in change per hour, and at the same time estimate the control time.

8.3.11 Priority of control action

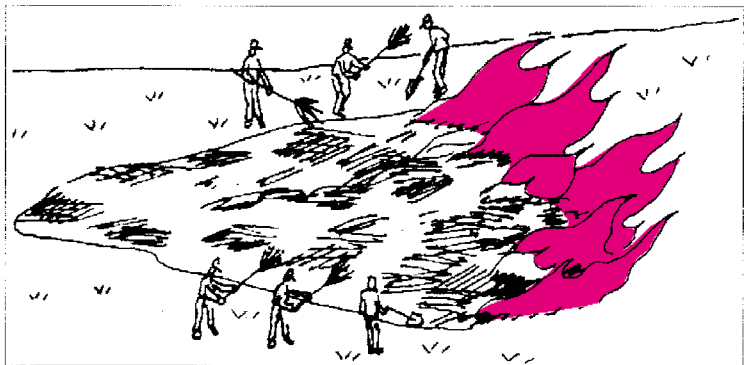
Some factors to be considered when deciding priority action are to:

- evaluate the hazard to life;
- estimate property values;
- estimate the relative value of the ground cover and / or resultant damage;
- cut off the fire from the most dangerous fuels;
- cut off the fire spreading on the head, or try to confine it by surrounding the fire with a fireline;
- make all the work contribute to the final control by becoming part of the final control line or by delaying the spread until the final line location can be built;
- use equipment in areas that are too hot for manpower, or where it can be used effectively;
- provide a line of retreat; and
- estimate the relative cost of control and evaluate any alternative action.

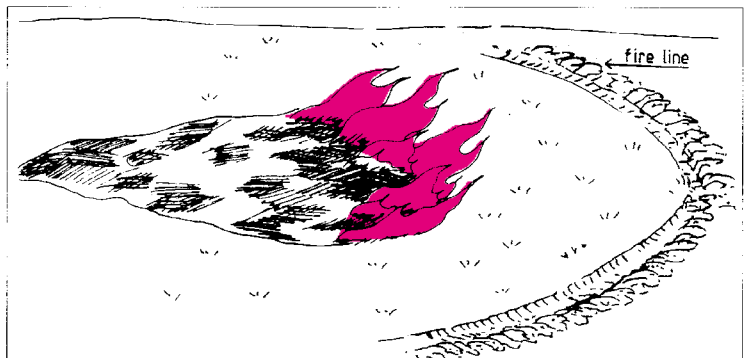
8.4 Methods of Attack

There are two basic methods of attack.

Direct - fighting the fire itself directly on the edge by using a water spray, throwing soil, using beaters, or building a line down to the mineral soil and throwing the burning edge into the fire, and then widening the line as necessary.

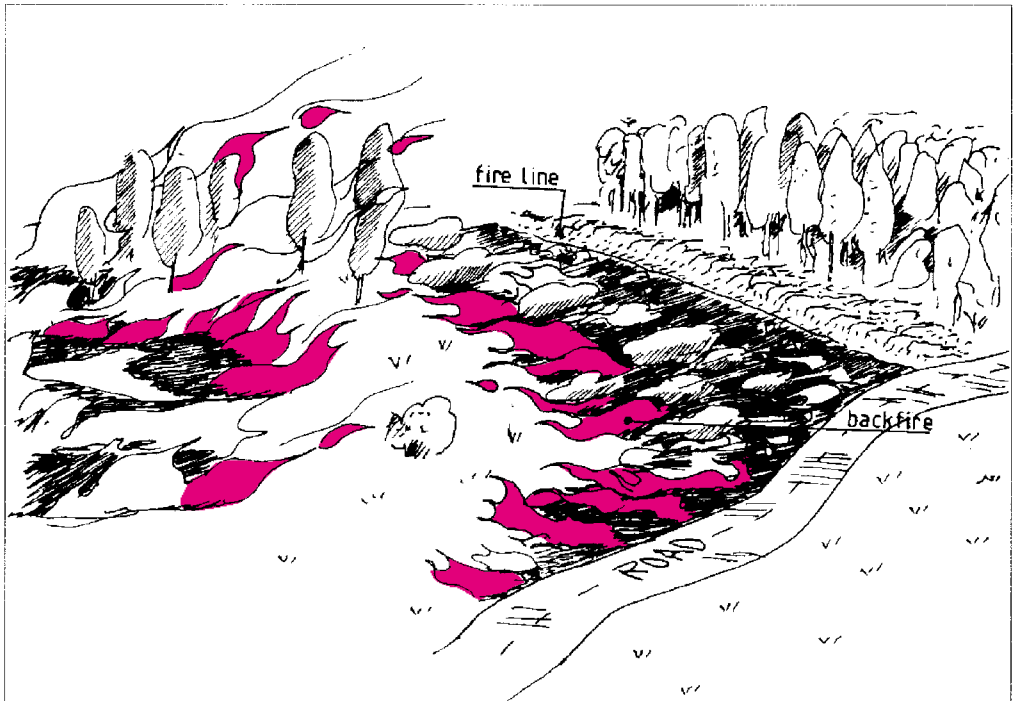


Indirect - building a line some distance from the edge of the fire, when the fire is too hot to fight directly.

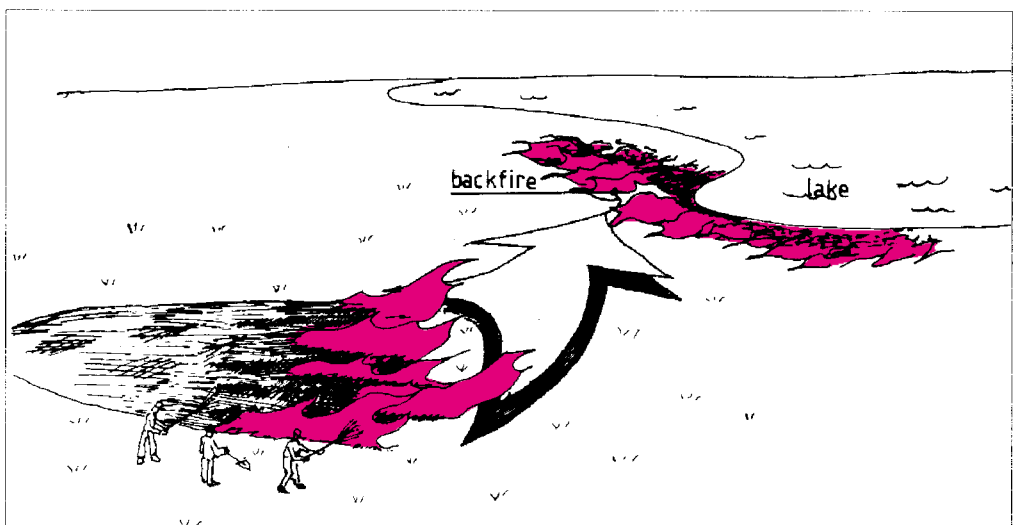


In addition, there are several variations and some combinations of these basic methods.

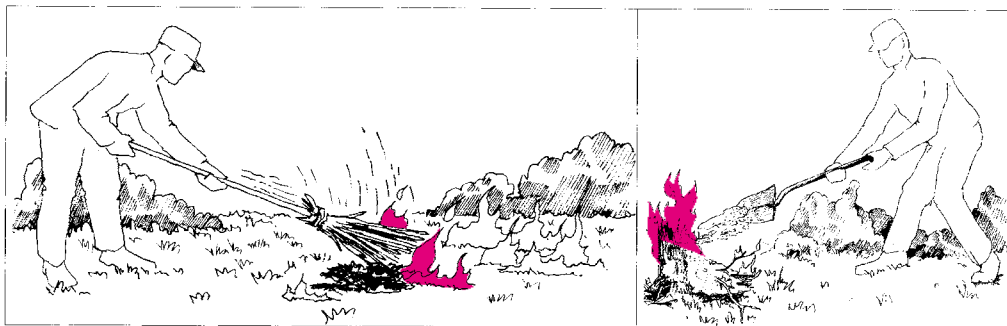
(i) **Fighting fire with fire.** Sometimes called backfiring. Fighting fire with fire is hazardous and complex. It should be used only by experienced fire fighters, and only as a last resort.



(ii) **Moving the direction of spread of the fire.** It is possible to stop the fire at a natural barrier some distance in front of the fire by altering its direction.



(iii) **Drowning the fire.** If the topography of the land permits, make the water source run down and cover the fire. This method is sometimes used on peatland fires.



(iv) **Initial attack.** The initial attack will be done as soon as possible - day or night. The first objective of the initial attack crew is to bring the fire to the state of “being held”. With a few exceptions the “kill as you go” technique is not acceptable as the rate of line construction is often much slower than the rate of growth of the perimeter. Only sufficient work is done on the first pass to hold the fire’s advance until the crew can return and affect the final control. A succession of passes is usually required before final control is attained.

The overall objective is to bring the fire under control, only mopping-up and patrolling work remaining during the first burning period (before 10 am on the next morning).

8.4.1 Direct attack

Direct attack is used mostly on ground or surface fuels, such as grass, brush, duff, underground fires, or on the flanks or rear of large fires. It is also used in the later stages of a large fire, and on any fire where the burning intensity, heat, and smoke are not too much for the fire fighters to work on the fire edge.

Direct attack is commonly used on the head of smaller fires, and on the flanks or rear of large fires where the heat intensity is such that the fire edge cannot be worked directly. It is also used on most grass fires, of any size, where pumps can be applied directly.

If the fire is small, and if the head can be attacked with safety, the control action is applied at the head first. After this both flanks can be attacked from head to rear. When the head is spreading fast and it is unsafe to get in front of it, the best method is to flank the fire on one or both sides. This method is used like a pincer movement, eventually cutting off the head.

The pincer action is normally done on both sides of the flank at the same time. However, sometimes topography, vegetation, or resources will determine that flanking can be carried out on only one side. After the head is cut off, and most of the spreading is stopped on the flanks a secure line must be prepared along the flanks. When this control line is established, mopping-up, spot fire control, and patrolling must be started in order to complete the operation.

8.4.2 Indirect attack

With the indirect method the line is located some distance from the fire's edge. How far it is located from the fire is of prime importance. All the factors of fire behaviour must be used in making the decision. Since the intervening material must be burnt out, the line must be located where it will be effective when the fire reaches it. The intervening area must be kept as small as possible so that no more is burnt than is necessary, otherwise the fire can build

up enough to jump the line. The right location can only be decided by experience and judgement.

The line must be wide enough so that the radiant heat developed by the type and amount of fuel inside will not ignite fuels outside the lines.

The primary factors of line locations are the:

- ability and efficiency of the line workers;
- time of day;
- intensity of the burning;
- speed and strength of the wind;
- topography and the degree of slope; and
- vegetation cover.

Since the indirect method is used where the fire edge is too hot to approach directly, it is the method that is most used on large fires and at the head of hot, fast running fires. It is also the method that is most used in the high fire danger classes.

The indirect method is often combined with the direct method in total line construction. The indirect method may be used during the time of day when the fire danger conditions are highest. When the conditions get easier, the attack may return to the direct method.

With the indirect method, the line is built some distance away from the fire's edge.

The main variations of the indirect methods are as follows.

(i) Surrounding / parallel method

With this version, the fire line is built about 0,5 - 10m from the fire edge. The distance away from the fire edge will depend on the fuel, the intensity of the fire, and the topography. In some cases the line can be built along one flank. The fire lines must be joined to a secure anchor point, such as a forest road, a stream, lake, or swamp. In any indirect line construction the intervening space between the line and the fire edge should usually be burnt-out to secure the line. This is called burning-out, in contrast to backfiring. Burning-out on the flanks is not nearly as hazardous as burning-out from a line in front of the head of the fire.

Because of the many combinations of conditions, a wide variety of methods are possible with the indirect method of attack.

(ii) Hot spotting, or point and cut off technique

This is a combination method that could be used in both the direct and indirect attack. In practice this method means that all the fingers of the fire are attacked first, and also the so called hot spots along the fire's edge by constructing part of the line across those edges that are burning faster.

Rule of thumb

The most effective place to stop a fire is at the advancing flame edge.
However this may not be practical or possible in many situations.

8.4.3 Burning methods

8.4.3.1 Burning-out or clean burning

Burning-out is one part of line construction. It consists of starting a fire along the inside edge of the control line so that the fuel in the area between the fireline and the fire edge will be burnt.

Pockets and islands should be burnt-out after the line is built so that they do not pose a threat of spreading at a later time. This burning forms a wider barrier to the spreading main fire. The burn-out can be started with a torch, or by pulling burning material along with a rake. If the burn-out is patchy and not complete it may be more hazardous at a later time when burning conditions increase.

On hillsides, the burn-out should start from the top and work downwards.

The burning-out procedure must be determined by:

- The type of fuel, particularly in relation to several storied fuel.
- The ability to obtain a clean burn.

The hazards relevant to clean burning are such things as snags, piles of heavy ground fuels, live trees with branches extending to the ground, and trees covered with moss. These must be removed and broken up.

8.4.3.2 Backfiring

Backfiring is one form of the indirect attack method. This method is normally used against a rapidly spreading fire. Backfiring is the process of intentionally starting a fire inside the fire edge or fire barrier in advance of a fire head, or along the forward flanks.

The person in charge of backfiring must have a lot of fire fighting experience.

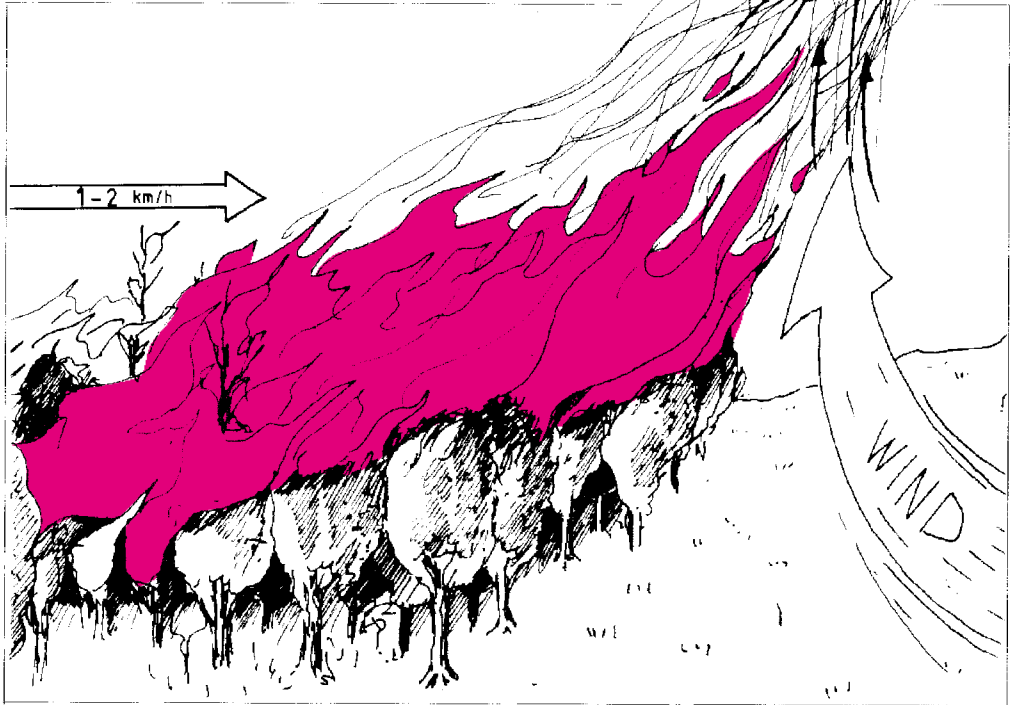
Backfiring means that the area between the control line and the fire head is burnt-out to eliminate all the fuel in front of the fire. This will widen the control line, change the direction of the fire, or slow the progress of the fire in order to gain time for line construction. The backfire is usually started a considerable way in front of the fire head. It is important that the fire that is started can be controlled, and that any spot fires from it can be extinguished quickly. There is no need to use backfire tactics on small or ordinary fires.

Organisation is of great importance. One qualified person must be responsible for controlling and directing the backfiring operation. On small fires the backfiring operation will be done under direct instructions from the fire chief. In large fires, the fire chief would delegate the operation to a qualified crew chief, or sector head of the sector involved. Constant communication between the person in charge and the fire crews is necessary.

In backfiring it is best not to use large crews as it is often difficult to control them.

Timing is another important factor in backfiring. The right time to start the backfire will depend on the:

- fuel;
- weather;
- resources of the crews;
- speed of spread of the main fire; and
- topography.



If backfiring is started too late it could result in an unsatisfactory burn. In large fires the best estimate and location of the backfire would be obtained from an aeroplane or helicopter flying over the area.

8.5 Factors Affecting Choice of Attack

Bringing a fire or part of the fire edge under control will depend on a number of factors, which can be determined after scouting the fire. These factors, which are also a check list for the fire chief before the start of planning the suppression tactic, are:

- (i) fuel - volume, size, type, arrangement, condition pattern, moisture content;
- (ii) topography - degree of slope, and aspect;
- (iii) wind - direction, velocity, effect;
- (iv) values to be protected - human life, property, natural and recreational, timber;
- (v) soil type;

- (vi) water sources;
- (vii) access to the fire - paths, forest roads, etc;
- (viii) available equipment;
- (ix) available manpower; and
- (x) fire behaviour at the fire site.

8.6 Suppression Techniques

Suppression technique means having a good knowledge of the methods of fire suppression together with the experience for selecting the right equipment.

8.6.1 The basic methods for extinguishing a fire

It should always be remembered that a fire cannot burn without HEAT, OXYGEN and FUEL in suitable combinations.

The extinguishing of a fire is therefore based on the removal of one or more of the three components represented in the fire triangle.

Extinguishing the fire can be done by:

- (i) Cooling - a method of extinguishing where the temperature of the fire is reduced to below the point of ignition. After cooling, the fire will not start by itself. In forest fires, cooling can be done by the application of water, and is called 'cooling the fuel'.
- (ii) Smothering - a method of extinguishing where the oxygen is removed from the fire. This can be accomplished in a forest fire by an application of sand or mineral soil, beating with the back of a shovel, or by swatting the fire with a firebeater. The fire is smothered by the sand or soil.
- (iii) Starving - a method of extinguishing where inflammable fuel is removed. In a forest the fire can be starved by removing the supply of available fuel, or by allowing it to burn into a natural barrier or fireline.

In a forest just one main method is normally used for extinguishing a fire, although several methods can often be used on the fire at the same time.

8.6.2 Equipment and techniques in use

Special information about forest fire equipment is contained in chapter 6.

A short summary of the equipment in use, divided into main groups is:

- (i) handtools and equipment for one person;
- (ii) large machines and earth-moving equipment;
- (iii) water suppression equipment; and
- (iv) tools for controlled burning.

In general practice, several tools and pieces of equipment can be used to combat the same fire.

What the best tools, equipment, and techniques are will depend on, among other things:

- (i) Type of fuel.
- (ii) Topography and situation (water sources).
- (iii) Fire intensity.
- (iv) Method of attack.
- (v) Manpower and experience.

8.6.3 Principal techniques for line construction

The fireline is constructed by a variety of methods, depending on the fuels involved, the available equipment and manpower, and the terrain.

The four principal techniques for fireline construction are as follows:

- (i) By using hand tools only.
- (ii) By using earth-moving equipment, which in this text includes bulldozers, trenchers, and ploughs. These must always be followed-up with hand tools, or water pumps where they can be used.
- (iii) By applying water from ground tanks, directly from the vehicle (pump and roll), or by laying hose lines. This type of fireline also requires follow-up action with hand tools. Light grass fuels can be mopped-up with just a backpack pump and shovel.
- (iv) By aerial application of retardants using helicopters or spray planes, followed up by ground forces using either hand tools, pumps, fire equipment, or any combination of these.

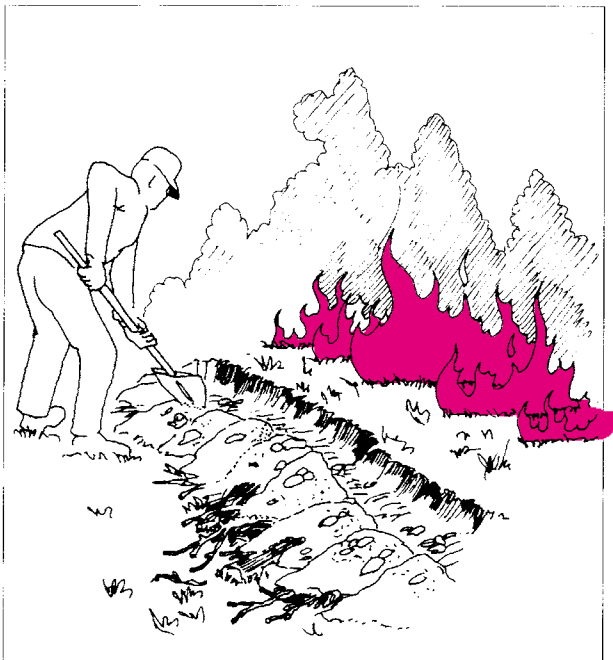
8.6.3.1 Line construction with hand tools

In the majority of wild fire situations, hand tools are the only means of attacking the fire. In some situations, the use of hand tools must be combined with other methods of attack.

The best way of using hand tools has been developed from experience of all kinds of fires throughout the world.

Different organisations may have different kinds of tools and ways of distributing them to the various sections, but the basic methods are the same.

The main hand tools are: axes, shovels, rakehoes, rakes, beaters, saws, and burning-out torches.



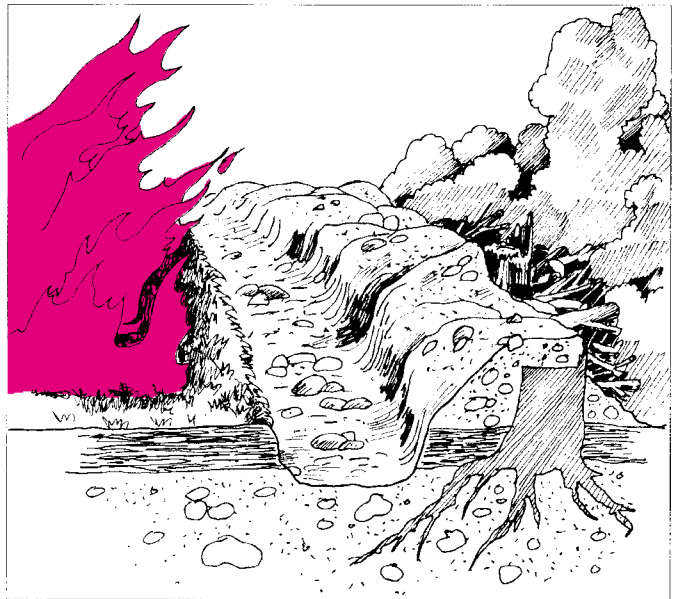
The hand tool crews start the line by cutting, fuel dispersal, scraping, burning-out, and holding. Later on their job is mopping-up and patrolling. In some fuels, all these functions are performed by the same crew as it works along the line. In general, the sector head is responsible for pointing out or locating the line.

Some good practices for line location and line construction are as follows:

- Locate the line so as to speed up the work, with the minimum of effort to the crew. Choose the best route for easy and fast construction.
- Avoid heavy fuel areas, and if possible keep them outside the fire area.
- Pick the easiest way through without having too much land under firelines.
- Avoid undercut lines as much as possible. Locate where burning material cannot roll across.
- Generally, try to avoid steep slopes and locate the line just over the top of a ridge rather than across the slope, except under low fire weather conditions or for other suitable reasons.
- When the indirect method is used, locate the line a good distance from the fire edge so that the line can be constructed and burnt-out before the main fire reaches it.
- Always anchor the lines to the best natural barriers, or to any immediately available control point.
- Take advantage of diurnal and predicted fire weather.

Any fuel material that is on fire must be thrown as far inside the line as possible, and must not be scattered. Avoid building up fuel concentrations inside the line.

In general, all the fuel removed from the line must be thrown outside the line, so that when the fire burns on the line the radiant heat will not ignite it. In some cases, the removed fuels may be needed inside the burning-out. In this case, the fuel is thrown inside the line, but avoiding bunches.



Rule of thumb

The width of the clearing should be at least half the height of the fuel.
Under some circumstances it may have to be wider.

The width of the line made by hand tools should be from 20 m to 50 m, depending on the fuel material, wind speed, and fire intensity.

The basic phases in line construction are:

- (i) line location;
- (ii) line clearing - cutting the trees;
- (iii) line digging - scraping down to the mineral soil;
- (iv) stopping the fire;
- (v) burning-out; and
- (vi) mopping-up.

8.6.3.2 Some special advice for line construction

The clearing of the line, (cutting standing trees and bushes, removing branches and logs) can be done by axe, brush hooks, hand (bow) saws, or power saws.

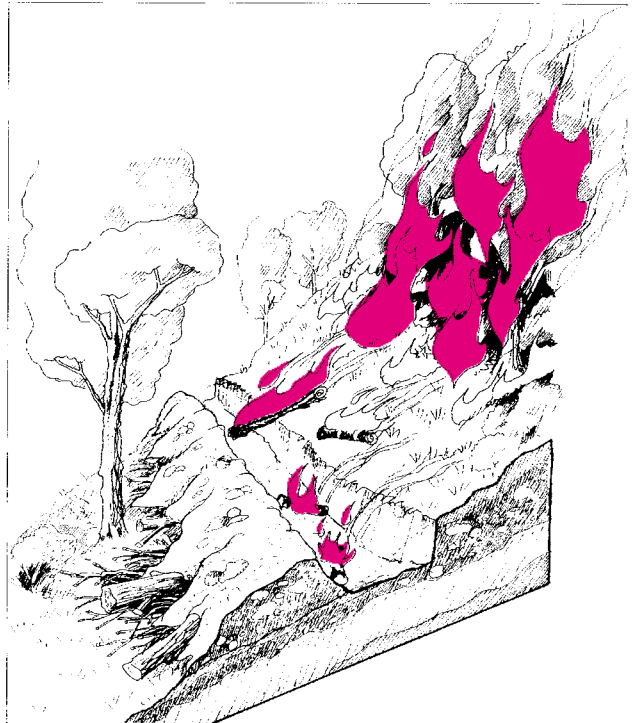
Line digging can be done by using an axe-hoe, hoe, rakehoe, shovel, or rake. The type of tools, or combination of tools, will depend on the type of fuel, amount of rock, and the type of soil. The line must be dug through the humus, right down to the bare mineral soil. All duff, litter, and humus from the digging must be removed to the outside of the line.

Burning-out can be one part of the operation in indirect attack. It is usually a critical operation that requires careful timing. The torchman follows the digging crew and must be ready to start the burning. He is usually assisted by men with shovels or backpack pumps, whose job it is to keep the fire inside the line. If the line is being built up a slope it should be fired downhill, against the line.

Full advantage should be taken of any winds blowing towards the main fire.

Undercut lines - where the fire-line must be built horizontally across a slope, and below the fire. It should be built as a trench or ditch to catch any rolling and burning fuel material from above. Pine cones and other pieces of burning material, even logs, often roll downhill as the fire burns around them, thus scattering burning material down the slope. An under cut line should be built as a deep trench that is well banked with earth on the berm and along its entire length.

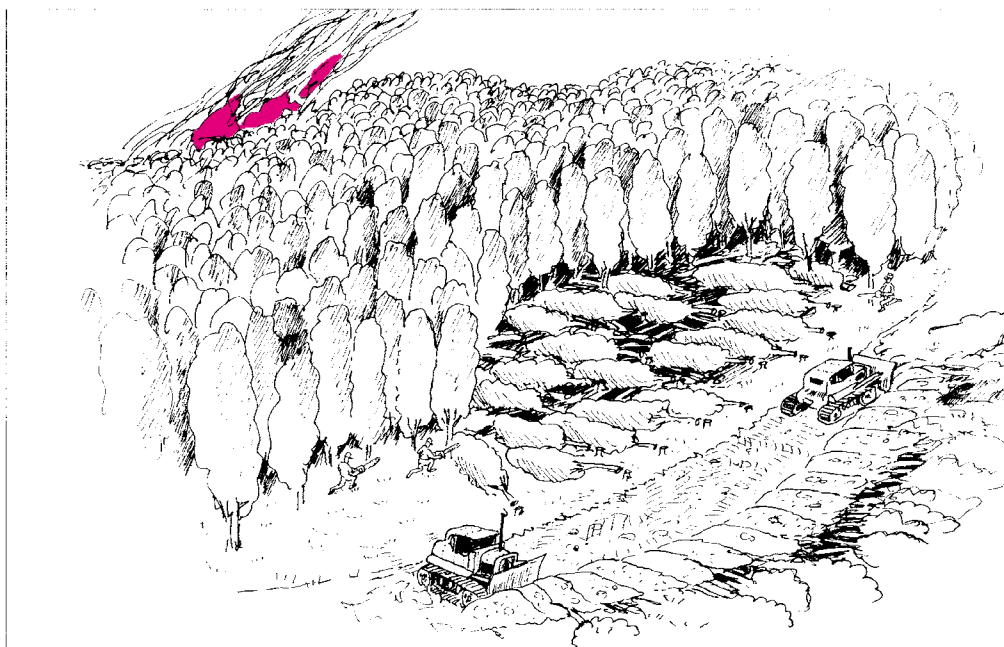
Logs, rocks, and any available material can be used to form the berm, but the surface should be of mineral soil. It should be deep enough to catch and hold any material that may roll into it.



Inflammable fuels outside the fireline which are not burning, such as rotting stumps, logs, and other material can be covered with mineral soil. Stumps and logs should be covered with enough soil so as to insulate them, or if possible, they should be wet down.

Ringing a snag tree - A snag tree is a standing dead tree, or part of a dead tree, from which the leaves and small branches have fallen. If the snag trees are inside and close to the line, but are not yet burning, and if there is insufficient time to fell them, the trees should be circled with a line and all burnable material removed from inside the ring. The circle should be at least 3 - 4 m in diameter, depending on the type and amount of ground fuel adjacent to it. This action prevents the snag tree from catching fire and throwing sparks across the line.

8.6.3.3 Line construction with earth-moving equipment



Bulldozers, fireline ploughs, and other heavy duty earth-moving equipment are extremely effective tools for building firelines, particularly in heavy fuels and brush. They must be followed by hand tools to finish the line, to burn-out where necessary, to hold the fire within the line, and to combat spill-overs and spot fires.

Once the fireline is built, it is necessary to begin the mopping-up from the fire edge towards the centre of the fire. This operation is done with hand tools. Often, if water is available, pumps and hose lines can be used to assist with the holding action and with the mopping-up. However, this will depend on the type and volume of the fuels.

Bulldozers can be used to a limited extent during the mopping-up operations. Very few fire services will have their own bulldozers or other heavy duty equipment. That is why in many countries the fire service has to make a contract with private owners or municipalities for use of the heavy duty equipment during the fire danger season. At the same time it must be checked that it is possible to obtain, when needed, good and experienced operators and mechanics for the equipment.

In addition, the heavy duty equipment requires special transport carriers, such as tilt-bed trucks or a truck and lowbody trailer for delivery of the unit to the fire site. Bulldozers and other heavy duty equipment can be used with success on heavy fuel areas, and where the humus layer is very thick.

A bulldozer line is normally needed in large and intense fires.

In general, experience has shown that it is not safe to use a bulldozer close to the fire edge during daytime hours. During this time the fire can spread so fast, or change direction, that the bulldozer cannot move away from it. The best working hours for heavy duty equipment are in the evening and in early morning when the wind is relatively calm.

Bulldozers - also called dozers, trail builders, and caterpillars - are effective fire fighting tools if they are correctly used. On the other hand, they are costly to operate and require good operators, good supervision, and adequate servicing facilities.



It is said that, in the same fuel type, one bulldozer will do the equivalent work of a crew of forty men. However, in excessively rocky areas and in dense timber stands where there are many large trees, their performance will be drastically reduced. In these areas the bulldozer will need a pioneer working ahead of it, such as a plough or fireline crew.

Locating a fireline across a slope with a bulldozer is not advisable either above or below the fire. Generally, on slopes of above 35% the production of the bulldozer drops off considerably.

A line locator should be assigned to the lead vehicle. He should be physically fit, have a good understanding of fire behaviour, and a good knowledge of the capability and limitations of the bulldozer. In many situations it pays to have a helper accompany the line locator, whose work is to blaze a trail on trees and bushes. The locator should know what is expected ahead and periodically check with the crew or sector head that the progress is on the right track.

Any location where the bulldozer cannot work effectively should be avoided and completed with hand tools. These locations would include areas of large rocks, rocky outcrops, excessively steep terrain, or any other obstacle that limits the use of the bulldozer.

As a general rule, in a bulldozer line all the material should be pushed outside the line, and not in a heavy pile. In all cases the amount and kind of fuel should be left in such a way that hot spots can safely burn-out inside the line without throwing fire over the line.

Bulldozer line principles

The following points apply to bulldozer line operations:

- (i) All unburnt fuels moved by the bulldozer should be pushed away from the fire line and scattered as extensively as possible.
- (ii) The bulldozer should work as far away from the burning fire edge as possible, so that it does not pick up any burning material. It should shove any material that it does pick up to the outside of the line. Also, it should work in safety by observing the direction and spread of the fire.
- (iii) In fuel types with large timber stands, wind thrown timber, or dry stands, it is best to use power saws ahead of the bulldozer; to cut the material, or break it, so that the bulldozer can easily and quickly move it aside. Usually one, or at the most, two saw cuts are all that are necessary. The route of the line to be built should be clearly marked.
- (iv) As a rule of thumb, it is best to work the bulldozers in pairs, so that they can assist and reinforce each other. The width of the line, the fuel, and the topography will determine the suitability of the tandem operation. Typically, the lead bulldozer pioneers the line by doing the ground clearing, while the second machine cleans up the line down to the mineral soil, widens the line where necessary, and breaks down and scatters any piles of material.
- (v) The width of the line will depend on many variables, such as the type and amount of fuel and the continuity, height, and steepness of the slope. The general rule for the width of the line is not less than one half of the height of the fuel. With the bulldozer, the minimum width would have to be one blade wide. The width of the line will mainly depend on the amount of heat that will be created when it is burnt. Where a wider line is required in tall timber the clearing should be made by felling the trees away from the line.
- (vi) A clean-up crew is used behind the bulldozer both to speed up the line construction, and to make it secure. The main point here is that hand tools are needed to follow the bulldozers in any type of fuel to make sure the line is ready to be burnt-out.
- (vii) The burn-out crew may be part of a combination crew that does both the cleaning-up and the burning-out. On large fires it will be separate crews supervised by, for instance, a section head. Usually, one to three torchmen are needed. The other men use shovels and backpack pumps. If the bulldozer line has been constructed in the evening or at night the burning-out can be done the next morning, when conditions for burning are more favourable.
- (viii) Proper and professional supervision must be provided for a successful operation and if hired equipment is used. This equipment is normally very expensive and cannot be operated for long periods without servicing. Plans for servicing and repairs must be made before starting work.
- (ix) Bulldozers are used in the suppression of wildfires by the direct and indirect (parallel) methods and to construct lines for backfiring and strip burning. They are also used to construct strategic secondary lines, assist hand crews with spill-overs, construct safe areas, open up alternative routes, clear out old firebreaks, and to construct roads and heli-pads.

Ploughs

Fireline ploughs are pulled by four-wheel drive trucks or by crawler tractor. There are two principal types of plough - hard ground (soil) ploughs, and peat-land ploughs.

Soil ploughs are the best to use in fuel types that can be traversed without too much interference from standing timber, where the topography is more or less flat, and where the soil type is generally sandy, friable, and free of rocks. Rocky soils are impossible to plough. Also, as the slope increases, the efficiency of the plough decreases.

In suitable average fuels and soils, most tractors are able to pull at a maximum of 5 km / hour (or 80 m/min.), which is equal to the walking speed of a man. The speed of ploughing will vary considerably below 5 km per hour where there are boggy sections, trees, and other obstructions.

Line construction and line location principles are the same for the plough as for the bulldozer. The indirect (parallel) methods are almost always used with ploughs, since the direct method is rarely used for initial attack.

The depth of ploughing should be as shallow as possible, but must be down to the mineral soil. A shallow line is equally as efficient as a deep line, as long as it is clean and continuous. The shallow lines also put less drag on the tractor so that the ploughing is faster.

If burning-out is used with a ploughed line, the line construction should be as straight as possible. Deep pockets and turns provide a chance for build-up of fire intensity, and the consequence of spill-over.

Peat-land ploughs can be used on dry areas if the fire is on peat-land, or is going to spread to peat-land. This plough will plough quite deep and makes a wide ditch which functions as a fireline.

In real peat-land fires, where the fire is spreading underground, this ditch should be deep enough and wet at the bottom in order that the fire will not spill-over the ditch. If the peat-land fire is very intense, and the fire is deep into the ground, it is better to plough two ditches side by side to be sure of stopping the fire.

Excavator

With an excavator a fireline can be prepared on hard ground or non peat-land by digging with its blade.

An excavator fireline always needs to be followed up with hand tools. An excavator can be used successfully in any type of fuel or ground, for instance in rocky areas.

In addition, by using an excavator holes can be dug in the ground to prepare a water source for the fire pumps, if of course there is water near the fire site.

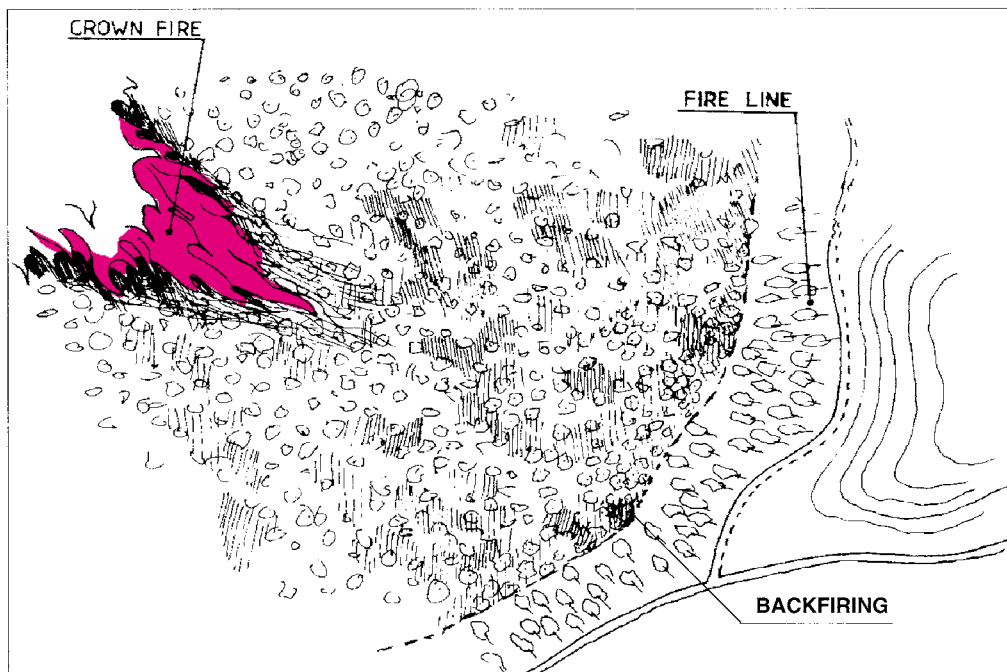
Other heavy duty equipment.

There are many other special types of heavy duty equipment that can be used, such as the different types of forest tractors. Often these will be used in combination with other specialist heavy duty equipment.

It is very important that this type of equipment is under the control of experienced and professional supervisors. The drivers should have direct radio contact with the sector head or the fire chief.

8.6.4 Backfiring techniques

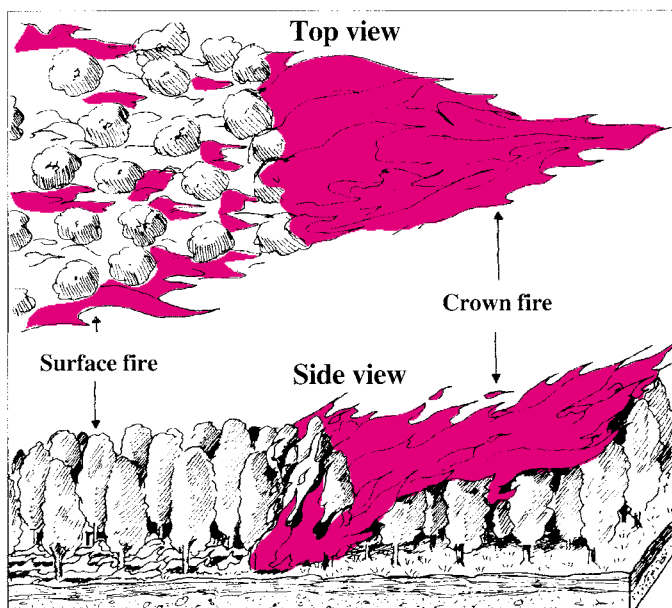
Normally, backfiring techniques are used in crown fires and in very fast spreading intense fires.



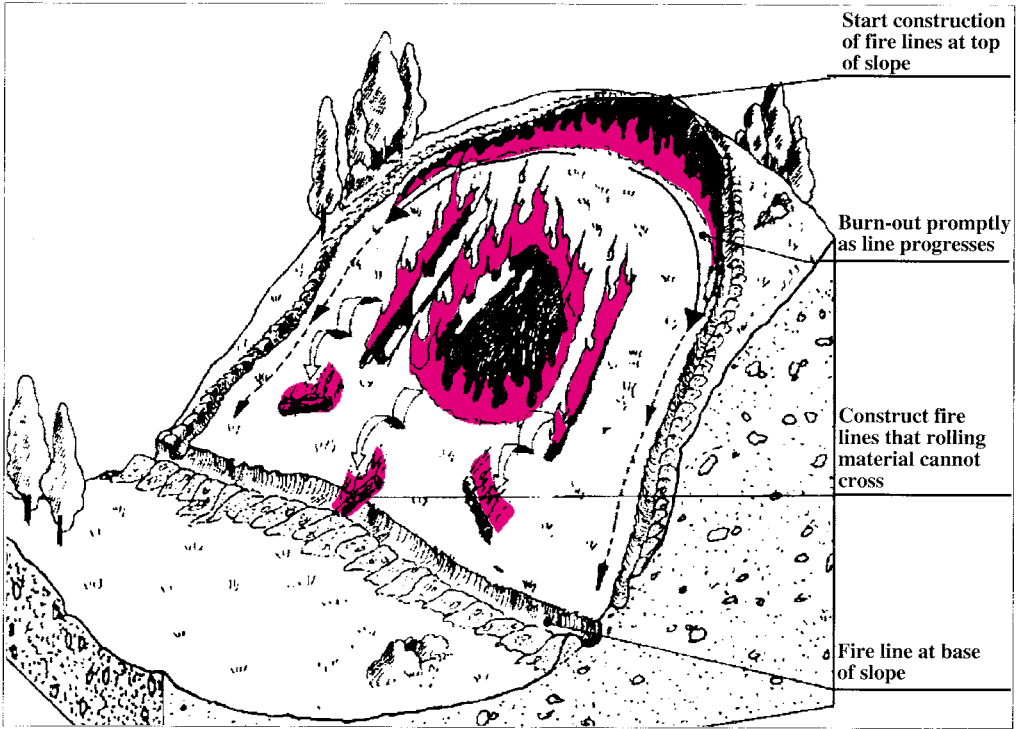
In these cases the only safe and accurate technique will be backfiring. If the fire is spreading very fast there will be no opportunity to send the crews and machines near the edge of the fire. In this situation it is best to prepare a fireline far in front of the head of the fire and start backfiring against the main fire at this line.

The use of backfiring techniques requires trained crews, sufficient manpower, and especially an experienced supervisor who can estimate the correct place to start the backfiring.

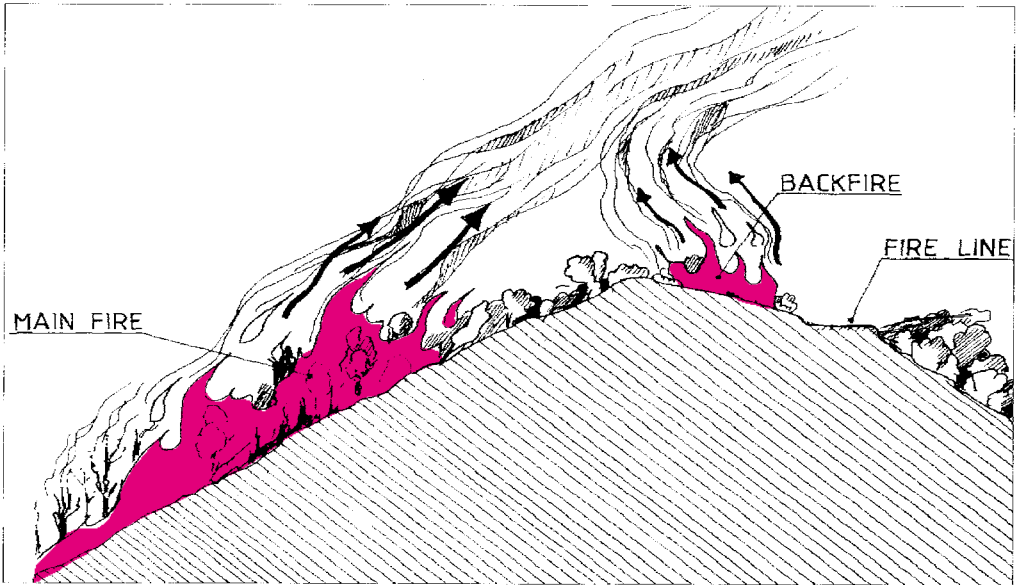
The principle of backfiring is based on the suction caused by the main fire, which produces a backwind.



The basic rules of backburning can be explained diagrammatically.



In hilly or mountainous terrain the best place to start a backfire is just over the top of a hill, away from the slope where the main fire is located.



A fireline of sufficient width to hold the fire must be built in advance of the main fire, or use should be made of natural barriers such as a ridge top or a pre-planned and pre-built firebreak.

Anchor points must be in place prior to firing. Anchor points are the places where lines or barriers on both flanks of the main fire join the line across the front of the fire, examples of which are: a road, a cliff, or a man-made line. Lines along the flanks should be built so that the total area of the fire can be contained when the main fire reaches the backfire.

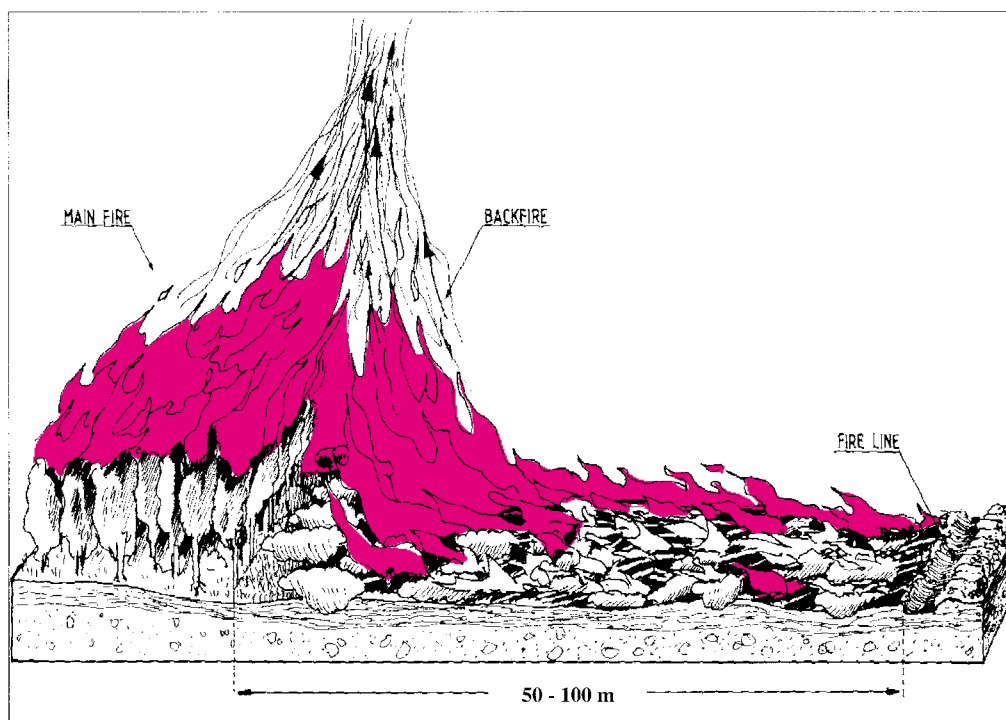
If the backfire is started too late, the impact of the main fire on the control line may become worse. The objective is to have the backfire drawn into the main fire at a safe distance from the control line.

Concentrations of fuel inside and adjacent to the control line should be scattered or removed, so that there will not be too much radiant heat and / or flames across the line for the resources to contain.

Before the start of the fire, all trees adjacent to the control line should be felled to fall inside and far enough from the line so that a surface fire will not jump outside the line.

The corners between the anchor points and the backfire line should be burnt-out first (these are the points that are the most difficult to hold). Then, the edge of the backfire line is established by burning from the anchor points towards the centre of the control line.

Next, burn from the anchor points downhill along the flanks. Where there is a choice, the backfire should always be started at the top of a slope and ignited towards the bottom, or downhill, to prevent the fire from building up and so that it can be held along the line.



A very slow rate of spread is not desirable with a backfire. On the other hand, a very hot backfire should also be guarded against because this may cause spot fires, jumping, and intense heat.

If the fire head is approaching in fingers, the backfire should be started at a place immediately at the head of each finger.

Burn only when you are sure that the wind direction and speed will remain steady.

Soil and / or water can be used along the backfire line to decrease the intensity of the backfire near the line until the backfire burns well away from the line and the intensity of the heat is diminished, or until the draught of the main fire pulls the backfire in.

It is a good practice to wet down an area outside and adjacent to the line in order to prevent ignition by sparks and embers. When using water, be careful not to extinguish the set fire.

8.6.5 Water suppression techniques

Water is the most widely used extinguishing agent for most fires because it has a high capacity to absorb heat.

It is usually readily available in most forest areas, but there are many areas where water is not available at all, especially in the dry season.

Rule of thumb

When water and adequate water equipment is available it should be used for fire suppression, as this is the most effective method in use. This method will also save manpower because one nozzle-man and his assistant are equal to 4 - 8 men with hand tools.

However, water alone will not do all the work in the control of wildfires and hand tools and patrolling will always be required.

The use of water equipment assumes a good knowledge of and practice with the equipment.

8.6.5.1 Principles of water suppression techniques

In planning fire tactics it is worth considering water suppression techniques. Usually, the forest patrolling objective at the fire site is to check if there is an available source of water nearby. The water source could be a river, a lake, a dam, etc. The quantity and accessibility of the water is another important point to consider. If the water source is situated down a very deep ravine it may not be available to the equipment.

If the water source is far from the fire there must be enough hose and several pumps (booster pumps) to transfer the water. When water is taken from a natural water source a portable water pump is normally used. The other supply method is to carry the water to the fire in a fire truck or other type of tanker vehicle. This will mean that the trucks and vehicles should have easily accessible routes to the fire site.

8.6.5.2 Procedure for attack and methods of nozzle use

In the case of a small fire, one or two nozzle-men are enough to keep down the flames, especially if the fuel type is light. If the fuel type is heavy, and the flames high and hot, several nozzle-men should be used, and they must work close to each other.

In crown fire attack there must be many nozzles in use at the same time. They should work very close to each other. The pressure in the nozzles must be high enough to produce a long straight stream of water because the nozzlemen cannot work close to the fire edge.

The first objective for the nozzleman is to stop the fire from spreading by knocking down the flames at the head of the fire. If this is not possible then the nozzleman should start to attack the flanks on both sides, or the surrounding fire edge. If the fire is small and fire weather conditions are moderate or low, the head of the fire is hit with a direct attack. This stops spreading. After that the flank attack is continued, and work proceeds from the rear along the flanks, around the head, and then back to the point of start. The point of start on the flank will depend on the extent of the fire and the amount and type of manpower and equipment available. If a part of the flank appears to be dead, attack starts where the fire is burning intensely. The edge must be checked out to make certain it is secure. If the fire should start again behind the fire fighter it may not be too long before he is outflanked and caught in a pocket between two fires. Continue to work on around the head to pinch off the spread, and then tie in the entire perimeter. Check for spotfires and finish by mopping-up.

To break into a burning line, reach into it with a straight stream of water, aiming at the base of a hot spot. Bounce the straight stream off the ground to make more spray and to cool the fuel. As soon as a part of the edge has been knocked down, move into it fast. Then turn towards the head, change to a spray, cover only the burning fuel to stop the burning, and use the spray as a protective shield.

Hit the hottest edges first and then tie in the whole perimeter. If the fuel type changes, or there are dead and slow burning sections, hit the worst places first and then mop-up the other areas.

The volume of the water supply and the capacity of the pumps should be known.

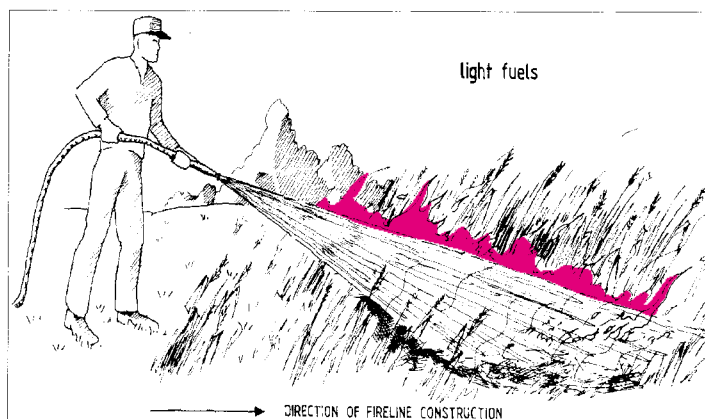
In the case of a surface fire or a crown fire, the fire is eliminated by the cooling and smothering effects of the water, and the condition of the fuel is changed by the addition of moisture.

The arrangement of the surface and sub-surface fuels can be altered by the force of the water from the nozzle. In the sub-surface layers this separation between the burning and unburnt fuels with water pressure is a most important action.

Skilled nozzlemen are required in order to obtain the best results from water under pressure.

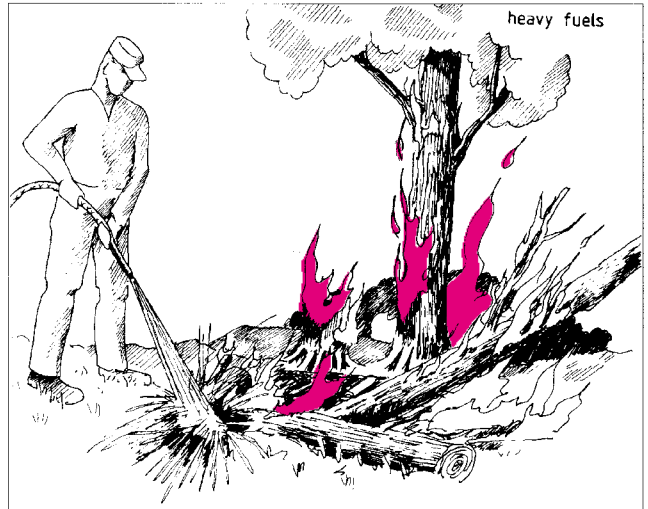
In general, the angle at which the water stream is directed onto the fire edge will determine the effectiveness of the separation.

In light flash fuels the angle should be nearly parallel to the fire edge, and the stream should hit the fire edge about 5 - 8m from the nozzleman.



As the sub-surface fuel or the flame front increases in depth, the angle of delivery should increase accordingly, and the stream should hit the fire edge almost at right angles, approximately 1,5 - 3 m in front of the nozzleman. At all times the primary objective of an initial attack is to place the line in a condition of 'being held'.

Some good advice for the nozzleman on the type of nozzle used in different fire situations is as follows:



Crown fire - direct or scattered nozzle with sufficient pressure and waterflow, depending on the intensity of the fire.

Intensive surface fire - scattered or direct nozzle pressure and water flow not so important.

Low surface fire- scattered nozzle, not very high pressure and waterflow. Instead of nozzles, backpack pumps can be used.

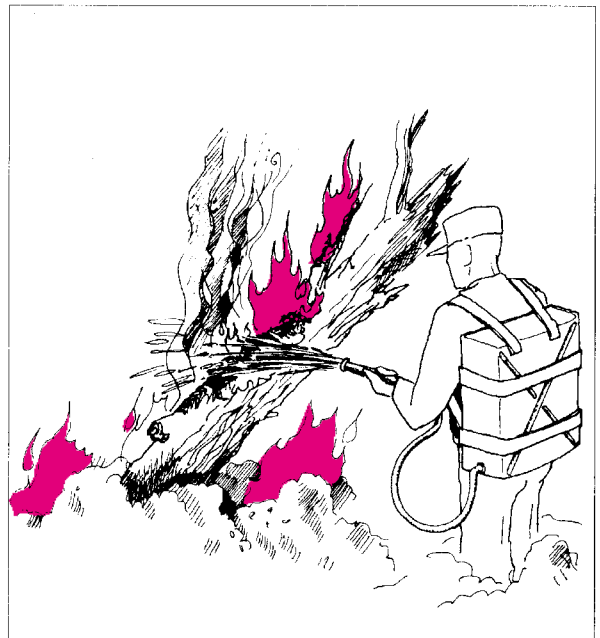
Mopping up - direct nozzle which can be used like a drill into the hot spots.

8.6.5.3

Backpack pumps

Backpack pumps are not the most useful and effective of the wildfire tools. They are however the most efficient and economical means of delivering water onto a fire when they are skilfully operated. Backpacks are very useful in initial attack.

When the pump is used, one hand should be placed close to the forward end and held steady, aiming the pump to where the water is needed and as close to the base of the flame as possible. Pumping is done with other hand. By holding the forward hand steady, accurate direction is given to the stream. If a fan-shaped spray is needed, the stump is placed over the nozzle end.



Water carried in a backpack becomes very precious. The quantity of water carried is not very much and it must be therefore used as effectively as possible.

Backpacks are very useful in initial attack, especially to stop the fire spreading in lighter fuels, to cool down hot spots along the line, and to knock fire out of snags. They are especially effective if they can be readily filled.

Backpacks are almost indispensable on spot fires, as adjuncts to hand tools in the initial attack and especially in mop-up operations and patrols. If plenty of backpacks are available they may be scattered along the line by whatever transport is available, so that they are on hand when they are needed to combat flare-ups and to mop-up. Often the best use for a water tanker or fire truck is to supply the backpacks with water, especially if they themselves cannot reach the fire area.

Practice and training is necessary for the correct use of this equipment and the only way to achieve a satisfactory performance is to practice with the equipment available.

8.6.6 Aircraft used in suppression actions

In addition to detection and patrolling activities, aircraft can be used in several other aspects of fire suppression.

The use of aircraft at the beginning of the fire could be conclusive, if they are readily available. Aircraft will also save a lot of manpower, but they are very expensive to use. The main uses of aircraft can briefly be listed as follows below.

Agricultural aircraft

These can have limited use for spraying water or chemicals over the fire. The carrying capacity of an agricultural aircraft is normally very low.

Helicopter

The helicopter has a definite advantage for observation because it can move relatively slowly, can turn quickly, and needs a very small landing area.

The transportation of fire fighters is an important use for the helicopter, especially for the initial attack crew. Crews can often be transported quickly by helicopter to areas where most of their energy would have been used up in hard walking.

The helicopter is ideally suited for the transportation of men and equipment over short distances. Fitted with stretchers, it will make an excellent ambulance for transporting any persons injured in the fire area.

In addition, helicopters are used for fire suppression. In some countries special bags have been developed to hang below the helicopter to transport and release water on fires.

Water bombers

There is a special aircraft which has been developed to transport and release water on the fire. These special aircraft are called 'water bombers'. They have an average load capacity of between 1 000 - 5 000 litres of water. This type of aircraft requires special techniques and knowledge to operate.

8.6.7 **Suppression techniques in peat-land fires**

Peat-land fires (ground fires) can occur in peat-land or moss areas which have been dried out by the digging of trenches. These fires spread on a dry surface in the peat-land production areas, or they run under the ground inside the peat fuel. The underground fire can spread without any visible signs for many weeks and over many metres, making hot channels in the peat fuel, before surfacing in some other place.

These underground fires are very difficult to extinguish and produce a lot of heavy smoke, which is a danger to the firemen because it contains a lot of carbon-monoxide. In a strong wind, light burning particles of peat can easily fly many metres, spreading the fire very quickly and causing many spot fires. The fire can jump very easily over a 2 - 3 metre wide water ditch.

Surface peat-land fires can be extinguished with pumps and water sprays, and/or by flanking by using beaters.

Ground fires can be stopped by digging a very deep trench around the fire area. Another way to extinguish this type of fire is to use water. If a pump and nozzle is used it is best to use a high pressure and a straight stream, and to dig hot spots out of the ground.

If backpack pumps or buckets are used for water extinguishing a wetting agent must be used in the water, as untreated water has no effect against a ground fire. The wetting agent can be a liquid soap that breaks the surface tension of the water. This water sinks easily into the ground, through the peat fuel.

8.6.8 **Mopping-up**

Mopping-up is the process of putting out the whole fire, or putting out the fire in most of the area around the perimeter so that spot fires and breakaway fires cannot occur.

The size of the area to be mopped-up will depend on the fuel, the location of any smouldering fire in relation to the perimeter, and any possible changes in the weather. The burnt area should be mopped-up for at least 30 m from the perimeter towards the centre of the fire. In some fuels, and in small fires, it is necessary to mop-up all of the fire inside the line.

In heavy fuels the cost of a complete mop-up may be excessive. If all the fuel inside the line cannot be burnt completely, or if the fire cannot be completely extinguished, the area must be patrolled until there is no possibility of any ignition outside the line.

Mopping-up can mean the success or failure of the entire fire control operation. More fires have been lost because of poor or incomplete mopping-up than for any other reason. Mopping-up should begin as soon as the line is complete. In many situations the mopping-up may start during the line construction of the initial attack. Control is not achieved until enough mopping-up is accomplished to make sure the fire is permanently confined to a definite area.

Mopping-up is dirty, hard, and dangerous work. It is a real test of the effectiveness of the crew and its leaders. In many cases it is better to take a fresh crew to do the mopping-up work because the first crews will be tired after the initial control operations. Good leadership is required to obtain an effective job.

Snags inside the line and in places where sparks can be thrown across the line should be felled away from the line and extinguished.

Special snag safety precautions and notes for caution are as follows:

- Remove the roots from across the line.
- Fire can travel underground along the roots and can break out on the surface many metres away, and up to two weeks later.
- Fire in heavy duff may smoulder for a long time.
- A trench, dug down to the mineral soil, should be made around the outside of the area of burning duff. The area can then be allowed to burn-out, or be drenched with water.

In mopping-up, all the smoke must be out, all hot spots must be cooled and all burning material must be extinguished. Patrolling must be carried out after the mopping-up work in order to make sure that the underground fires are really out.

Where water is not available, or is in limited quantities, hand tools are very effective when they are used correctly. In fact, hand tools should be used with water for the best possible mopping-up results. The shovel, backpack pump, axe-hoe, pole axe, rake, and saw are the best tools for mopping-up.

Try to eliminate trouble spots before they flare-up and endanger the line. Keep the fire out of heavy fuels, concentrations of fuel, and unburnt islands. Break-up any concentrations of fuel that are burning. Improve the line and make sure it is secure and continuous. Turn logs over 180 degrees in their bed of ash, and cool the log and the bed. Do not cover burning stumps, logs, or large pieces of wood with soil and expect them to go out completely. Usually the soil drops away as it dries and the smouldering material underneath breaks into flame, sometimes allowing sparks to be carried by the wind. It is much better to completely extinguish all burning material by using water.

If water is available and can be applied it makes the mopping-up operation much faster and easier to accomplish. The best combination is water and hand tools.

Mopping-up with water may be carried out with backpacks or pumps and hose lines. It is not the amount of water that is used, but how effectively it is used.

A fine light spray is usually the best, and it saves water. Any burning material should be separated and exposed and a fine light spray applied until it is certain that all the fire is extinguished. In some instances a straight stream may be needed to penetrate or reach the burning material. If enough water is available some areas can be drowned. In heavy fuel areas, or around stumps and roots, a high pressure and straight stream can be effective for digging out hot spots from under the ground.

Fire Intensity

The Fire Intensity indicates the amount of energy produced by the fire. The Intensity of fire expresses the amount energy or heat towards a surface-area and time unit, for example kcal/m²/s or kW/m²/s. The height of the flames described very well the Fire Intensity and can therefore easily be assessed in the field.

Height of flames m	Intensity kW/m ² /s	Description of fire
< 1, 2	< 345	Fire spreads slowly and is easily controlled
1,2 - 2,4	345 - 1720	Fire burns with steady flame and moves forward
2,4 - 3.3	1720- 3450	Fire spreads rapidly and continues to grow
> 3,3	> 3450	Fire burns fiercely, crown and spot fires occurring



ORGANISATION AND MANAGEMENT OF WILDFIRES

9. ORGANISATION AND MANAGEMENT OF WILDFIRES

9.1 General Management

The fundamental principle of forest fire management is: regardless of the size of the fire, certain basic management principles are necessary to obtain prompt and efficient control of the fire with the smallest acceptable fire damage, and with reasonable cost.

The principles of fire management are the same for all fires, regardless of size.

Usually, the problems involved in controlling a wildfire become larger and more complex as the fire increases in size and the rate of spread increases. Therefore, the manpower, equipment, and apparatus must also increase, as must the number of specialists and section heads needed to handle the increased work loads of the several functions that would normally be administered by the fire chief.

Forest fire fighting is an emergency operation. To achieve success in the complex work of fire control, good organisation is needed, together with professional staff. Fire control management and organisation is similar to the military command structure, both being based on certain principles.

The two most important principles are:

- (i) unity of command; and
- (ii) span of control.

In order to achieve unity of command each person must have only one superior officer. The person must know to whom he reports, as well as who reports to him. The responsibilities of each person in a supervisory capacity must be clearly defined.

The second important principle is to avoid exceeding the span of control. There is a practical limit to the number of men or units of organisation that one person can effectively supervise.

Experience has shown that in general, one person is able to: supervise, direct, lead, or keep in effective control at one time a maximum of 6 - 8 persons.

Exceeding the span of control is a common fault. Another common fault is to send men to a fire site without clearly appointed duties or supervision.

Success in the initial attack on a small fire, or a successful strategy and the tactics employed on a large fire depends first of all on the fire chief. At small fires the fire chief can lead all the activities and all the crews. At large fires he must delegate duties and responsibilities to members of his staff.

Management of the forces used in a large fire requires experienced personnel, good command offices, and the minimum equipment of management, such as maps and communication systems. In any organisation there should only be one responsible fire chief, who should take all the decisions during suppression activities and delegate responsibilities clearly and in detail to his supervisory staff.

9.2 The Basic Requirements for a Fire Chief

The basic requirements for a fire chief are that the fire chief:

- (i) should have an excellent knowledge of forest fire behaviour, and all the factors affecting fire control;
- (ii) must have sufficient knowledge of fire suppression strategy, tactics, and techniques, and also be able to set up fire suppression time objectives;
- (iii) must be familiar with the practical use of all fire suppression equipment and techniques of application (including a working knowledge of the speed with which a fireline can be constructed using different types of equipment, under varying conditions and fuel types);
- (iv) must be able to organise and plan objectively under stress, and give confidence to his staff and crews;
- (v) must have full management experience of forest fire suppression;
- (vi) must be able to plan for the safety and welfare of staff at all times;
- (vii) must accept the authority and carry out duties assigned to a fire chief; and
- (viii) must be able to make decisions and give commands.

These same requirements, but on a smaller scale, are also valid for the other heads of divisions, sections, units, etc.

9.3 Management Procedures

In any fire situation the fire chief should go through a management procedure, or at least the principles of it. He must go through a shorter or longer procedure, depending on the size of the fire.

Large and long duration forest fires will include a lot of management procedures which will coordinate the many and various actions to be carried out during the fire.

The general management procedures can be divided clearly and logically, and are carried out in seven different phases.

Phase 1 - Fire reports that are received in the alarm centre or fire headquarters.

The fire report is the first information that the fire chief receives of the fire and he must start the fire suppression activities at this time. The more accurate the first report, the better will be the start of management.

Normally, the first report will include the following information:

- An accurate location of the fire (site, location on the map).
- The size of the fire (large, medium, small).
- The type of forest (fuel).
- The behaviour, type of fire (ground, surface, crown).
- Fire intensity, speed of spread.
- Access to the fire (roads, paths, topography).
- Water sources.
- Are there any people, residences, or structures in danger?
- Are there any people nearby who are available for fire suppression?

Phase 2 - Additional information on the fire conditions.

Many times, the fire report does not include all the necessary information. Therefore the fire chief should, immediately after receiving the report, try to get more information about the fire. More information can be obtained by studying maps, using the telephone, and so on. Additional information could include, among other things:

- What kind of forest, fuel, and topography is in the path of the fire?
- Are there any natural barriers or fuel breaks in front of the fire?
- What are the weather conditions and forecast?
- What is the speed of the fire?
- What are the positions of natural water sources?.
- Is there a civil organisation available for use in the fire suppression?

Phase 3 - Scouting the fire area.

This is what the fire chief normally finds out on arrival at the fire site.

The fire chief must scout, among other things:

- What are the largest risks and danger areas (lives, structures)?
- How far, and how quickly the head of the fire is spreading?
- Direction and speed of the wind.
- What type of forest fuel and topography is directly in front of the fire?
- Access in and around the fire area.

The principal objectives of scouting are to establish information on:

- (i) forest fires;
- (ii) forest, ground, and topography;
- (iii) weather;
- (iv) use of the crews and equipment; and
- (v) danger to lives and structures.

Scouting must be continuous and effective during the fire danger season.

Phase 4 - Appraisal of the situation

After receiving all the reports and scouted information on the fire, the fire chief must evaluate the strength of the fire and estimate his own manpower. Then the effectiveness of the suppression should be estimated. In this appraisal he should estimate, and / or know the:

- number of crews in use;
- experience and effectiveness of the crews;
- equipment and tools in use;
- usable water supplies;
- possibility of restricting and suppressing the fire;
- communication and management possibilities;
- possible scouting activities;
- supplies;

- order of importance of activities; and
- timing, and the estimated time for various activities.

Appraisal of the situation is an evaluation of the manpower available and the strength of the fire. The objective is to estimate the maximum and most important suppression effect against the fire with the manpower available.

Phase 5 - Decision

On the basis of the appraisal the fire chief must make, among others, decisions about the following:

- the activity goal;
- responsible areas, sections;
- suppression tactics and methods;
- the activity control centre;
- resources immediately in use, and any required additional resources to be dispatched;
- usable water sources;
- the management plan and organisation;
- communications;
- supplies; and
- reserves.

Decision is an attack plan. What will be the most optimistic and, on the other hand, realistic goal for fire suppression under the conditions?

Phase 6 - Commands to crews

Commands should be given so that the quickest and easiest work proceeds immediately. Later on, more commands can be issued for more precise work.

Commands to the fire crew should include information on the:

- state of affairs at the fire site;
- the main objective of the fire chief;
- command base of the fire chief;
- following up the work required; and
- suppression organisation, areas of responsibility, communications, supplies, etc.

The commands must include answers to the following:

- (i) Who? The objective of command.
- (ii) What? Which kind of job.
- (iii) Where? Which way.
- (iv) How? Techniques.

Phase 7 - Reserve crews

It is necessary to have a reserve force for every medium and large sized fire. The fire chief must establish the size and location of the reserve. If events of the fire are hazy the reserve

must be big enough to cope with the worst scenario. If the events of the fire are good and the fighting resources limited the reserve force need only be a small unit. The reserve unit must be able to move quickly to any place along the perimeter. Scouting and appraisal of the events must be continuous at the site of the fire because they are changing often and quickly.

9.4 Incident Command System (ICS)

9.4.1 Introduction

The Incident Command System (ICS) is used to manage an emergency incident or a non-emergency event. It can be used equally well for both small and large situations.

The system has considerable internal flexibility. It can grow or shrink to meet differing needs. This makes it a very cost-effective and efficient management system. The system can be applied to a wide variety of emergency and non-emergency situations.

9.4.2 ICS Organization

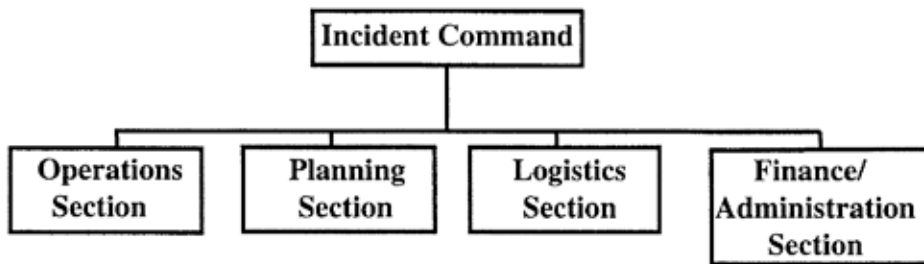
Every incident or event has certain major management activities or actions that must be performed. Even if the event is very small and only one or two people are involved, these activities will still always apply to some degree.

The organization of the Incident Command System is built around five major management activities. These are depicted in figure below.

<u>COMMAND</u> SETS OBJECTIVES AND PRIORITIES, HAS OVERALL RESPONSIBILITY AT THE INCIDENT OR EVENT
<u>OPERATIONS</u> CONDUCTS TACTICAL OPERATIONS TO CARRY OUT THE PLAN DEVELOPS THE TACTICAL OBJECTIVES, ORGANIZATION, AND DIRECTS ALL RESOURCES
<u>PLANNING</u> DEVELOPS THE ACTION PLAN TO ACCOMPLISH THE OBJECTIVES, COLLECTS AND EVALUATES INFORMATION, MAINTAINS RESOURCES STATUS
<u>LOGISTICS</u> PROVIDES SUPPORT TO MEET INCIDENT NEEDS, PROVIDES RESOURCES AND ALL OTHER SERVICES NEEDED TO SUPPORT THE INCIDENT
<u>FINANCE/ADMINISTRATION</u> MONITORS COSTS RELATED TO INCIDENT, PROVIDES ACCOUNTING, PROCUREMENT, TIME RECORDING, AND COST ANALYSES

These five major management activities are the foundation upon which the ICS organization develops. They apply whether you are handling a routine emergency, organizing for a major event, or managing a major response to a disaster.

Small incidents: these major activities may all be managed by that one person, the Incident Commander (IC). Large incidents usually require that they be set up as separate Sections within the organization as shown in figure below.

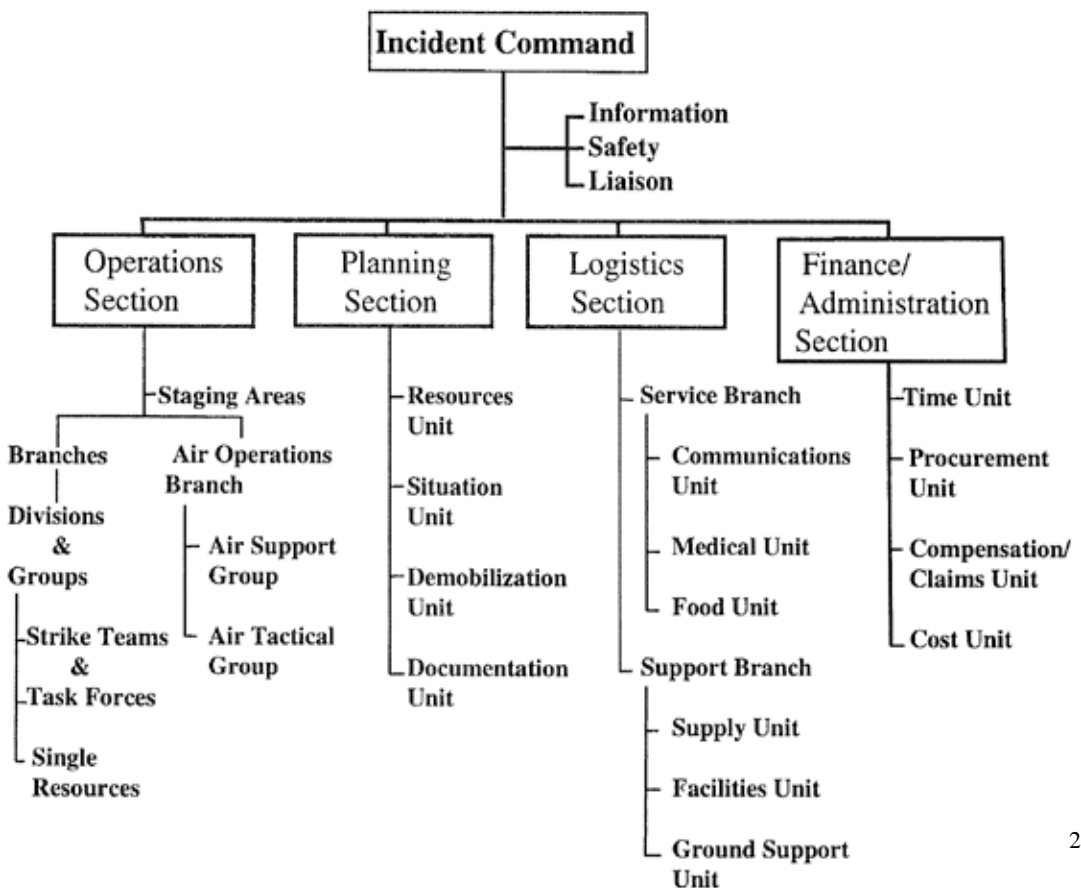


Each of the primary ICS Sections may be sub-divided as needed. The ICS organization has the capability to expand or contract to meet the needs of the incident.

A basic ICS operating guideline is that the person at the top of the organization is responsible until the authority is delegated to another person. Thus, on smaller situations where additional persons are not required, the Incident Commander (IC) will directly manage all aspects of the incident organization.

In the next section we will look at each of the major functional entities of the ICS organization, starting with the Incident Commander and the Command Staff.

9.4.3 Example of ICS staff requirements for a large fire



On potentially dangerous and rapidly spreading fires, the fire area becomes larger and larger, and the number of additional groups and crews will be required. These fires often involve a number of divisions because the perimeter of the fire is very long. Therefore it is necessary to add more levels to the Operations Section.

9.4.4 Incident Action Plan

Every incident must have an oral or written action plan, larger incidents always a written plan. The purpose of the plan is to provide all incident supervisory personnel with directions for future actions. Action plans which include the measurable tactical operations to be achieved are always prepared around a timeframe called an Operational period.

9.4.5 Span of Control

Span of control means how many organizational elements may be directly managed by another person. Maintaining adequate Span of Control throughout the ICS organization is very important. Effective Span of Control may vary from three to seven, and a ratio of one to five reporting elements is recommended.

9.5 Management Check-list for the Incident Commander or Fire Chief

One example of a check list to assist the IC or Fire Chief in the management of the work to be carried out with every wildland or forest fire is:

- (i.) Alarm, the first information at the start of a fire;
- (ii.) Arrival at the site of the fire, quick scouting and appraisal of the scene;
- (iii.) Appraisal of all the circumstances, and decision making;
- (iv.) Commands for the first operations;
- (v.) Continue with the scouting, for more information;
- (vi.) How to clear up, suppression plan takes shape;
- (vii.) Dealing with the work;
- (ix.) Commands for the work;
- (x.) Follow-up of the situation;
- (xi.) Required additions to the organisation;
- (xii.) Commands for the additional work;
- (xiii.) Patrolling the work area;
- (xiv.) Mopping-up;
- (xv.) Removal of the organisation; and
- (xvi.) Evaluation, collecting experiences.

9.6 A detailed list of “must follow up” activities

Preparation before the start of a fire includes:

- firelines;
- forest roads;
- planning;
- training;
- equipment care;
- assessing fire danger;
- fire weather forecasts; low, moderate, high, extreme;
- fire suppression organisation; the IC, fire chief, small, medium, large fires;
- fire service organisation; operation of the fire headquarters, supplies, transport, communication, accounts;
- maps and records;
- safety; and
- the district fire centre service organisation.

Leadership during the fire involves:

Formation of:

- The IC or the Fire Chief establishes the Incident Command Post (ICP) or command base;
- Staging areas
- Base
- Camps
- Helibase
- Helispot

Routine activities:

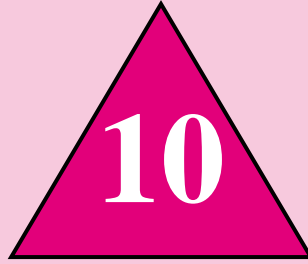
- scouting;
- rescue;
- restrictions;
- fire fighting.
- commands, order keeping; communications; maintenance of supplies; and
- information.

Control and maintenance during ongoing activities:

- patrols must be maintained; and water supplies should be replenished.

Activities after the incident or fire equipment and supplies should be:

- collected;
- checked;
- repaired; and
- returned to normal storage points.



**SAFETY, WELFARE
AND FIRST AID**

10. SAFETY, WELFARE AND FIRST AID

10.1 Responsibility for Safety

Forest fire fighting is always a hazardous activity. In many countries several lives are lost and many men become injured during the forest fire season. The safety and welfare of the entire fire fighting organisation is the responsibility of the fire chief. Each person in authority is also responsible for the safety of the men under his / her direction.

Of course, every fire fighter must work safely and take heed of the fire fighting safety instructions. Safety activities should also include welfare and first aid services in the field.

Most governments have some kind of insurance cover for fire fighters.

10.2 General Safety Measures

Forest fire fighting activities and extinguishing fires is often a very difficult and dangerous task.

Accidents occur due to sliding, rolling or falling branches, lacerations from sharp tools, moving equipment and tools, being trapped by wildfire in the course of fire fighting, and many other reasons.

Based on recent literature, the accident frequency rate in the industrialised countries has stayed steady because of a thorough handling of the safety policy. However, in the developing countries there is an alarming increase in the number of accidents. The frequency of fatal accidents in the developing countries has at least doubled during the past ten years.

Some of the reasons for this sad reality are:

- lack of, or no observance of the safety regulations;
- high unemployment levels;
- ignorance of the dangers; and
- lack of adequate training.

It is important to realise that accidents cause heavy costs and losses. The knowledge of the losses due to accidents is important in order to assess the aims of the organisation for efficiency and to analyse the cost-benefit ratio for implementing the safety policy and regulations.

10.3 Accident Prevention

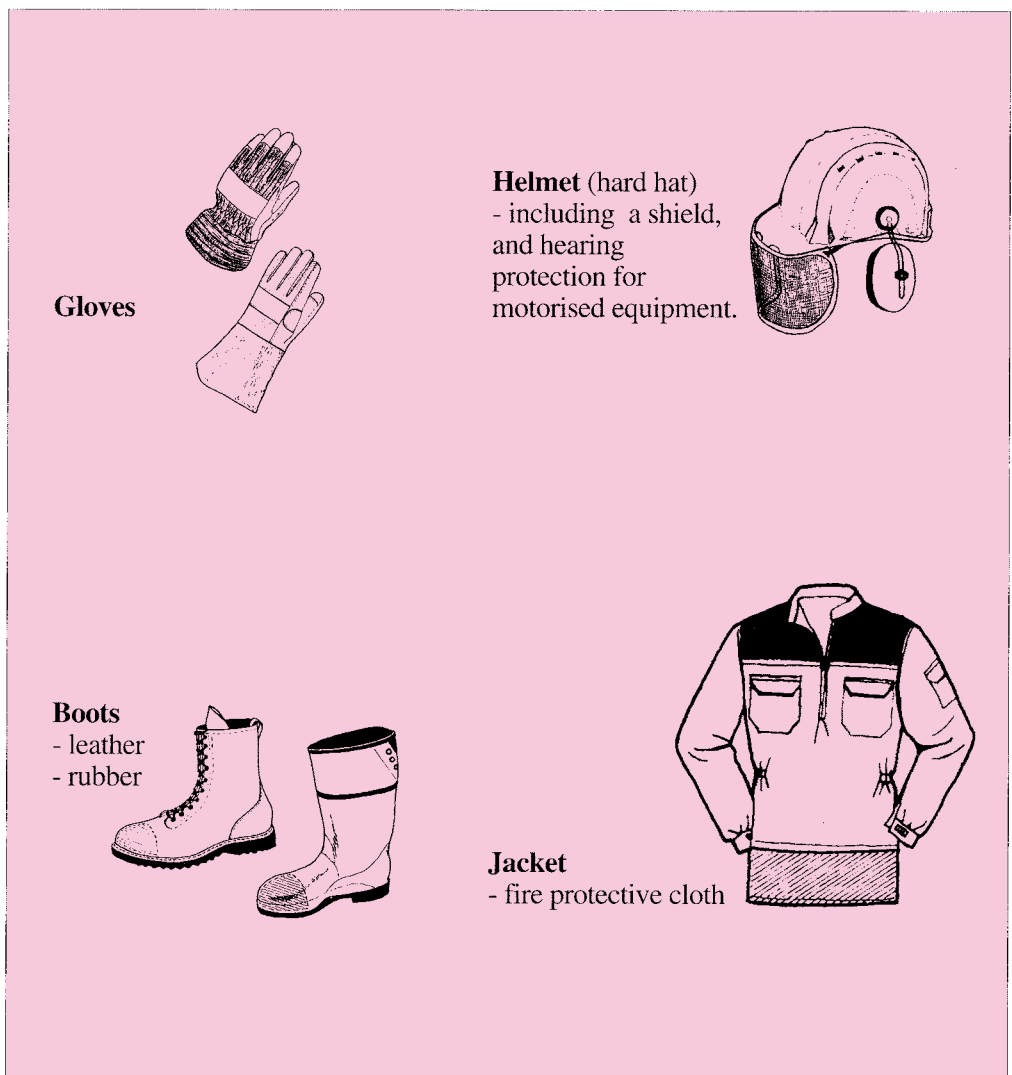
An accident is defined as an unwanted and sudden occurrence caused by an unsafe action and / or an unsafe situation, leading to death, injury, or damage.

These unsafe acts are influenced by the following factors.

- (i) **The background** - which is also called the indirect or primary cause, concerns questions beyond the influence of the safety plans, such as:

- lack of safety legislation; and
 - constructional faults.
- (ii) **Human error** - is, in one way or another, involved in causing accidents. It is the question of attitudes that is difficult to control. It is only through education and safety campaigns that the people can be made more accident conscious.
- (iii) **Unsafe acts or situations** (direct or secondary causes) - are the most important factor that can influence accident prevention. If this factor can be eliminated, the accident will not happen. Extension methods and training could eliminate most of these unsafe acts and situations.

Injury and accidents can be prevented by the wearing of personal protective clothing and equipment. The important items of protective clothing and equipment are shown below.



10.4

Ten Fire Fighting Rules

The Fire Service of America has developed ten special safety rules for fire fighting. These rules are based on an analysis of the causes of accidents and death to wildfire fighters. When death or injury has occurred it is usually because one or more of these rules has been broken. Every person involved in fighting wildfires should know and follow these ten rules:

- (i) Keep yourself informed about the weather conditions and forecasts.
- (ii) Know what the fire is doing at all times, observe it personally.
- (iii) Base all actions on the current and expected behaviour of the fire. For instance, if the wind changes, change the position of the crews to a place of safety.
- (iv) Plan escape routes for all personnel, and inform them where they are located.
- (v) Post a look-out when there is any possibility of danger.
- (vi) Be alert, keep calm, think clearly, and act decisively.
- (vii) Maintain prompt communication with your men, your head of section, and all adjoining forces. The best communication is a radio network.
- (viii) Give clear instructions and commands, and be sure that they are understood.
- (ix) Maintain contact with your men at all times. Stay together as a crew. Never allow anyone to be completely out of contact with the group. Those who do leave the group are the ones prone to injury.
- (x) Fight the fire aggressively, but always place safety first.

10.5

Dangerous Situations

Several dangerous situations may arise during the course of a forest fire. Every fire fighter should know what these potentially dangerous situations are.

- (i) **When building a line downhill towards a fire.** This situation can be very dangerous if the fire makes a fast run and overtakes the crew. The crew must have a well defined and easily accessible escape route.
- (ii) **When fighting a fire on a hillside where rolling materials can ignite a fire below.** If the fire does start below, the fireman can be pocketed between it and the main fire. Patrol for spot fires below and have a definite planned escape route. Maintain a look-out.
- (iii) **When the wind gets stronger or changes direction.** Watch out for spot fires, snags on fire, and a possible mass transport of embers. Be ready for a blow-up, check the escape routes.
- (iv) **When in an area where the topography and/or cover makes travel very difficult.** The fireman must have an escape route planned in case the fire starts to run in his direction. Provide for observation of the progress of the fire. Try to avoid this situation.
- (v) **When in unfamiliar country, or your fire fighters are not familiar with local conditions influencing the fire behaviour.** Know the fire weather forecast and provide for communication. Request and arrange for local information.
- (vi) **When the main fire cannot be seen and there is no communication with anyone who can see it.** Arrange to correct these conditions, or at least to maintain communications. Be certain that a satisfactory escape route is available and known to the crews.
- (vii) **When drowsy and / or tired.** Keep moving. Check your fitness and welfare. Do not go near the fire.

10.6 Welfare of the Crew

Only men in good physical condition should work on wildfires. To be effective, the crew must be kept in good physical condition. Eight to twelve hours work per day is all that should be expected from the crew. An overworked crew is much less productive and becomes accident prone. Experience has shown that the work effectiveness of the men is reduced by about 50% after 6 - 8 hours of forest fire fighting work. A good time to change crews is late in the afternoon and early in the morning since the wind is usually calm and the fire is less fierce.

If the control operations continue past the hours of daylight, provision for a rest is necessary. The crew may be released to return home and be replaced with a fresh crew, or sleeping facilities may be provided. On some operations, bedrolls and eating facilities are provided at camps which have been set up to support the control action.

Food is essential for the firemen. It is sometimes provided in the form of packed lunches or hot meals delivered to the line. Other meals are provided at the camp or at a local cafe. Good nourishing food, and plenty of it, are essential for good fire suppression.

Drinking water is also essential. This is usually provided by individual canteens for crews on the line. Re-supply can be made by water carriers, air drops, or any number of other methods. The important point is that adequate, portable, and safe water must be provided to all the firemen. It has been noticed that if the firemen do not receive any drinking water during the first 1 - 2 hours of work their effectiveness is greatly reduced.

Planned rest periods will maintain the energy of the crew. Line workers should not be overworked, except in emergencies. If to control a hot spot or break-out it is necessary to work under very hot, smoky conditions, the men should be changed frequently and provided with a rest period. The men should also be rotated between tough and easy work.

Wildfire crewmen should wear suitable protective clothing. Heavy, laced leather shoes or boots with nonskid soles are necessary. Rubber boots are unsuitable for wildfire fighters. The most flame resistant clothing should be worn, such as denim, cotton, or wool.

Nozzlemen who are working close to the fire should also have equipment with face shields or goggles. Gloves should always be worn.

10.6.1 Safety briefing

A safety briefing must be given to all fire fighters before they go on the line. The crew leader is responsible for the safety of the men under his command and should conduct the safety briefing. First of all, the crew leader should determine if any fire fighter is too old, too young, or physically unable to fight fire. Secondly, the men should gather in a tight, compact group and the leader should speak with emphasis, and loud enough for instructions to be heard. Thirdly, safety supervision and instruction should be continued on the fire line, where it can be stressed during shift changes.

The following are suggested safety points to be given to fire fighting crews.

- (i) Your leaders are experienced. Stay with them, and do what you are told.

- (ii) The way to carry fire-fighting tools safely is down at your side (demonstrate). It is dangerous to carry tools on your shoulder.
- (iii) When you walk to and from the fire line, keep at least 6 feet (2 metres) apart in single file (demonstrate).
- (iv) When you are working with tools, keep a safe distance from other fire fighters; stay about 10 feet (3 metres) apart.
- (v) Your feet are your worst hazard. Keep sure footing at all times to avoid injury.
- (vi) Stay with your crew. Men have burnt to death by sneaking off for a nap.
- (vii) Watch out for tree branches which might injure your face or poke your eye. Don't injure someone else by letting a branch fly back in their face.
- (viii) Keep away from old dead trees, especially if they are burning. They may fall.
- (ix) Be alert for rolling rocks or rolling logs when you are walking or working on slopes.
- (x) Avoid stepping in burnt-out stump holes that will be full of hot coals.
- (xi) When you are hot and thirsty drink water slowly and do not drink too much at one time.
- (xii) Sit down when you are travelling in a truck equipped with seats. Otherwise, sit on the floor.
- (xiii) If you cut yourself, blister your heels or hands, or incur any other injury, report it to your leader immediately and obtain first aid treatment.
- (xiv) Safety is a matter of common sense. Use it, and you will keep yourself and others out of trouble.

10.6.2 Hand tool safety

The following precautions should be observed by all fire fighters to ensure the safe use of hand tools.



- (i) Carry hand tools at the balance point of the handle with the hand alongside the body. With one exception, never carry hand tools on the shoulder. Crosscut (ribbon) saws should be carried on the shoulder with the teeth pointing away from the body and preferably with a guard over the teeth.
- (ii) Sharp tools should have guards over the blades when they are not in use (e.g. axes, saws, etc.).

- (iii) Keep tools sharp; blunt tools are dangerous. Hand tool maintenance is described in chapter 7.
- (iv) When they are not in use, place tools so that the blades will not injure passers by. Avoid placing a tool where feet may be cut. Lean tools against a tree, rock, or stump in plain view.
- (v) Keep handles tight in the heads and free of splinters. Do not use tools with damaged or broken handles until they are repaired.
- (vi) Walk at least 2 metres away from others when you are carrying tools.
- (vii) Work at least 3 metres away from others when you are using tools.
- (viii) Use tools only for the purpose intended. Use the right tool for the job.

When using cutting tools such as axes, brush hooks, hatchets, machetes, etc:

- (i) have a firm grip and a firm footing;
- (ii) always chop away from the body and be ready to check a glancing blow (if it is necessary to cut toward your body, have complete control, use lighter blows, and be ready to avoid a glancing blow);
- (iii) remove all underbrush and overhanging limbs that might interfere when swinging a tool;
- (iv) use a natural stance with plenty of room to swing the tool, and never chop cross-handed;
- (v) guard against chips that may hit the eyes;
- (vi) be especially careful on hillsides;
- (vii) do not use chopping tools as wedges; and
- (viii) when using files to sharpen tools, use a handle and a knuckle guard.

10.6.3 Pumper and tanker safety

The following precautions should be observed by all fire fighters to ensure safety when pumpers and tankers are in use.

- (i) Pumpers and tankers must be maintained in top condition at all times. They must be kept clean and free of accumulated grease and oil. Particular care should be given to maintaining fuel and hydraulic lines without leakage. Tight-fitting fuel caps should be used.
- (ii) Crews should be fully trained in the use of the apparatus.
- (iii) Tankers should be kept at a reasonable distance from the heat of the fire. In a pump-and-roll stance, this may require that the nozzleman carry the hose while walking alongside the pumper.
- (iv) Pumpers and tankers should be positioned on the side of the road away from the oncoming fire, to reduce heat on the equipment and to allow passage of other equipment.
- (v) Fire apparatus parked on a highway at a fire should be marked by flags, flares, or red lights at both front and rear.
- (vi) Adequate supervision and communications with the pumpers, including the use of hand signals, should be maintained.
- (vii) Pumper crews should wear protective clothing. Goggles or transparent face shields should be worn by nozzlemen.
- (viii) If caught in front of a head fire with a pumper, do not panic. Be alert, keep calm, think clearly, and act decisively. Hopefully, each fireman and each officer will operate so that no pumper will ever be caught in front of an oncoming fire. However, in spite

of the best efforts, pumpers have been caught in front of a running fire, and in some instances the vehicle engine has stopped running. Usually, the engine stops because of a vapour lock or because the vehicle becomes stuck. It helps to install an electric fuel pump on pumpers and other fire vehicles.

- (ix) It is strongly recommended that any wildfire pumper have a separate engine for the pump; the pump should never be driven by the truck engine alone. A separate engine doubles chances that the pumper will continue to pump water in an emergency.
- (x) If caught and water can be pumped, wet down the area around the truck and the truck itself. Use backpacks or gravity flow if the pumps are inoperable. Then, as the head fire approaches, use fog streams to protect you from the heat and flame and to punch a hole in the oncoming front. Even if only a small area around the truck has been wet down, firemen have been known to survive in the cab of the truck in grass fuel fires. Do not try to outrun the fire, unless you are positive that you are very near one flank. Stay together to assist one another.
- (xi) Protective coats have several good breaths of air between them and the body. As a last resort, get your nostrils, eyes, and mouth under the coat and make a run through the flame front. On reaching the burnt area, help each other put out any flames on clothing. Running is a last resort. Usually, it is best to stay with the truck if possible.
- (xii) The best air is closest to the ground. High heat and flame are the killers; it takes a while for protective clothing to catch fire. It is important to think your way out by using what you have to the best advantage - wet down or burn out the area you are in. The burnt area is the safest escape route if it can be reached.

10.6.4 Tractor safety

The following precautions should be observed by all fire fighters to ensure safety when tractors are used.

- (i) Guides, spotters, or helpers for dozers should be selected for their physical fitness as well as their other abilities. At least one helper should be assigned to each tractor.
- (ii) Anyone working around tractors should be specifically instructed on their job requirements.
- (iii) At night, men on the ground assigned to tractors should wear two head lamps, one shining forwards and one shining backwards, so that the tractor operator can see them at all times. Tractors must be furnished with lights for night work.
- (iv) All men in the vicinity of a tractor should be well aware of the tractor's movements instead of depending on the tractor operator to keep away from them.
- (v) In dozer operations in advance of the fire, a safety strip should be built for a retreat in case the fire makes a run. This strip is especially necessary when you are working along a ridge top above a fire in the valley below.
- (vi) Machines must not work directly above each other or in close proximity when lines are being constructed upslope or downslope.
- (vii) Men should never sit or bed down near a tractor.
- (viii) When the tractor is idling or stopped, the blades should be on the ground.
- (ix) No one should ever get immediately in front of or behind a tractor in operation.
- (x) No one but the operator should be allowed to ride on the tractor, except a spotter or a tractor boss when they are necessary in heavy brush.
- (xi) Men must not work directly above or below a tractor on a slope.
- (xii) Tractor hand signals should be learned and used for direction and safety.
- (xiii) All tractors should have approved spark arresters.

- (xiv) Long sustained grades on the fire line should be broken in order to avoid excessive erosion.
- (xv) Tractors should be equipped with safety canopies in wooded areas.
- (xvi) No one should ever get on or off moving equipment.

10.6.5 Foot travel safety

The following safety precautions should be observed by all fire fighters travelling on foot.

- (i) Travel at a sensible pace. It is useless to arrive at the fire worn out from hiking. Avoid steep up-and-down travel as much as possible.
- (ii) Stay at least 6 feet (2 metres) apart and carry tools properly at your side.
- (iii) The crew must keep together.
- (iv) Communications should be maintained.
- (v) Lights should be provided for night travel.
- (vi) Pass burning fire-weakened trees, or “leaners,” on the side uphill or opposite to the lean, watching it closely while doing so.
- (vii) Stay away from snag-felling areas. Only a qualified snag-felling crew should be allowed in these areas.
- (viii) Watch for rolling rocks and logs.
- (ix) Watch for rock slides, cliffs, outcrops, and other hazards to travel, especially at night.
- (x) Fast travel through dense unburnt brush is practically impossible.
- (xi) In fast-burning fuels, watch out for fast spread of the fire in any direction. Communicate with a lookout and have an escape route planned at all times.
- (xii) Travel far enough apart so that swinging branches will not slap the face of the person behind.

10.6.6 Safety on the line

The following precautions should be observed regardless of fire size or the number of fire fighters.

- (i) Officers (squad boss or fire boss) should instruct crews on area hazards and safe working practices before they start work. The men in charge must have experience and/or training in these practices. Each person in charge should be identified to all crew members. The crew must understand this person's authority to issue instructions and must follow instructions at all times, particularly in emergencies.
- (ii) Escape routes should be chosen to avoid traps. Each crew should be thoroughly instructed in escape route use. Lookouts should be posted where necessary. If it is obstructed, the escape route should be cleared in advance to make it usable.
- (iii) A safe place should be provided for resting, lunching, or bedding down. If necessary, a lookout should be posted.
- (iv) Night crews should arrive on the line in daylight to familiarize themselves with the area. They should be advised of unsafe working conditions by the crew that they are relieving.
- (v) Every fire fighter should be alert to the action of the fire, since it can overtake them day or night.
- (vi) Individuals on the line should work at least 10 feet (3metres) apart.
- (vii) Reasonable rest periods should be provided. Shifts should not exceed twelve hours. Some reserve energy should be saved for emergencies.

- (viii) Immediate first aid must be administered to the injured. First aid equipment and knowledgeable first aid people should be at the fire. If it is a large fire, an emergency medical technician or a physician should be immediately available.
- (ix) Fire weather information should be used.
- (x) Men or machines should not work directly above one another.
- (xi) Extra fuses should be packed in the hand, not in clothing. Use a stick in the fuse ferrule to get the flame close to the fuel. Keep falling slag off clothing.
- (xii) If possible, power lines in the fire area should be cut off by the power company. If they cannot be cut off, men should not work underneath a power line when fire is producing any appreciable amount of heat or smoke under the line. Back off 30 metres or so until the main heat and smoke have passed. Nozzlemen must not direct a straight stream toward the electric wires. Never approach a broken line, since it can whip over a wide area. Do not consider either end of a broken line dead until the power company has grounded both ends and has advised that it is safe. Fence wires can become charged by broken power lines coming in contact with them. Be aware of this possibility and keep everyone away from the fences until the situation is corrected.
- (xiii) Do not place drip torches or flame throwers where they will get hot, and never open them while hot. Use only the recommended mix of fuel.
- (xiv) Avoid stepping on hot ashes; there may be a hole burnt underneath, and it may be full of hot coals. Check around stumps for concealed burning roots. As a general rule, do not walk on ashes unless the spot is checked with a stick or a tool.
- (xv) Be alert for sudden flare-ups that may scorch hands or face.
- (xvi) Only experienced crews should be used in snag felling; the area must be cleared of other workers.
- (xvii) Unauthorized persons should not be allowed on the fire line, especially underaged boys. They can be used on mop-up or in the camp but not on the hot fire line.
- (xviii) Observe **the ten fire-fighting rules** (section 10.4) and avoid situations that shout, "Watch out!"

10.6.7 Advising civilians

Objectives

The first priority at any fire is to save life, and the second is to save as much property as possible, particularly the more valuable and important property. The third priority is to prevent panic. The fourth is to permit un-hampered fire-fighting operations.

Property owners can aid in the protection of their homes and property. Water supply, earth-moving and water-dispensing equipment, and hand tools should be made ready. Fire fighters should advise property owners how their actions can aid fire-fighting operations.

Action by property owners

Property owners can aid operations by taking the following actions:

- (i) Close all doors and windows on the outside of the structure and all doors inside to slow room-to-room fire travel.
- (ii) Connect garden hoses and leave them loosely coiled in plain sight. Conserve water and fill any large containers, such as tanks, swimming pools, etc. Place available ladders against buildings.

- (iii) Wind up car windows and back the car into the garage.
- (vi) Cars left in the open should be placed in cleared areas and located so that they will not obstruct fire apparatus.
- (v) Leave the lights on in buildings. In case of general evacuation, leave the front door unlocked.
- (vi) Consider tearing down and removing combustible objects (wooden fences, wood piles, light patio furniture, bamboo screens, etc.) that present an exposure hazard to adjacent structures. Seal up attic and ground vents.
- (vii) Chop down highly combustible shrubbery and place it where it will not become hazardous to adjacent structures. Examples are cypress hedges and dead trees.
- (viii) Remove combustible fences and leaves from roofs and rain gutters. Remove dry grass from around structures, butane tanks, etc.
- (ix) Lower and close Venetian blinds. Remove inflammable window curtains and other readily combustible items (newspapers, furniture, rugs) from rooms where heat and draughts might logically break windows.

10.6.8 Personal safety

To ensure personal safety, civilians should observe the following precautions:

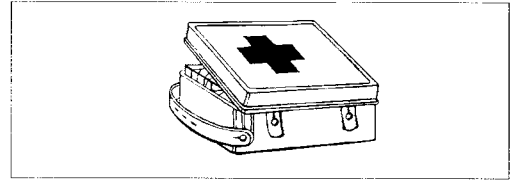
- (i) Keep the family together in a safe place, such as a large clearing or burnt area, or stay in the house.
- (ii) Stay away from hillsides above brush fires. Remember that smoke and heat draughts may be fatal.
- (iii) If it becomes necessary to drive through a brush or grass fire or through a smoky area, wind up car windows, close vents, and drive slowly with the lights on.
- (iv) Be aware of congestion on narrow roads. Do not drive down steep and unfamiliar roads.
- (v) Carry a shovel, an axe, and a water bucket in each car.
- (vi) If retardant drops have been made across roads, use extreme care because the retardants are slippery.
- (vii) If you are caught in an emergency, stay in your car with windows wound up and vents closed.
- (viii) Usually, it is safer to stay in the average residence than to flee uphill from a sweeping fire. A house may eventually be destroyed but before it becomes untenable a great amount of mass heat will have swept by so that later a person can survive outside even though the structure is eventually lost. Wetting down the roof and eaves enhances the probability of survival.
- (ix) Be alert, keep calm, think clearly, and act decisively.

10.7 First Aid

Immediate first aid must be administered to the injured. First aid equipment and a knowledge of first aid should be given to each and every fireman.

In every fire suppression organisation there must be a named person responsible for all first aid activities. In large fires there should be several trained first aid people or crews. All regular fire fighters, both permanent and volunteer, should have completed a standard Red Cross first aid course. Supervisors should also have completed the Red Cross course, or a more detailed course, in order to qualify for the wild fire service.

A good first aid kit should be carried with each wildfire backpack pump and should be checked and replenished before and after every fire.



The following is a first aid reminder list, and is not intended to be a substitute for completing a basic first aid course.

- (i) Examine the victim thoroughly. Treat all injuries immediately in the following order.

Stoppage of breath

- Give artificial respiration.
- Treat the victim for shock (see shock below).

Serious bleeding

- Elevate the injured part, unless it is broken.
- Remove clothing from the wound.
- Apply pressure in order to stop the bleeding.
- Bandage the injury.
- Treat the victim as for shock.

Burns

- Remove all clothing from the burn, **if it has not stuck to the skin.**
- Cover the burn with a sterile dressing.
- Treat the victim for shock.
- Give the victim frequent small drinks of water.

Broken bones

- Immobilise the injury (using splints or padding) before moving the victim.
- Treat the victim for shock.

Shock

- Keep the victim lying flat, preferably with legs higher than the head.
- Keep the victim warm enough to prevent shivering.
- Give the victim a cup of warm water, tea, or coffee unless he is exhausted, unconscious, or internally injured (in the stomach).
- Reassure the victim.

Heat exhaustion

- Place the victim in the shade and loosen clothing.
- Keep the victim warm and lying down.
- Stimulate circulation by rubbing the victim's body briskly.
- Use an ammoniac inhalant.

- (ii) Get help immediately. Report all injuries to the fire chief.
(iii) Arrange transport to a first aid station, or find an ambulance.
(iv) No less than fifteen men should be assigned to carry a stretcher in turn through rough timbered country.



**COMMUNITY BASED FIRE MANAGEMENT
(CBFiM)**

11. Community Based Fire Management (CBFiM)

11.1 Background

Community Based Fire Management or (CBFiM) was first introduced into the fire terminology in the late 1990s and CBFiM practices were first analyzed in South East Asia (Moore 1998) where persistent fires arising from a complex set of circumstances, primarily from land conversion. The analysis stressed that the underlying causes to fire needed to be investigated, before any other actions towards the use of fire could be assessed.

Fire management also include activities such as: early warning, detection, mobilization and suppression of unwanted fires; in addition also restoration and rehabilitation of burned areas.

However, also policy/legal/regulatory frameworks had to be adapted to the new understanding of the role of fire in ecosystems worldwide. It was also recognized, that controlled or prescribed use of fire in local communities, allowed them to play an important role in wildland fire management.

11.2 CBFiM – What is it?

11.2.1 Definition

Community-Based Fire Management (CBFiM) (FAO, 2006) is a management approach based on the strategy to include local communities in the proper application of land-use fires (managed beneficial fires for controlling weeds, reducing the impact of pests and diseases, generating income from non-timber forest products, creating forage and hunting, etc.), wildfire prevention, and in preparedness and suppression of wildfires. CBFiM approaches can play a significant role in fire management, especially in most parts of the world where human-based ignitions are the primary source of wildfires that affect livelihood, health and security of people. They include planning and supervision of activities, joint action for prescribed fire and fire monitoring and response, applying sanctions, and providing support to individuals to enhance their fire management tasks. Fire management should be safe, effective, environmentally, and socially acceptable, therefore communities can only assist in large-scale fire suppression, but should not be expected to shoulder the entire burden.

11.2.2 Gender and fire

An intrinsic aspect in community based fire management is gender, and in developing nations in particular, the roles of women, men and children. These roles can be quite specific, detailed and different. One example that illustrates this well comes from North-eastern Namibia. Data collected in North-Eastern Namibia in 1996, was similar to the data from the neighbouring countries of Angola, Zambia, Zimbabwe and Botswana: fire scar mapping of the area by satellite revealed; that between 50-85% of the forests, woodlands, savanna and grasslands was found to have burned each year.

In meetings with traditional leaders, technical staff discussed possible fire management strategies and steps that should be taken to reverse the trend of increasing, uncontrolled fires, aimed at restoring the situation to one in which the use of fire in the region was practiced in an environmentally sustainable manner.

When collecting data to serve as a basis for a study underpinning the above discussions, it was found that when men were interviewed, the main reason given for burning was because of "traditions", inherited from father to son. When women were asked the same questions, they stated that most wildfires had escaped from scheduled agricultural burning, a task that was exclusively carried out by women. Although the clearing of new land for shifting cultivation was carried out by men, it was found that spot-burning to kill and remove stumps and trees from clearings was mainly done by women, who also carried out all agricultural burning following the harvesting of crops. It is evident that in order to prepare a viable strategy for sustainable fire management in which local people are involved, gender aggregated baseline data is needed.

Gender aggregated data from pilot regions showed that 80% of the number of all fires was lit by women and 20% by men; but for primarily different reasons. It was concluded that in this case fire programmes should to a large extent target women not men, as had been previously done by the donor community. This targeting of men arose from the focus of all efforts on detection and suppression, activities dominated by men; instead of on prevention which was a women's domain.

The people, women fire users, know very well that fire outbreaks threaten the very resources they need for survival, in addition also their housing, children and elderly people.

In a survey in Mozambique 17 % of women said that their crop had burned during the last year and 16% that their house had burned down; all in all 39% of women confirmed that their house had burned down one time or the other. Out of men 48% and out of women 36% confirmed that they had experienced losses due to wildfires encroaching into their land.

In poor countries the use of fire is mainly about the lack of economic choice and alternatives. There is no choice but to keep using fire in agricultural activities despite having no resources to handle a large fire outbreak resulting from burning in livelihood activities. Since women are involved in most rural burning activities in many countries, therefore they should also receive high priority when planning fire training. Particularly so, because in most cases women are excluded from primary decision-making processes on management of land resources – a situation that needs to be addressed in the context of CBFiM as well as other frameworks.

11.2.3 Forms of CBFiM

There are communities involved in fire management in a range of ways:

- In Finland where most members of the Voluntary Fire Brigades in local communities have most of their assets invested in "forest farming" and are private forest owners and will therefore protect their forests; and
- Australia through Volunteer Fire Brigades that arise from the community and are mainly for protection of community assets and perhaps in many cases less engaged in forest and land management for subsistence or dependence on it in other ways.

These groups are volunteers, from the community and in a sense 'for' the community but they are focused on fire fighting in two respects - preparedness and response with a little bit of prevention if they participate in prescribe burning or other measures. They are not really "community based" in the sense that CBFiM has been considered to date in developing nations.

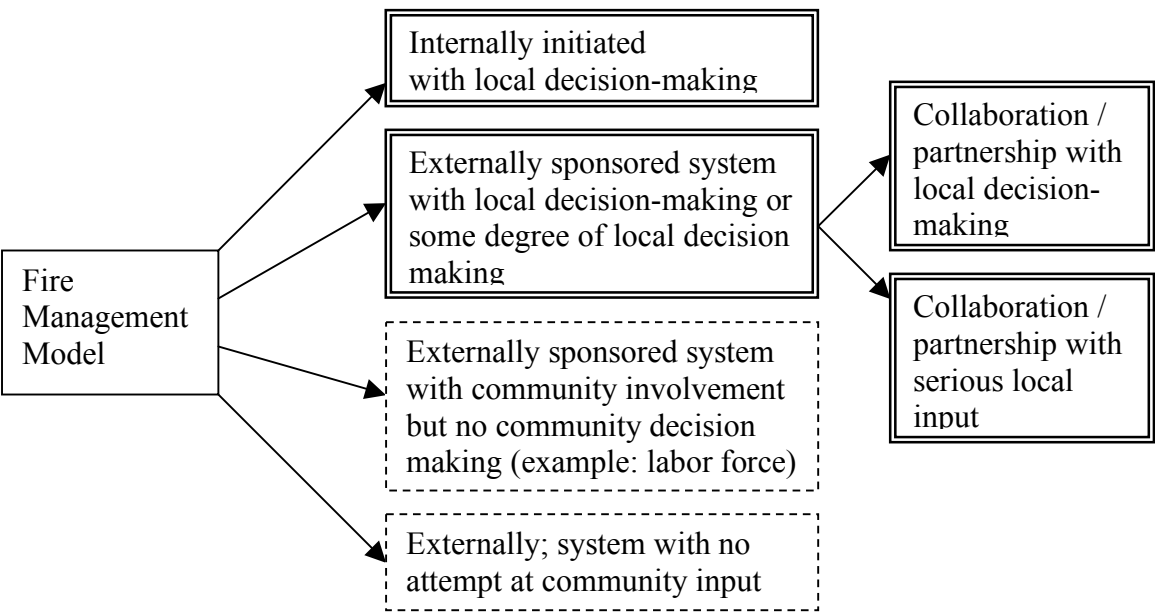
”Some (Moore, 2004) modes of management that do not allow for community input but do allow for community involvement (*Figure 1 - dashed lines*) are not considered CBFiM as per the definition previously given.

Although there is some emphasis on whether the system is initiated internally or externally, it should be noted that the initiation is not as important as the amount of credibility given to local decision making (*Figure 1 - double lines*)”.

Any attempt to improve and support CBFiM must start with an understanding of the causes and functions of various types of fires, and with their implications to various stakeholders within and outside a community. Similarly whether various stakeholders see a fire as beneficial or damaging is important before deciding what management is appropriate or possible.

The technical and organisational capacities of communities should also be considered.

Figure 1: Modes of Community Input in Decision Making in Fire Management (Moore, 2004)



11.2.4 Policy/legal/regulatory frameworks and CBFiM

In most developing nations, fire is not well dealt with in legislation. The tenure covered is usually restricted to public lands and the responsibility for fires is not clearly stated.

Fire legislation is often also split up into many small paragraphs within a number of separate Ministries. Generally legislation is treating fires as negative and destructive. The use of fire for livelihoods purposes is seldom accepted, with exceptions in a few countries. The lighting of open fires is in many cases an offence punishable under the laws. Malaysian legislation is an exception where deliberate fire is allowed under permit for local and small-scale activities that are specified in the law. Commercial scale fire use is however banned in Malaysia.

Specific Legislation most often criminalises local farmers using fire as illustrated by the "old" Forest Act, Article 40 from Mozambique:

"Anyone who, voluntarily, sets fire and thus partially or totally destroys crops, forests, woods or a grove of trees, shall be condemned to an imprisonment sentence of up to one year and to the corresponding fine".

Millions of local families are daily practicing shifting cultivation around the world; how then apply socially inappropriate laws to the essential livelihood practices in local communities? The only solution is to involve these communities in; fire awareness, mitigation and education activities (CBFiM). Thereby their traditional knowledge and inherent skills are applied to the avoidance of unwanted damaging fires, and leads to expanded use of beneficial fires.

Increasing awareness of the damaging effects of fires (in monetary terms) e.g. on local people's food security and livelihoods, can have a strong effect on motivating communities. Local communities may not have recognized the negative fire impacts on their livelihood, as demonstrated in Brazil, India and Tanzania. People often perceive wild fire only as a seasonal nuisance related to local traditions.

With the meager resources usually allocated to fire management, Governments often cannot supervise culturally accepted use of daily fires; and the tightening of legislation, will not have any impact on wildfire occurrence as long as people will have to practice shifting cultivation because of lack of other livelihood opportunities.

In Namibia a similar situation was approached by developing National Guidelines on Fire Management; wherein directives were laid out on the responsibilities of various stakeholders in CBFiM, including principles for community participation in forest protection.

11.2.5 Land tenure

A further consideration is the clarity of tenure under laws and regulation. In CBFiM efforts, the formal or informal rights of access, and use of lands was globally identified as a key aspect of communities taking an active role in fire management. The allocation of rights, access and operational efforts to clarify tenure are in many case not well formed in many nations. This is not necessarily restricted to developing nations as an issue.

There are many important components involved in fire management at the policy and field level, but a recurring theme is the fundamental question of who should control the use of fire and manage it appropriately? The rural landscape in developing nations remains home to hundreds of millions of people, both indigenous inhabitants as well as voluntary and forced migrants. Rural communities inevitably compete with internal and external factors for access to natural resources and the right to use fire as a management tool. Increased competition for land, water and forest resources may be an important factor driving the need for more clearly defined roles and responsibilities in fire management.

3.3 Fire and burning

Fire is a disturbance that has played, and will continue to play, a major role in both fire sensitive and fire adapted ecosystems throughout the world. In almost all of these ecosystems, humans have altered the natural fire regimes by changing the frequency and intensity of fires. Local communities are often blamed for fires which are considered harmful, the benefits of burning to the ecology nobody seem to recognise. Evidently because local people usually have most at stake in the event of a harmful fire, they should clearly be involved in mitigating unwanted fires.

In many cases, the re-introduction of fire is as important as preventing damaging, unwanted fires. It is also important to recognize that human values and cultural norms are as important as ecological values.

11. 3.1 Agricultural Burning

Agricultural burning globally, seem to be accepted as a necessary daily practice in most countries. However, when these often uncontrolled fires, despite being planned, run out of control, then agencies argue about whose responsibility the management of these fires are. However, seldom if ever, do the Agriculture Departments claim responsibility for causing these fires.

Out of all global fires 95% stem from various human activities, it is estimated that 80% of fires globally burning in forested areas, stem from escaped agricultural fires. When an agricultural fire spreads in to a forest, then the fire management responsibility is automatically transferred to forestry staff or lately also to staff of Fire and Rescue Departments e.g. as recently in Tanzania.

Agricultural fires are used for a wide range of purposes including:

- Management and maintenance of rangelands agricultural lands;
- Land conversion from forest land to agricultural land;
- Beekeeping, Hunting, Wildlife Management; and
- Native/Indigenous people's fires and cultural fires.

Escaped agricultural fires represented 91% of all wildland fires in Italy (Corpo Forestale) and 95% of fires in Portugal in 2002.

The proportion of forest fires arising from escaped agricultural fires indicate that strengthening or encouraging of community based fire management is likely to be a significant means of improving the impacts of unwanted and damaging fires. The impact of this approach might be enormous; therefore community fire use must be recognised as potentially the largest source of information, expertise and experience available.

Fires cannot be completely excluded from the daily lives of people and the landscapes they inhabit. Studies illustrate the ways communities use smaller wanted fire to cultivate crops and non-timber forest products, hunt, create forage and manage pests and disease need to be distinguished from uncontrolled fires. In Australasian, European and North American context of recent years, alarmingly many of these fires are caused by arson i.e. they are deliberately lit.

11.4 The Current State of CBFiM

To varying degrees, governments have begun to adopt collaborative or community-based forest management strategies. The emphasis on "community-based" is not only the community involvement, but also where community capacity has been recognized and supported by external agencies (governments, non-government organizations, projects and others).

More common are instances where CBFiM has resulted from the formation of community institutions and mechanisms that support more efficient fire management entities.

In some countries, the driving force behind CBFiM approaches is indigenous land and/or use rights, including the right to use fire as a management tool. The securing of these rights may ultimately help maintain the beneficial uses of managed fires.

It is also important to caution in respect of over-emphasizing the role and capacity of local communities to fight fires historically larger and of higher intensity than those of the regimes of the past. Several of the CBFiM approaches documented in various sources occur in remote locations, where the government's fire control/suppression approaches are severely hindered by access, response time and availability of funding.

11.5 External Intervention

Since external actors have generated most of the documentation and assessment on CBFiM, there is also an emphasis on the means and modes of approaches to intervention. To lead to *sustainable CBFiM*, the aim should be to build on existing knowledge. Communities must own the fire management activity and design their community participation approach fitting their locality. It was recommended that: Communities should call/arrange their own meetings and invite experts that they think will be of use for their location considering their available resources. This will only happen if fire management is integrated with their production/livelihood systems.

Recently the awareness has been increasing on the role of food security and health security (HIV) of local populations from forests. Hundreds of millions of people are gathering their food (medicines) from forests; therefore more external support should be provided for increasing skills of local people in using fire beneficially.

11.5.1 CBFiM Processes and Activities/Products by External Actors

Based on experiences especially in Latin America, Sub-Saharan Africa and South East Asia, the following processes and activities are proposed for planning and implementing sound fire programmes, which give due consideration to both technical issues and stakeholder involvement.

A critical facet of the processes for supporting CBFiM is to carry out a baseline study at village level to record local community aspirations. Together with forestry and/or agricultural extension workers and the village leaders organize community workshops to discuss the fire history of the village, fire use, wildfire causes, wildfire impacts, past fire management efforts.

11.6 The lengthy process of changing human behaviour

Out of all global fires 95% stem from various human activities; consequently therefore, unwanted fires globally should be reduced by proactive means of educating people.

However, many Governments, especially in developed nations, have over the last years, invested most of their resources in heavy fire fighting equipment, rather than in educating their people. The neglect to educate the growing population can in many cases be seen in the growing number of wild fires (uncontrolled fires).

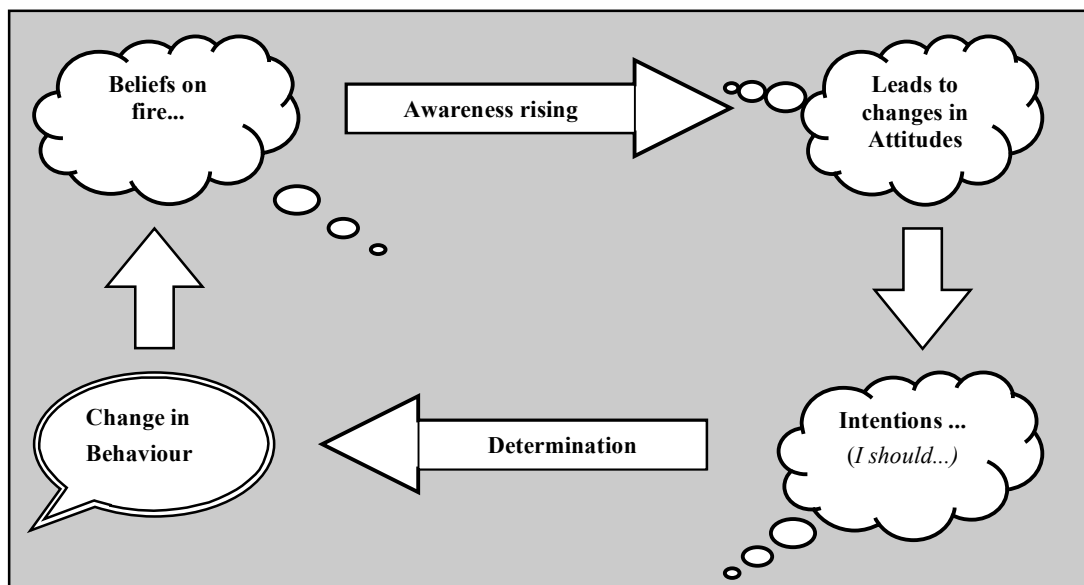
Therefore, awareness rising was in the early 2000s, considered a key issue when aiming at success in fire prevention, mitigation and education programmes worldwide. Human values, perceptions, beliefs, behaviour and cultural norms, were considered as important as ecological values in fire management. Enabling local people to become involved in managing their fires is a lengthy fundamental process, which will require several years to become effective.

Awareness raising and increased participation of rural populations in wildfire prevention and fire management, is the main goal of organizing national, regional or local Fire Campaigns. Based on experience drawn from many prevention campaigns carried out around the world, the following aspects should be included into village campaigns in one or the other way:

- Functions and importance of landscapes;
- The ecological, economic, social and cultural benefits of fire;
- The role of fire in the landscape;
- The implications of removing fire from its ecological, traditional or economic function in the landscape;
- Possible wildfire risks;
- Negative impacts of wildfires;
- Introduction to laws and regulations related to fire;
- Prescribed burning in shifting cultivation and agriculture; and
- Possibilities for the participation of rural communities in fire management.

The active participation of communities in village campaigns is very important and facilitators should understand local culture. The programme should allow as much contribution and inputs as possible from the participants and good visualization and easy-to-understand contents are crucial in presentations given by facilitators.

Fishbein 1967; ("Theory of reasoned action") applied to fire awareness rising



By analyzing Fishbein's "Theory of reasoned action" one can easily understand that if the aim is to introduce controlled use of fire by the local population, then one cannot approach the human population with contradicting messages such as; "fire is good" but you burn too much.

Even the "Theory of Planned Behaviour" (Ajzen 2002) still discusses the processes needed to change human behaviour. The success of fire awareness rising depends on how to make the task socially acceptable; community members clearly have to be able to see their own personal benefits, before they are going to change their behaviour.

To truly convince the local population, acquired Gender data and literacy levels, will further help to indicate as to what extent e.g. movie shows, theatre plays etc. should be used during the Campaign. The fire staff need to co-operate and co-ordinate efforts with all other government, non-government and outreach agencies. They also closely co-operate with the provincial fire officials, which should be responsible mainly for the development of concepts, campaign material, and the training of facilitators. Only these combined approaches will ascertain that; people move from the level of beliefs to new attitudes and further to *intentions*. The difficult final step is to move the human mind from mere intentions to changes in behaviour.

11.7 Development of Rural Community Fire Institutions

Community or village fire management has to be institutionalized at an early stage of any development effort. Responsibilities and tasks have to be assigned to community members who will, on a voluntary basis, make up a village fire crew or unit. Confirming the safe use of fire and effective fire management practice, including use of fire for ecological management is a key aspect of institutional development.

The village Fire Unit has to detect, prevent, and suppress unwanted fires in the village area. Importantly, they have to promote community preparedness, safe burning practices in agriculture in coordination and co-operation with village and district authorities and other communities of interest.

Importantly, a village fire unit has to manage fires at landscape level and not only in the home village.

Additional budget sources can be government agencies, NGOs, or private enterprises.

11.8 Training

The sections above have dealt with the steps to take to achieve sustainable participatory approaches in fire management. These steps need to be complemented by training. The basic information (baseline study) on fire in communities, including gender segregated and literacy data, will provide the basis for planning of training activities of *which* target groups should be trained (notably women as identified for Southern Africa) in *what* and at *what level* should they be trained?

The training plan should answer the following questions:
(*The 5W + 1H*) (*Why, What, Who, Where, When and How*)

Approaches in response to fires from both national as well as external actors, including donors, have generally (and still do) emphasised fire suppression. Implicit in this is the assumption that the fire "problem" results from a lack of awareness about fire damage and unwanted impacts and a shortage of skills and perhaps organisation.

By analyses of the 5W + 1H, the training may be directed to the right target group as well as contain the right curricula to meet the local needs.

11.8.1 Components of fire training

Issues related to training in fire management are complex; there is a need to cover both fire inclusion and fire exclusion in curricula and training programmes. Frequently, there is a generalized need to train staff in Government agencies, NGOs, local populations and interest groups in various aspects of fire management. Staff responsible for fire management and local people alike, need to appreciate and understand the role and relationship between the basic components of fire (fuel, heat, oxygen), as well as the principles of fire behaviour. In addition, they need to master, at least in principle the skills of prescribed burning. Such knowledge will form the basis of a more common understanding of local fire ecology, requirements of fire for keeping the forest healthy, and for regenerating the forest.

The generalized view that local people will not understand complex biological and ecological issues has been proven wrong in many instances. More than 100.000 local people and government staff were educated or trained in forest fire management activities in Burkina Faso, Namibia and Mozambique between 1996 and 2006. Only very few of those who received education/training, were not able to relate the environmental information to their own community or home area.

Fire management training should provide a balanced mix of theory and field-practice, which incorporates local conditions and knowledge and experience of the participants. The curriculum includes fire prevention activities, environmental education, institutional issues, the role, functions, and responsibilities of fire crews, fire preparedness rising, the use and maintenance of simple equipment, and also fire fighting strategies, tactics and techniques.

Assumptions and gross over estimations are often made of peoples capabilities to fight fires by using tree branches, palm leaves etc. Barefooted people, without any protection against radiant heat, smoke inhalation and flames, are next to "useless" in combating fires, unless equipped with tools, clothing and water to contain the fire. Well made rake-hoes, fire swatters and backpack sprayers are required for community fire fighting (Jurvélius, 1980).

The temperature in a burning fire, with several metres of flame height, is ranging from 300 to 500 degrees Centigrade, depending on the fuel load and fire intensity. No human being will be able to go even near a 300-500 degree fire, without appropriated tools, boots and uniforms with helmet and face shield.

11.8.2 Training in controlled or prescribed burning

The use of fire for subsistence and livelihoods is much more common than community institutions set up to only fight fires. CBFiM mainly exists where fire is used in some way that generates benefit for the local people. Active fire use generates skills, understanding and awareness and strengthens community institutions that deal with fire and related aspects.

Training in prescribed burning can have a range of benefits for the local people but importantly also for other actors and stakeholders that influence or are affected by managed fires. The training can ensure that skills and capacities are maintained and improved. Maintaining and understanding the use of fire at the local level is becoming an increasingly important; especially in places like Northern Australia, where skills are rapidly lost due to urbanization.

11. 9 The way forward

The active, intentional use of fire is an important factor in many, perhaps most, communities especially in developing nations. The initial focus for CBFiM should be on improving skills in the use of deliberate fires, increasing community preparedness, incorporating key aspects of gender, developing community institutions and implementing appropriate training.



FIRE: A NECESSARY EVIL

12. Fire: a Necessary Evil

12.1 Background: Why Fire is perceived harmful

Uncontrolled fire has become one of the main environmental issues facing the global community, and in fact, the most important global disturbances, considering the observed effects it has on land area and biodiversity. At global level an estimated 150 to 250 million ha (Mha) of the recorded 1.8 billion ha of tropical forests are affected by wildfire annually. Many mature and immature forest trees are killed by high intensity fires annually. In the Amazonian forests for instance, wildfire has been reported to cause high mortality in many useful species with the rate ranging between 36-96%. Consequently fires affect timber supplies from which income and other livelihood needs are generated for the majority of people, particularly, in developing countries.

In Ghana, (one of the leading exporters of timber in Africa), for instance, wildfires caused more than 4 million m³ of exportable timber in losses between 1982-1983. An estimated annual loss of 3% of GDP was recorded for the past two decades, due to wild fires. In South East Asia, the loss of tropical forest resources was much higher. Areas (in Java, Borneo, Sulawesi, Irian Jaya and Sumatra) in Indonesia which were the most affected in Asia lost about 9.5 Mha of land to fires, out of which about 4.6 Mha (49%) was forested. For the same period, Brazil lost an estimated 3.3 Mha hectares of land of which 1.5 million was rainforest in northern Amazonia alone. In Mexico and Central America a further 1.5 million hectares was burnt affecting biodiversity and ecosystem processes. During the same period, over 5 million hectares of temperate forests were also affected in the United States and Canada and 2 million hectares in Russia (Rowell and Moore, 2000).

In many cases, wildfire caused heavy financial losses in terms of people loosing their homes and property. Wildfires also pollute the air with smoke that causes health hazards and making aerial communication difficult. Also the carbon emitted during wild fires also contributes significantly to the build-up of greenhouse gases in the atmosphere. Further more the destruction of forests by wild fires terminates the role of forests to act as sinks for carbon.

Obviously, the harmful effect of wildfire is very clear and explains why the public generally have the opinion, that fires are always harmful to nature. However, for some of us, fire is a necessary "evil". Thus, despite the destructiveness of fire, it can be a legitimate land management tool, if carefully timed and used (Goldammer, 1999)". As a result, FAO, (2006) projects the idea that there is good fire and should be advocated and supported". However, the dilemma faced by particularly the public, rural communities, is that fire can be very destructive and at the same time, act as a useful tool in the enhancement of ecosystems. This section of the book presents a review of the role of fire in global ecosystems. This review, seeks to, particularly, highlight the importance in the application of the "right kind of fire" by local people, to enhance the ecosystem and their livelihoods.

12.2 Fire as Conservation and Livelihood issue¹

Fires are increasingly damaging the world's forests, impacting ecosystem processes and shaping landscapes. Today, among globally important ecoregions for conservation, 84% of the area assessed is at risk from altered fire regimes (judged to be "degraded" or "very degraded") (Figure 1) and 46% of the area assessed is classified as fire-dependent/influenced, 36% as fire-sensitive, and 18% as fire-independent (Figure 2) (TNC, 2004). See pages: 49 and 245 for Figures 1 & 2 respectively.

In recent years interests to adopt comprehensive fire management programmes and to consider fire as a conservation issue has grown internationally. The reasons for the growth in interest are two-fold. Firstly, there is the recognition of the increase in occurrence of extremely severe fires and excessive application of fire in land use system, which threaten natural resources and livelihood systems. Secondly, the recognition of how some of the current approaches to fire prevention are out of step. Both issues have led, among others, to the emergence of the concept of integrated forest fire management (IFFM) during the recent years.

Myers defined IFFM as the integration of science and society with fire management technologies at multiple levels. This implies an integrated approach to forest fire management where fire programs are not limited to the traditional efforts of fire prevention and fire suppression only, but also embraces the use of prescribed or managed fire as a tool, community involvement, and law enforcement. This also imply integrating fire-related issues with other ecological (e.g. climate change) socio-economic (e.g. culture), and technical factors and forest management practices during conservation and land use planning efforts.

12.2.1 The Role of Fire in Ecosystems

In discussing and addressing fire as a conservation issue, it is important to recognize and understand the different roles that fire plays in different ecosystems. The Nature Conservancy (TNC), in its preliminary global assessment of fire as a conservation threat, identified three broad categories of vegetation responses to fire: fire-dependent, fire-sensitive and fire-independent. That report focused on the predominant fire effect at the level of biome and ecoregion, recognizing that within ecoregions there can be a variety of ecosystems and habitats that have responses different from the predominant effect. Because this report focuses on potential management actions to fire within conservation areas where multiple responses may be manifested, a fourth category is included: fire-influenced. These ecosystems may be linked hierarchically to fire-dependent and fire-sensitive ecosystems because they are frequently found as transitions between them. All ecosystems or native vegetation types do not fit perfectly into each of these categories, but the groupings provide a means of illustrating and discussing the threats and conservation needs and opportunities associated with fire in diverse vegetation types and how management actions may vary among them.

¹ Text copied with permission from the publication "Living with Fire – Sustaining Ecosystems & Livelihoods through Integrated Fire Management; Ronald R. Myers TNC, 2006.

12.2.2 Fire-Independent Ecosystems

Fire-independent ecosystems are those where fire normally plays little or no role. They are too cold, too wet or too dry to burn. Examples are deserts, tundra and rain forests in a seasonal environment. Fire becomes a threat only if there are significant changes to these ecosystems brought about by land use activities, species invasions or climate change. The preliminary assessment of fire as a conservation issue, which focused on 200 priority (i.e. based on their biodiversity value) ecoregions worldwide, identified 18 percent by area as dominated by fire-independent ecosystems.

12.2.3 Fire-Dependent Ecosystems

Fire-dependent ecosystems are those where fire is essential and the species have evolved adaptations to respond positively to fire and to facilitate fire's spread, i.e. the vegetation is fire-prone and flammable. They are often called **fire-adapted** or **fire-maintained** ecosystems. Fire in these areas is an absolutely essential process. If fire is removed, or if the fire regime is altered beyond its normal range of variability, the ecosystem changes to something else, and habitats and species are lost. Individual species within fire-dependent ecosystems have evolved in response to specific fire regime characteristics such as frequency, intensity and season of burn, and to the variability of those characteristics. Types of fire regimes vary greatly, ranging from frequent, low-intensity, non-lethal surface fires to those characterized by mixed-severity fires (i.e. lethal and non-lethal effects varying across the landscape), to relatively infrequent, high-severity, lethal or stand replacing fires that arrest or re-set ecological succession creating a diversity of habitats in time and space as the vegetation recovers. On an area basis, approximately 46 percent of the world's priority ecoregions are dominated by fire-dependent ecosystems, meaning they need to burn under an appropriate fire regime if they are to persist in the landscape. Examples of fire-dependent ecosystems abound around the world. In Mesoamerica, there is a wide variety of fire dependent pine forests and pine savannas. Mexico, with its temperate and tropical environments, has the highest pine species diversity in the world – 55 species and varieties.

Most species of pine are linked to disturbance, often defined by specific fire regimes. Several of these forest types extend into Central America. The same can be said of Mexico's high diversity of oak species – 110 species, a large number of which may require fire or are favoured by fire-induced disturbances. Elsewhere in Mesoamerica and the Caribbean, fire-dependent *Pinus caribaea* savannas and woodlands range from the Bahamas through Cuba and on to Belize, Honduras and Nicaragua. The Dominican Republic has forests and savannas of the endemic *Pinus occidentalis*, which are dependent on fire. Besides *P. caribaea*, Cuba has three species of endemic pines that persist in fire prone environments.

Fire-adapted pine species also form extensive open forests and woodlands in the tropical and subtropical environments of Southeast and South Asia. Fire plays a key, though poorly understood, role in the maintenance and characteristics of *Pinus kesiya* and/or *P. merkusii* forests ranging from the Assam Hills of India, across Myanmar, Thailand, Southern China, Cambodia, Laos, Vietnam and the Philippines to Sumatra. Africa has been referred to as the "fire continent" primarily because much of Sub-Saharan Africa, with the exception of the

tropical forests of western and central equatorial Africa, once consisted of a vast landscape of tropical and subtropical fire-prone savannas, and fire-influenced woodlands and shrub lands that have been shaped by the longest history of human involvement with fire in the world.

South America is just as much a "fire continent" as Africa. A significant proportion of South America lies in the same bioclimatic zone that supports savanna in Africa. The Brazilian Cerrado, once covering 22 percent of the country or 2 million sq. km, is a mosaic of savanna and shrubland moulded by a diversity of fire regimes. Other tropical grassland types in South America are found in the Gran Sabana and Llanos of Venezuela, and in Bolivia, Peru and Paraguay. Temperate South America claims the vast Argentine pampas and other grasslands. Fire's role in other South American temperate ecosystems, such as the Araucaria forests, is poorly understood.

Fire-maintained palm forests and palm savannas are common throughout the tropics, along with a variety of fire-dependent and fire-influenced coastal and freshwater marshlands. Scientists are just beginning to understand that fire is also an integral part of tropical alpine areas such as páramo in the Americas and Afro-alpine vegetation.

Other strongly fire-dependent environments include Mediterranean-type forests, shrublands and savannas located in widely dispersed parts of the world; temperate and boreal coniferous forests and oak-dominated forests and grasslands of North America, Central Asia, China, Russia and Mongolia; and the eucalypt forests, savannas and heathlands of Australia.

12.2.4 Fire-Sensitive Ecosystems

Fire-sensitive ecosystems have not evolved with fire as a significant, recurring process. Species in these areas lack adaptations to respond to fire and mortality is high even when fire intensity is very low. Vegetation structure and composition tend to inhibit ignition and fire spread. In other words, they are not very flammable. Under natural, undisturbed conditions, fire may be such a rare event that these ecosystems could be considered fire-independent. Only when these ecosystems become fragmented by human activities, fuels are altered and ignitions increase, do fires become a problem. As fires become frequent and widespread, the ecosystem shifts to more fire-prone vegetation. Tropical forests become savannas of introduced grasses and semi-arid grasslands are invaded by non-native grasses that create a continuous fuel. On an area basis, 36 percent of ecoregions are dominated by fire-sensitive ecosystems.

Examples of fire-sensitive ecosystems are the wide variety of tropical and subtropical broadleaved forests found along both altitudinal and moisture gradients and temperate zone broadleaved and conifer forests at the wetter end of the moisture gradient. There are a number of ecosystems whose category is uncertain. An example is the Chilean Matorral, a Mediterranean-type shrubland. Although flammable, it appears to lack the regenerative responses to fire of species found in other types of Mediterranean shrublands around the world. In some ecosystems the ecological role of fire simply has not been identified.

12.2.5 Fire-Influenced Ecosystems

This category includes vegetation types that frequently lie in the transition zone between fire-dependent ecosystems and fire-sensitive or fire-independent ecosystems, but it may ultimately include broader vegetation types where the responses of species to fire have not been documented and the role of fire in maintaining biodiversity is not recognized. They are ecosystems that generally are either sensitive to fire but contain some species that are able to respond positively to fire disturbances, or they are ecosystems that would persist in the absence of fire but fire disturbances play a role in creating certain habitats, favouring the relative abundance of certain species, and maintaining biodiversity.

In fire-influenced ecosystems, fires generally originate in adjacent fire-dependent vegetation and spread to varying degrees and at varying intervals into the fire-influenced vegetation, although a low level of traditional agricultural clearing and burning may have been important endogenous sources of ignition. Here, fire may be important in creating certain habitats by opening forest or shrub canopies, initiating succession and maintaining the transitional vegetation. Fire-influenced ecosystems present challenging management issues because of the subtle role that fire may play. Examples include the transition zone of wet sclerophyll forest between savanna and rain forest that occurs in north-eastern Queensland, the riparian vegetation or gallery forests along water courses in savanna or grassland vegetation, the "islands" of fire-sensitive vegetation often embedded in a matrix of fire-prone vegetation such as "hammocks" in the Everglades of Florida and similar vegetation patterns in the Pantanal of Brazil, and certain types of tropical and subtropical forests like those identified in Mesoamerica where fire has maintained the dominance of mahogany (*Swietenia macrophylla*) and associated species.

Climate change may cause significant changes in the structure and shifts in location of fire-influenced ecosystems. In other words, it may be in these ecosystems where climate change-induced shifts in vegetation will become most apparent over the short term".

12.3 The Source of Fire Threats to Biodiversity

The nature of fire-related threats varies depending on ecosystem responses and the adaptations of species to fire. A wide variety of fire-sensitive ecosystems in the tropics and elsewhere are threatened by land use activities and vegetation conversion efforts that either use fire or increase the probability of ignitions. Forest vegetation that rarely burns and normally resists fire is being modified by human activities such that fire is entering these ecosystems at shorter intervals. An initial fire is usually of very low intensity, but the impacts are severe - killing trees, increasing fuel loads and opening the canopy, allowing fuels to dry and grasses and ferns to grow. Without subsequent ignitions the forests can recover, but the predominant trend is toward increased ignitions leading to repeated fires and rapid changes in vegetation structure and fuel characteristics. Fire creates a positive feedback loop that leads to increasing flammability and drier conditions.

These fire-sensitive ecosystems are now being exposed to frequent ignitions and require urgent and aggressive measures to counteract the sources of the threat or to mitigate their impacts. Experience gained from preventing and fighting fires in temperate and boreal ecosystems may not be transferable to tropical environments primarily because of different social and economic

contexts and due to the costs associated with high-technology fire suppression. Greater emphasis needs to be placed on the underlying causes of the fires and on developing local and regional solutions that are sustainable.

Conversely, as governments, land management entities and scientists attempt to address fire-related threats through policy changes, incentives and community-based prevention and suppression programs, there is a danger that the vital role of, and need for, fire in many ecosystems will be overlooked, as was done in much of the United States over the last century and has occurred in portions of Australia and Canada. There is a misconception (at least by fire professionals and the interested public in temperate climes) that the tropics is a vast fire-sensitive rain forest threatened by rampant logging-induced fire and agricultural burning. In reality, the tropics include some broadleaved forest types where periodic fire is part of the system, i.e. fire-influenced ecosystems, but where excessive burning is clearly a threat. The tropics and subtropics also harbour ecosystems and habitats that require fire.

12.3.1 Case Studies: Fire as tool for Livelihood and Ecosystem improvement

Currently there are several good examples of case studies highlighting the importance and reality of anthropogenic fires in improving livelihood, improving soil conditions, controlling pest and diseases and invasive species and maintaining biodiversity, in forest ecosystems. The contexts in which fire is often used are presented below

12.3.1.1 Economic and social context

In Africa and Asia, even though in some case wild fires had been ignited for apparently no valid ecological reasons, the use of fire had been and is still an integral part of land use and livelihood systems. Fire is used for field preparation in slash-and-burn agriculture (Figure 3) on which majority of the rural people depends to meet energy and food needs.

Figure 3. Slash-and-burn agricultural land preparation method in Ghana.



(Photo by Mark Appiah)

During the agricultural activities, the local people use fire to control pest, suppress

weeds. In Ghana for instance, fire is also used to prevent the rottenness of the palm tree, and to ensure better taste and to increased yield of wine during palm wine processing. To the hunters, fire is a tool for smoking out games. This tells us some of the ways in which communities use fire to cultivate crops, manage pests and disease, hunt and ensure the availability of non-wood forest products. While the public, particularly those, in developing countries may have the opinion that fires are always harmful to nature due to the devastating effects of wildfire, they do recognize some importance of fires that are connected to their livelihood. They also have different views about wildfire which is important to consider in strategies for community-based fire management programs. Quite often there is a mismatch between the perceptions of policy makers, fire managers and those of local resources users.

12.3.1.2 Nutrient cycling

In grassland ecosystems, fire is the primary mode of decomposition, making it is crucial for returning nutrients to the soil and allowing the grasslands to sustain their high productivity. Research of two controlled burns on organic carbon, revealed, that the total and available nitrogen, phosphorus, and sulphur of surface soils (0-5cm) of the southern Caldenal region in Argentina (Castelli and Lazzari, 2002) and; confirmed the general accepted trend, that the first controlled burn generally caused a beneficial effect on the total elements, either immediately, or one or two years after the burn. It also caused a considerable flush of the available nutrients that was more persistent under the shrubs. This could be explained by the fact that grasslands burn more readily than shrub ecosystems, with fire moving through the stems and leaves of herbaceous plants and only lightly heating the underlying soil even in cases of high intensity (DeBano et al. 1998), thus, releasing nutrients that are locked up in slowly decaying woody material into the forest nutrient recycling system. These results indicated that in a fire-prone habitat such as in semiarid ecotones, long-term ecosystem health could rely upon a balance between fire-related nutrient outputs and succession-related nutrient inputs to ecosystem nutrient capital.

12.3.1.3 Plant growth initiation and forage improvement

Research conducted over the past five decades has revealed that fire not only helps to maintain the ecosystem but also helps to ensure the availability of quality forage. For instance, it was found that in South Africa and Namibia, freshly burnt savanna areas had new plant growth that provided palatable forage compared to unburnt areas with older grasses. The threshold level seems to be at 4.000 kg/ha of grass sward. Below 4.000 kg/ha burning is not required whereas anything above 4.000 kg/ha will require burning to remove unpalatable grass sward. In this part of the world animal keeping is a way of life and domestic animals like sheep, goats and cattle obtain greater than 85 % of their nutrition from forage. In addition, wildlife usually intermixes with domestic cattle in grazing in Sub-Saharan Africa. Therefore, pasture created by fire, especially on lands that is normally unsuitable for crop production, can be a useful source of forage. More importantly, the fresh forage will encourage large herbivores to move to less preferred areas in order to minimize the overuse of preferred areas which are areas kept short by constant grazing (Trollope and Trollope, 1999;

Archibald et al. 2005), and allow grazing-intolerant grass species to grow in these areas and thus persist within the ecosystem. Fire does not only helps to ensure the availability of quality forage, but also certain wildlife species like the "grass cutter" and Giant rats do benefit significantly from periodic fires (FORIG, 2003).

12.4. Ways forward

The fact is that trying to eliminate fire from the wildland is not a practical option, and has adverse effects on regeneration of some species and biodiversity. Fire and ecosystems have been linked in many ways for millennia and that must be recognized for any wildland fire management policy to be effective. More importantly, fire should be well integrated into the practice of forest conservation and management. At least there is sufficient information from these case studies to be sure about the importance of planned burning in ecosystems to maintain biodiversity, ensure regeneration and improve soil fertility and forage production, particularly in the savanna areas where biodiversity loss, soil erosion, and availability of animal feed are environmental issues of great concern in the future.

Appendix

Figure 1 Fire Regime Status and Trend (TNC, 2004. Fire, Ecosystems & People: A Preliminary Assessment of Fire as a Global Conservation Issue, The Nature Conservancy <http://www.nature.org/initiatives/fire/science>)

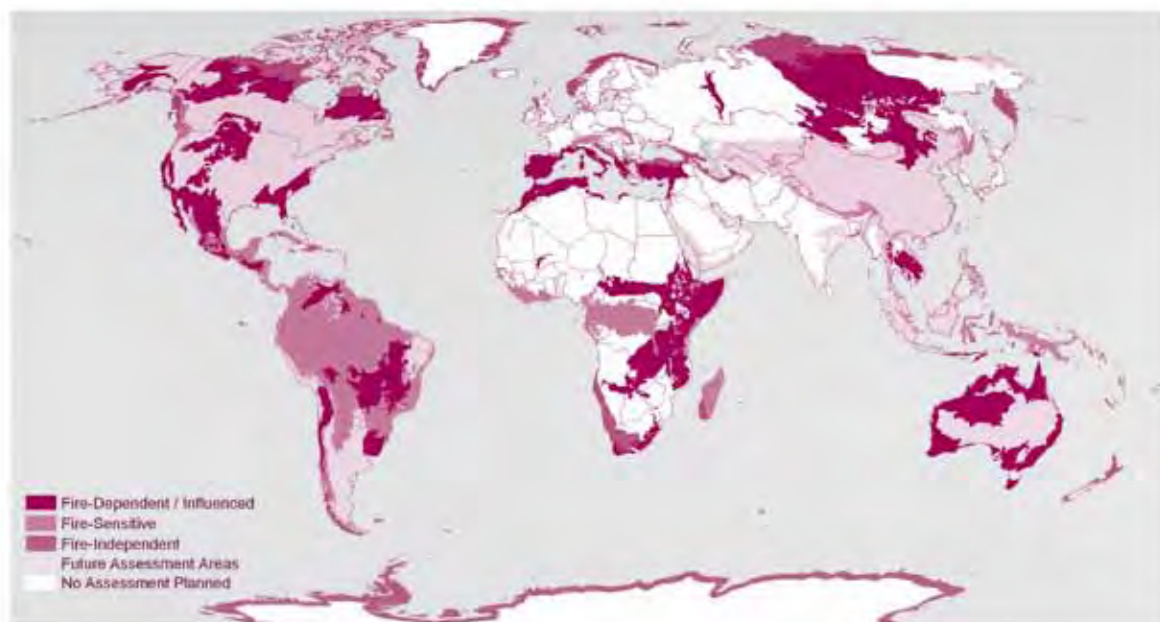


Figure 2 See page 49.

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