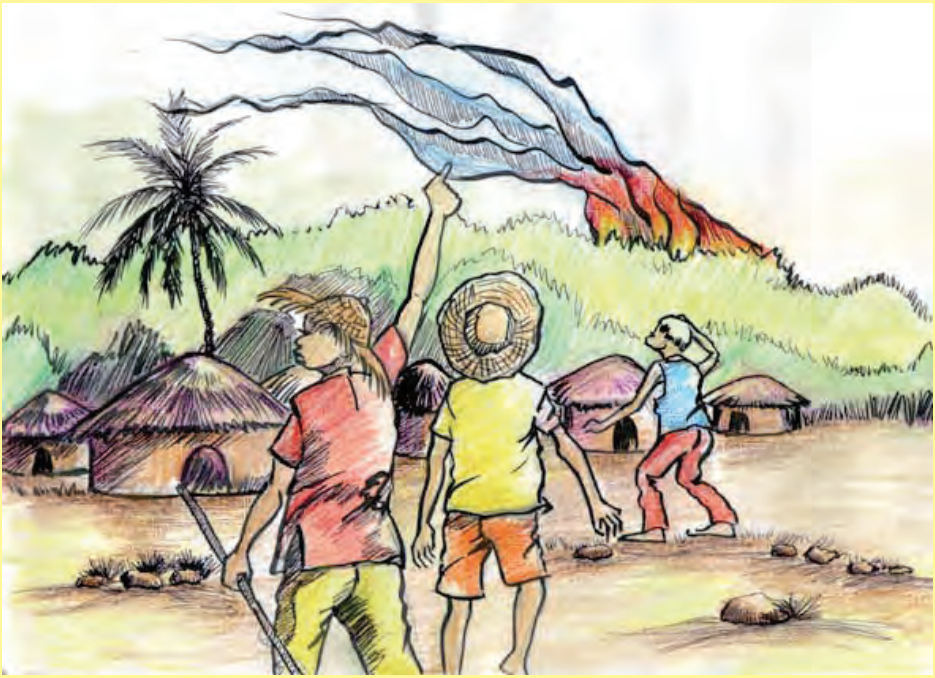
REPUBLIC OF GHANA

Guidelines & Manual

Procedures for Community-Based Fire Management – CBFiM

Ghana



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FOREWORD

Fire is an important land management tool but its careless or unplanned use can have devastating effects. Wildfire is a major cause of ecosystem degradation including the loss and extinction of biodiversity. It can also lead to the loss of human and animal life, economic devastation, social disruption and environmental deterioration. Fires are known to be responsible for the annual destruction of several millions of hectares of valuable timber, other forest products, and environmental services provided by forest ecosystems.

In Ghana, it has been estimated that the land area prone to annual wildfire ranges from 30% in the high and transitional zones of the country to over 90% of the drier northern savannah zone. The continued expansion of land conversion and the use of fire for cultural and related purposes have been blamed for the increasing incidence of wildfire in the country. Information from the country' s forestry sector indicates that the annual loss of revenue from marketable timber as a result of wildfire is approximately USD 24 Million. The combined effect of wildfire is an annual loss of 3% of the country' s Gross Domestic Product (GDP), estimated at USD 210 Million. Even though the negative effects of wildfire affect virtually everyone, the poor are mostly at risk as their livelihood directly depends on land and its resources, even as they reside in the most fragile and fire prone ecosystems.

Good management practices can help reduce the extent and severity of unplanned wildfire. With most wildfires stemming from fires generated out of forest ecosystems, the sustainable management of forests and their related resources requires the participation of the local population adjacent to these basic fire areas. Good fire management has been revealed to produce direct benefits to local communities. Wherever people have a direct interest in protecting their natural resources, unplanned wildfires will be reduced. Interactions with local community members have revealed that they will mobilize themselves to prevent wildfires when they acknowledge that by so doing, they will benefit in maintaining their natural resources, and consequently their livelihood.

The ITTO/IUCN/FORIG/RMSC project: Fire Management and post fire Restoration with Local Community Collaboration in Ghana, PD 284/04/Rev 2(F); determined the relationship between the use of natural resources by rural communities and effective fire management. Project results revealed that with adequate wildfire management, significant gains can be made for the national economy with enormous livelihood benefits for local communities. The project consequently advocated the importance of community involvement in fire management. It enhanced the capacity of local communities in several project areas through training in fire management, an activity which this Guidelines/ Manual expects to perpetuate.

This Manual is first and foremost a community tool to facilitate implementation of Ghana' s National Wildfire Management Policy. However it will also serve as an instrument for fire management trainers in communities with little experience in fire management and for consultation by professionals, students, policy makers, practitioners and communities when faced with fire related problems and incidents. It is expected that the Manual will constitute a solid base for capacity building in fire management. It is also expected that the Government of Ghana, District Assemblies in fire prone areas and other stakeholders will embrace the approaches outlined in the Manual and commit resources for the implementation of its outlined principles and practices. It is also hoped that the use and application of the prescriptions contained in the Manual will help to reduce the frequency of wildfires that have been plaguing Ghana in recent years.

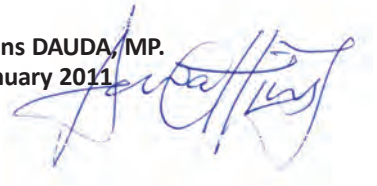
The process for the development of this Manual witnessed a series of meetings, seminars and workshops with a multiplicity of stakeholders for over three years. The process also involved concrete interventions that ranged from equipping communities and practicing fire fighting operations to the rehabilitation of fire degraded lands.

This Manual is different in that it is developed based on experiences from the past and provides clearly illustrated guidance for wildfire management interventions by communities and others in the country. The Manual is divided into two main sections; a first section that interprets legal prescriptions, and a second section with illustrations to promote capacity building in wildfire management. This takes into consideration, variations in fire ecology, fire regimes and community preparedness nationally.

It is my ardent expectation that this Manual will contribute significantly towards community interventions against wildfire, act as an encouragement for all natural resource management professionals and educators as well as policy makers at different levels to actively and effectively campaign against wildfires in the country.

The Minister of Lands & Natural Resources

Hon. Collins DAUDA, MP.
Accra, January 2011



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SECTION 1: BACKGROUND, LEGAL AND MANAGEMENT PRESCRIPTIONS

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1.1 The National Wildfire Management Policy of the Republic of Ghana (2006)

1.1.1 Introduction

Wildfire is perhaps the most important single threat to the integrity of forests in Ghana. In recent years, Ghana has lost an ever increasing percentage of its Gross Domestic Product (GDP) to the indiscriminate ravages of wildfires. It is also the direct cause of irreversible environmental damage in the country. In certain areas the process of desertification has been hastened by wildfires, which have permanently destroyed delicate but vital organic soil material. At present, most fire-affected areas show progressive degradation. A number of Forest Reserves, formerly made of tall, dense tropical forests and rich biodiversity have transformed to grassland with littered pockets of fire-damaged relic forests.

Therefore, to conserve, enhance and protect the natural environment from uncontrolled fire, it is important to have a comprehensive national policy, which will give a more proactive, pragmatic and comprehensive framework to guide and determine government actions towards wildfire in the country. In addition to the policy framework, Ghana will be addressing global concerns for environmental quality management, and minimize risks from climate change.

1.1.2 The Policy Framework

In order to address the above challenges this policy provides a holistic framework for addressing the problems of wildfire management in the country and ensures an effective system, which will minimize the incidence and impact of wildfire and enhance the socio-economic transformation of the country.

1.1.3 Guiding Principles

The National Wildfire Management Policy is based on the principles that:

- Land and its resources provide the direct source of livelihoods for the majority of the rural population and that poverty reduction and wealth creation in the country are dependent upon effective management of wildfire for sustainable management of natural resources;
- Different ecological zones and natural resource management systems exist in the county, which require different wildfire management approaches;
- Fire will continue to be used as a tool for rural land management but this must be done in a controllable and environmentally friendly manner;
- Wildfire management requires a multi-sectoral approach and gender sensitive collaboration among stakeholders, including the vulnerable;
- District Assemblies (DAs), Traditional Authorities (TAs), opinion leaders and local community groups, including women and youth groups are important actors in wildfire management;
- Wildfire management activities at all levels will be carried out based on effective and efficient planning and networking;
- The capacity of communities and community structures will be developed in wildfire management and this will be sustained through the provision of adequate and appropriate logistic and technical support by taking into consideration their indigenous knowledge;
- International best-practised systems and indigenous knowledge are important ingredients in evolving sustainable wildfire management practices;
- A nationally co-ordinated early warning system and well formulated public education programmes are essential for sustainable wildfire management;
- Sustainable incentives, rewards and benefit-sharing systems are indispensable in successful wildfire management; and
- Adequate research needs to be encouraged and promoted in collaboration with local and international bodies and sustained to provide the basis for developing best practices in wildfire management.

1.1.4 Specific Policy Objectives

The objectives of the Ghana Wildfire Management Policy are fourfold, namely:

i. Ensure *effective and efficient prevention and control* of fires;
ii. Encourage the *adoption of alternative resources management systems* that will minimize the occurrence of wildfires;
iii. Develop necessary *structures and systems which will ensure stakeholder participation* in wildfire management; and
iv. P*romote user-focused research* in wildfire management.

1.1.5 The globally approved 11 UN-Principles in Wildfire Management

The 11 United Nations-approved Principles[1] for fire management address the cultural, social, environmental and economic dimensions of fire management at all levels. This is in accordance with recommendations of the International Wildland Fire Summit in 2003, the Ministerial Meeting on Sustainable Forest Management in 2005 and other international forums on the conservation of forests and nature such as the United Nations Forum on Forests, and the World Conservation Congress. The Fire Summit proposed a Fires Working Group which evolved into a multi-stakeholder process and developed principles and strategic actions as part of a global strategy for international cooperation in fire management. The principles and strategic actions are global in scope and are provided as guidance to: national policy makers; all elements of civil society and the private sector; senior managers of sub-regional, regional and global organizations whether governmental or non-governmental; owners and managers of forests, range and grasslands, and other ecosystems; and all stakeholders concerned with the protection of lives, property and resources from the effects of unwanted and damaging fires. The principles however also recommend the use of fire to enhance ecosystems and economic benefits. Other sectors may also find the principles and strategic actions useful in their roles in society such as: insurance companies, advocacy groups, and specialists in communication, disaster management and public relations.

The Principles serve as a checklist to strengthen policies, legal and regulatory frameworks, plans and procedures and, where these do not exist, serve as a useful basis for their development and implementation.

[1] FAO Fire Management: Voluntary Guidelines; Principles and Strategic actions FM17E (Mike Jurvelius).

2. The Guidelines & Manual of Procedures for Community Based Fire Management (CBFiM)

2.1 Background

The Guidelines and Manual of Procedures for Community Based Fire Management in Ghana is developed within the framework of the National Wildfire Management Policy of the Republic of Ghana. It is guided by the 11 United Nations-approved Principles[2] for fire management. The development of this Guidelines and Manual received the support of the ITTO/IUCN/FORIG/RMSC Project PD 284/04 Rev. 2 (F), which identified the need and was given the mandate to prepare a specific and detailed Procedures for Community based Fire Management in Ghana. The aim was to specify and adapt the broad orientations provided by the Ghana Wildfire Management Policy and its recommended Strategies.

Human behaviour

More than 90% of wildfires in Ghana are caused by various human activities. Therefore, this Guidelines and Manual of Procedures for Community Based Fire Management is centred on changing the behaviour of local people in their daily use of fire and burning (See Figure 1 on adjacent page). It consequently focuses on the modification of traditional beliefs, values, and perceptions that promote uncontrolled fires, towards attitudes and eventually new intentions, which gradually over time, will lead to new behaviour that can effectively contribute towards implementation of the new Fire Policy.

Because most fires in Ghana are caused by individuals, this Guidelines and Manual targets the learning potential of individuals. It defines learning[3] as a modification of a person' s behaviour through his/her activities and experience, so that his/her knowledge, skills and attitudes towards his/her environment are changed, more or less permanently. Based on extensive experiences in fire awareness-raising in other tropical countries, the lengthy process of changing human behaviour takes 2-3 fire seasons to achieve. People have to see clear changes in their surroundings (environment), as proof to change their behaviour.

2 FAO Fire Management: Voluntary Guidelines; Principles and Strategic actions FM17E.

3 L.B. Curzon 1990, Teaching in Further Education (slightly modified).

Impact from excessive land conversion

The Environmental Protection Agency (EPA) of Ghana has estimated that the increased emissions of carbon dioxide gas (CO2) from uncontrolled burning will result in an annual increase in temperatures. Consequently, annual rainfall will decrease by as much as 170 mm, leading to lower crop yields, increased poverty and reduced food security. Consequently, the Government of Ghana has stated in its Wildfire Management Policy and Strategies; that the solution to the problem is increased direct involvement of Traditional Authorities (TAs) and District Assemblies (DAs) (i.e. local communities) in the management of fires.

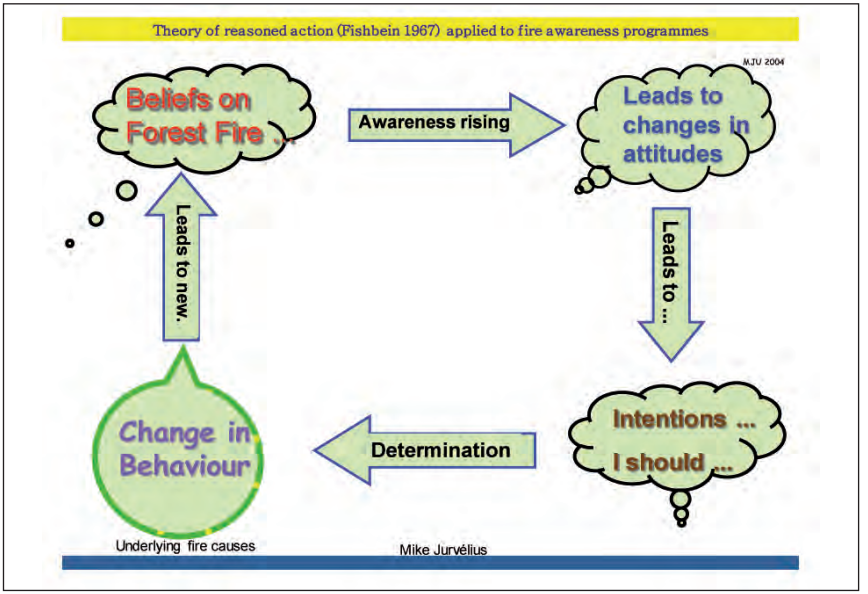


Figure 1. The process of behavioural change in fire management (Fishbein, 1967; modified in Jurvelius, 2007)

Dimensions and Principles for Community Based Wildfire Management (CBFiM[4]) in Ghana.

2.2 Social and cultural

Principle 1: Sustainable livelihoods

The appropriate use and management of fire will promote sustainable livelihoods.

2.2.1 Strategies

2.2.1.1 Enhancement of the participation of communities and environmental groups in planning, implementation, monitoring and evaluation of wildfire prevention and control activities.

Actions

☞ Train key stakeholder groups in fire management activities; fire prevention, fire detection, pre-suppression, community fire preparedness, fire suppression and rehabilitation/ restoration of burned areas;

Training plans, guidelines and operational procedures should be developed with a view to mitigate any unwanted or damaging impacts from planned burnings in targeted areas.

☞ Collect community specific data on the number and frequency of local fire incidents;

☞ Prepare a community fire management plan, at an appropriate level of detail for every aspect of fire management, including use, prevention, fuel management, detection, initial attack, and rehabilitation/ restoration work;

Fire Plans should identify the unique character of and objective for the area, considering the role that fire plays in restoring or maintaining that special character.

Assign dates for restricted use of " open fire" locally, depending on geographic location and susceptibility of the ecosystem to fire.

[4] (CBFiM) Community Based Fire Management.

2.2.1.2 Empowerment and support of Traditional Authorities (TAs) and District Assemblies (DAs) to take the responsibility of managing and coordinating wildfire problems.

Actions

☞ Traditional Authorities and District Assemblies should develop and approve local by-laws for fire management;

☞ Develop a local fire management structure including the organization and leadership of Fire Volunteers and Community Based Organisations;

☞ Develop job descriptions and necessary qualifications for community positions in fire management;

☞ Actively suppress unplanned fires that threaten assets and sustainable livelihoods;

☞ Allow and promote the appropriate management and responsible use of fire for sustainable silviculture, agriculture, livestock and watershed management and biodiversity conservation in local communities;

☞ Actively plan and undertake littered fuel reduction programmes as cost effective methods for fire prevention and reduced fire risk;

☞ Assess and if beneficial, allow wildfires to burn within an appropriate range of frequency, season and intensity in fire-dependent ecosystems for economic and social benefits, as well as for maintaining habitats and reducing the cost of suppressing unwanted fires; and

☞ Promote effective monitoring and evaluation of the impacts of planned and unplanned fires.

Principle 2: Human health and security

Human health and security will be improved by minimizing the adverse effects of fire.

2.2.2 Strategies

2.2.2.1 Involvement of women and other vulnerable groups at all levels of wildfire prevention and control programmes in the country.

Actions

☞ Collect community specific data on gender distribution among fire users, including purposes of using various types of fire and burning.

2.2.2.2 Promoting and sustaining public awareness, training and environmental education campaigns at all levels of governance, to prevent wildfires particularly in communities located in high to medium fire risk areas.

Actions

☞ Provide education and training to ' at-risk' communities and to communities of interest;

☞ Fire awareness and educational materials should be gender sensitive and should reflect local literacy levels, including oral presentations where printed material or local language barriers limit effective communication;

☞ Age-appropriate information and educational materials should be developed cooperatively by technical experts and educational specialists and provided to all levels, introducing ecological and fire management concepts into local schools;

☞ Primary and secondary schools, universities, non-governmental organizations and other institutions should be encouraged to develop locally and ecologically appropriate fire management programmes for teachers and other educators, based on local conditions, beliefs, values and traditions;

☞ Assign specific fire management responsibilities to various groups of community members such as: Traditional Authorities, District Assemblies, and Volunteers.

☞ Educate community members on definitions, characteristics and the extent of fire-sensitive versus fire-adapted ecologies, locally;

☞ Provide for fire-fighter, fire manager and public safety in all fire activities;

☞ Maintain and support an effective fire prevention programme that minimizes the number and impacts of unwanted, destructive fires;

☞ Utilize early detection and warning systems to reduce the health and security impacts of wildfire;

☞ Conduct community-based risk-reduction activities during all stages of fire management activity: pre-fire, during fire events and post-fire;

☞ Balance the negative and positive effects of fire on local communities, when utilizing fire as a land management tool; and

☞ Empower communities to accept responsibility for the management of fire and its effects on their health, safety and welfare.

Principle 3: Traditional uses of fire

The traditional uses of fire on the lands of indigenous peoples and traditional rural communities should remain as a practice for those communities and be adapted to the current environment.

2.2.3 Strategies

2.2.3.1 Integration of indigenous knowledge and international best practises in developing systems of wildfire prevention and control.

Actions

☞ Continue the traditional use of fire provided that any potential negative impacts on communities and resources can be prevented or mitigated;

☞ Prepare prevention plans that include traditional uses of fire based on laws or regulations restricting fire, and involve local community leaders and organizations; and

☞ Assess and classify traditional uses which need to be restricted time wise or otherwise, when defining the annual calendar of fire management activities.

2.2.3.2 Support development of the capacities of local people in the management of common property natural resources such as communal forests and grazing lands as well as key sites in pastoral land use systems.

Actions

☞ Maintain a range of landscapes and environments that provide a diversity of habitats, species, resources and opportunities for recreation, commerce, community enjoyment and cultural and religious practices; and

☞ Gather and maintain the traditional laws and knowledge of indigenous and traditional peoples and integrate their practices into a modern fire management programme.

2.2.3.3 Support the adoption of improved and sustainable methods of wood carbonization for the commercial production of charcoal.

Actions

☞ Provide technical assistance, training and financial support to charcoal makers so that they can develop more efficient kilns and carbonization methods;

☞ Train charcoal makers in appropriate technologies for wood harvesting practises to maximize the yield locally.

2.3 Economic

Principle 4: Protecting lives and assets

The destructive impacts of unplanned fires on lives, property and resources should be minimized, if not totally prevented.

2.3.1 Strategies

2.3.1.1 Establishment of a National Wildfire Management Fund and a District based insurance scheme to ensure sustainable participation of all stakeholders in wildfire management.

Actions

☞ Minimize or prevent the likelihood of unwanted, damaging fires through knowledge, training, participatory planning and preparation, and appropriate suppression and mitigation systems;

☞ Respond promptly and safely to unwanted and unplanned fires;

☞ Actively manage fire to protect lives, property and resources during fire suppression, including the use of fire as a suppressive agent;

☞ Operate in an environmentally sensitive manner while suppressing fires and restoring altered or damaged lands in order to lessen severe, long-term impacts;

☞ Influence the planning, construction and location of new buildings and adjacent vegetation to minimize the risk of damage from fires, and discourage inappropriate development in fire-prone ecosystems; and

☞ Collect fire data on a monthly and annual basis on frequency, specific causes and locations of human-caused fires, reasons for starting the fire, and area burned in order to establish an effective fire prevention programme.

2.3.1.2 Promotion of sustainable rural enterprises such as snail farming, apiculture, ecotourism, domestication of wildlife, mushroom farming and herb gardens.

Actions

☞ Influence the planning and implementation of fire-prone activities in agriculture, forestry and other industries in order to minimize the risk of damage from unplanned fires to lives, property and resources; and

☞ Allocate resources based on the probability of ignition and expected fire behaviour, and balance the costs of fire prevention, preparedness and suppression.

Principle 5: Economic impact

An effective and efficient fire management programme requires a balance between the benefits that the society receives from the use of fire and the costs, damages or undesirable impacts caused by unwanted fire.

2.3.2 Strategies

2.3.2.1 Institution of incentive, reward and benefit sharing schemes for communities, individuals and institutions that distinguish themselves in wildfire management.

Actions

☞ Establish community fire statistics for assessing performance in fire management activities;

☞ Fully account for ecosystem benefits, costs and economic outputs from the use of fire for resource management and the public good in communities;

☞ Identify the benefits of mitigating the unwanted effects or damages to lands and resources from unwanted fires at community level;

☞ Develop and implement all fire management strategies and fire-use programmes in order to maximize both the ecological and environmental benefits and the economic returns locally;

☞ Develop methodologies and standards for quantifying positive and negative fire effects and assessing fire damage, including effects on noneconomic or non-commodity values, as well as on other social and environmental values; and

☞ Develop a set of benefit sharing tools and incentives for communities who perform well in fire management activities.

2.3.2.2 Encouragement of agro-forestry, enrichment planting, enhanced natural regeneration and reforestation.

Actions

☞ Establish a data base on fire mitigation activities in local communities for the purpose of developing incentives schemes.

☞ Promote and establish community fire management networks around communities in fire prone areas involved in natural resources enterprises of the current section.

2.4 Environmental

Principle 6: Interactions between climate change and fire

The interactions of climate change with vegetation cover and fire regimes should be understood and appropriately considered in the planning and implementation of fire use.

2.4.1 Strategies

2.4.1.1 Research Institutions and other relevant bodies to conduct basic and adaptive research on wildfire management.

Actions

☞ Define the impacts of regional climate change issues on ecosystem properties and fire regimes geographically by regions and districts;

☞ Modify fire management plans and policies to take into account observed and anticipated changes in fuel and vegetation type, burning conditions and additional fire risk as a result of climate change locally;

☞ Utilize planned forest and other fuels for energy production systematically, with the dual goals of reducing the threat from fire and the consumption of fossil fuels in local communities;

☞ Nationally, maximize the storage of carbon in ecosystems – especially during restoration of degraded ecosystems;

☞ Minimize greenhouse gas emissions that occur as a result of large-scale, unwanted fire by restoring and maintaining ecologically appropriate fire regimes in communities;

☞ Minimize and mitigate the short and long-term consequences of fire induced vegetation depletion, such as soil erosion, landslides, floods, waterway pollution and desertification locally;

☞ Establish a fuels (biomass) flammability testing procedure, which is compulsory to be used, before any burning is allowed to start; and

☞ Establish a community based monitoring system to monitor fire impacts.

Principle 7: Fire effects on ecosystems

Fire should be managed in an environmentally responsible manner to ensure properly functioning and sustainable ecosystems into the future.

2.4.2 Strategies

2.4.2.1 Introduction and promotion of appropriate fuel treatment procedures and technologies to reduce combustible residue in the environment.

Actions

☞ Maintain or restore appropriate fire regimes to enhance the vigour and diversity of populations of species and communities of native flora and fauna in fire-dependent ecosystems;

☞ Protect identified fire-sensitive ecosystems locally;

☞ Recognize that strategically placed, planned burning with some short-term negative environmental impacts may be necessary for long-term landscape and community asset protection; and

☞ Apply principles of environmental management and care, to the prevention of environmental disturbances resulting from fire management activities in local communities;

2.4.2.2 Dissemination and enforcement of decentralized regulatory measures on prescribed burning within farmlands and non-farmlands (i.e. wild-lands).

Actions

☞ Plan fire preparedness and suppression operations with a holistic landscape view that considers archaeological, historical, cultural and traditional heritage values in local community areas;

☞ Promote the re-establishment of ecological processes, with the restoration of native flora and fauna that may have been compromised, damaged or eliminated by fire suppression actions or excessive use of high intensity fires;

☞ Minimize and prevent the introduction and spread of pest or invasive plants and animals, plant diseases, insect pests and biological contaminants after fires;

☞ Conduct planned burns in a manner that minimizes the spread of unwanted alien species and promotes or re-establishes natural or other preferred species.

2.5 Institutional

Principle 8: Legislation and governance

All fire management activities should be based on a legal framework and supported by clear policy and procedures.

2.5.1 Strategies

2.5.1.1 Periodic review and amendment of laws and regulations on wildfire to meet changing situations.

Actions

National level

☞ Envisage an independent National Fire Coordination unit for Ghana; i.e. a *National Fire Authority,* Fire *Council* — as necessary, to facilitate the coordination of decisions on national fire management duties such as, defining national mandates, national responsibilities and allocation of resources for fire management.

NB: Section 4 (a) of the National Wildfire Management Policy (2006) states, that the Ministry of Lands, Forestry & Mines – MLFM (now Ministry of Lands and Natural Resources - MLNR) has been assigned the role of lead-agency in wildfire, even as the Ghana National Fire Services (NFS) has been assigned the role of managing all fires in Ghana (Act 537); additionally the Ghana Defence Force also has a specific fire management unit albeit with a less specified mandate.

☞ Use the principles, strategies and actions as a basis for developing and implementing national or local fire management legislation;

Community level

☞ Implement all aspects of the principles and strategic actions appropriate in each fire regime and for each community management area;

☞ Develop guidelines locally for prescribed burning, that fit within the legal framework and policies; and

☞ Recognize that implementation of the strategic actions may impact on, or be impacted by, other sectors, such as forestry, agriculture, conservation and protection of the environment, air-quality management, climatology, hydrology and broader land-use management. Therefore, emphasize coordination with those sectors.

2.5.1.2 Introduction and promotion of a Fire Danger Rating System to provide signals on potential for wildfire occurrences.

Actions

☞ Develop or adapt an existing fire danger rating system, in conjunction with reliable weather forecasting, to provide hazard and risk assessments to agencies, land managers and communities.

Principle 9: Multi-stakeholder approach

Successful fire management requires participatory approaches to leadership and management that are appropriately shared by public and private landholders, the fire services and communities of interest.

2.5.2 Strategies

2.5.2.1 Development of adequate infrastructure and manpower to support wildfire prevention and control.

Actions

☞ Take into account that fire management plans and fire occurrence at the local level can have international and global impacts on the environment;

☞ Encourage cross-sectoral participation in the development and implementation of plans, including community members, land managers, fire agencies, emergency services, enforcement and medical agencies, non-governmental organizations and the media;

☞ Recognize the leadership role of land managers in fire and other land-use issues;

☞ Understand and take into account the different backgrounds and roles of the urban, structural fire services and the land management and rural fire services, and utilize each of them to the best advantage, based on the strengths of each;

☞ Prepare a contingency plan for incidents where fire escapes and damages resources, property, habitats and local communities;

☞ Base-burn area for rehabilitation and restoration on planned or natural fire regimes for each specific site to facilitate actions that accomplish healthy sustainable ecosystems or cultural areas (e.g. sacred community forests) for future generations; and

☞ Prepare rehabilitation plans, using native trees, plants and grasses for areas where natural processes do not provide for sufficient regeneration, while avoiding further damage or unexpected consequences to the ecology or to the local community.

2.5.2.2 Develop appropriate capacities of all stakeholders in wildfire management.

Actions

☞ Accomplish integrated land management objectives on safety, environmental, and resource management in local communities;

☞ Provide appropriate training for local ecological, social and political conditions delivered at the same standard for volunteers or other rural workers for the expected fire characteristics.

2.5.2.3 Institutionalization of participatory approaches in wildfire management at all levels and empowering traditional authorities and community leaders to take full responsibility for the prevention and control of wildfires at community and village levels.

Actions

☞ Ensure that all parties of a community fire organization hold an annual pre-fire-season meeting, to review their Fire Plan and discuss changes and improvements to the annual communal operational plan;

☞ Ensure that there is a coordinated approach to effective fire management in areas where multiple organizations and stakeholders have responsibilities and interests in the fire programme;

☞ Recognize and use the knowledge, leadership and expertise of local citizens and community groups;

☞ Involve community members at the local, sub-national, national, regional and international level to ensure that processes are open and accessible to people of different backgrounds and cultures (especially indigenous and traditional rural communities);

☞ Train and equip volunteer groups, community members and rural workers in order to enhance their role and effectiveness in fire management activities; and

☞ Organize a pre-fire season drill in the community to test the level of preparedness.

2.6 Enhanced fire management capacity

Principle 10: Cooperation

No single agency or community has the ability to manage every situation. As fires routinely affect multiple jurisdictions, agencies should develop cooperative arrangements to mitigate trans-boundary impacts.

2.6.1 Strategies

2.6.1.1 Inter-agency coordination, cooperation and networking at international, national, district and community levels shall be vigorously pursued.

Actions

☞ Establish a national fire management group (e.g. Fire Council/Authority) representing various national fire / wildfire management jurisdictions; to decide protection and resource allocation through coordinated management direction and policy implementation;

☞ Use information from fire prevention programmes to develop monitoring systems that measure the effectiveness of fire prevention programmes at: national, regional and community levels;

☞ Encourage the use of common terminology, systems and standards to enhance cross-border and international cooperation;

☞ Promote ongoing exchange of knowledge, technology and resources to facilitate rapid nation-wide and international response to fires;

☞ Participate in international conferences, International Strategy for Disaster Reduction ISDR[5] networks, forums and activities to enhance domestic and international capacity and rapid international response;

☞ Use available guidelines and examples of successfully implemented agreements as a framework for the development of binding and non-binding international instruments; and

☞ Prepare plans prior to fire season on: resources for fire management, prioritizing of activities including trans-boundary actions.

2.6.1.2 Promotion of effective communication strategies, training and environmental education to sustain public awareness.

Actions

☞ Develop a Communication Plan, which will be translated into local languages to inform the public of threats and potential severe weather conditions and provide prevention messages;

☞ Train, equip and support Initial-Attack preparedness (or the organisation) to meet local requirements;

☞ Build support and acceptance from local resources, by utilising local knowledge and experience within the community, to develop appropriate fire policies, plans, strategies and by-laws;

☞ Prepare Initial-Attack preparedness (or the organisation) for non-fire activities, such as protecting private citizens and directing evacuations, search and rescue operations, emergency medical procedures; for which they need to receive specialised training from the National Fire Service (NFS); and

[5] (ISDR) UN-International Strategy for Disaster Reduction, Wild-land Fire Network for Sub-Sahara Africa

☞ Train the Initial Attack organization in data collection and evaluation procedures with the aim of improving organizational effectiveness as well as in work with the media to keep citizens informed about the level of community fire preparedness.

2.6.1.3 Promotion of effective collaboration and coordination among relevant local and international research institutions and other bodies such as the Global Fire Monitoring Centre (GFMC).

Actions

☞ Plan, develop, and establish a fire detection system which uses a combination of remote sensing, established land-water based locations, aerial routes and private citizens and rural community networks.

Principle 11: Knowledge transfer

Access to and appropriate application of knowledge is essential in all fire management activities.

2.6.*2* *Strategies*

2.6.2.1 Ensuring that primary and secondary schools, Agriculture and Forestry Institutions of higher learning incorporate courses in wildfire management in academic curricula.

Actions

☞ Establish a national Advisory Group on higher learning, to develop appropriate curricula and teaching materials for community based wildfire management activities, with special emphasis on Adult Education;

☞ Develop learning criteria for students in higher education reflecting the domains (Cognitive, Affective and Psychomotor) domains required to mitigate the present climate change process, as well as to arrest the present level of ongoing land conversion in the country; and

☞ Develop up-to-date training materials for educators in wildfire management.

2.6.2.2 Development and promotion of integrated wildfire prevention and control practices based on appropriate technologies and systems.

Actions

☞ Incorporate effective communication and provide community education on fire management issues in order to enhance community preparedness and response;

☞ Communicate to members of local communities and communities of interest, that; properly applied and managed fire can result in positive ecological, cultural and economic benefits;

2.6.2.3 Inclusion of wildfire prevention and control issues in resource management planning at all levels by relevant institutions.

Actions

☞ Provide appropriate knowledge and skills development for personnel involved in fire activities to render them competent for their roles and tasks;

☞ Develop a two-way flow of information so that local knowledge of the environment and the historical uses of fire can be considered and used by managers and researchers;

☞ Collect traditional, local knowledge, and use that knowledge in appropriate aspects of the fire management programme;

2.6.3.4 Collation and dissemination of relevant research findings to appropriate institutions and stakeholders for adoption or adaptation.

Actions

☞ Engage in quality scientific research as well as in applied research for the creation of new knowledge, especially for CBFiM in the country and confirm the utility of fire-fighters' practical knowledge in order to support the creation or improvement of policies, regulations, guidelines and practices;

☞ Translate scientific, research and technical materials and make them accessible, at the appropriate technical level, to local managers, fire-fighters and communities.

DEFINITIONS

Anthropogenic fires: Fires caused by human activities.

Community-based fire management (CBFiM): Fire management approach based on the inclusion of local communities in the proper application of fire, fire prevention, and in preparedness and suppression of wildfires. CBFiM approaches can play a significant role in fire management, especially in parts of the world where humanbased ignitions are the primary source of wildfires that affect livelihood, health and security of people. The activities and knowledge that communities generally practise and apply are primarily those associated with prevention. 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.

Controlled Burning: The planned application of fire to a predetermined area.

Firebreak: Any natural or constructed discontinuity in plant fuel (burning vegetation) which is utilised to segregate, stop or control the spread of fire. The firebreak may also act as a control line from which to suppress the fire thus providing defensible space for the fire fighters, or from which to apply prescribed fire.

Fire danger: A general term used to express an assessment of both fixed and variable factors of the fire environment that determine the ease of ignition, rate of spread, fire intensity, difficulty of control and fire impact-often expressed as an index.

Fire Danger Index: a numerical index describing the flammability and potential fire intensity of plant fuels as influenced by air temperature, relative humidity, wind speed and degree of curing.

Fire danger rating: A component of a fire management system that integrates the effects of selected fire danger factors into one or more quantitative or numerical indices of current fire protection needs.

Fire-dependent ecosystems: : An ecosystem where fire is essential and the species have evolved adaptations to respond positively to fire and to facilitate fire spread. If fire is removed, or if a fire regime is altered beyond its historical range of variability, the ecosystem changes to another state; dependent species and their habitats decline or disappear. Vegetation is fire prone and highly flammable. Ecosystem structure and plant architecture facilitate fire spread. Boundaries

between fire-dependent and fire-independent ecosystems are largely determined by the relative continuity of burnable fuels or probability of fire-enabling climatic conditions.

Fire hazard: (1) A fuel complex, defined by volume, type, condition, arrangement and location that determine the degree both of ease of ignition and difficulty of fire suppression; (2) a measure of that part of the fire danger contributed by the fuels available for burning. Fire hazard is worked out from their relative amount, type and condition, particularly their moisture content.

Fire-independent ecosystems: Ecosystems where fire normally plays little or no role being too cold, wet or dry to burn e.g. tundra, rain forests or desert. Fires characteristically would not occur because of a lack of fuel and/or ignition sources. Fire regimes can be altered by a change in fuels (e.g. invasive species) or ecologically inappropriate human-caused ignitions.

Fire management: All activities related to the use of fire to achieve land-use objectives and the protection of people, property and natural resources. It involves the strategic integration of such factors as knowledge of fire regimes, probable fire effects, values at risk, level of forest protection required, cost of fire-related activities, and prescribed fire technology into multiple-use planning, decision-making and day-to-day activities to accomplish stated resource management objectives.

Fire management plan: The organization, facilities, resources and procedures required to protect people, property and natural resources and to use fire to accomplish specific land-use objectives e.g. range and forest management. (1) A statement, for a specific area, of fire policy and prescribed action; (2) the systematic, technological, and administrative management process of determining the organization, facilities, resources and procedures required to protect people, property, forest areas and rangelands from fire and to use fire to accomplish forest management and other land-use objectives (cf. fire prevention plan or fire campaign, pre-suppression planning, pre-attack plan, fire suppression plan, end-of- season appraisal, prescribed burning program).

Fire protection: All actions taken to limit the adverse environmental, social, political, cultural and economic effects of fire.

Fire regime: The season and frequency of burning and the type and intensity of fire. The classification of fire regimes includes variations in ignition, fire intensity and behaviour, typical fire size, fire return intervals and ecological effects.

Fire risk: The chance of a fire starting when considering the presence of all contributing factors like e. g. weather, fuel and anthropogenic activities.

Fire season: (1) Period(s) of the year during which fires are likely to occur and affect resources sufficiently to warrant organized fire management activities; (2) a legally enacted time during which burning activities are regulated by state or local authority.

Fire suppression: All activities concerned with controlling and extinguishing a fire following its detection (synonyms: fire control, fire fighting).

Fire-sensitive ecosystems: Ecosystems that are prone to fire damage but whose structure and composition tend to inhibit ignition and fire spread. The majority of species generally lack adaptations to respond positively to fire. Fire can influence ecosystem structure, relative abundance of species and/or limit ecosystem extent, or may occur naturally very infrequently or during extreme climatic events. Fire may create habitats for key species by creating gaps, regeneration niches or by initiating or affecting succession. If fires are too frequent or too large, they can be damaging and cause ecosystem shifts to more fire-prone vegetation. Some fire-sensitive ecosystems are also known as fire-influenced, particularly those adjacent to fire- dependent ecosystems.

Forest fire: An unattended fire that burns in a forest area or causes damage to the forest or the forest produce which in turn causes economic, social and environmental losses.

Forest fire detection: Activities carried out to discover or locate a forest fire as early as possible so that appropriate and prompt control or suppression measures can be applied before the fire spreads to wider areas.

Forest fire prevention: All measures in fire management, fuel management, forest management, forest utilization and concerning the land users and the general public, including law enforcement that may result in the prevention of the outbreak of fires or the reduction of fire severity and spread.

Forest fire protection: All activities to protect the forest from damaging fire (prevention, pre-suppression and suppression).

Forest fire suppression: All the work and activities connected with fire extinguishing operations. Suppression work begins with the discovery of the fire and it continues until the fire is completely extinguished. Pre-suppression measures include those activities that are required to enable fire protection organisations to cope with wild fires before they start.

Fuel: All combustible organic material in forests and other vegetation types, including agricultural biomass such as grass, branches and wood, infrastructure in rural or urban areas, which create heat during the combustion process.

Forest fuel: All organic materials in forests, either alive (living fuel) or dead (dead fuel). Living fuels are fuels which occur naturally and in which the moisture content is physiologically controlled within the living plant. Dead fuels are fuels having no living tissue and in which the moisture content (relative humidity and precipitation) is governed almost entirely by, air temperature, wind speed and solar radiation.

Fuel management: Act or practice of controlling flammability and reducing fuel loads by mechanical, chemical, biological or manual means, or by fire, in support of land management objectives.

Fuel reduction: Manipulation, including combustion, or removal of fuels to reduce the likelihood of ignition, potential fire intensity and/or to lessen potential damage and resistance to control.

Incident Command System (ICS): A standardized, on-scene emergency management concept specifically designed to allow its user(s) to adopt an integrated organizational structure equal to the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries.

Integrated Forest Fire Management (IFFM): All activities related to the protection of forest and natural resources and the use of fire as a management practice. All activities required for the protection of burnable forest and rangeland against destruction by fire or activities using fire. IFFM includes prevention, suppression and the controlled (planned) use of fire. Integration refers also to fire management being an inseparable integral part of land management.

Planned fire: (Same as Prescribed Burning). This term is synonymous with prescribed fire and has the same definition. A planned fire is a management-ignited fire or a wildfire that burns within

prescription, i.e. the fire is confined to a predetermined area and produces the fire behaviour and characteristics required to attain planned fire treatment and/or resource management objectives. The act or procedure of setting a prescribed fire is called prescribed burning (cf. prescribed burning, prescribed fire).

Prescribed (or controlled burning) fire: Use of fire to achieve specific management objectives i.e. controlled application of fire to vegetation in either their natural or modified state, under specified environmental conditions, which allow the fire to be confined to a predetermined area and at the same time to produce the intensity of heat and rate of spread required to attain planned resource management objectives (cf. prescribed fire). Note: this term has replaced the earlier term ' controlled burning' .

Rehabilitation: The activities necessary to repair damage or disturbance caused by wildfire or the wildfire suppression activity (cf. restoration).

Restoration: Restoration of biophysical capacity of ecosystems to previous (desired) conditions. Restoration includes rehabilitation measures after fire or prescribed burning, where certain fire effects are desired (cf. rehabilitation).

Risk: (1) The probability of fire initiation due to the presence and activity of a causative agent; (2) a causative agent.

Smoke management: The application of knowledge of fire behaviour and meteorological processes to minimize air-quality degradation during prescribed fires.

Wild fire: Any unplanned and uncontrolled fire regardless of ignition source.

Wild land: Any vegetated land in which development is essentially non-existent except for widely scattered roads, railroads, power lines, transportation facilities and structures. In fire management terminology this general term includes all burnable vegetation resources including rangelands, managed forests and forest plantations (cf. residential/wild land interface, wildfire).

Wild land fire: Any fire occurring on wild land regardless of ignition source, damage or benefit (cf. wild land, wildfire, and residential/wild land interface).

SECTION 2: CAPACITY BUILDING IN COMMUNITY WILDFIRE MANAGEMENT

[Most of this section is adapted from Heikkilä, T. V., Grönqvist, R., & Jurvelius, M. 2007]

Section 2.1 Wildfire Description

In addition to using this section of the Guidelines and Manual in formal training, it is most useful to be read out and translated in the local dialect during community meetings especially before the danger fire season.

General – Fire Behaviour

The first requirement of every community forest fire fighter' s knowledge of forest fire is its behavior. Fire behavior can be defined as the manner in which fuel or inflammable vegetation ignites, flames develop, and the fire spreads and exhibits different patterns.

Knowledge on how fires start, their speed and habitual direction of movement as well as their frequency of burning enables the leaders of community fire fighters to: develop a more effective and efficient forest fire pre-suppression and suppression plan that helps in decisions about when, where, and how to control the fire, work safely, and train more efficient community fire fighters in forest fire control.

Main Factors Influencing Fire Behaviour

There are three main factors which influence fire behaviour:

(i) Fuel
(ii) Weather, and
(iii) Topography

Fuel or inflammable vegetation

Fuel or inflammable vegetation is any organic material that will ignite and burn. It can be either living or dead, in the ground, on the ground, or in the air. It is necessary to be familiar with certain properties and characteristics of the fuel, i.e.

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

During the analysis of any fire situation, all the above fuel factors must be taken into account.

Size of fuel

The size of fuel is an important factor in determining its rate of combustion. If the pieces of fuel or inflammable vegetation 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, 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 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 light fuel. Heavy fuels are therefore referred to as being slow-burning fuels. Heavy fuels continue to burn for a much longer time.

Generally, fire spreads faster in fine fuels than in heavy fuels.

Fuel arrangement

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 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. Essentially, fuel arrangement determines, the:

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

Fuel type and fuel type pattern

Fuel type refers to the general classification of forest cover type, i.e. grass, slash, mixed forest, deciduous, immature fallow, mature fallow, etc.

Fuel type pattern refers to the arrangement of barriers and the different types of fuel. Fire spreads more rapidly in certain types of patterns than in others, depending on the seasons. For example, hardwoods usually form good fire barriers, while lighter woods don' t. The fuel type pattern indicates 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
(ii) The ground.

There is a relationship between 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.

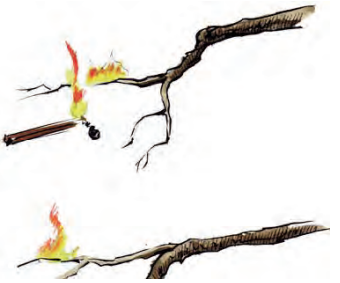
Ground and aerial fuels

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 roots, branches, dead leaves, grass, fine deadwood, logs, slash, brush, and small trees. With grass and weeds 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, leaves, small branches, bark, and rotting materials are classed as fine deadwood. They ignite easily and provide 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 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.

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 form the canopy of the forest or tall brush.



Tree crowns react quickly to the relative humidity, and it is rare for a crown fire to occur when under 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 forest stands, a sufficient amount of dead stems and branches may be present to allow for a fast spreading crown fire.

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 should be taken 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 can be referred to as precipitation. Like relative humidity, rain influences the moisture content of the fuels. Large or heavy fuels are more likely to hold their moisture content longer.

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. If the wind speed is high a forest fuel will dry out much faster than it would if the speed is 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 generally drops in the evening. This 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 to a new fuel where it can start spot fires, the wind has two other important and direct effects on fire behaviour, it:

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

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 wind close to a fire.

Temperature influences the condition of forest fuel as its main effect is to dry the fuel. Temperature also has a very direct affect upon fire fighters as 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 implies that 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, i.e. if the relative humidity is 80%, the fuel will be less inflammable than it would have been if the relative humidity were 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.

The changing influences of weather

Two natural conditions influence the weather which, in turn, influences fire behaviour.
The same fire may burn at very different times of the day. The time of day influences wind, relative humidity, and temperature. 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. During this time, the wind speed is high, relative humidity is low and the temperature is high.

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.

Topography

Knowledge of topography is important to understanding fire behaviour. Topography 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 reveals the physical state of the land i.e. 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, etc.

Slope

Slope has a great influence on fire behaviour. Fire will burn much faster uphill than it will on a level surface or downhill. When the ground is sloppy 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 i.e. a fire burning at ground level spreading towards the shores of a large lake will probably burn itself out. Also, lakes, dams, rivers, roads, cliffs, and swamps may serve as effective natural fire barriers. The presence or absence of natural barriers constitutes an important topographical factor.

Rate of Spread

The rate of spread of forest fire 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.

When the weather is dry enough for single tree crowns to be easily ignited, but there is insufficient wind to sustain a crown fire, the resulting phenomenon is called torching. Torching is a danger signal as it means that any increase in wind may result in a crown fire, and small pieces of bark, and other material may be lifted above the burning tree and cause spot fires some distance away.

Large Fire Behaviour

On average, 5% to 10% of all forest fires grow to a large size. These are the fires that cause the most damage, often reaching catastrophe.

The transition from a small to a large fire is usually sudden, sometimes only between 15 to 30 minutes. This transition 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 gases in the flame, and often an increase in the amount and distance of spot fires.

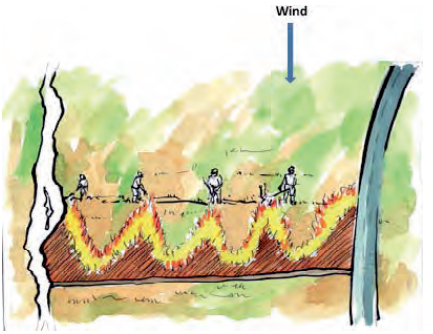
A blow-up is a sudden increase in fire intensity and an increase in the rate of spread, or both. Blow-ups are often the result of violent convection, and may have some characteristics of a firestorm. When fires have reached extreme fire behaviour the combustion chain becomes so strong that it cannot be broken by conventional fire-fighting methods.

It is then necessary to plan control for the changing conditions, and to anticipate the place and time where changes will occur. Meanwhile, only part of the perimeter may be tenable for the fire control forces.

Parts of a forest fire

Head: This 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 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: It 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 between two or more fingers, where fire spread is slow because of fuel or slope conditions.

Rear: The sides, or parts of the fire' s perimeter roughly parallel to the main direction of spread. 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.

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.

Types of fuel layers and forest fires

There are different fuel layers in the forest, i.e. on the sub-surface, on the surface, and crown.

A forest fire can burn in one or any combination of the above layers. However, most fires occur and burn in the surface fuel. Occasionally, surface fires, burning intensely, will spread to the crowns of 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 fuel 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 it will leap upwards to become a fast moving crown fire under favourable fuel and weather conditions.

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

(i) Sub-surface or below the ground surface fires;
(ii) Surface fires; and
(iii) Crown fires

Sub-surface fire burns in the organic material under the surface litter and spreads 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.

Surface fire burns in the fuel on the surface of the ground. This category includes burning slash, brush, grass and surface litter (twigs, dry leaves, and other un-decomposed material), or anything which burns on the surface of the ground.

Crown fire develops from a surface fire where the type, volume, and vertical arrangement of fuels carries the fire and gases from the surface to the crown fuel layer. Such an arrangement of fuels presents a " step-ladder" effect. The crown fire burns independently of fire burning on the surface and advances from tree top to tree top with leading edge outrunning the surface fire below. Fires burning in the crown layer are extremely difficult to control and spread quite rapidly. This usually occurs in forest plantations. Generally in natural tropical forests, there is a very low 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 tree crowns, it will pre-heat them.
- The convention 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. Wind will cause the spread of fire from crown to crown and the crown fire will spread ahead independently of the surface fire below.

Fire Behaviour Rules of Thumb

Both the rate of spread and the flame height of fire 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 fuel-beds 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 packaged fuel-beds the spread rate is less affected by loading.

Fuel moisture content

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

Wind

The rate of spread of fire will double for every 4 metres, per second increase in the wind speed. The 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.

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

Section 2.2 Wildfire Prevention

In addition to using this section of the Guidelines and Manual in formal training, it is most useful to be read out and translated in the local dialect during community meetings especially before the danger fire season.

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

Activities for the Prevention of Wildfire

Wildfires may occur in any vegetation 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.
The prevention of unwanted or escaped fires must be understood as a job that never ends.

In addition, direct fire prevention activities are 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, amongst others:

- Knowledge of fire and its causes;
- Trained community fire fighters or others for fire prevention activities;
- Good advanced planning for fire prevention; and
- Funds.

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

- Education of the community and other stakeholders;
- Elimination of the fire hazards; and
- Fire enforcement laws and byelaws.

Risk

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

Hazard

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

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

A fire prevention plan is needed for the effective organization of fire prevention operations. The written part of the fire prevention plan should include maps, tables, and graphs. The material should be updated at least once a year.

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

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

This analysis determines the realistic and logical goals of the fire prevention plan. It also helps in the development of a summary of the main problems, such as

responding to the following questions:

- What are the main causes of wildfire? (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 in wildfire prevention should be education. The second step should be to enforce the laws and regulations which control fires caused by agriculture, shifting cultivation and pasture management.

After the above, the next step could be the preparation of regulations to control camping fires by tourists and fires caused by hunters. This should be done through education.
After the summary of responsibility for fire prevention actions has been completed, the following decisions will have to be taken:

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

Main contents of a wildfire prevention plan

The following example for a fire prevention plan is a general guideline.

1. Basis of the fire plan:
   - 1.1 Fire occurrence map
   - 1.2 Fire statistics, graphs
   - 1.3 Fire risk area(s) map(s)
   - 1.4 Slash and burn and pastures operations map(s)
   - 1.5 Hazard areas map(s)
   - 1.6 Signs (panels) and warning board map(s)
2. Fire prevention objectives
3. Summary of problems and measures to be taken
4. Resources for fire prevention operations

4.1 Use of trained community fire brigade, forestry personnel, etc
4.2 Contact persons and co-operation with village leaders
4.3 Finance (funds)

5. Laws, regulations, byelaws, rules, and management restrictions for fires;
6. Public and community education, mass media, and guidelines for tourists, hunters, etc.
7. Rules and regulations for graziers, farmers, hunters, etc.
8. Reduction of the physical hazards in high risk areas;
9. Signs, posters, stickers, panel boards with warnings, etc.
10. Fire prevention training and education;
11. Feedback information on aspects related to wildfires on the landscape.

For every fire prevention plan there needs to be individual information and statistics on each of the above guidelines. 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 analyzed to determine what effect the planning had.

The Causes of Wildfire 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.

Land owners, farmers, and local communities

(i) Agricultural burning such as in shifting cultivation, and fires in pastures to control vermin, insects and to encourage the growth of new vegetation for livestock together with the many variations of rubbish and debris burning, are major causes of wildfire.

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 minimize the number of escaped fires caused from agriculture and pasture related burning, there should be local regulations or bye laws which require that:

A burning permit or other form of authorization is obtained;
Burning should be carried out only in designated areas; and
Burning should be carried out only under certain weather conditions.

(ii) The best way to reduce the causes of wildfire is by education. First of all, communities and the general public should be taught how to burn safely. Then they must learn how to minimize all hazards safely. Communities and the public should then learn how to minimize all outdoor burning during fire hazard periods. Good results can be obtained during fire hazard periods by diffusing information through the local radio and television especially when weather conditions show a high risk factor. Regulations and byelaws should prohibit anyone from starting an outdoor fire during such fire hazard periods.

There is also need for effective patrolling and fire detection during all periods of high fire risk. The National Fire Service should cooperate with local communities and traditional authorities. The objectives' of this cooperation and the education of the public and communities should be to encourage the right attitude towards wildfires. When communities and the public understand the value of forests and other natural resources and the loss that comes from wildfires, they will be more careful when lighting outdoor fires. In addition, there must be byelaws and regulations to forbid outdoor fires at certain times. However, before these laws and regulations are made, the living conditions, religious and cultural traditions, and the realistic needs of the rural people for outdoor fires must be taken into account.

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

(i) Burn only during safe conditions, for example, when there is little or no wind and after rainfall if possible.
(ii) Obtain a permit or an authorization from the local fire authority or service.
(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.
(vi) Burn at a safe time and never on a windy day. Generally, early in the morning or late in the evening are the best times.
(v) Before starting a large outdoor fire, there must be stand-by fire suppression equipment and people available to prevent the fire from spreading.

Cigarette Smocking

One of the major causes of wildfire is the careless smoker. Picnickers, campers, hikers, fishermen, hunters, tourists, or local community residents who smoke while in a forest, farm 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.

During the fire danger season, smoking while walking or working in a forest area should be prohibited.

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

(i) 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.
(ii) Crush the butt-end of the cigarette against a bare rock, or into a sandy soil.
(iii) Use a cigarette lighter or make sure that the match is extinguished.
(iv) Use the ashtray in the vehicle.

Campfires and fires from temporary farm sheds

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

(i) The campfire should be contained in a specially constructed fireplace which should be well away from overhead and surrounding hazardous dry or flammable matter.
(ii) The campfire should be kept small.
(iii) The campfire should never be left unattended, as wind could spread the fire into nearby dry or flammable matter.
(iv) Make sure that the fire is properly extinguished before leaving the site. This can be done by pouring water or sand over it 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 and local communities should be educated and well informed about wildfire prevention methods.

Signs and warning panels should be erected and information on how to prepare a safe camp site available at all public camping sites and in areas where farmers stay in temporary sheds on farms during the cultivation or crop harvesting seasons.

Logging and related forest interventions

Frequently, logging and other forestry operations including trawling can 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 wildfires.

The use of approved spark arresters in tractors in the forest as well as on 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 and bye laws. 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.

Arsonists

Arson has taken the top spot as the cause of wildfire in recent years.

General investigations have revealed that the number of wildfires started by arsonists is increasing at an alarming rate.

Law enforcement however has proved to be a general deterrent to arson.

It remains problematic to prevent arson without emphatic investments in behavioral change.

Children

Children who play with matches or with other sources of fire cause an ever increasing number of wildfires each year. Children are generally too young to understand what could constitute dangerous playing. Training, relevant education, and proper parental supervision are necessary to prevent this cause of wildfire.

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 smolder for days before conditions become favorable for the spread of the fire.

Constant monitoring is a requirement for the location of these dormant or sleeping fires. Lightning storms usually follow a definite path across the landscape.

A map which shows the fires caused by lightning over a period of several years will usually show the lightning fire pattern. Prompt detection is the best defence against fires caused by lightning.

Secondary causes of wildfire

The carelessness of people is a major cause of wildfires.

Secondary causes of wildfire include amongst others: broken power lines and poles, army training operations, negligent people, fire knock-outs, children' s fireworks, fire sparking toys etc.
It is important to analyze these fires causes over a long period of time.

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

Methods of Wildfire Prevention

There are different methods employed to prevent wildfires; some need a lot of human effort while others require relatively more money. If satisfactory results are to be expected from the fire protection objectives some of these methods should be combined. It is therefore important that the fire prevention plan should have estimates of both financial and human resource requirements. Generally it should be acknowledged that fire prevention requires intensive and patient work regularly and on an annual or year to year basis.

Mass media

The mass media includes radio, television, newspapers, and various publications designed to reach the general public, community or specific groups.

Use of the mass media is one of the best means of public education in the prevention of wildfires. However, efforts must be made to ensure that the method used reaches the target audience. For example, the number of people who can read and the number who own a radio or television set should be known. Advertising over the radio, on television, and in newspapers during the high and extreme fire danger periods against external burning activities, will help keep down the numbers of escaping fires. These warnings to the public and communities should be done through the local weather forecasting service, as well as the local radio or TV stations.

Associations and groups

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

- Specific project beneficiaries;
- Environment groups;
- Sensitized pupils and students i.e. Boy Scouts and Girl Guides;
- Camping and tourism associations;
- Holiday and tourist home owners; and
- Community associations.

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 errors and carelessness.

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 Head Master / Mistress, Principal or Manager to find out the most suitable type of presentation to be made. Teachers can be involved by providing them with information and furnishing them with relevant materials. The main benefit of school contacts is that in addition to the students, the parents are also reached through the message that the students carry home.

Personal contact

Personal contact is probably the most effective method of fire prevention, if done correctly. The best place to demonstrate fire prevention techniques is at the site of a potential fire, where i.e. it can be demonstrated how to build a safe campfire, how to smoke cigarettes carefully, and how to prevent the different types of fire from starting.

The most far-reaching results are gained through public and community understanding and cooperation which in turn depends on the awareness, interest, attitude, opinion, and beliefs of individuals in the community or general public.

Signs, warning panels and notice boards

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

- Along roadsides;
- At camping grounds;
- At petrol stations; and
- Anywhere, where people congregate such as around village markets.

Timing is also important, for example, a sign warning of extreme danger should be removed as soon as the danger has passed or else such signs will lose their significance and effect in future.

Signs should be placed so as to be clearly seen as well as clear in order not to be in conflict with other notices.

Posters

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

Other methods of fire prevention

There are a number of other methods that can be used in fire prevention such as using totem animals with fire prevention messages around them. In such cases, a revered or nationally respected animal portrayed as a flagship species is used to teach about wildfire prevention. The message around the species generally gives good advice and instructions on the appropriate way to use a fire in the forest and on other landscapes. Such programmes are effective, especially for children, when presented in films on television, in posters, cartoons, and in advertisements.

Also, well conceived letters aimed at a specific aspect of fire prevention dispatched with a clear message to a group or several groups of stakeholders may be very effective. For example, wildfire prevention letters sent to local hunting associations just before the hunting season or to herdsmen just before the transhumance season, could produce very favourable results.

Fire danger forecast

The national weather forecasting or meteorological service should be able to send out a fire danger rating daily, throughout the fire danger season. Agreements can be reached with radio and television stations to include in their regular weather forecasts, some fire danger warning, particularly when the fire rating is high or extremely high. This is a useful service both for fire prevention and for fire suppression. It is also an appropriate means to make the general public more aware of the dangers of wildfire.

Firebreaks and fuel-breaks

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

The width of the strip will depend on the type of vegetation, location, the topography of the landscape, and weather conditions. Generally, the width of

the clearing will not be less than one half the height of the tallest tree whose foliage and stock supplies the combustible material. A fuel-break 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. It may or may not have fire-lines built into it. Fuel breaks are generally placed strategically along ridges and in valleys. They also include any access roads. Firebreaks and fuel-breaks should also be constructed to prevent wildfire from spreading from one area into another area. A greenbelt is an adaptation of a fuel-break in which the vegetation is kept green and living through irrigation.

Laws and Regulations

An important basis for success in wildfire prevention is the development and application of local laws and regulations against wildfires, as well as from knowing how to behave with outdoor fires.

National laws, byelaws and regulations for smoking, as well as for the establishment of campfires, and debris burning are important for wildfire prevention. Laws, byelaws and regulations must be impartial and aggressively enforced. Enacting legislation which advocates the collection of fire suppression costs from those who cause wildfires is a good method of wildfire prevention.

Cooperation with the national and municipal police agencies may be required to enforce such a provision.

Fire Investigation

For every wildfire, immediate investigation of possible causes and protection of evidence at the fire site is necessary. The first fireman or trained community fire-fighter to arrive at the fire scene should be responsible for preserving 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 community fire-fighter should:

(i) Record information about anyone or anything that could relate to starting the fire;
(ii) Observe vehicles, motorbikes, bicycles, and other mobile equipment near the fire area and those moving away from it; as well as,
(iii) Take note of the license plate numbers, descriptions of vehicles, people, descriptions, and the location and moving direction of the fire.

Fire hazard (fuel or concentration of flammable vegetation) is one factor which can contribute to the starting of wild fires. Potentially hazardous areas such as the boundary of forest reserves or forest plantations must be monitored through a fire prevention objective of the fire service or community fire brigade. Prevention consists of eliminating the hazard or the potential causes of such fires.

Controlled Burning of Fire Hazard Areas

The most effective fire hazard reduction intervention is to eliminate the fuel or inflammable material from hazardous areas. This can be done by burning off all hazardous vegetation, known as controlled burning (or prescribed burning). For example, dry grass along roads forms very hazardous fire risk areas. Such grasses should be burnt before the hazardous fire season. It is also possible to engage in controlled burning of slash in production forests after timber cutting, which reduces the hazard on such areas. The technique of " early firing" is also used especially around conservation areas in drier zones, to control eventual wildfires as well as achieve other management objectives. Controlled burning needs knowledge and experience from those undertaking the activity otherwise the fire can easily escape to devastate unintended areas.

Meanwhile, controlled burning is useful for understanding fire behavior and provides an opportunity for training in the use of hand tools and equipment. It also provides practice for men and women to work with hot flames and inside smoke. Controlled burnings or " early firing" is usually done just before the fire season. Inflammable material in the control burning area should be dry enough for burning, but not too dry, or else the fire may easily escape, facilitated by strong winds.

As a summary, the following points should be considered before engaging in controlled burning:

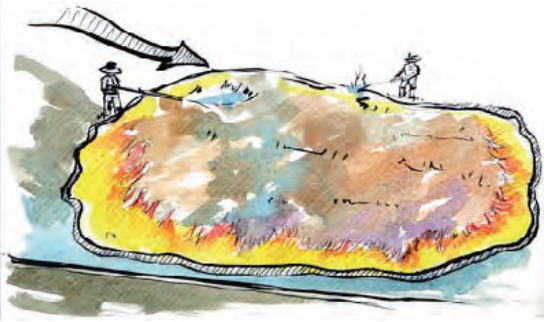
(i) The fuel or inflammable vegetation should be dry enough, but not extremely dry. Relative humidity should be between 40-60%. Below 30% relative humidity, fire could become dangerous, with an increasing risk of spot fires.
(ii) The weather conditions should be favorable and safe for burning. Slow wind is good and its speed should be monitored and the operation stopped if it increases remarkably. Increased wind constitutes a risk as the fire can escape and develop into spot fires, which are difficult to spot and control.
(iii) Before setting an early fire, the burning area must be surrounded by a sufficiently wide fire-line. Generally, the safe width depends on the height and volume of the inflammable vegetation.
(iv) There should be sufficient amounts or quantities of extinguishing equipment and materials on the site, such as: swatters, backup-pumps, shovels, hooks, rakes, etc. Moreover, there should be enough fire men and or fire women 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 leader of the controlled burning operation. The leader should have enough knowledge and experience of controlled burning-techniques.
(vi) Before starting the controlled burning operation, the fire leader must explain the plan of the burning to the local fire service chief and/or fire headquarters, village chief, and neighbors.
(vii) The best time to start firing is in the afternoon, because the humidity is most appropriate and the wind is stable.

Before controlled burning is started, it must be verified that the fuel moisture and conditions are favorable for burning. This can be done by using small test fires. The firing technique in controlled burning, for dry and humid inflammable vegetation is basically as follows:

Dry fuel – the fire starts and spreads easily:

(i) The fire is started beside the control / fire-line, from the downwind side to the upwind side. The control line surrounds the area (on flat land).
(ii) On slopes, the fire is started from the upslope and spreads to the down-slope.
(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, spot-fires can be made inside the fire control area, which creates suction to the central direction as the entire 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 fire control area' s (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 do 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, spot-firing should be used inside the control area.

(iii) To ensure effective burning, the finger burning technique should be used inside the control area.

(iv) When on slopes, firing should preferably be started from the down-slope towards the upslope.

Section 2.3 Wildfire Pre-suppression

In addition to using this section of the Guidelines and Manual in formal training, it is most useful to be read out and translated in the local dialect during community meetings especially before the danger fire season.

Wildfire pre-suppression includes all actions required in fire fighting for the successful fire suppression with the exception of fire prevention. This includes all sorts of preparation, i.e. organization, maintenance of equipment and materials, planning, cooperation and mutual support arrangements with other agencies, and training. Fire suppression will only be as effective as the quality and the continuity of the pre-suppression operations. A lot of effort is required in pre-suppression. In these efforts, it is wise to remember an old proverb;

' Good planning is the work half done' .

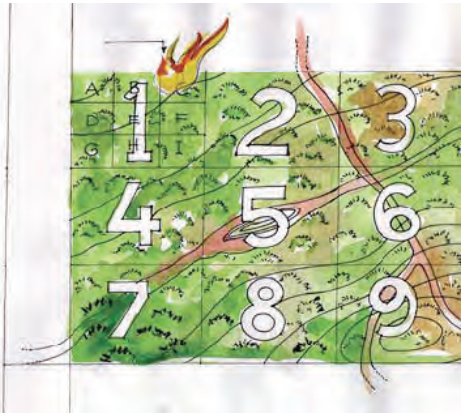
Pre-suppression planning is one of the most important duties of the agency or community organization for forest fire control. Planning must be done at the local community level, regional, and governmental levels. Most details should be included in the local or regional fire plan. Pre-suppression plans 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 community fire leader or responsible agency for forest fire control is responsible for the preparation of the pre-suppression plan. Regional and local fire plans should include personnel, paid or voluntary as in the case of local community fire volunteers, the procurement of equipment, and all the activities needed in forest fire suppression.

The forest fire control plan should cover the following:

(i) The organization of suppression activities.
(ii) Cooperation with other agencies, their crews, and equipment.
(iii) Equipment, tools, machines, and transport.
(iv) Fire detection.
(v) Communication, including identification maps, radio, TV and newspaper articles.
(vi) Reporting and alarm systems.
(vii) General suppression plan for different types and sizes of fire.
(viii) Fire danger measuring and rating system.
(ix) Measures for closing high hazard areas to communities and the public.
(x) Training programs.

The general plan requires different maps and background data, i.e.

- Map of hazard areas;
- Map of forest roads and paths;
- Map of the organization for forest fire control, showing the location of headquarters, contacts of fire brigades, lookout towers, weather stations, telephones areas, etc;
- Map showing water supplies, fire-breaks, natural barriers, and fire-lines;
- Annual statistics of fire occurrences by causes; and
- List and records of management of the fire service , community brigade members, equipment and materials.



Most of this background information can be on one map i.e. the fire map.

This special forest fire map should be in every District Assembly and every fire 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, i.e. for a five year period. This medium to 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 agencies and fire projects for the evaluation of resources including personnel.

Cooperation with other authorities

Very few forest fire agencies can clear up unusual fires, serious fires, or very large fires on their own. It is also not abnormal for the fire agency to have sufficient funds with which to purchase equipment, special machines, and vehicles for fire management. Therefore, the necessary arrangements with other organizations and communities for help and cooperation in forest fire suppression must be planned and pursued. These other organizations may have special equipment which will be useful in fire suppression, i.e. the Air Force can predispose light aircraft and helicopters. The degree of cooperation and arrangements will depend on the local situation and the resources of the fire agency. National agencies can assist in the development of cooperation and agreements in

accordance with local laws. All the special equipment, machines, and crews of these other authorities and organizations should be listed at the fire agency headquarters and known to senior members of the community fire brigade.

Forest Fire Detection

General

An essential part of forest fire pre-suppression is the ability to detect 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 is done by people who live and work in the area, by travellers passing through the area, or by aircraft passing over the area. This type of detection is referred as 'general detection' and is effective if people are active and interested in reporting fires. Although general detection is effective in small sections of the protection area, a specific system of detection during the fire danger season must be planned and organized. This is referred as, 'organized detection'. Most forest fires are detected by communities and the public. The first step in fire detection planning is to find out where and how effectively the fire is discovered by general detection. Generally, up to 80% of wildfires are reported by community members. The government should order the obligatory reporting of all forest fires as a civic duty.

All fire and smoke reports should be concentrated in one place, i.e. the District Assembly fire alarm or information centre. This centre must be provided with communications, maps and information about fire crews, community brigades and other units. The centre is also responsible for dispatching the fire crews.

(i) Ground patrolling;
(ii) Lookout towers, points, and stations: and
(iii) Air patrols and satellite if possible.

A combination of these methods may be the most appropriate, and effective.

Ground patrolling

Ground patrolling can be carried out by forest guards or rangers who patrol the area around the forests for which they are responsible. They move along appointed routes, forest roads, forest paths, etc. and should be equipped to take initial attack against any small fire that may be found. They must have some kind of communication or alarm system and good maps to report the location of a fire.

Fixed lookout stations

Established lookouts can be fire lookout towers, or points. They are appropriate on flat terrain and 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 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 fire detection is organized 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 of transmitting information, and to receive notification of every other observation from the fire alarm centre. Normally, the fire tower is supplied with some form of communication system, i.e. mobile or radio-telephones. Other essential items for the towers are binoculars, maps, an angle bearing indicator and compass.

The responsible agency for forest fire suppression should agree on some sort of arrangement for fire observation with local communities before the start of the fire season.

Air patrolling is an appropriate method of fire detection in extensive, sparsely populated areas. Its advantage is that the forest fire agency can give prompt and reliable information, and an accurate location of the fire. Patrolling aircraft can also guide the fire attack crews and brigade by the fastest and easiest route to the fire. Another importance of air patrol is that it is flexible. The area to be covered and the frequency of flights can be changed daily or cancelled, depending on the actual fire danger and risk. Additionally, an experienced pilot and observer in the detection aircraft can continue with 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. It should

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

Communication

More than any other support activity, the successful control of forest, brush, and grass fires depends on communication. Effective communication could provide a successful conclusion to most fire fighting operations.

Some available systems and methods of communication include:
(i) Fixed lines, such as telephone and telex;
(ii) Wireless communication networks (radio-telephone):
(iii) Written messages (messenger on root, on bicycle. etc.); and
(iv) Visual or voice signals.

The most popular and effective method of communication in use today is the radio network or radio-telephones. 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 pre-suppression and suppression operations is important for the safety of the fire crews and community fire brigades.

Communication equipment and methods

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

Regional / District Assembly fire alarm centre system

It is important to provide and concentrate all information and reports of smoke, fires, and the dispatching and alerting of fire fighting teams at some regional or District Assembly fire alarm centre.

The regional or District Assembly fire alarm centre may cover many villages and municipalities. 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 others:

- 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 and brigades, equipment, available, etc;
- Alarm systems to alert fire crews and brigades, and other units for fire pre-suppression and suppression, and trained personnel who are on duty during the fire danger season.

Methods to alert fire crews or community fire brigades 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.

(i) Cellular telephone;

(ii) Radio-telephone:

(iii) Fire sirens;

(vi) Church, or other loud bells;

(v) Drums;

(vi) Flags etc.

Location and Maps
Location

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 appropriate position definition systems used in the forest fire service, as described in the following pages.

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 coordinator.
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 coordinates 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 the latitudes, which is known as the international method. This system does not require any plastic roamer grid.

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

Regional maps

Regional maps must contain information about main roads, forest roads, and 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. 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 an important ' tool' for the fire chief, especially in large fires. All senior personnel in the fire suppression agency and the fire service and community brigades should be trained in the use of maps.

Fire Weather Services

Generally, weather forecast for the general public is not accurate enough for the forest fire service. The responsible agency for forest fire suppression must have its 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 communities and the general public of fire danger situations.

For the fire danger rating a weather index scale is needed and daily weather observation around the protected areas must be taken. This information requires basic meteorological observations from around the country. The service can be organized by meteorological stations at airports, harbors, forest stations, etc,

Fire weather index

The fire weather index (FWI) is an important indicator of burning conditions, because each day it indicates the expected fire behavior 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 there is no danger of a serious forest fire.

Measuring fire danger

Measurement of fire danger depends amongst others on 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 behavior, and of the daily fire control requirements. All personnel responsible for the suppression of forest fires and grassfires must be aware of the daily fire danger and fire weather index.

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 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.

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 and community fire brigades 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 and community fire brigades 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 and community fire brigades should be completely mobilized and on stand-by for immediate action. Reserve forces should be on call.

Extreme fire danger (FWI 23 and over)

Explosive condition! 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 and community fire brigades should be available on call and emergency action should be taken as required.

Training

Objective

The objective of the training is to build the capacity of participants in theoretical and practical aspects of forest fire prevention and fire fighting. The training also seeks to demonstrate the use of manual and light motorized forest firefighting equipment to facilitate better planning, organization, and to 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 organizational, technical, and tactical aspects of forest fire fighting;
- Be conversant with methods to control different types of forest fires using manual or light firefighting equipment;
- Be able to draw up fire fighting plans and advise the responsible regional authorities on fire fighting measures.

Theoretical part

- Forest fire prevention; methods and possibilities.
- Preparation of a fire plan.
- Fire suppression organization.
- Fire service organization.
- Mobilization 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 hand-tools.
- Maintenance and control of fire-fighting equipment and hand-tools.

Warning signs and boards

In order to prevent fires, all notice boards should be along the main roads and in the protected forest areas. One of the most important operations is to check and prepare adequate firebreaks and fire-lines in production forests and protected areas. If they are old they must be cleared of all fuel and must be wide enough to prevent fire from spreading.

Forest Fire Equipment

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 organization 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 pre-suppression and suppression, the purpose of using the tool is to reduce combustion, in any one or a combination of ways.

Firstly, the person / tool combination may reduce combustion by removing potential fuel from the path of the fire i.e. 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.

Local tool manufacture and training in the use of tools

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. The 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.

Hand tools used for fuel separation

Hand tools are frequently used for separating fuels when constructing firebreaks before the beginning of the fire season.

During fire fighting, they are used to construct a baseline for back burning, or to separate burning fuel from un-burnt material at the perimeter of a fire.

The main role of hand tools 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, rake-hoes, spades, forks, and road brooms. Chain saws meanwhile provide the best means for cutting large material and felling timber and snags.

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 thronged beaters are used, the main point is that sparks should be swept towards a fire, not scattered in directions. Shovels can also be used for beating out flames, smothering burning fuel and for burying smoldering material.

Water sprays

The engine driven fire pump, or fire-engine, also called pumper, is the most important piece, of equipment for the modem fire brigade at the scene of the fire. The goal of the fire pump is to give pressure and momentum to water at the scene of the fire. The fire pump itself is driven by a gasoline or electrical engine or by human power. Backpack sprayers should be included in the firefighting equipment because of their portability and effective use of small quantities of water. The use of water in the forest fire should be limited to use of the fog stream nozzle which can be cool fires 4- 5 times more effectively than with the straight nozzle spray. The fog stream nozzle spray is excellent for wetting down un-burnt fuel and for building a narrow but effective break in the fuel. The length of the straight stream can be more than 10 meters and the maximum water use

can be 101/min.

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, etc. 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.

Section 2.4 Wildfire Suppression

In addition to using this section of the Guidelines and Manual in formal training, it is most useful to be read out and translated in the local dialect during community meetings especially before the danger fire season.

General

Suppression relates to all the procedures which start on, or after the fire alarm. The main objective of suppression is to extinguish the fire. To start suppression, the community brigade volunteer needs to know about the fire-line. It is the line around an actual fire that is cleared by men or machines. It does not include live barriers. The fire-line, or simply the line, is usually prepared 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, and weeds.

The required clearing width of the fire line depends 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 fire-line about half a metre wide, is usually made with hand tools unless scrapper blades, ploughs, or other suitable earth moving equipment is available. Water spraying is most effective in light fuels. In all these cases the main objective is to keep the fire inside the fire-line until control is certain. The meaning of the term ‘ fire-line’ is – an obstruction line build during a fire in order to encircle it. Sometimes, the fuel-breaks which are prepared inside the protected forest before the fire danger season are also called ‘ fire-lines’ . Another principle to know is sizing-up. It is the evaluation and estimation of a fire by the fire person to determine a course of action for suppression of the fire. It is the first action upon arrival at the scene of the fire. Sizing-up begins on the way to the fire, as soon as the smoke is seen and the location is determined.

Sizing-up 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 a large problem solving and decision making process. Firstly, the problems must be analyzed 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 behavior, a course of action must be formed to control the fire. Consequently, follow-up operations are undertaken to ensure that the correct action has taken. 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 behavior is a basic requirement when sizing-up. If someone has a lot of experience of forest fires and fire behavior they are able to make an accurate and prompt size-up. They must analyze the fuel, weather, and topography, and how these will affect the behavior of the fire. The following questions will help in guiding decision making:

- What is the direction of spread?
- Is the wind steady, or gusty or 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 colored 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?

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 must be evacuated. It must be checked whether there are any other areas where there could be a fire hazard. Also, any hazards to the community fire volunteers, such as steep slopes, blind area, rolling rocks, falling snags, and power lines must be verified.

Threatened property and some tactical advice

After the hazard to life has been determined, property, buildings, non-flammable storage, livestock ——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.

It is important to prepare a fire line around the buildings or estate i.e. economic trees 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 or valuable tress 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.

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, the following should be known:

- How many fire-fighters 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 daytime 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 environment considerations?

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 needed for planning.

Water is the best and most effective control method if it is available and can be applied with efficiency. In most locations, hand-tools are the most useful method of building the fire-line. The use of hand-tools is best restricted to daytime use, while machines are best worked at night. Earth-moving equipment, such as a bulldozer, is very productive; however, it still has to be followed-up by manual labor. Normally, during the day, when the fire behavior 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 only to those sections where they can be most effective. All the forces available should be used 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.

Priority of control action

Some factors to be considered when deciding priority action include the following:

- 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 fire-line;
- 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

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 needed.

Indirect: building a line some distance from the edge of the fire, when the fire is too hot to fight directly.

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 volunteer fighters to work on the fire edge. Direct attach 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 only on 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.

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 behavior 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 as is necessary, otherwise the fire can build up enough to jump the line. The right location can only be decided by experience and judgment.

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.

- 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 method are as follows:

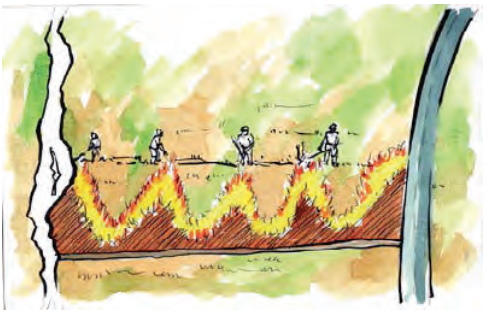
(i) Surrounding/parallel method

In this method, the fire line is made 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 built-out to secure the line. This is called building-out. Burning-out on the flanks is not nearly as hazardous as burning-out from a line in front of the head of the fire.

(ii) Hot spotting, or point and cut off technique

Because of the large variety of conditions, a number of methods are possible with the indirect method of attack. One method is " the combination of methods" . 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 are also attacked 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.

Burning methods

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 fire-line and the fire edge will be burnt. Pockets and islands should be burnt-out after the line is made 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 burnt.

The hazards relevant to clean burning are snags, piles of heavy ground fuels, live trees with branches extending to the ground, and tree covered with moss. These must be removed and broken up.

Backfiring

Backfiring is one form of the indirect attack method. It 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 implies 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.

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 head of the fire operations. In large fires, the head of operations would delegate the operation to a qualified team head, or head of the community volunteers involved. Constant communication between the person in charge and the fire teams is of prime necessity. 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 can be obtained from an airplane or helicopter flying over the area.

Factors affecting choice of attack

Bringing a fire or part of the fire edge under control depends on a number of factors, which can be determined after scouting the fire. These factors, which are also a check-list for the head of fire operations before the start of planning the suppression tactics, 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 behavior at the fire site.

Suppression Technique

Suppression technique means having a good knowledge of the methods of fire suppression together with the experience for selecting the right equipment.

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. This is known as the fire triangle. The extinguishing of a fire is therefore based on the removal of one or more of the components represented in the fire triangle. The following methods are advised:

(i) Cooling: a method of extinguishing where the temperature of the fire is reduced below the point of ignition. After cooling, the fire will not start by itself. In forest fire, cooling can be done by the application of water, and is called ‘ cooling the fuel’ .

(ii) Smothering: a method of extinguishing fire where the oxygen is removed from the fire. This can be accomplished in a forest fire by an application of sand or soil or beating with the back of a shovel, as well as by swatting the fire with a fire-beater.

(iii) Starving: a method of extinguishing fire by removing the inflammable fuel. 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 fire-line.

In general practice, several tools and pieces of equipment can be used to combat the fire. Their choice depends on:

(i) Type of fuel.
(ii) Topography and situation (water sources).
(iii) Fire intensity.
(iv) Method of attack.
(v) Manpower and experience.

Some special advice for line construction

The clearing or 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, rake-hoe, shovel, or rake. The type of tools, or combination of tools, depends 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 torch-man 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.

Undercut lines: 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. Such pieces of burning material, even logs often roll downhill as the fire burns around them, thus scattering burning material down the slope. An undercut line should be built as a deep trench that is well banked with earth along its entire length.

Inflammable fuels outside the fire-line, which are not burning, such as rotting stumps and logs 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 wetted through.

Ringing a snag tree: A snag tree is a standing dead tree or part of a dead tree from where leaves and small branches have fallen. If the snag trees are inside and close to the fire 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 – 4m 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.

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. It constitutes the most effective method. 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.

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 vehicle. This implies that vehicles should have easily accessible routes to the fire site.

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 nozzle-men cannot work close to the tire edge.

The first objective for the nozzle-man 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 nozzle-man should start to attack the flanks on both sides, or on 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 the fire from spreading. After that, the flank attack is continued and work progresses from the rear along flanks, around the head, and then back to the point of start. The point of start on the flank depends 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 ensure that it is secure. If the fire starts again behind the fire fighter it may not be too long before he is outflanked and caught in pocket between two fires. He should continue to work around the head to pinch off the spread.

To break into a burning line, the fire fighter should reach into it with a straight stream of water, aiming at the base of a hot spot. Bounce the straight stream of water off the ground to make more spray and to cool fuel. As soon as a part of the edge has been knocked down, move into it fast. Then 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, it should be 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 the separation between the burning and un-burnt fuels with water pressure is a most important action. In general, the angle at which the water stream is directed onto the fire edge will determine the effectiveness of the separation. In light fuels the angle should be nearly parallel to the fire edge, and the stream should hit the fire edge about *5* - 8m from the nozzle-man. 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 nozzle-man. 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 nozzle-man on the type of nozzle used in different fire situations is as follows:

Crown fire - direct or scattered nozzle with sufficient pressure and water flow, depending on the intensity of the fire.

Low surface fire - scattered nozzle, not very high pressure and water flow. Instead of nozzles, backpack pumps can be used. Although 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 skillfully operated. Backpacks are very useful in initial attacks.

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 the 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. They also serve 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 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.

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 smoldering 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 fire fighting team and its leaders. In many cases it is better to take a fresh fire fighting team to do the mopping-up work, because the first team will be tired after the initial control operations.

Snags inside the fire line and in places where sparks can be thrown across the line should be felled away from the line and extinguished.

- Remove the roots from across the line.
- Fire can travel underground along the roots and can break out on the surface many meters away, and up to two weeks later.
- Fire in heavy duff may smolders 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 working order to make sure that the underground fires are really out. Where water is not available, or is in limited supply, 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.

Trouble spots should be eliminated before they flare-up and endanger the line. Keep the fire out of heavy fuels, concentrations of fuel, and un-burnt islands. Break-up any concentrations of fuel that are burning. Improve the line and make sure it is secure and continuous. Turns 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 smoldering 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.

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.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