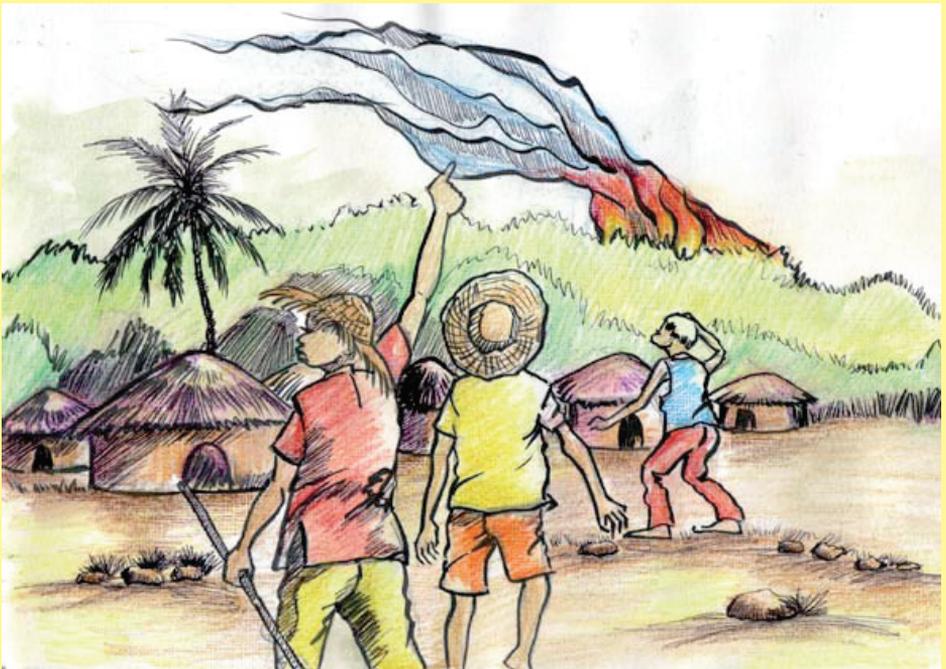




REPUBLIC OF GHANA

Guidelines & Manual

Procedures for Community-Based Fire Management – CBFiM Ghana



Published by : Ministry of Lands and National Resources of Ghana, with the support of ITTO and IUCN.

Utilization : This is a public document and should not be sold or employed for commercial objectives. It is produced for the purposes of information, education and training. It can be reproduced and translated into simple English or other relevant languages and dialects under the guidance of the Ministry of Lands and Natural resources of Ghana.

Citation : Ministry of Lands and Natural resources, Ghana. 2011. Guidelines & Manual : Procedures for Community-Based Fire Management - CBFiM, Ghana 90pp.

ISBN : 978-2-8317-1334-2

Graphics and Printing : GRAPHI IMPRIM 01 BP 5286 Ouagadougou 01 - Burkina Faso - Tél. (226) 50 31 12 34 - Fax (226) 50 30 45 49

Availability : Ministry of Lands and Natural resources, Accra Ghana; Forestry Research Institute of Ghana (FORIG), Kumasi, Ghana; and IUCN Ghana P.O. Box M239 Accra. Telephone +233 021 66 46 54

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



TABLE OF CONTENTS

SECTION 1: LEGAL AND MANAGEMENT PRESCRIPTIONS

1. Policy background to the Guidelines & Manual of Procedures 7

The National Wildfire Management Policy of the Republic of Ghana (2006) . . 7
1.1.1 Introduction 7
1.1.2 The Policy Framework 7
1.1.3 Guiding Principles. 8
1.1.4 Specific Policy Objective 9
1.1.5 The globally approved 11 UN-Principles in Wildfire Management 9

2. The Guidelines & Manual of Procedures for Community Based Fire Mgt. 10

2.1 Background 10
2.2 Social and cultural aspects 12
Principle 1: Sustainable livelihoods 12
Principle 2: Human health and security 13
Principle 3: Traditional uses of fire. 15
2.3 Economic aspects 16
Principle 4: Protecting lives and assets 16
Principle 5: Economic impact 17
2.4 Environmental aspects 18
Principle 6: Interactions between climate change and fire 18
Principle 7: Fire effects on ecosystems 19
2.5 Institutional aspects 21
Principle 8: Legislation and governance 21
Principle 9: Multi-stakeholder approach 22
2.6 Enhanced fire management capacity 24
Principle 10: Cooperation 24
Principle 11: Knowledge transfer 26
Definitions 28

SECTION 2: CAPACITY BUILDING IN COMMUNITY FIRE MANAGEMENT

Section 2.1	Wildfire Description.....	33
Section 2.2	Wildfire Prevention.....	45
Section 2.3	Wildfire Pre-suppression.....	62
Section 2.4	Wildfire Suppression.....	76

SECTION 1: BACKGROUND, LEGAL AND MANAGEMENT PRESCRIPTIONS

1. Policy background to the Guidelines & Manual of Procedures, CBFiM

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. *Promote user-focused research* in wildfire management.

1.1.5 The globally approved 11 UN-Principles in Wildfire Management

The 11 United Nations-approved Principles¹ 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 Principles² 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 learning³ 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.

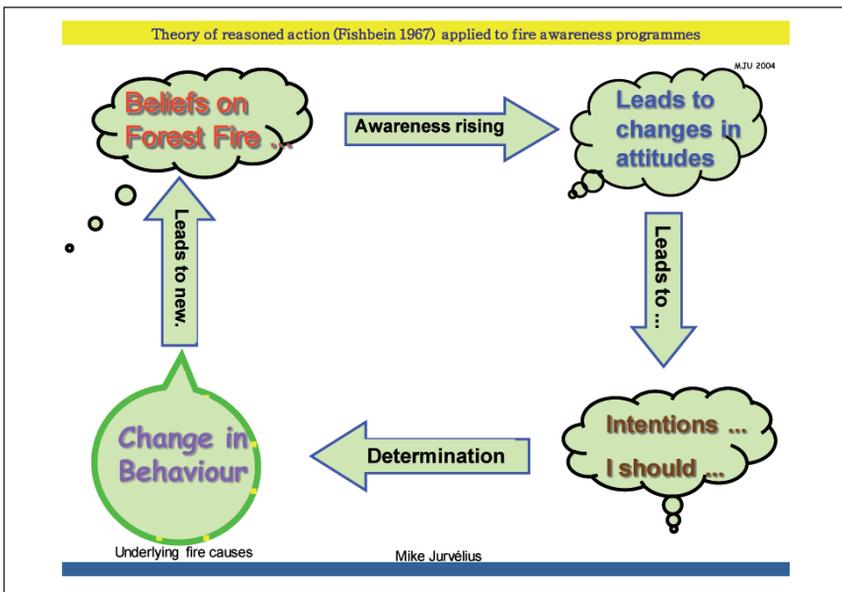


Figure 1. The process of behavioural change in fire management (Fishbein, 1967; modified in Jurvelius, 2007)

Dimensions and Principles for Community Based Wildfire Management (CBFiM⁴) 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. wildlands).

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 ISDR⁵ 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.

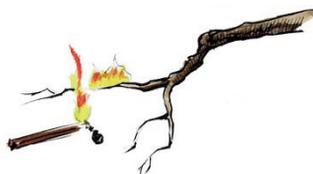
Ground and aerial fuels

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 slopply 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.



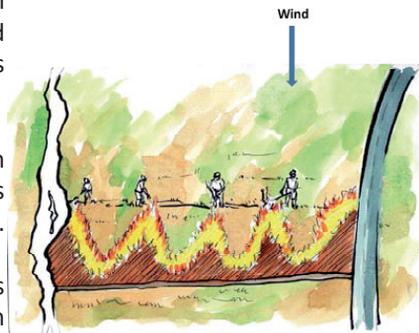
Parts of a forest fire

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 undecomposed 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 convection column may also carry burning leaves and branches up to the pre-heated crowns, setting them on fire.
- Once the crown of one tree begins to burn, it may set the crowns of trees next to it on fire. 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.