RESEARCH NOTES

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Kenya Forestry Research Institute

FIELD GUIDE MANUAL FOR FOREST FIRES MANAGEMENT IN KENYA

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MT ELGON INTEGRATED CONSERVATION AND DEVELOPMENT PROJECT

FIELD GUIDE MANUAL FOR FOREST FIRES MANAGEMENT IN KENYA

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1.0 INTRODUCTION

This manual is a summary of information contained in the following publications/documents and, we sincerely thank the authors of these documents, Institutions and individuals who contributed to their realisation.

- Forest Fire Management Planning Kenya: Fire danger rating for forest areas, FO: DP/KEN/74/024. United Nations Development Programme, 1980, Rome;
- Forest Fire Management Planning Kenya: Observers' handbook for fire weather, Forestry Department, Ministry of Environment and Natural Resources, 1980, Nairobi;
- Fire in Tropical Pine Forests: With special reference to *P. caribea* var. hondurensis, Wolffsohn, 1998, Oxford;
- Reports on Forest Fires, Forestry Department, File No. FOR 207/10, Ministry of Environment and Natural Resources, Nairobi.
- Forest Department Technical Orders, File No. FOR 2/26, Ministry of Environment and Natural Resources, Nairobi.
- Forest Department General Orders, File No. 2/28, Forestry Department, Ministry of Environment and Natural Resources, Nairobi.
- Laws of Kenya, The Grass Fires Act, Chapter 327, Revised Edition 1972 (1962), Government Printers, Nairobi;
- Laws of Kenya, The Forest Act, Chapter 385, Revised Edition 1972 (1962), Government Printers, Nairobi; and
- Laws of Kenya, The Wildlife Conservation and Management Act, Chapter 376, Revised Edition 1972 (1962), Government Printers, Nairobi

1.1 Kenya's forest resource

The total gazetted forested area of Kenya is less than 3% of the country's total land area. Primary forests are mainly the closed tropical forests; open mixed and semi-tropical rain forests. The closed forests are scattered on the slopes ad foothills of the higher parts of south western third of the country and the open mixed forests are found in the lower elevations in other parts of the country except the north eastern.

In addition to the natural forests, there are about 165 000 ha of commercial forests plantation area. However, the area covered by trees is not exactly known because inventories are rarely carried. The major tree species in plantations are pines, cypress and eucalypts.

The closed forests are classified into montane rain forests; montane conifer forests and lowland rain forests while the mixed forests are classified into lowland rain forests, dry land forests, lowland savannah forests and mangrove forests. Of these, the conifer forests are the most important economically. The dominant commercial indigenous species are *Juniperus procera, Podocarpus latifolius* and *P. falcatus, Olea europaea var africana* and *O. hochstetteri.*

Semi-tropical rain forests occur on the lower slopes of northeast and east Mount Kenya and in the Lake Victoria basin. They are humid, and trees are tall and multi-storied. The dominant tree species are *Croton megalocarpus, Olea capensis, Cordia abyssinica* and *Newtonia buchananii* along streams.

The lowland rain forests are almost entirely confined to remnants of a few hundred hectares along the coastal strip. These forests are multi-storied with dense shrub layer, and are often dominated by *Milicia excelsa, Antiaris toxicaria, Trachylobium verucosum,* and *Combretum schumanii.*

The lowland dry forest type occurs as relicts north of the Tana River and in Arabuko-Sokoke forest. They have open canopies and low shrub layers. The dominant species are *Brachylaena huillensis, Brachystegia spiciformis, Afzelia quanzensis* and *Combretum schumanii.* These forests are of little economic importance, but have great potential for tourism, provision of non-woody forest products, wood fuel round wood for carving.

The mangrove forests form a unique coastal ecosystem but are of limited extent. They occur in the intertidal zone, on estuaries and creeks at scattered points along the coast. The major species are *Rhizophora mucronata, Ceriops taga* and *Bruguiera gymnorhiza.*

1.2 Contribution of the forestry sub-sector to national development

The forestry sub-sector is important in the national development both directly and indirectly particularly through its association with the agriculture and livestock sectors. It is also closely linked with other sectors such as energy, water, wildlife and tourism, etc.

In 1994 (World Bank), the gross forest products, excluding indirect roles, were valued at Kasha 962 million per annum, providing about 10% of the country's Gross Domestic Product. Nonetheless, the most important value of the forests, the indirect role of the indigenous forests, e.g., protection of water catchments, stabilisation of the agricultural sector, supply of non-wood products (honey, medicinal plants, etc), traditional and recreational uses have not been valued. In addition, these forests are the home of 50% and 25% of the country's mammal and bird population; respectively. The coastal forests also provide habitat to some endemic animals and plants.

Economic multiplier effects from the forestry sub sector related industries are immense. For example, charcoal and fuel wood provide more than 90% of the country's energy consumption. Charcoal processing probably creates the equivalent of 50 000 jobs for charcoal burners and about 2000 within the marketing chain. In addition, about 14 000 persons are directly employed within the forests management and up to 10 000 in wood processing industries. However, the recent decision to ban logging in all government forests has (in June 2000) resulted in massive job cuts in the forestry sector. In addition, the forestry sector is in crisis because there is a deficit in the supply of wood and related products, and particularly wood fuel. Demand for saw timber, plywood, pulp and paper has also outstripped supply lead to harvesting of immature wood and overexploitation of the mixed and closed forests. Unfortunately, there seems to be no solution in the near future because the government is accelerating the crisis by converting large areas of forest to other uses and particularly small-scale cultivation and because forest fires continue to destroy the forests. The trend of losses inflicted by forest fire is presented in Figures 1and 2; and appendix 1. The damage figures are deceptive because of four reasons.

i. It is difficult to have exact figures bearing in mind the elements that can be included in costing a forest estate. Such elements are environmental degradation; forest recreation; additional job opportunities; improvement of infrastructure resulting from the existence of the forest estate; soil texture deterioration etc. which all result the devastated forests;

ii. To date the Forest Department has no rationalised guidelines of assessing the damage caused to forest by fires in monetary terms; and

iii. Because the most detrimental effect of wildlife, potential loss of the basic resource - soil - through erosion is not included. Most of the land areas of Kenya are covered by only a thin layer of organic material due to the rapid rate of decomposition in tropical climates. When this layer of material is destroyed by fire, surface water run-off is increased. Any nutrients that remain on the soil surface, plus ashes and the solid itself are washed into the main drainages and start their trip to the sea. Since all major rivers in Kenya have their origin in the Gazetted Forests or National Parks, each fire that destroys vegetation affects stream flow and water quality. Streamside clearing and burning have caused much erosion, and this mistreatment has had a major impact at the mouth of the Tana River at Kipiriri. Eroded material and ashes from fires are degrading the beaches, as well as the length of the river itself. This loss of soil and subsequent loss of nutrient has direct impact on human settlement in the affected areas.

iv. No attempt was made to cost the long-term effect of forest fires, i.e. the change in composition and structure of vegetative cover to less desirable timber species, highly flammable bush and eventually to completely barren land.

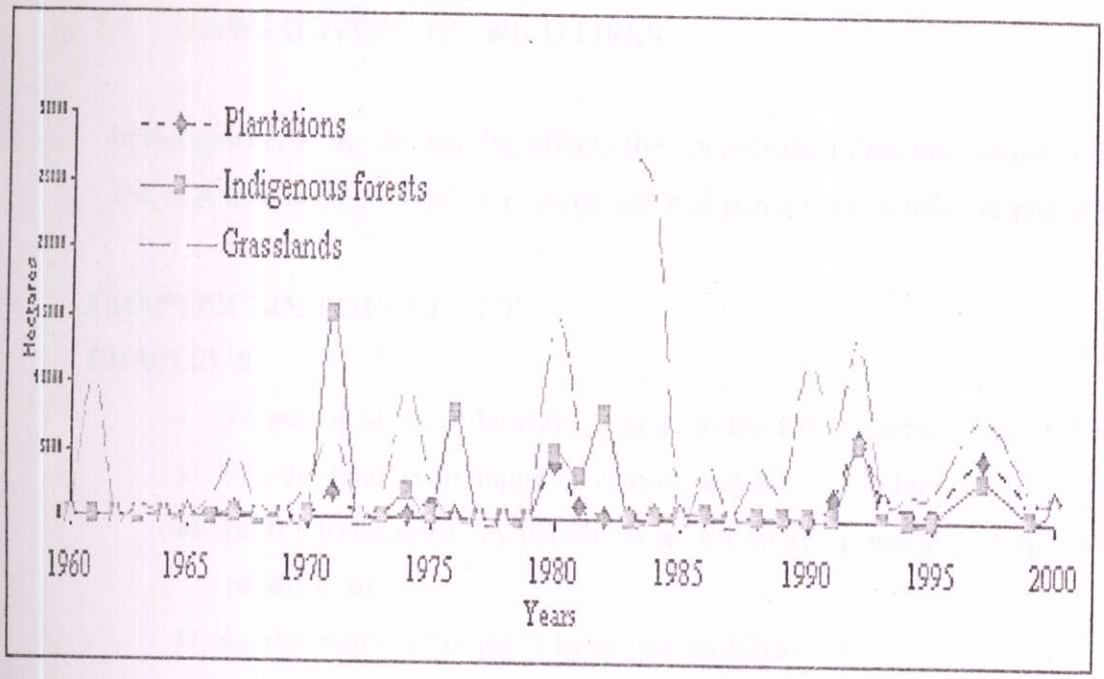

Figure 1. Trend of forest area destroyed by forest fires in Kenya

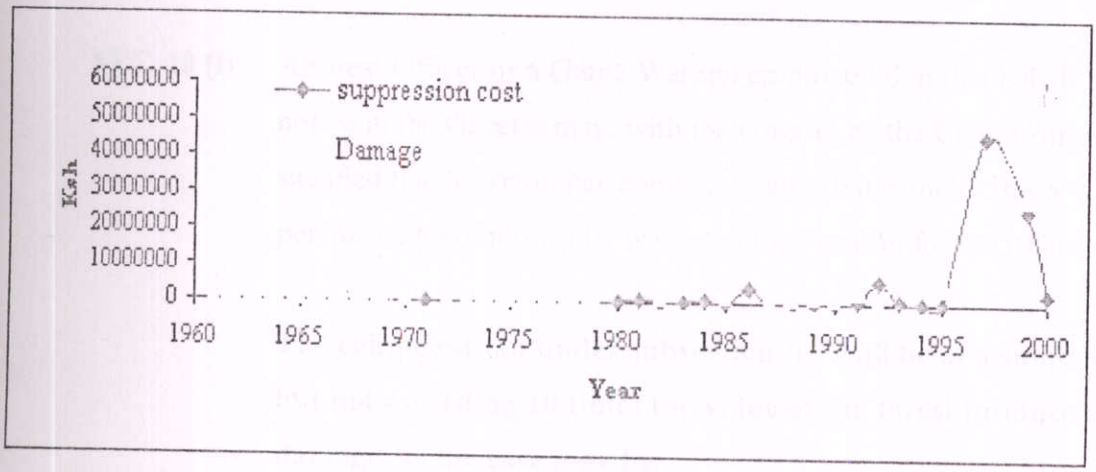

Fig.2 Trend of forest fires damage in Kenya

2.0 LAWS GOVERNING WILD FIRES

In recognition of the devastating effects the uncontrolled fires may cause to the environment, the law of Kenya does provide for prohibitions and penalties towards fire prevention in various acts.

CHAPTER 385: FOREST ACT

CHAPTER 8:

i. No person shall, without the licence of the Chief Conservator of Forests:

ii Fell, cut take, burn, injure or remove any forest product; or

iii. Set fire to or assist any person to set fire to any grass or undergrowth or any forest produce: or

iv. Smoke, where smoking is by notice prohibited, or

v. Kindle, carry or throw down any fire, match or other lighted material.

The same applies for unalienated government land.

In section 8 (i) (b). Any person going against the aforesaid shall be guilty of an offence.

SEC. 10 (i) AForest Officer or a Game Warden empowered in that behalf by the minister by notice in the Gazette may, with the consent of the Chief Conservator, if he is satisfied that a person has committed an offence under this act, accept from that person a sum of money by way of compensation for the offence.

The compensation under subsection (i) shall be of a sum not less than 5 times but not exceeding 10 times the value of the forest produce of the estimated damage, as the case may be.

Sec. 14 (i) Any person who commits a breach of or fails to comply with the Provisions of this act or of any rules made there under

Shall be guilty of an offence and liable to a fine not exceeding ten thousand shillings or to imprisonment for a term not exceeding six months.

Provided that:

(ii) in the cause of offence under section 8, the fine shall be less that ten times the value of the forest produce in respect of which the offence is committed or of the estimated damage caused and where the Chief Conservator of Forest cannot determine the value of such produce or damage. Such person shall be liable to a fine not exceeding ten thousand shillings or to imprisonment for a term not exceeding six months or both

THE FORESTS BILL, 2000 **Not yet law)

Sec. 51. Sub Sec. 1,2,3, prohibited activities in forests.

(1) Save under a licence or permit or a management agreement issued or entered into under this act, no person shall in a state, local authority or provisional forest-

(i) Fell, cut, take, burn, injure or remove any forest produce.

(ii) Set fire to or assist any person to set fire to any grass or undergrowth or any forest produce.

(iii) Smoke, where smoking is by notice prohibited, or kindle, carry or throw any fire, match or other lighted material;

(2) Save under a licence or permit or a management agreement issued or entered into

(a) Set fire to or assist any person to set fire to any grass or undergrowth or any forest produce.

Any person, who contravenes the provision of subsection (1) (2) and (3) of this section commits an offence and is liable on conviction to a fine not exceeding fifty thousand shillings or to an imprisonment for a term not exceeding fifty thousands shillings or to both such fine and imprisonment.

CHAPTER 376: WILDLIFE CONSERVATION AND MANAGEMENT ACT

SEC. 13 SUBSECTION (3). Any person who without authorization:

(a) Cuts, injures or sets fire to any vegetation in a National park, or allows any fire lighted by himself or his servants to enter a National Park shall be guilty of an offence and liable to a fine not exceeding ten thousand shillings or to imprisonment for a term not exceeding one year or to both.

CHAPTER 327:THE GRASS FIRES ACT

Sec. 3 (i) & (ii)	Burning of vegetation without authority.
Sec. 4 (i) & (iii) a+b	Notice to be given fore burning vegetation.
Sec. 5 (i) a+b, 2	**Power to prohibit burning of vegetation.**
Sec. 6 Subsection (1)	burning of vegetation by employees.
Sec. 7	Fire breaks
Sec. 8.	Local authorities/owners may order compulsory firebreaks.
Sec. 9.	Restrictions as to removal of bees and honey from land.
Sec. 10.	Engagement of fire rangers.
Sec. 11.	State of danger (fire danger).
Sec. 12.	Refusal to assist in putting out fire.
Sec. 13.	Protection of life, person or property by counter firing.
Sec. 14.	Liability of servant.
Sec. 15.	Arrest.

Offences under this Act or under rules made thereunder shall be cognisable to the Police.

Sec. 16. The general penalty under this Act is as follows:

A person who is guilty of an offence under this act for which no penalty is specially provided, or who fails to comply with any of the provisions of this act or any order made thereunder, shall be guilty of an offence and liable to a fine not exceeding four thousand shillings or to imprisonment for a term not exceeding twelve months, or to both such fine and such imprisonment.

3.0 CAUSES OF WILD FIRES

In 1976, analysis of available fire reports from the Forest Department files shows that the major causes of wildfire in Kenya is shamba burning. Approximately 40% of the reported fires for which the cause was identified were the result of fire entering the forest areas from adjacent agricultural land. Many fire causes were classified as "unknown", and undoubtedly a portion of these were also due to shamba burning. During the same year it was noted that arson and incendiaries were credited with 14% of the reported fires on gazetted land. Honey hunters, cooking fires and fires from unknown causes were responsible for the remainder i.e. 46%.

During the 1979/80 major fire season the situation had changed. Shamba contributed 33% of reported fires for which the cause was identified, arson 32%, honey hunting 13%, other causes 22%. In 1982 the scenario was, shamba 16.5%, honey 11.0%, arson 18.7%, smokers 4.4%, charcoal 2.2%, forest workers 1.1%, and unknown 39.5%, and grazers, children 6.6%. Since then arson and shamba have remained as the major causes of forest fires in Kenya.

4.0 PREVENTING WILD FIRES

Now that we know the causes of fires, we can discuss how to involve communities in forest fires management. It is important at this juncture to note that the number of fires attributed to arson, shamba development and honey hunting have increased dramatically in recent years. These changes are very important factors to consider in developing a realistic fire prevention programme. The specific prevention measures are as follows.

Arson fires are very difficult to prevent by direct means. Long hours of investigation are necessary to apprehend the individuals responsible. Forest officers have been mobilising night patrols, manning fire towers, and staying continually on the alert during times when arson is expected. All the same arson related fires continue to occur. A better long-term solution is to identify the reasons behind the act of arson and then take prevention measures with all stakeholders in the forestry.

1. From the discussions with Field forest officers, there seem to be two primary reasons for arson in gazetted forest:-

2. Dissatisfaction with the Government's afforestation programme in general. Certain individuals feel they should have been given the forest land for settlement rather than Forestry department "taking" it for timber production; and
3. Encouragement by the Department itself through past actions. In some instances, when forests are destroyed by fire, the shamba system is issued to prepare the area for replanting. This action alone encourages people to engage in arson.

To reduce arson related fires the following suggestions may be adopted: -

a) When forests are destroyed by fire, the "shamba system" should not be employed to prepare the site for replanting. The staff of the Forestry Department or casuals should prepare the site. This may eliminate any incentive for acts of arson.
b) The staff of the Forestry Department and other institutions having a stake in the forestry sub-sector should explain to local residents how wildfires destroy the natural resources of Kenya and endanger the industrial development of the entire country. This can be accomplished through mass media, public barazas (meetings), fire prevention posters in the settlements, and personal contacts.

The use of the **shamba** system as a method of preparing land for afforestation greatly increases the risk of fire problems. Cooking fires, debris burning, smoking, unsupervised children, all compound the normal risk. A recommendation to completely eliminate the shamba system as a method of site preparation is probably appropriate at this point but the decision involves too many political and socio-economic considerations. However, this system provides only temporary solution for land-hungry people because it encourages the perpetuation of a migrant agricultural population that will be a continuing problem until they find permanent homes.

Assuming that the shamba system will continue to be used by the Forest Department, shamba related fires can be reduced by: -

a) Forest Officers personally contacting the local populations next to the forestland and educating them on the damage that the fires can cause and the prevention measures they can take. Such contact should be made several times during the fire season.
b) Forest Officers should work with the Provincial Administration and especially the Chiefs, District Officers and the District Commissioners to obtain their co-operation in carrying out the fire prevention programme.
c) The District Foresters and Provincial Administration Officers should hold village meetings at the beginning of the fire season to explain the need for care in use of fire by all residents.
d) A buffer zone should be set up to separate settlement from the forest. The width of such a zone will vary depending on topography, prevailing wind conditions and fuel, but in no one case should it be less than 30 metres wide. During the fire season, all uses of fire in this strip should be prohibited. It should also be free from any habitation. It would however be economical and more advantageous if the strip is planted with fire resistant crops such as tomatoes, sweet potatoes etc.
e) Constructing a "fire-safe" zone to separate agricultural land from forested area.

Pursuing aggressive law enforcement action on all fire trespass cases may prevent fires related to **illegal honey hunting and game poachers**. When the violators are punished, the results of the case should be highly published as a deterrent to other violators.

Prescribed burning and re-born fires can be completely prevented through training in the basic concepts of fire behaviour and better supervision. This can best be achieved if all the prescribed burning projects and controlled wild fires are personally inspected on the ground by a competent line officer before patrols are abandoned and the fire declared out "kabisa". Such an officer should be an officer of the Foresters rank and above.

Fires from **other sources** can be minimised through mass media. The Forest Department should expand the use of mass media to educate all forest users on the importance of preventing fires.

5.0 DETECTING FOREST FIRES

Several methods of fire detection are presently in use. The co-operative communities living in or near the forested areas discover majority of fires. They generally initiate suppression action and report the fire to the nearest Forest office.

In the course of walking their beat, Forest Guards, Patrolmen and Game Rangers are continually alert for fire out breaks and instances of unauthorised fire use that could result in damage to forests Community leaders should also be authorised to patrol the forests during the fire season.

During the fire season, observers are stationed on ridge tops in fire towers and other vantage points to watch for smoke. In the past, where fire towers have been constructed, and are manned, they have been credited with first discovery of numerous fires.

Aircrafts are also used for detection. However, this is not practised in Kenya, but in a few instances aircrews of Kenya Wildlife Services, Kenya Police and Kenya Air Force have reported forest fires.

6.0 SUPPRESSING FOREST FIRES

6.1 General

Once a fire has been detected, it must be put out. We should therefore learn fire suppression tactics. For a fire suppression exercise to be a success, the Fire boss should know the behaviour of the fire to be suppressed. Fire behaviour depends on the environment in which the fire is burning. This environment consists of fuels, topography and weather.

The drier the fuel, the higher the percent that will burn and the hotter the fire will be. Certain types of fuel burn hotter because of the flammable oils in them. Size and arrangement also affect the fire's behaviour.

The faster the wind, the faster the fire spreads. Dry air and high temperatures cause the fuel to dry out quicker and, in turn the fire burns "hotter" because more of the fuel is burning and is burning more rapidly.

The steeper the slope, the faster the fire spreads uphill. Fires travel upslope with the prevailing wind faster than on level ground. A 10^0 slope doubles the rate of spread, and a 20^0 slope causes a fire to spread 4 times faster. Corresponding reduction of speed can be discovered when a fire moves down slope.

Modifying these factors (fuel, weather and topography) help in reducing the speed of the fires. This in turn helps to ease the suppression exercise. However, two of these factors i.e. weather and topography are beyond our modification. We can therefore modify only fuels. Thus to suppress a fire, we must change the fuel situation. This may be readily be done by cutting a fire line, wetting the fuel with water or by backfiring.

6.2 Equipment and tools

The following is a list of the most important equipment in use today. Those marked with asterisk are currently being used in Kenya and those marked with # are suitable for mountain ecosystem.

- Vehicles for transporting fire fighting crews*#
- Vehicles for transporting fire fighting equipment*#
- Fire beaters*#
- Axes*#
- Pangas*#
- Power saws*#
- Bow saws*#
- Hoes**
- Shovels*#
- Rackhos*
- Bank pumps*#
- Foam extinguishes

- Motorised pumps*#
- Water tanker*#
- Disc plough* and tractors to pull them*
- Disc harrow*
- Bulldozer
- Radio equipment, for communication between fire fighting vehicles, crews and control room*#
- Walkie talkies*#

The number of pieces of each item one actually needs cannot be indicated here. This depends very much on the local conditions, the size of the forests, climate, topography, size of the fire to be suppressed, etc.

Most of the heavy and expensive equipment consists of items that are needed for other purposes as well. This part of equipment may therefore be used for general transportation, road construction, clearing, etc during the other part of the year. It must only be made absolutely sure that it is checked and overhauled before the onset of the fire season so that there can be no doubt that it will be in good working conditions in case of a fire emergency.

6.3 Man-power

If a fire is severe, a large number of people are normally required to suppress the fire successfully. In addition to the trained fire fighting crews and supervisory staff that always must be kept ready for immediate action throughout the fire season, the community must be sensitised on the importance of suppressing forest fires. However, it is not economical or practical to employ a large number of people for the single purpose of fighting fires that may or may not occur. In case of a severe fire it has been always cheaper to mobilize labour of the Forestry Department and the public.

6.4 Infrastructure

If fire suppression exercise is to be effective, fire suppression crew must be able to reach the place of the fire within a minimum of time from the moment the alarm is sounded. To make this

possible all forest areas must be made easily and rapidly accessible. It is of particular importance that all types of equipment and personnel can be deployed without difficulty or delay to the fire front. Such an action is only possible if an infrastructure of good roads and dense network of access tracks are in existence. With good public relation, little cash and opening the roads to the public, the communities can easily be involved in maintenance of the road network.

6.5 Fire fighting

6.5.1 General

When a fire in the forest is reported, a fire fighting crew headed by the fire master on duty, must leave immediately, let say before 10 minutes at the most, to the location of the fire. Thus, only an emergency crew of about 12 people need be kept ready for immediate turn out. In addition one more stand by crew need be kept ready for departure at short notice, let say about 30 minutes. At the initial stage of a fire, what really matters is that competent people with means to suppress the fire arrive at great speed to the fire while the fire front is still small. Speed is much more essential than numbers at the initial attack. Effort should therefore be directed toward stopping the head fire. The communities adjacent to the forest may best be suited to do this because of their nearness to the fire front.

Situations may also occur where the lookouts report a very violent fire. In such a case a general alarm must be raised immediately so that reinforcements can join the emergency crew as rapidly as possible.

6.5.2 Readiness for action

For rapid, efficient action there are three prerequisites: -

a) The people concerned must know what to do without hesitation;
b) The people needed for rapid action must be available without delay; and
c) The equipment must be ready for transportation and in operational condition.

It is essential that the crews be well trained so that they will be able to attack a fire rapidly, efficiently and without hesitation. In addition the crews must be able to organize and lead the large numbers of government staff and the community members that may be mobilised to help fighting a serious fire. The crew must be well informed about where the "lines of command" go within the organization.

When the fire alarm is sounded, the Fire Boss on duty must have unquestioned authority to lead and direct not only his crew but all additional number of the fire fighting team without any consideration of the other members status under other circumstances. He must have authority to delegate power to anyone member of his crew. If you are the Fire boss, the District Forest Officer and even a District Commissioner are subject to your authority.

The Fire Boss must not only be empowered to give orders to all people that are involved in the fire extinguishing operation, but must also have authority to order removal or eventually, destruction of fire hazards, e.g. burning of a plantation, in the absence of the Direct of Forestry. In brief, when the fire alarm has been sounded, the Fire Boss must be unquestionably in charge. What he orders must be done without discussion or delay.

For efficient fire fighting, the crews must be trained on: -

a) Instruction in fire fighting methods;
b) Practical training in operation of the fire fighting equipment;
c) To locate reported fires; and
d) Rapid turn out.

After working hours, the fire fighters must stay close to the office and the fire control centre must be alert. Special care must also be taken to ensure that the Fire Boss on duty can be reached without delay.

Finally, just as the Fire Boss and crews must be prepared for immediate action, so the equipment must be ready. Light equipment and tools must be loaded on the vehicles beforehand. Vehicles, power saws, motorised pumps must be ready with full fuel tanks. Back pumps must be operational and loaded with water. The ignition key for vehicles must be present. To say it more briefly, all

equipment must be prepared in such a way that it can be brought into operational status without the slightest unnecessary delay. A Fire Boss who is alert on the status of his fire control tools and the skills of the individual members of the community is likely to be efficient in fighting forest fires.

6.5.3 Actual suppression

When the alarm is sounded, the emergency crew should rush out to the spot where the smoke has been observed. The crew should take with them fire beaters, hoes, shovels, matchets, axes, back-pumps, the essential light equipment by means of which most small fires can be suppressed. The Fire Boss ***must*** of course accompany the crew and the vehicle carrying him must be provided with a radio (?) so that he can continuously be in contact with the control point i.e. the office. In this way he will be able rapidly to call for reinforcement, both equipment and personnel.

If the crew finds a very limited ground fire advancing over a short front through short grass, it should attack the fire directly by hitting with beaters. Most small fires can be extinguished in this way. When the fire has been stopped, "mopping up" is carried out. This operation consists of extinguishing all remaining embers by beating them, covering them with soil or spraying with water. In addition it is often advisable to the burnt area with a narrow fire line (1 metre wide). Despite these precautions there is always a risk that some embers have been overlooked, and if these happen to get burnt, there may be another outbreak of fire. A guard must therefore be mounted on the spot until it is ***absolutely*** certain that there are no hidden embers left.

In the case of more violent ground fires, direct attack with fire beaters is impossible, because heat and smoke will prevent the fire fighters from getting near enough. If the fire perimeter is still small, the crew must therefore concentrate all effort on the rapid clearance of a fire line in front of the advancing fire, unless the fire already is approaching an existing fire line. When the fire reaches the fire line, some spotting across the line is likely to take place. Such fire spotting must be controlled very rapidly before the new fire gets so violent that it cannot be approached.

The Fire Boss must always be on the watch out for fire hazards in front of the advancing fire. If a fire is for instance approaching a young, recently pruned cypress plantation, it may be necessary to call in reinforcements to prevent the fire from getting out of control. Plenty of people equipped with power saws may remove a few rows of trees to widen the gap between the fire and the threatened plantations.

Against more extensive fires and especially fires that are fanned by a strong wind or moving up steep hillsides, it is only possible to mount the back firing along the existing firebreaks or rapidly established fire lines. If the firebreak towards which a fire is advancing has not been properly kept, it may be necessary to improve it rapidly by means of slashing with machets, burning with great care or by disc-hurrow in a case a tractor hurrow is available. Quite often even a permanent firebreak will be too narrow to stop a violent fire unless some additional measures are carried out. For instance in Laikipia District during 1981 fire season, a tarmac road of about 10 metres wide was unable to stop a fierce advancing fire.

The most effective measure in such a situation is often backfiring. The back firing is done along the side of the fire line or firebreak that is facing the advancing fire. Back firing is widely practised in Kenya and is has proved very successful especially in west slopes of Mt. Kenya and Laikipia district.

Crown fires are dealt with in much the same way as violent ground fires, the main difference being that they often are much more violent and develop an intense heat that makes it completely impossible to approach the fire front. A very wide fuel free zone may therefore be required to control a crown fire.

Fire behaviour varies according to the wind, the slope, the type of fuel etc. and it is rather the exception that one fire follows same pattern as a fire that has previously been fought within the same forest. Almost all fires offer at least some surprises. It is therefore necessary that Forest Officers and Fire Bosses in charge of fire control apply a high degree of imagination, skill and decision where they are faced with a major forest fire. It is also very important, in such circumstances, that decisions can be made in consultation with people that possess a considerable practical experience in fire fighting.

Finally, I should mention that the leader of the battle against a major fire must be courageous and quick to make intelligent decisions. Not only is fire fighting dangerous, but it also needs courage to take the responsibility for sacrificing forests when backfiring is deemed necessary and must be decided within minutes if not seconds.

6.6 Problems faced in fire management

When performing their duty, Forest Department staff face a number of problems. Among them, the most common are:-

- Hostile community;
- Insufficient levels of equipment and tools;
- Insufficient funds;
- Pre-suppression and suppression measures are not up to date (firebreaks, hazardous fuel reduction, poor road network etc.);
- Fire damage appraisal is not up to date - economics of fire damage needs to be rationalised. At present there are no sound guidelines for assessing damage to the forest in monetary terms;
- Fire effects on the environment are not well understood; and
- Staff level preparedness is low.

6.7 Reporting forest fires

All forest fires must be reported to the Chief Conservator of Forests by completing the Forest Fire Report: FDGO No. 37 (Appendix 2).

7.0 FIRE DANGER RATING

7.1 Predicting forest fires danger

The relative danger of forest fires can be assessed by measuring and analysing weather data on day-to-day basis. In Kenya, it is the failure of the short rains in October-December that is of paramount importance for forecasting the severity of the "normally" dry seasons from January-April. Generally, failure of short rains extends the dry season and forest fuel become dry earlier than normal. Subsequently, the curing of grasses occurs sooner than normal and fire becomes more volatile or dangerous under these conditions. Together with the flammability of the fuel, successive weeks of hot conditions with strong dry winds and the constant presence of source of fire (man) compound fire risk.

7.2 Forecasting fire weather

There are four major components of weather that interest us in Forest Fire Management. The first is **rainfall**, which is the main contributing factor in determining whether or not a dangerous period exists for the ignition of forest fuels. During rainy or so- called wet seasons, the danger of fire is nil and during dry periods the fire danger increases. In the dry season, fire danger is low only when there are sporadic showers. So, the forecasting of rain is all-important both in macro and micro scale. By "macro" scale we mean the forecasting of wet seasons and by "micro" scale is the forecasting of rain in sporadic relieving showers during the dry seasons.

Forecasting of rain in East Africa has always been difficult and despite all the recent developments in weather forecasts from satellites and modern meteorological equipment, the weather analysts in the Meteorological Department are still unable to make accurate long-range forecasts of rainfall. This has always been the case in Kenya and there is no sign of any improvement of long range forecasting of rain. Seasons are unpredictable, both in time of rain and in quantity. This is a major constraint for long term planning. The financial system is inflexible. Budgeting for recurrent forest operations are done so far ahead of each season. Thus, it is not possible to match financial requirements to actual seasonal weather, particularly the occurrence of rain, which determines the severity of the mildness of the fire season.

The second component is **wind**. Given a dry period, and a dangerous fire season, wind becomes the paramount factor in determining fire behaviour. It supplies the vital element of oxygen to a fire. Without oxygen a fire will not burn; and conversely the more oxygen that is supplied, the hotter will be the fire.

Wind direction is also important, because of the characteristics of the earth's surface over which air passes. A wind passing from the sea to the land is laden with moisture and a wind blowing over dry hot land is deficient in moisture. The winds from the North East and North are dry and hot and have a major effect on fire behaviour. Winds from the South East can bring moist conditions, provided other conditions of convergence are supplied. In general terms we are more concerned with wind speed than with direction. Thus, during the fire season we must have reasonable access to data on wind speed if we are to forecast the Fire Danger.

The other two components are the estimated **maximum temperature** and **the minimum relative humidity for the day**. These should also be forecast with increasing with accuracy because they also have an effect on the state of the forest fuels. The higher the temperature and lower the relative humidity, the more easily forest fuel will be ignited because the fuel moisture content will be low. To return once again to rainfall, it is useful to look at the pattern of wind flow over Eastern Africa and Arabia. These are the patterns, which affect the weather in Kenya. When the winds behave as they normally do, we can expect certain weather conditions. When they do not behave so, unusual weather occurs.

As was said before, the failure of the Short Rains is vital for forecasting the severity of the future fire season from January to April. The wind pattern for November shows a convergence of winds from the Northeast and Southeast and rainfall results. In 1979, the wind flow did not behave according to normal pattern. The high pressure areas or anti-cyclones failed to build up in the southern hemisphere and so the winds from the South-East did not occur or were not strong enough to form a convergence zone with the North-East winds and so the rains failed and the weather in Kenya was characterised by stable dry conditions which continued into 1980 to give to drier conditions.

This situation cannot be forecast on long term but it can be monitored within the Meteorological Department on daily basis, and short-term forecasts are possible with implications for longer term.

This is what was done in 1979. First, by following the law of averages, having had three good wet and rainy years, we estimated that late 1979/80 would be dry. This estimate was formed in August 1979 and we had to wait until November when the Short Rains stopped suddenly in mid November. This was a good enough indication that the failure of the rains would lead to a severe fire season in late 1979 and early 1980, and further early warnings were issued to Forestry Department to pay particular attention to Fire Prevention and the state of preparedness for Fire suppression.

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On realising the problems faced in obtaining data of the four elements mentioned above, Forest Protection (Fires) Section with the help of UNDP installed 10 weather stations:

1. Ngong Forest Station
2. Ontulili Forest Station
3. Saboti Forest Station
4. Turbo Forest Station
5. N. Marmanet Forest Station
6. Machakos Forest Station
7. Kenya Forestry College
8. Njukiini Forest Station
9. Kwale Forest Station
10. Maralal Forest Station
11. Nzoia Forest Station

Each station was supplied with:

- Cup-counter anemometer
- Wind vane
- Maximum thermometer
- Manson's hydrometer consisting of wet and dry bulb thermometers
- Rain gauge.

Today, none of these stations is operational and fire danger rating is not done.

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7.3 Fire danger rating

Fire danger rating is the resultant of both constant and variable fire danger factors which affect the inception, spread and difficulty of control of fires and the damage they cause. Fire danger rating is a fire control management system, which integrates the effects of selected fire danger factors into one or more qualitative or numerical indices of current protection needs.

Fire danger rating provides a yardstick for planning daily fire control operations. If fire danger is assessed inaccurately inefficiencies are inevitable in these operations. Thus, for efficient management of forest fires, it is important that the fire danger assessment is done accurately and the results integrated into fire management.

The status of forest fuels in terms of dryness (the ability to burn) depends on the amount of water the plants can draw from the soil. The amount of the moisture available in the soil can be expressed in terms of the amount of effective rainfall necessary to restore the soil to field capacity, the Soil Dryness Index (SDI) and the index rises with evapo-transpiration, rain lost from canopy interception, rain lost from flash runoff and falls with the effective rainfall penetrating the soil. The index ranges from 0 (soil moisture at field capacity) to 2000 (maximum soil dryness). At 1750 rainfall totalling 175 mm is required to restore field capacity. The S.D.I. can be started at 0 when 150 to 200 mm of rain has fallen in past 30 days or run-off is observed in catchments. The index is calculated daily from readings of previous day's maximum temperature ^{0}C and 24 - hour rainfall mm. The calculations involve estimating soil moisture lost from evapo-transpiration, estimating rainfall loss from canopy interception and run-off. The grassland fire danger rating can be described diagrammatically as shown in Figure 1. The procedure for calculating SDI is outlined in the exercises section (Q1). The application of SDI in fire operations in Kenya is demonstrated in Table 1 and Form 1 (Fire operations order).

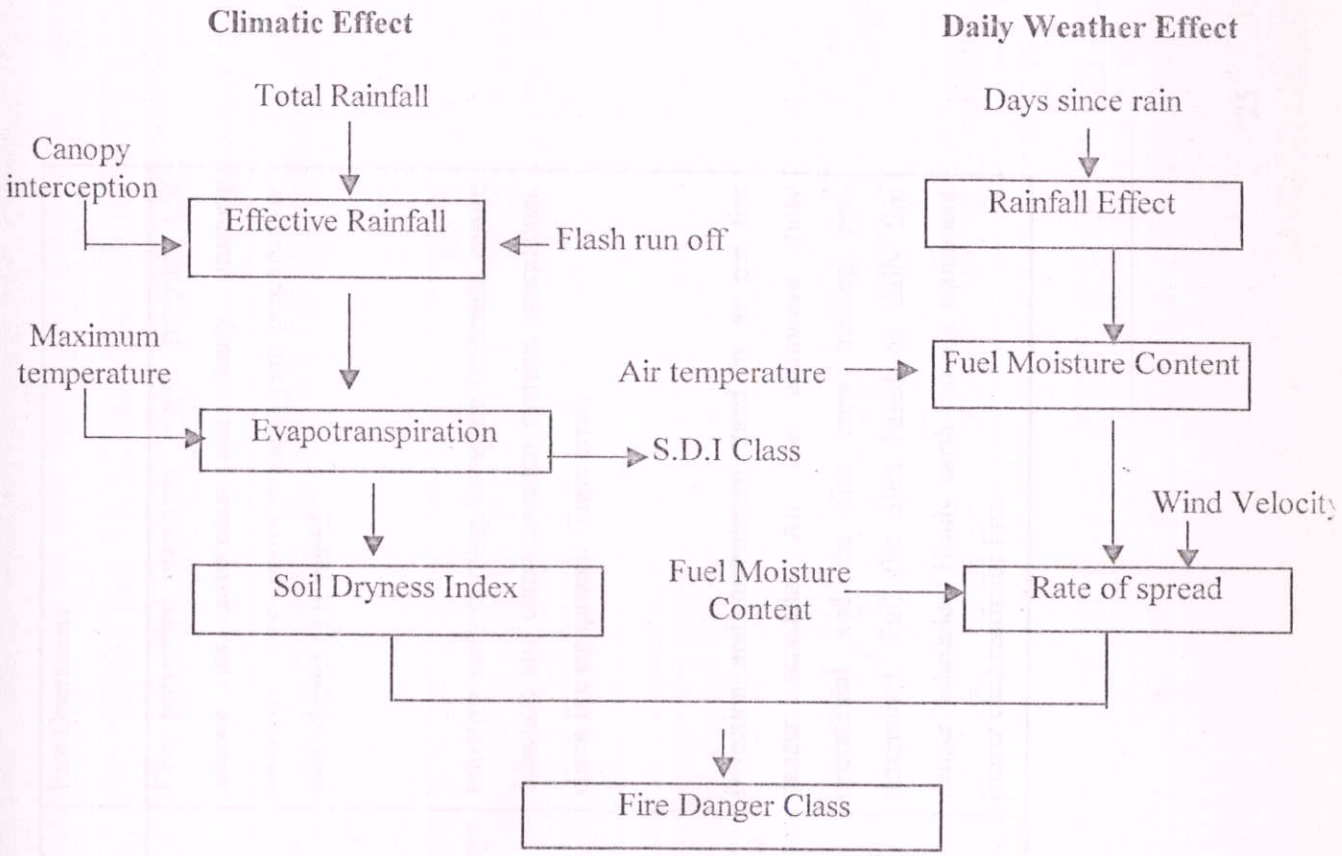

Figure 1. Schematic presentation of grassland fire danger rating

Table 1. The role of Soil Dryness Index (SDI) in planning forest fire operations in Kenya

S.D.I.	Fuel Availability for burning	Fires weather Forecasting Fire Danger Assessment	Fire Operations
0 to 500	Grass 100% green	Nil requirement	Fire prevention measures works program and finance for firebreaks and "early" burning arranged. Fire control working plan prepared for each district as required.
500 to 1000	Grass 50% cured	Required for high-risk areas on days moderate and above.	Initiative early burning, complete firebreaks ensure detection and communication systems operational, check fire equipment. Train crew.
1000 to 1500	Grass 70% cured	Required all areas for days Moderate above.	Detection and suppression stand by as per fire danger schedule. All fire equipment fully operational and the fire crew training pre-determined. Full fire alert based on daily fire danger schedules. Heady earth moving equipment (dozer etc.) ready for fire.
1500+	Grass 80% + cured	Required all areas daily	

Form 1. Fire operations order

1. **From Technical Assistant to Forester** **Date** .....

A. Forecast maximum temperature ^{0}C .....

Forecast minimum relative humidity % .....

Forecast wind velocity (Max) KPH .....

B. Soil Dryness Index .....

C. Rate of Spread .....

D. Fire Danger Class .....

2. **From Forester to Forest Department, or** .....

FIRE OPERATION REQUIREMENTS

A. Detection System .....

.....

.....

B. Tanker readiness .....

.....

.....

C. Crew readiness .....

.....

D. Other .....

.....

Forester..... **Time** ..... **Date** .....

Received by ..... Time ..... Date .....

EXERCISES

Q1. Calculating Soil Dryness Index (SDI): for the month of August 2001in the table below as follows:

Step 1. This section applies where rain is separated by dry days or *I* fail to reach capacity. Calculate effective rainfall (EFF) from tables 1 and 2. From section a. in Table *1*, calculate loss of rainfall from canopy interception and note that maximum capacity of canopy interception in savannah = 13 and pines plantation = 36 units.

Section b applies when rain occurs on consecutive wet days and *I* remain at capacity, and it's the loss from crown evaporation per wet day (W), and in savannah its 5 units and 8 units for pines.

Table 1. Canopy interception

When to use	Amount of Rain mm	*I* (mm x 10)	
		Savannah	Pines
Section a.			
First wet day,	0 - 0.5	1	2
consecutive wet	0.5 - 1.0	2	4
days I<W	1.1 - 2.0	4	10
	2.1 - 3.0	6	15
	3.1 - 4.0	8	20
	4.1 - 5.0	10	25
	5.1 - 6.0	12	30
	6.1 +	13	36
Section b.			
Consecutive wet			
days I > W	> 2 mm/day	5	8

Table 2. Loss of rainfall from run-off (FR)

Calculate FR daily from 24-hour rainfall recording. When rainfall exceeds table limits divide mm by 3 for savannah and by 6 for pines (note ***not*** rainfall x 10)

24-hour Rainfall		
Savannah	Pines	FR (mm x 10)
2	3	1
5	9	2
8	15	3
11	21	4
14	27	5

Calculate evapotranspiration per day from maximum temperature and then SDI morning and afternoon from Table 3.

Table 3. Loss of rainfall through evapotranspiration (ET).

SDI	Daily maximum temperature, °C																
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	>31
	evapotranspiration																
0- 250	0	4	8	12	16	20	24	29	35	40	46	51	57	62	68	73	79
251- 500	0	3	6	8	10	13	17	22	28	33	39	44	50	55	61	66	72
5001- 1400	0	0	1	3	5	8	12	17	23	28	34	39	45	50	56	61	67
1401- 1650	0	0	0	1	3	4	5	7	8	10	11	13	14	16	17	19	20
>1651	0	0	0	0	1	1	2	3	3	4	5	5	6	7	7	8	9

Fuel type: savannah **Forest station**: Saboti **Month**: August 2001

P.M SDI for 31 July 2001 = 50

Date	Effective rainfall (EFP) EFF = rain × 10 – I – FR					Determine SDI (a.m) morning and (p.m) afternoon			
	Rain, mm	Rain mm × 10	I	FR	EFF	Max temp, °C	a.m	ET	p.m
1	5	50	10	2	38	20	12	16	28
2	2	20	4	1	15	20	13	16	29
3	0	0	0	0	0	23	29	29	58
4	0	0	0	0	0	22	58	24	82
5	25	250	13	8	229	21	0	20	20
6	10	100	5	4	91	22	0	24	24
7	1	10	2	1	7	26	17	46	63
8	0	0	0	0	0	26	63	46	109
9	20	200	4	1	15	22	94	24	118
10	15								
11	12								
12	3								
13									
14									
15									
16									
17									
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31									

Note; (1) Todays's a.m SDI = previous day's p.m SDI – EFF, and if negative a.m, SDI = 0

(2) Todys's p.m SDI = a.m SDI + ET

The steps in determining the FDR are: (Tables 1- 3 below)

1. Determine the effect of any recent rainfall on fuel flammability, from Table 1. If the effect is such that the moisture content is 17% or above then there is no need to proceed further because the recent rain has an over riding effect and the FDR is so low as not to cause a threat. This will rarely occur in the fire season. If however, the effect of recent rainfall has disappeared, then the next step is to refer Table 2.
2. Determine the moisture content of cured grass from Table 2. Enter the table with the maximum temperature forecast for the day and the minimum relative humidity predicted for the day to find the moisture content.

3. From Table 3 determine the rate of forward spread of head fire by entering the table with the moisture content (from step 2 and Table 2) and the forecasted wind velocity.

   Note that Table 6 refers to partially grazed grasslands, which are 10 to 30 cm high and average 14 tonnes per hectare. For heavy grass fuels, say unburnt or not grazed for up to 4 years where the fuel will be about 40 tonnes per hectare, the Rate of Forward Spread (ROFS) should be multiplied by 2. For grass fuels with an over storey of flammable scrub, multiply ROFS by 2.5 or 3.

4. On Table 3 at the right hand side, determine the Fire Danger Class. Enter the table with the ROFS and the SDI to find the class.

UNDP/FAO/GK
FOREST FIRE MANAGEMENT PROJECT

Forest Department, Kenya.

Grassland Fire Danger Rating

Instructions

1. Determine effect of recent rainfall on fuel flammability Table 1. If no effect proceed to Table 2.
2. Determine moisture content of cured grass table 2. Enter the table with maximum temperature °C and minimum relative humidity %.
3. Determine rate of forward spread of headfire Table 3. Enter the table with moisture content (from Table 2) and maximum wind velocity.
   N.B. Table 3 refers to partially grazed grass fuels 0.1 to 0.3 m in height and ranging from 5 to 30 tonne/ha. average 14 tonne/ha.
   For heavier grass fuels greater than 0.3 m high (approximately 40 tonne/ha) multiply R.O.F.S. x 2.5.
   For grass fuels with overstorey of flammable scrub species multiply R.O.F.S. x 3.
4. Determine Fire Danger Class from Table 3. Enter the table with R.O.F.S. and current Soil Dryness Index.

Table 1.

Effect of Rainfall on Fine Fuel Moisture Content

Rain mm	Days Since Rain 0	1	2	3	4	5	6
50+	MC 17% Fire Danger Low						
35-50							
25-35							Refer Table 2
12-25							
5-12							
2-5							
<2							

Table 2.

Prediction of fine fuel moisture content %

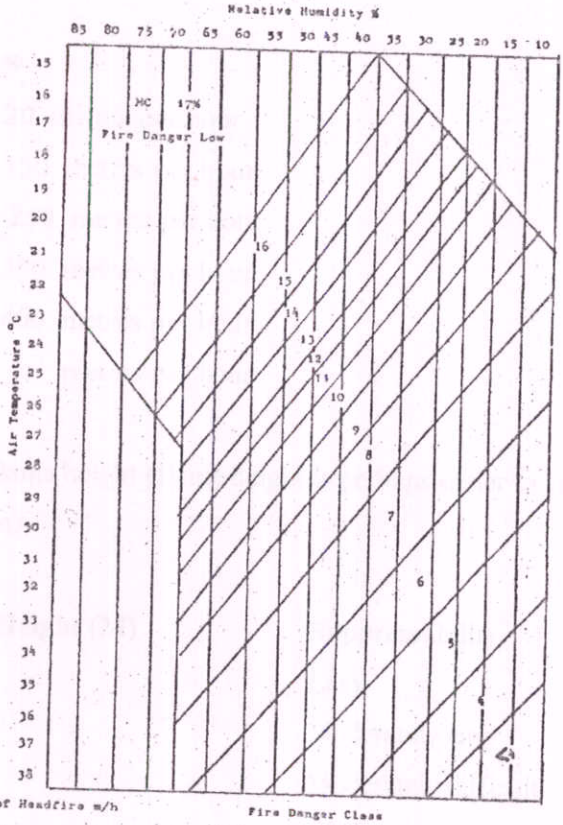

Table 3

Rate of Forward Spread of Headfire m/h

Fuel Moisture Content %	Wind Velocity Xph 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	> 40
> 17	Low Fire Danger								
16	42	54	66	78	96	114	132	150	>168
15	44	56	70	85	104	123	142	161	>180
14	47	59	73	92	113	134	155	176	>197
13	49	61	77	100	121	142	163	186	>205
12	52	64	80	107	130	153	176	189	>222
11	54	66	84	114	138	162	186	210	>234
10	72	84	108	150	216	282	348	414	>480
9	84	102	132	186	264	342	420	498	>576
8	102	126	168	234	330	426	522	618	>714
7	126	162	210	288	390	492	594	696	>798
6	144	186	242	332	428	575	696	818	>939
5	162	210	273	375	466	657	798	939	>1080
4	180	234	305	419	544	740	900	1061	>1221
<4	198	238	336	462	642	822	1002	1182	>1362

ROFS R.O.F.S. m/h	S.D.I. 0-500	501-1000	1001-1500	>1500
0-20	Nil			
21-50		Low		
51-100				
101-150		Moderate		
151-200				
201-250		High		
251-300				
301-350		Very High		
351-400			Extreme	
>400				

MAY 1980

For supervisors (DFO's and above), the following guidelines are of practical significant:

i..The relationship between the Fire Danger Class and the Rate of Forward Spread in grasslands is:

Fire Danger Class	R.O.F.S
NIL	0 - 20 meters per hour
LOW	21 - 150 metres per hour
MODERATE	151 - 250 metres per hour
HIGH	251 - 350 metres per hour
VERY HIGH	351 - 400 metres per hour
EXTREME	>400 metres per hour

ii. The relationship between ROFS and flame height (flame height is perhaps easier to imagine and indicates the difficulty of suppression)

R.O.F.S	Flame Height (M)	Suppressability
50	0.3	Easy
100	0.6	Moderately easy
200	1.0	Moderately difficult
300	1.3	Difficult
400 and above	>1.5	Very difficult

Q2. Prepare a brief fire control management plan for Mt Elgon forest. The plan should be in two parts; Part 1 an annual work programme related to soil Dryness Index and Part 2, daily fire orders (for the fire season) related to fire danger rating.

Q3. Briefly describe your role and the perceived role of the community in forest fires management .

Appendix 1. Forest fires data in Kenya

Year	No. Of fires	Area burnt, ha				Suppression cost, Ksh	Damage, Ksh
		Plantations	Indigenous forests	Bushes and grasses	Total		
1960	3	55	25	-	-	-	-
1961	-	85	-	10 530	-	-	-
1962	Few	-	-	-	-	-	-
1963	Few	-	-	769	-	-	-
1964	Few	37.3	-	-	-	-	-
1965	166	224	-	-	-	-	15 496
1966	21	143	32	1 422	1 597	1 478	6744
1967	122	486	258	4 382	5 126	4 044	19 747
1968	56	69	1	735	805	80	4 579
1969	75	127	40	547	714	68	5 566
1970	50	67	181	2 637	2 885	39	6 461
1971	142	1 942	15 003	6 431	23 376	25 887	11 757 256
1972	39	82	-	488	570	306	6 902
1973	57	661	357	1 671	2 689	1 667	28 476
1974	41	349	2 002	9 964	12 31	7 698	31 511
1975	56	935	157	2 481	3 573	3 533	54 382
1976	-	262	7 838	-	8 100	3 970	22 183
1977	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-
1980	79	4178	4 951	14 934	20 383	38 263	3 827 040
1981	98	957	3 227	6 031		759 180	16 404 320
1982	21	217	7 838			79 180	443 680
1983	43	239	40	27 847		7 5380	12 226 500
1984	766	401	176	23 517		562 920	8 346 080
1985	28	371	157	275		103 600	1 101 680
1986	70	541	384	4 511		3 727 040	15 550 540

1987	37	282	99	545	120 220	224 780
1988	30	188	155	3 792	177 420	639 080
1989	46	231	175	2 356	105 000	1 203 600
1990	36	85	331	12 183	128 600	366 060
1991	64	1 705	236	6 697	456 420	2 996 340
1992	180	6 170	5 494	13 302	5 859 300	99 127 00
1993	48	1 731	515	1 718	500 820	11 901 420
1994	40	690	69	1 913	3 18 700	37 847 500
1995	40	689	69	1 913	318 770	3784 651
1997	121	4 726	2 961	7 729	45 727 733	51 979 918
1999	59	1 499	317	2 041	25 878 790	28 606 232
2000	159	1758	1 315	1 484	2 629 280	78 166 289

Appendix 2. FOREST FIRE REPORT, FDGO, 37

TO: chief Conservator of Forests

P.O Box 30513

NAIROBI

Attention: Head Fire unit

1. Station: .....
2. District: .....
3. Province .....

DETECTION:

4. Time .....
5. Date .....
6. Fire danger rating on the day of detection.
7. Soil dryness Index on the day of detection.
8. cause of the fire.....
9. Did the fire start inside or outside gazetted Forest/National Park/Shambas.....

DISPATCHING DETAILS

10. Time and date when first suppression forces reached the fire .....
11. Reason for any delay.....
12. Time and date when reinforcement forces reached the fire.
13. Reasons for any delay .....
14. Where was the fire when suppression forces reached the fire:

    Inside or outside a plantation? .....

    In natural Forest?.....

    In the National Park?.....

    In the Grassland Morland? .....

CONTROL

16. Time and date fire brought under control.

17. Number of men and officers who brought the fire under control

a. Men .....

b. Officers, specify.....

18. No. of days it took to bring the fire under control.

19. Approximate cost of labour and officer time spent to bring the fires under control:

Kshs.....

....

Here give details of labour manday * average cost per manday and officer* cost per manday .....

MOP UP

20. Time and date fire completely mopped up and declared safe.

21. Approximate cost of labour and officer time spend to mop up the fire after it was brought under control.....

Here, give details of labour mandays and average cost per manday and officer mandays and average cost per mandays.....

.....

COSTS

22. Total cost of fire suppression (control mop up cost) Kshs.

Total value of night out allowance for department labour and officer: Kshs.....

Total value of any cost incurred by non-departmental personnel for suppressing the fire: Ksh. .....

Total No. of days given to department labour and officers to compensate days spent putting out the fire .....

23 (a) Labour.manday

(b) Officers ..... manday

24, Cost of rations supplied Kshs.....

25. Cost of machines and equipment used.

(a) Machine/Equipment .....

(b) Hours or amount of fuel.....

(c) Total cost per hour or fuel.....

(d) Total cost .....

SUMMARY

26. Grand Total of Complete Suppression Cost.

(a) Total departmental labour cost (labour and officer cost) Kshs .....

(b) Total value of night out allowances Kshs.....

(c) Total cost of non-departmental personnel Kshs.

(d) Cost of rations Kshs .....

(e) Machine and equipment costs Kshs .....

(f) Value of off days given to departmental labour and officers to compensate days spent

Putting off the fire Kshs.....

27 **DETAILS**

FOREST TYPE	SPECIES	AREA IN (Ha)	ESTIMATE VALUE OF DAMAGE KSHS
A, Plantations			
B, indigenous			
C, bush and grass			
D, Bamboo			
E, Moorland			
Total			

28. REMARKS

.....

.....

.....

Signed. .....

Designation. .....

Date .....

C.C. The Provincial Forest Officer

.....

Thro

The District Forest Officer

.....