Chapter-7

FIRE PROTECTION AND FIRE SAFETY REQUIREMENTS

7.1 SCOPE

This part covers the requirements of the fire protection for the multi-storeyed buildings (high rise buildings) and the buildings, which are of 15 m. and above in height and low occupancies of categories such as Assembly, Institutional., Educational (more than two storeyed and built-up area exceeds 1000 sq m)., Business (where plot area exceeds 500 sq m.), Mercantile (where aggregate covered area exceeds 750 sq m.), Hotel, Hospital, Nursing Homes, Underground Complexes, Industrial Storage, Meeting / Banquet Halls, Hazardous Occupancies.

7.2 PROCEDURE FOR CLEARANCE FROM FIRE SERVICE

a) The concerned Authority shall refer the building plans to the Chief Fire Officer for obtaining clearance in respect of building identified in clause 7.1 of these Bye-Laws.

b) The Authority shall furnish three sets of complete building plans along with prescribed fee to the Chief Fire Officer, after ensuring that the proposals are in line with Master Plan/Zonal Plan of the area.

c) The plans shall be clearly marked and indicate the complete fire protection arrangements and the means of access/escape for the proposed building with suitable legend along with standard signs and symbols on the drawings. The same shall be duly signed/certified by a licensed Fire Consultant/Architect. The information regarding fire safety measures shall be furnished as per Annexure ‘D’ along with details.

d) The Chief Fire Officer shall examine these plans to ensure that they are in accordance with the provisions of fire safety and means of escape as per these bye- laws and shall forward two sets of plans duly signed for implementation to the building sanctioning Authority.

e) After completion of fire fighting installations as approved and duly tested and certified by the licensed Fire Consultant / Architect, the Owner/ Builder of the building shall approach the Chief Fire Officer through the concerned Authority for obtaining clearance from fire safety and means of escape point of view. The concerned Authority shall ensure that clearance from Chief Fire Officer has been obtained for the building identified in clause 7.1 before granting the completion certificate.

f) On receipt of the above request, the Chief Fire Officer shall issue the No Objection Certificate from fire safety and means of escape point of view after satisfying himself that the entire fire protection measures are implemented and functional as per approved plans.

g) Any deficiencies observed during the course of inspection shall be communicated to the Authority for rectification and a copy of the same shall be forwarded to the concerned building owner /builder.

7.3 RENEWAL OF FIRE CLEARANCE

On the basis of undertaking given by the Fire Consultant / Architect, the Chief Fire Officer shall renew the fire clearance in respect of the following buildings on annual basis:-

1) Public entertainment and assembly
2) Hospitals
3) Hotels
4) Under ground shopping complex

7.4 FEE

a) For augmentation of fire service facilities for effecting rescue/fire fighting operation in high rise building, fee payable to Chief Fire Officer by the applicant(s) along with sets of plans for obtaining the No Objection Certificate shall be as prescribed by the Authority.

7.5 FIRE CONSULTANT

The Architect of the project will be responsible for making provisions for fire protection and fire fighting measure as provided in this Chapter and for that she / he may consult an expert in this field, as in case of other professionals for structural, sanitary and others.

7.6 TERMINOLOGY

For the purpose of this Chapter all the technical terms shall have the meaning as defined in National Building Code of India, Part-IV, Fire Protection as amended from time to time but for the terms which are defined otherwise in these bye-Laws.

7.7 GENERAL

The Chief Fire Officer may insist on suitable provisions in the building from fire safety and means of escape point of view depending on the occupancy, height or on account of new developments creating special fire hazard, in addition to the provision of these building bye laws and part IV (Fire Protection) of National Building Code of India

7.8 MEANS OF ACCESS

As provided in Building Bye-Laws 4.7.

7.8.1 ***Provisions of Exterior Open Spaces around the Building :***As provided in building bye laws *4.9.4.*

7.9 EXIT REQUIREMENT

As provided in Building Bye-Laws 4.8.

7.9.1 ***Type of Exits:*** *As* provided in Building Bye-Laws 4.8.1

7.9.2 ***Number of Size of Exits:*** *As* provided in Building Bye-Laws 4.8.2

7.9.3 ***Arrangements of Exits:*** As provided in Building Bye-Laws 4.8.3

7.9.4 ***Occupant Load:*** As provided in Building Bye-Laws 4.1

7.9.5 ***Capacity of Exit:*** As provided in Building Bye-Laws 4.8.4

7.9.6 ***Staircase Requirements:*** *As* provided in Building Bye-Laws 4.8.5

7.9.7 ***Minimum Width Provision for Stairways:*** As provided in Building Bye-Laws 4.8.6

7.9.8 ***Minimum Width Provision for Passageway/Corridors:*** As provided in Building Bye-Laws 4.8.7

7.9.9 ***Doorways:*** As provided in Building Bye-Laws 4.8.8

7.9.10 ***Stairways:*** As provided in Building Bye-Laws 4.8.9

7.9.11 ***Fire Escapes or External Stairs:***

a) Fire escape shall not be taken into account while calculating the number of staircases for a building.

b) All fire escapes shall be directly connected to the ground.

c) Entrance to the fire escape shall be separate and remote from internal staircase.

d) The route to fire escape shall be free of obstructions at all times except the doorway leading to the fire escape which shall have the required fire resistance.

e) Fire escape shall be constructed of non-combustible materials.

f) Fire escape stairs shall have straight flight not less than 125 cm wide with 25 cm treads and risers not more than 19 cm.

g) Handrails shall be at a height not less than 100 cm.

h) Fire escape staircase in the mercantile, business, assembly, hotel buildings above 24 m. height shall be a fire tower and in such a case width of the same shall not be less than the width of the main staircase. No combustible material shall be allowed in the fire tower.

7.9.12 Spiral Stairs

a) The use of spiral staircase shall be limited to low occupant load and to a building height 9 m.

b) A spiral stair shall not be less than 150 cm in diameter and shall be designed to give the adequate headroom.

7.9.13 ***Staircase Enclosures***

a) The external enclosing walls of the staircase shall be of the brick or the R.C.C. construction having fire resistance of not less than two hours. All enclosed staircases shall have access through self-closing door of one-hour fire resistance. These shall be single swing doors opening in the direction of the escape. The door shall be fitted with the check action door closers.

b) The staircase enclosures on the external wall of the building shall be ventilated to the atmosphere at each landing.

c) Permanent vent at the top equal to the 5% of the cross sectional area of the enclosure and openable sashes at each floor level with area equal to 1 to 15% of the cross sectional area of the enclosure on external shall be provided. The roof of the shaft shall be at least 1 m. above the surrounding roof. There shall be no glazing or the glass bricks in any internal closing wall of staircase. If the staircase is in the core of the building and cannot be ventilated at each landing, a positive of 5-mm. w.g. by an electrically operated blower/blowers shall be maintained.

d) The mechanism for pressurizing the staircase shaft shall be so installed that the same shall operate automatically on fire alarm system/sprinkler system and be provided with manual operation facilities.

7.9.14 Ramps

a) Ramps of slope of not more than 1 in 10 may be substituted for and shall comply with all the applicable requirements of all required stairways as to enclosure capacity and limiting dimensions. Larger slopes shall be provided for special uses but in no case greater than 1 in 8. For all slopes exceeding 1 in 10 and where the use is such as to involve danger of slipping, the ramp shall be surfaced with approved non-slipping material.

b) The minimum width of the ramps in the Hospitals shall be 2.4 m. and in the basement using car parking shall be 6.0 m.

c) Handrails shall be provided on both sides of the ramp.

d) Ramp shall lead directly to outside open space at ground level or courtyards of safe place.

e) For building above 24.0 m. in height, access to ramps from any floor of the building shall be through smoke fire check door.

f) In case of nursing homes, hospitals etc. area exceeding 300 sq m. at each floor one of the exit facility shall be a ramp of not less than 2.4 m. in width.

7.10 PROVISION OF LIFTS

a) Provision of the lifts shall be made for all multi-storeyed building having a height of 15.0 m. and above.

b) All the floors shall be accessible for 24 hrs. by the lift. The lift provided in the buildings shall not be considered as a means of escape in case of emergency.

c) Grounding switch at ground floor level to enable the fire service to ground the lift car in case of emergency shall also be provided.

d) The lift machine room shall be separate and no other machinery be installed in it.

7.10.1 Lift Enclosure/lift

General requirements shall be as follows

a) Walls of lift enclosures shall have a fire rating of two hours. Lift shafts shall have a vent at the top of area not less than 0.2 sq m.

b) Lift motor room shall be located preferably on top of the shaft and separated from the shaft by the floor of the room.

c) Landing door in lift enclosures shall have a fire resistance of not less than one hour.

d) The number of lifts in one lift bank shall not exceed four. A wall of two hours fire rating shall separate individual shafts in a bank.

e) Lift car door shall have a fire resistance rating of 1 hour.

f) For buildings 15.0 m. and above in height, collapsible gates shall not be permitted for lifts and solid doors with fire resistance of at least one hour shall be provided.

g) If the lift shaft and lobby is in the core of the building a positive pressure between 25 and 30 pa shall be maintained in the lobby and a possible pressure of 50 pa shall be maintained in the lift shaft. The mechanism for the pressurization shall act automatically with the fire alarm/sprinkler system and it shall be possible to operate this mechanically also.

h) Exit from the lift lobby, if located in the core of the building, shall be through a self-closing fire smoke check door of one-hour fire resistance.

i) Lift shall not normally communicate with the basement. If however, lifts are in communication, the lift lobby of the basement shall be pressurized as in (g) with self closing door as in (h).

j) Grounding switch (es), at ground floor level shall be provided to enable the fire service to ground the lifts.

k) Telephone/talk back communication facilities may be provided in lift cars for communication system and lifts shall be connected to the fire control room of the building.

l) Suitable arrangements such as providing slope in the floor of the lift lobby shall be made to prevent water used during fire fighting, etc at any landing from entering the lift shafts.

m) A sign shall be posted and maintained on every floor at or near the lift indicating that in case of fire, occupants shall use the stairs unless instructed otherwise. The sign shall also contain a plan for each floor showing the location of the stairways. Floor marking shall be done at each floor on the wall in front of the lift-landing door.

n) Alternate power supply shall be provided in all the lifts.

7.10.2 Fire Lift

Following details shall apply for a fire lift in addition to above requirements:

a) To enable fire service personnel to reach the upper floors with the minimum delay, one or more of the lifts shall be so designed so as to be available for the exclusive use of the fireman in an emergency and be directly accessible to every dwelling/lettable floor space on each floor.

b) The lift shall have a floor area of not less than 1.4 sq.mt. It shall have a loading capacity of not less than 545 kg. (8 persons lift) with automatic closing doors.

c) The electric supply shall be on a separate service from electric supply mains in a building and the cables run in a route safe from fire, that is within a lift shaft. Lights and fans in the elevator having wooden paneling or sheet steel construction shall be operated on 24-volt supply.

d) In case of failure of normal electric supply, it shall automatically switchover to the alternate supply. For apartment houses, this changeover of supply could be done through manually operated changeover switch. Alternatively, the lift should be so wired that in case of power failure, it comes down at the ground level and comes to stand still with door open.

e) The operation of a fire lift shall by a single toggle of two-button switch situated in a glass-fronted box adjacent to the lift at the entrance level. When the switch is on landing; call points will become inoperative and the lift will be on car control only or on a priority control device. When the switch is off, the lift will return to normal working. This lift can be used by the occupants in normal times.

f) The words 'F1RE LIFT' shall be conspicuously displayed in fluorescent paint on the lift landing doors at each floor level.

g) The speed of the fire lift shall be such that it can reach to the top floor from ground level within one minute.

7.11 BASEMENT

As provided in Chapter- 3 and Building Bye-Laws 4.5.5

7.11.1 Requirements

i) The access to the basement shall be either from the main or alternate staircase providing access and exit from higher floors. Where the staircase is continue the same shall be enclosed type serving as a fire separation from the basement floor and higher floors. Open ramps shall be permitted if they are constructed within the building line subject to the provision of the (iv).

ii) In case of basement for office, sufficient number of exit ways and access ways shall be provided with a travel distance not more than 15.0 m. The travel distance in case of dead-end shall be 7.5 m.

iii) The basement shall be partitioned and in no case compartment shall be more than 500 sq m. and less than 50 sq m. area except parking. Each compartment shall have ventilation standards as laid down in Bye-Laws separately and independently. The partition shall be made in consultation with Chief Fire Officer.

iv) The first basement (immediately below ground level) can be used for services/parking/other permissible services. Lower basement, if provided, shall exclusively be used for car parking only.

v) Each basement shall be separately ventilated. Vents with cross-sectional area (aggregate) not less than 2.5 percent of the floor area spread evenly round the perimeter of the basement shall be provided in the form of grills or breakable starboard lights or pavement lights or by way of shafts. Alternatively a system of air inlets shall be provided at basement floor level and smoke outlets at basement ceiling level. Inlets and extracts may be terminated at ground level with starboard or pavement lights as before. But ducts to convey fresh air to the basement floor level have to be laid. Starboard and pavement lights should be in positions easily accessible to the firemen and clearly marked "SMOKE OUTLET" or AIR INLET" with an indication of area served at or near the opening.

vi) The staircase of basement shall be of enclosed type having fire resistance of not less than two hours and shall be situated at the periphery of the basement to be entered at ground level only from the open air and in such positions that smoke from any fire in the basement shall not obstruct any exit serving the ground and upper stories of the building and shall communicate with basement through a lobby provided with fire resisting self closing door of one hour rating. In case of basement being used as car parking only, the travel distance shall be 45 m.

vii) In multi-storeyed basements, intake duct may serve all basements levels, but each basement and basement compartment shall have separate smoke outlet duct or ducts. Mechanical extractors for smoke venting system from lower basement levels shall also be provided. The system shall be of such design as to operate on actuation of smoke, heat sensitive detectors/sprinklers, if installed, and shall have a considerably superior performance compared to the standard units. It shall also have an arrangement to start it manually.

viii) Mechanical extractors shall have an internal locking arrangement so that extractors shall continue to operate and supply fans shall stop automatically with the actuation of fire detectors. Mechanical extractors shall be designed to permit 30 air changes per hour in case of fire or distress call. However, for normal operation, only 30 air changes or any other convenient factor can be maintained.

ix) Mechanical extractors shall have an alternate source of power supply.

x) Ventilating ducts shall be integrated with the structure and made out of brick masonry or RCC as far as possible and when this duct crosses the transformer area of electrical switchboard, fire dampers shall be provided.

xi) Kitchens working on gas fuel shall not be permitted in basement/sub-basement.

xii) If cutouts are provided from basement to the upper floors or to the atmosphere, all side cutout openings in the basements shall be protected by sprinkler heads at closed spacing so as to form a water curtain in the event of a fire.

xiii) Dewatering pump shall be provided in all basements.

7.12 PROVISION OF HELIPAD

All high-rise buildings 50 m. and above shall have provision for a Helipad on the terrace. The same shall be approved by the Authority.

7.13 SERVICE DUCTS/REFUGE CHUTE

a) Service duct shall be enclosed by walls and door, if any, of 2 hours fire rating. If ducts are larger than 10 sq m. the floor should seal them, but provide suitable opening for the pipes to pass through, with the gaps sealed.

b) A vent opening at the top of the service shaft shall be provided between one-fourth and one-half of the area of the shaft. Refuge chutes shall have an outlet at least of wall of non-combustible material with fire resistance of not less than two hours. They shall not be located within the staircase enclosure or service shafts or air-conditioning shafts. Inspection panel and door shall be tight fitting with 1 hour fire resistance; the chutes should be as far away as possible form exits.

c) Refuge chutes shall not be provided in staircase walls and A/C shafts etc.

7.14 ELECTRICAL SERVICES

Electrical Services shall conform to the following:

a) The electric distribution cables/wiring shall be laid in a separate duct shall be sealed at every floor with non-combustible material having the same fire resistance as that of the duct. Low and medium voltage wiring running in shaft and in false ceiling shall run in separate conduits.

b) Water mains, telephone wires, inter-com lines, gas pipes or any other service lines shall not be laid in ducts for electric cables.

c) Separate conduits for water pumps, lifts, staircases and corridor lighting and blowers for pressuring system shall be directly from the main switch panel and these circuits shall be laid in separate conduit pipes, so that fire in one circuit will not affect the others. Master switches controlling essential service circuits shall be clearly labeled.

d) The inspection panel doors and any other opening in the shaft shall be provided with airtight fire doors having fire resistance of not less then 1 hour.

e) Medium and low voltage wiring running in shafts, and within false ceiling shall run in metal conduits. Any 230 voltage wiring for lighting or other services, above false ceiling should have 660V grade insulation. The false ceiling including all fixtures used for its suspension shall be of non-combustible material.

f) An independent and well-ventilated service room shall be provided on the ground floor with direct access from outside or from the corridor for the purpose of termination of electrical supply from the licenses service and alternative supply cables. The doors provided for the service room shall have fire resistance of not less than 1 hour

g) MCB and ELCB shall be provided for electrical circuit.

7.15 STAIRCASE AND CORRIDOR LIGHTS

The staircase and corridor lighting shall be on separate circuits and shall be independently connected so that it could be operated by one switch installation on the ground floor easily accessible to fire fighting staff at any time irrespective of the position of the individual control of the light points, if any. It should be of miniature circuit breaker type of switch so as to avoid replacement of fuse in case of crisis.

a) Staircase and corridor lighting shall also be connected to alternate source of power supply.

b) Suitable arrangement shall be made by installing double throw switches to ensure that the lighting installed in the staircase and the corridor does not get connected to two sources of supply simultaneously. Double throw switch shall be installed in the service room for terminating the stand by supply.

c) Emergency lights shall be provided in the staircase and corridor.

7.16 AIR-CONDITIONING

a) Air- conditioning system should be installed and maintained so as to minimise the danger of spread of fire, smoke or fumes thereby from one floor of fire area to another or from outside into any occupied building or structure.

b) Air -Conditioning systems circulating air to more than one floor area should be provided with dampers designed to close automatically in case of fire and thereby prevent spread of fire or smoke. Such a system should also be provided with automatic controls to stop fans in case of fire, unless arranged to remove smoke from a fire, in which case these should be designed to remain in operation.

c) Air- conditioning system serving large places of assembly (over one thousand persons), large departmental stores, or hostels with over 100 rooms in a single block should be provided with effective means for preventing circulation of smoke through the system in the case of fire in air filters or from other sources drawn into the system even though there is insufficient heat to actuate heat smoke sensitive devices controlling fans or dampers. Such means shall consist of approved effective smoke sensitive controls.

7.16.1 Air- Conditioning should conform to the following:

a) Escape routes like staircase, common corridors, lift lobbies; etc should not be used as return air passage.

b) The ducting should be constructed of metal in accordance with BIS 655:1963

c) Wherever the ducts pass through fire walls or floor, the opening around the ducts should be sealed with fire resisting material of same rating as of walls / floors.

d) Metallic ducts should be used even for the return air instead of space above the false ceiling.

e) The material used for insulating the duct system (inside or outside) should be of flame resistant (IS 4355: 1977) and non- conductor of heat.

f) Area more than 750 sq m. on individual floor should be segregated by a firewall and automatic fire dampers for isolation should be provided.

g) In case of more than one floor, arrangement by way of automatic fire dampers for isolating the ducting at every floor from the floor should be made. Where plenums used for return air passage, ceiling and its features and air filters of the air handling units, these should be flame resistant. Inspection panels should be provided in the main trenching. No combustible material should be fixed nearer than 15 cm. to any duct unless such ducting is properly enclosed and protected with flame resistant material

h) In case of buildings more than 24 m. in height, in non-ventilated lobbies, corridors, smoke extraction shaft should be provided.

7.16.2 Fire Dampers

a) These shall be located in air ducts and return air ducts/passages at the following points:

i) At the fire separation wall.

ii) Where ducts/passages enter the central vertical shaft.

iii) Where the ducts pass through floors.

iv) At the inlet of supply air duct and the return air duct of each compartment on every floor.

b) The dampers shall operate automatically and shall simultaneously switch off the air- handling fans. Manual operation facilities shall also be provided.

Note: For blowers, where extraction system and dust accumulators are used, dampers shall be provided.

c) Fire/smoke dampers(for smoke extraction shafts) for building more than 24 m. in height.

For apartment houses in non-ventilated lobbies /corridor operated by detection system and manual control sprinkler system.

For other buildings on operation of smoke/ heat detection system and manual control/sprinkler system.

d) Automatic fire dampers shall be so arranged so as to close by gravity in the direction of air movement and to remain tightly closed on operation of a fusible link.

7.17 BOILER ROOM

Provisions of boiler and boiler rooms shall conform to Indian Boiler Act. Further, the following additional aspects may be taken into account in the location of boiler/ boiler room

a) The boiler shall not be allowed in sub-basement, but may be allowed in the basement away from the escape routes.

b) The boilers shall be installed in a fire resisting room of 4 hours fire resistance rating, and this room shall be situated on the periphery of the basement. Catch pits shall be provided at the low level.

c) Entry to this room shall be provided with a composite door of 2 hours fire resistance.

d) The boiler room shall be provided with fresh air inlets and smoke exhaust directly to the atmosphere.

e) The furnace oil tank for the boiler if located in the adjoining room shall be separated by fire resisting wall of 4 hours rating. The entrance to this room shall be provided with double composite doors. A curb of suitable height shall be provided at the entrance in order to prevent the flow of oil into boiler room in case of tank rupture.

f) Foam inlets shall be provided on the external walls of the building near the ground level to enable the fire services to use foam in case of fire.

7.18 ALTERNATE SOURCE OF ELECTRIC SUPPLY

A stand by electric generator shall be installed to supply power to staircase and corridor lighting circuits, lifts detection system, fire pumps, pressurization fans and bowlers, P..A system, exit sign, smoke extraction system, in case of failure of normal electric supply. The generator shall be capable of taking starting current of all the machines and circuits stated above simultaneously.

If the standby pump is driven by diesel engine, the generator supply need not be connected to the standby pump. The generator shall be automatic in operation.

7.19 SAFETY MEASURES IN ELECTRIC SUB-STATION

1) Clear independent approach to the sub-station from outside the building shall be made available round the clock
2) The approaches/corridors to the sub-station area shall be kept clear for movement of men and material at all times.
3) The sub-station space is required to be provided with proper internal lighting arrangements.
4) In addition to natural ventilation proper ventilation to the sub-station area is to be provided by grill shutters and exhaust fans at suitable places so as to discharge all smoke from the sub-station without delay in case of fire so that sub-station operations can be carried out expeditiously.
5) Cable trenches of 0.6 m. X 0.6 m. dummy floor of 0.6 mt. depth shall be provided to facilitate laying of cable inside the building for connecting to the equipment.
6) Steel shutters of 8’X 8’ with suitable grills shall be provided for transformers and sub-station room.
7) The floor of the sub-station should be capable of carrying 10 tons of transformer weight on wheels.
8) Built up substation space is to be provided free of cost.
9) Sub-station space should be clear from any water, sewer, air conditioning, and gas pipe or telephone services. No other service should pass through the sub station space or the cable trenches.
10) Proper ramp with suitable slope may be provided for loading and unloading of the equipment and proper approach will be provided.
11) RCC pipes at suitable places as required will be provided for the cable entries to the sub station space and making suitable arrangement for non-ingress of water through these pipes.
12) The sub station space is to be provided in the approved/sanctioned covered area of the building.

13) Any other alteration /modification required while erection of the equipment will be made by the Owner / builder at site as per requirement.

14) Adequate arrangement for fixing chain pulley block above the fixing be available for load of 15 tons.

15) Provision shall be kept for the sumps so as to accommodate complete volume of transformer oil, which can spillover in the event of explosion of the transformer in the basement of the building. Sufficient arrangement should exist to avoid fire in the sub-station building from spread of the oil from the sumps.

16) Arrangement should be made for the provision of fire retardent cables so as to avoid chances of spread of fire in the sub-station building.

17) Sufficient pumping arrangement should exist for pumping the water out, in case of fire so as to ensure minimum loss to the switchgear and transformer.

18) No combustible material should be stacked inside the substation premises or in the vicinity to avoid chances of fire.

19) It should be made mandatory that the promoters of the multi-storeyed building should get substation premises inspected once a year to get their license revalidated for the provision of electric supply from Electricity Board so that suitable action can be taken against the Owner / Builder in case of non-implementation of Bye-Laws.

20) The sub-station must not be located below the 1^{st} basement and above the ground floor.

21) The sub station space should be totally segregated from the other areas of the basement by fire resisting wall. The ramp should have a slope of 1 : 10 with entry from ground level. The entire Sub-station space including the entrance at ground floor be handed over to the licensee of electricity free of cost and rent.

22) The sub-station area shall have a clear height of 12 feet (3.65 m.) below beams. Further the Sub-station area will have level above the rest of basement level by 2 feet.

23) It is to be ensured that the Sub-station area is free of seepage / leakage of water.

24) The licensee of electricity will have the power to disconnect the supply of the building in case of violation of any of the above points.

25) Electric sub station enclosure must be completely segregated with 4-hours fire rating wall from remaining part of basement.

26) The Sub-station should be located on periphery /sub basement and (not above ground floor).

27) Additional exit shall be provided if travel distance from farthest corner to ramp is more than l5 m.

28) Perfect independent vent system 30 air changes per hour linked with detection as well as automatic high velocity water spray system shall be provided.

29) All the transformers shall be protected with high velocity water spray system / Nitrogen Injection System Carbon Dioxide total flooding system in case of oil filled transformer. In addition to this, manual control of auto high velocity spray system for individual transformers shall be located outside the building at ground floor.

30) Suitable arrangement for pump house, water storage tanks with main electrical pump and a diesel-operated pump shall be made if no such arrangement is provided in the building. In case the water pumping facilities are existing in the building for sprinkler system, the same should however be utilized for high velocity water spray system. Alternatively automatic CO2 total flooding system shall be provided with manual controls outside the electric sub-station.

31) System shall have facility to give an audio alarm in the basement as well as at the control room.

32) Fire control room shall be manned round the clock.

33) The electric sub station shall have electric supply from alternate source for operation of vent System lighting arrangements.

34) Cable trenches shall be filled with sand

35) Party walls shall be provided between two transformers as per the rules.

36) Electric control panels shall be segregated.

37) Exits from basement electric substation shall have self-closing fire smoke check doors of 2-hours fire rating near entry to ramp.

38) All openings to lower basement or to ground floor shall be sealed properly.

39) Yearly inspection shall be carried out by electrical load sanctioning Authority.

40) Ramp to be designed in a manner that in case of fire no smoke should enter the main building.

41) Electric sub station transformer shall have clearance on all sides as per BBL/relevant electric rules.

42) Other facility will be as per Building Bye-Laws and relevant electric rules.

43) Rising electrical mains shall consist of metal bus bars suitably protected from safety point of view.

44) Oil less transformer shall be preferred.

7.20 FIRE PROTECTION REQUIREMENTS

Buildings shall be planned, designed and constructed to ensure fire safety and this sha1l be done in accordance with part IV Fire Protection of National Building Code of India, unless otherwise specified in these Bye-Laws. In the case of buildings (identified in Bye-Laws No. 7.1) the building schemes shall also be cleared by the Chief Fire Officer.

7.20.1 First Aid /Fixed Fire Fighting /Fire Detection Systems and other Facilities

Provision of fire safety arrangement for different occupancy from. SI no. 1 to 23 as indicated below shall be as per Annexure 'A' 'B' & 'C'.

1. Access
2. Wet Riser
3. Down Comer
4. Hose Reel
5. Automatic Sprinkler System
6. Yard Hydrant
7. U.G. Tank with Draw off Connection
8. Terrace Tanks
9. Fire Pump

10. Terrace Pump
11. First Aid Fire Fighting Appliances
12. Auto Detection System
13. Manual operated Electrical Fire Alarm System
14. P.A System with talk back facility
15. Emergency Light
16. Auto D.G. Set
17. Illuminated Exit Sign
18. Means of Escape
19. Compartimentation
20. MCB /ELCB
21. Fire Man Switch in Lift
22. Hose Boxes with Delivery Hoses and Branch
23. Pipes Refuge Area

Note for Annexure 'A' 'B' & 'C'

1 Where more than one riser is required because of large floor area, the quantity of water and pump capacity recommended in these Annexures should be finalized in consultation with Chief Fire Officer.

2 The above quantities of water shall be exclusively for fire fighting and shall not be utilized for domestic or other use.

3 A facility to boost up water pressure in the riser directly from the mobile pump shall be provided in the wet riser, down comer system with suitable fire service inlets (collecting head) with 2 to 4 numbers of 63 mm inlets for 100-200 mm dia main, with check valve and a gate valve.

4. Internal diameter of rubber hose for reel shall be minimum 20 mm. A shut off branch with nozzle of 5 mm. size shall be provided.

5 Fire pumps shall have positive suctions. The pump house shall be adequately ventilated by using normal/mechanical means. A clear space of 1.0 m. shall be kept in between the pumps and enclosure for easy movement /maintenance. Proper testing facilities and control panel etc. shall be provided.

6 Unless otherwise specified in Bye-Laws, the fire fighting equipments /installation shall conform to relevant Indian Standard Specification.

7 In case of mixed occupancy, the fire fighting arrangement shall be made as per the highest class of occupancy.

8 Requirement of water based first aid fire extinguishers shall be reduced to half if hose reel is provided in the Building.

7.21 STATIC WATER STORAGE TANK

a) A satisfactory supply of water exclusively for the purpose of fire fighting shall always be available in the form of underground static storage tank with capacity specified in Annexure-A with arrangements of replenishment by town's main or alternative source of supply @ 1000 liters per minute. The static storage water supply required for the above mentioned purpose should entirely be accessible to the fire tenders of the local fire service. Provision of suitable number of manholes shall be made available for inspection repairs and insertion of suction hose etc. The covering slab shall be able to withstand the vehicular load of 45 tonnes in case of high rise and 22 tonnes in case of low rise buildings. A draw off connection shall be provided. The slab need not strengthened if the static tank is not located in mandatory set- back area.

b) To prevent stagnation of water in the static water tank the suction tank of the domestic water supply shall be fed only through an over flow arrangement to maintain the level therein at the minimum specified capacity.

c) The static water storage tank shall be provided with a fire brigade collecting branching with 4 Nos. 63mm dia instantaneous male inlets arranged in a valve box with a suitable fixed pipe not less than 15 cm dia to discharge water into the tank. This arrangement is not required where down comer is provided.

7.22 AUTOMATIC SPRINKLERS

Automatic sprinkler system shall be installed in the following buildings:

a) All buildings of 24 m. and above in height, except group housing and 45 m. and above in case of apartment /group housing society building.

b) Hotels below l5 m. in height and above 1000 sq m. built up area at each floor and or if basement is existing.

c) All hotels, mercantile, and institutional buildings of 15 m. and above.

d) Mercantile building having basement more than one floor but below 15 m. (floor area not exceeding 750 sq m.)

e) Underground Shopping Complex.

f) Underground car / scooter parking /enclosed car parking.

g) Basement area 200 sq m. and above.

h) Any special hazards where the Chief Fire Officer considers it necessary.

i) For buildings up to 24 m. in height where automatic sprinkler system is not mandatory as per these Bye-Laws, if provided with sprinkler installation following relaxation may be considered.

   i) Automatic heat/smoke detection system and M.C.P. need not be insisted upon.

   ii) The number of Fire Extinguisher required shall be reduced by half.

7.23 FIXED CARBON DI-OXIDE / FOAM / DCO WATER SPRAY EXTINGUISHING SYSTEM

Fixed extinguishing installations shall be provided as per the relevant specifications in the premises where use of above extinguishing media is considered necessary by the Chief Fire Officer.

7.24 FIRE ALARM SYSTEM

All buildings of 15 m. and above in height shall be equipped with fire alarm system, and also residential buildings (Dwelling House, Boarding House and Hostels) above 24 m. height.

a) All residential buildings like dwelling houses (including flats) boarding houses and hostels shall be equipped with manually operated electrical fire alarm system with one or more call boxes located at each floor. The location of the call boxes shall be decided after taking into consideration their floor without having to travel more than 22.5 m.

b) The call boxes shall be of the break glass type without any moving parts, where the call is transmitted automatically to the control room without any other action on the part of the person operating the call boxes.

c) All call boxes shall be wired in a closed circuit to a control panel in a control room, located as per Bye-Laws so that the floor number from where the call box is actuated is clearly indicated on the control panel. The circuit shall also include one or more batteries with a capacity of 48 hours normal working at full load. The battery shall be arranged to be a continuously trickle charged from the electric mains.

d) The call boxes shall be arranged to sound one or more sounders so as to ensure that all occupants of the floor shall be warned whenever any call box is actuated.

e) The call boxes shall be so installed that they do not obstruct the exit ways and yet their location can easily be noticed from either direction. The base of the call box shall be at a height of 1.5 m. from the floor level.

f) All buildings other than as indicated above shall, in addition to the manually operated electrical fire alarm system, be equipped with an automatic fire alarm system.

g) Automatic detection system shall be installed in accordance with the relevant standard specifications. In buildings where automatic sprinkler system is provided, the automatic detection system may not be insisted upon unless decided otherwise by the Chief Fire Officer.

Note: Several type of fire detectors are available in the market but the application of each type is limited and has to be carefully considered in relation to the type of risk and the structural features of the building where they are to be installed.

7.25 CONTROL ROOM

There shall be a control room on the entrance floor of the building with communication system (suitable public address system) to all floors and facilities for receiving the message from different floors. Details of all floor plans along with the details of fire fighting equipment and installation shall be maintained in the Control Room. The Control Room shall also have facility to detect the fire on any floor through indicator boards connecting fire detection and alarm system on all floors. The staff in charge of the Control Room shall be responsible for the maintenance of the various services and fire fighting equipment and installation. The Control Room shall be manned round the clock by trained fire fighting staff.

7.26 FIRE DRILLS AND FIRE ORDERS

The guidelines for fire drill and evacuation etc. for high-rise building may be seen in Appendix (B) of National Building Code part IV. All such building shall prepare the fire orders duly approved by the Chief Fire Officer.

7.27 A qualified fire officer and trained staff shall be appointed for the following buildings.

a) All high rise buildings above 30 m. in height where covered area of one floor exceeds 1000 sq m. except apartments / group housing.

b) All hotels, identified under classification three star and above category by Tourism Department and all hotels above 15 m. in height with 150 beds capacity or more without star category.

c) All hospital building of 15 m. and above or having number of beds exceeding 100.

d) Underground shopping complex where covered area exceeds 1000 sq m.

e) All high hazard industries.

f) Any other risk which Chief Fire Officer considers necessary.

7.28 The lightening protection warning light (red) for high-rise buildings shall be provided in accordance with the relevant standard. The same shall be checked by electrical department.

7.29 MATERIAL USED FOR CONSTRUCTION OF BUILDING

a) The combustible/flammable material shall not be used for partitioning, wall paneling, false ceiling etc. Any material giving out toxic gases/smoke if involved in the fire shall not be used for partitioning of a floor or wall paneling or a false ceiling etc. The surface frames spread of the lining material shall conform to class-I of the standard specification. The framework of the entire false ceiling would be provided with metallic sections and no wooden framework shall be allowed for paneling/false ceiling.

b) Construction features/elements of structures shall conform to National Building Code and BIS code

7.30 LPG

The use of LPG shall not be permitted in the high-rise building except residential/hotel/hostel/kitchen/pantry (if any) and shall be located at the periphery of the building on the ground level.

7.31 HOUSE KEEPING

A high standard of house keeping must be insisted upon by all concerned. There must be no laxity in this respect. It must be borne in mind that fire safety is dependent to a large extent upon good housekeeping.

7.31.1 Good House-Keeping includes the following:-

a) Maintaining the entire premises in neat and clean condition.

b) Ensuring that rubbish and combustible material are not thrown about or allowed to accumulate, even in small quantity, in any portion of the building. Particular attention must be paid to corners and places hidden from view.

c) Providing metal receptacles/waste paper basket (of non-combustible material) at suitable locations for disposal of waste. Separate receptacles must be provided for disposal of cotton rags/waste, wherever it is generated, these must under no circumstances be left lying around in any portion of the building.

d) Ensuring that receptacles for waste are emptied at regular intervals and the waste removed immediately for safe disposal outside the building.

e) Ensuring that all doors/fixtures are maintained in good repairs, particular attention must be paid to self-closing fire smoke check doors and automatic fire/doors/rolling shutters.

f) Ensuring that self-closing fire/smoke check doors close properly and that the doors are not wedged open.

g) Ensuring that the entire structure of the building is maintained in good repairs.

h) Ensuring that all electrical and mechanical service equipments are maintained in good working condition at all times.

i) Ensuring that Cars / Scooters etc. are parked systematically in neat rows. It is advisable to mark parking lines on the ground in the parking areas near the building and in the parking area on ground floor and in basement(s); as applicable, inside the building. A parking attendant must ensure that vehicles are parked in an orderly manner and that the vehicles do not encroach upon the open space surrounding the building.

7.31.2. Smoking Restrictions

a) Smoking shall be prohibited throughout the basement(s) and in all areas where there is a profusion of combustible materials. Easily readable "NO SMOKING" signs must be conspicuously posted at locations where they can catch the eye. Each sign must also include a pictograph. The sign may also be illuminated.

b) In all places where smoking is permitted ashtrays, half filled with water, must be placed on each table/at each other suitable locations for safe disposal of spent smoking material. The design of the ashtrays must be such that they cannot easily topple over. If, for any reason, this is not practicable a minimum of one metal bucket or other non-combustible container half filled with water must be provided in each compartment for disposal of spent smoking materials.

7.31.3 Limiting the Occupant Load in Parking and Other Areas of Basement(s)

Where parking facility is provided in the basement(s) no person other than the floor-parking attendant may be allowed to enter and remain in the parking areas except for parking and removal of Cars/Scooters. Regular offices must not be maintained in the storage /parking area in the basement(s). The stores / godowns must be opened for the limited purpose of keeping or removing stores.

No person other than those on duty may be permitted in the air-conditioning plant room(s), HL/LT switch room, transformer compartment, control room pump-house, generator room, stores and records etc.

7.32 FIRE PREVENTION

In addition to the measures recommended above, the following fire prevention measures must be implemented when the building is in occupation.

a) Storage of flammable substances, such as diesel oil, gasoline, motor oils, etc must not be allowed anywhere within the building. The only exception to this rule may be:

   i) Storage of diesel oil in a properly installed tank in a fire-resisting compartment in the generator room;

   ii) Diesel oil, gasoline, motor oil etc, filled in the vehicle tanks.

b) Preparation of tea and warming of food must be prohibited throughout the building.

c) Where heaters are used during winters, the following precautions must be taken.

   i) All heaters, except convector heaters, must be fitted with guards.

ii) Heaters must not be placed in direct contact with or too close to any combustible material.

iii) Heaters must be kept away from curtains to ensure that the latter do not blow over the heater accidentally.

iv) Heaters must not be left unattended while they are switched on.

v) Defective heaters must be immediately removed from service until they have been repaired and tested for satisfactory performance.

vi) Use of heaters must be prohibited in the entire basement, fire control room and in all weather maker rooms throughout the building. Also in all places where there is profusion of combustible flammable materials.

d) Use of candles or other naked light flame must be forbidden throughout the building, except in the offices (for sealing letters only) and kitchen. When candles/ spirit lamps are used for sealing letters/packets, extreme care must be take to ensure that paper do not come in direct contact with the naked flame and the candle/spirit lamp does not topple over accidentally while still lighted. All candles/spirit lamps kitchen fires must be extinguished when no longer required.

e) Fluorescent lights must not be directly above the open file racks in offices/record rooms. Where this is unavoidable, such lights must be switched on only for as long as they are needed.

f) Filling up of old furniture and other combustible materials such as scrap paper, rags, etc. must not be permitted anywhere in the building. These must be promptly removed from the building.

g) More than one portable electrical appliance must not be connected to any single electrical outlet.

h) Used stencils, ink smeared combustible materials and empty ink tubes must not be allowed to accumulate in rooms/compartments where cyclostyling is done. These must be removed and disposed off regularly.

i) All shutters/doors of main switch panels and compartments/shafts for electrical cables must be kept locked.

j) Aisles in record rooms and stores must have a clear uniform width of not less than 1.0 m. Racks must not be placed directly against the wall/partition.

k) In record rooms, offices and stores, a clear space of not less than 30 cm. must be maintained between the top-most stack of stores/records and the or lighting fittings whichever is lower.

l) A similar clearance, and at (k) above must be maintained from fire detectors.

m) Fire detectors must not be painted under any circumstances and must also be kept free from lime/distemper.

n) Records must not be piled/dumped on the floor.

o) Welding or use of blow torch shall not be permitted inside the building, except when it is done under strict supervision and in full conformity with the requirements laid down in IS: 3016-1966 code of practice for fire precautions in welding and cutting operation.

p) Printing ink/oil must not be allowed to remain on the floor, the floor must be maintained in a clean condition at all times.

7.33 OCCUPANCY RESTRICTIONS

a) The premises leased to any party shall be used strictly for the purpose for which they are leased.

b) No dangerous trade/practices (including experimenting with dangerous chemicals) shall be carried on in the leased premises;

c) No dangerous goods shall be stored within the leased premises.

d) The common/public corridor shall be maintained free of obstructions, and the lessee shall not put up any fixtures that may obstruct the passage in the corridor and/or shall not keep any wares, furniture or other articles in the corridor.

e) The penalty for contravention of the condition laid down below must be immediate termination of lease and removal of all offending materials.

f) Regular inspection and checks must be carried out at frequent intervals to ensure compliance with conditions above.

Fire Management Study Unit

Prepared by

Rachel G. Schneider
USDA Forest Service
1755 Cleveland Hwy.
Gainesville, Georgia 30501

and

Deborah Breedlove
Georgia Forestry Commission
P.O. Box 819
Macon, Georgia 31202-0819

Fire Management

Overview

For the past 400 million years, Earth has had the capacity to burn. Fire is a natural event in most forest ecosystems. Lightning ignited fires in prehistoric times that helped stimulate life by catalyzing Earth's earliest organic compounds. Entire plant communities have adapted to and now depend on the fire process. Fire's influence causes certain types of vegetation to thrive and regenerate in the fire dependent ecosystem.

Fire can have both positive and negative effects on the environment. Understanding this catalyst is important in managing fire to promote forest health, protect natural resources and achieve sustainability of ecosystems.

Fire Behavior

Objectives

Understand the process of combustion.
Identify methods of heat transfer.
Describe how a fire starts, spreads and burns.
Describe how weather and topography affect fires.
Recognize nature's danger signals.

Combustion

The manner in which a spark flames into life, flares up, spreads, fades and eventually dies is all in accordance with natural laws. Fire is a chemical reaction sometimes called rapid oxidation. When a substance is affected by enough heat a flammable gas is released. Then, in the presence of enough oxygen and continued heat, a flame (combustion) occurs. With a continuous supply of heat furnished by the combustion itself, air to supply oxygen, and fuel to burn, a fire will exist. Fires need *heat*, *fuel*, and *oxygen* to burn. These three elements are known as the "fire triangle". Remove any one of these three elements in the fire triangle and the fire will go out.

Reasonably accurate predictions can be made on what will happen given certain conditions of fuel, topography and weather during the process of combustion. These are discussed in this unit.

Heat Transfer

Heat must move from one molecule of fuel to another for combustion to continue. This heat is transferred by three processes of movement called ***radiation, convection*** and ***conduction.***

Radiation is waves or rays that move away from the source of heat. For example, the sun radiates heat to the earth's surface and causes it to grow warmer. During the cool of night, part of that heat radiates away from the earth into the cooler air. The transfer of heat by radiation varies inversely (increases or decreases when the other proportion increases or decreases) as the square of the distance from the heat source. For example, a camper is comfortable at 68 degrees Fahrenheit (68^o F.) two feet from the campfire. The second camper cannot receive the same amount of radiated heat at a distance of four feet away unless the fire is made four times as hot. The third camper at a distance of six feet away will not receive a comfortable amount of heat (68^o F.) unless the fire is made nine times as hot. However, nine times the heat to make the third camper comfortable will ignite the clothing of the camper nearest the fire.

Convection is the way heat moves in heated air masses. Air absorbs heat, expands, becomes drier and lighter than the surrounding cooler air and rises. Think of convection as a smoke column with hot gases and embers that dry and ignite other fuels.

Conduction is the way heat moves through solid objects to the air which touches it much like electricity. Most forest fuels like wood are poor conductors of heat. That is why a burning log must be turned over to allow heat from the underside to radiate into the air or why a smoldering fire must be chopped out of a log or tree.

Start and Spread of Wildland Fire

Weather, fuel and ***topography*** are the three principal environmental elements that affect wildland fire behavior. Each of these elements have certain conditions and characteristics that determine the intensity of the fire and how fast or slow a fire will spread. Weather is difficult to understand because it is constantly changing. However, because it has tremendous influence on fire, a basic knowledge and ability to make field observations of weather is important in fire management.

Weather

The main forces that "create" weather are solar energy (heat from the sun), the force of gravity and the phenomenon that all elements seek a state of balance or equilibrium. *Temperature, wind, relative humidity*, and *precipitation* are the main weather factors that affect the start and spread of wildland fire.

Temperature is the measurement of warmth or coldness. The main source of heat for outside air is solar energy from the sun. Fuel (any combustible material) and ground temperatures receive and reflect radiation from the sun. The surface air temperatures rise or cool as contact is made with the fuels and the ground. Fuels in the sun will be easier to ignite than fuels in the shade because of temperature differences which can be as much as 50° F. between open sunlit areas and dense shade. Wood ignites between 400° and 700° F. Woody fuels will burst into flame at approximately 540° F. provided enough oxygen is present. The sun can only heat a surface to around 160° F. which is far below the possibility of spontaneous combustion. However, this heat will boost fuel combustion a hundred degrees or more before the igniting spark is applied.

Wind is the movement of air. The average person thinks of wind as the horizontal movement of air that can be felt, but convection winds carry air upward. Wind is one of the most important influences on fire behavior. Wind increases the supply of oxygen, influences the direction the fire will spread, dries fuels, carries sparks ahead of the main fire and moves air heated by convection to downwind fuels. Air movement is unceasingly stimulated by several major forces over the earth. First, there are vast heated areas of the earth's surface that produce rising air currents which return to earth in cooler regions. Then, there is the gravitational effect of the turning earth on these tremendous currents. Seasonal changes alter the pattern of wind movement because the hot and cold regions of the earth are shifted. Wind and all weather with it are then modified by water bodies, land masses and lesser local elements on a smaller scale. Wind can be compressed under pressure, expanded and contracted with heat and cold, made moist or dry and may pause, then gust with violence in any direction.

It is estimated that one pound of fuel requires 200 cubic feet of air during combustion. Wind makes more oxygen available to the fire which increases the rate of fuel consumption. Winds may cause fires to jump prepared or natural barriers or send a fire through tree tops when there is little understory heat or fuel. Over areas such as plains or long, wide valleys, prevailing wind direction can be easily predicted throughout the year, but in rough topography, wind currents are thrown into confusion as vegetation, large rocks, mountains or hills create drag upon wind movements.

Winds change direction or intensity throughout the day and night with temperature fluctuations and local topography. Large bodies of water such as oceans and lakes, usually cause winds to blow inland as the sun warms the land then outward when the land cools more rapidly than the water. Winds will blow upward when mountain slopes warm under the sunshine and down slope as the surface cools at night.

Relative humidity is the relationship between the moisture vapor in the air now and the total it could hold at its present temperature. Air passes over surfaces picking up water vapor until it becomes saturated and precipitates moisture. When it has reached this point, the air has a relative humidity of 100 percent. Warm air can hold more moisture than cold air. When the relative humidity descends below 30 percent, conditions are more favorable for wildfire because the air can absorb more moisture from fuels. The less moisture in the fuel, the less time is required for heat to bring about combustion. Light fuels such as grass, dead leaves and pine straw lose moisture quickly with changes in humidity. Heavy fuels such as limbs, logs and tree trunks dry out more slowly.

Precipitation is the liquid or solid moisture that falls from the atmosphere. Fuel moisture is affected by the amount and duration of precipitation. Light fuels are affected more quickly than heavy fuels since they gain and lose moisture usually within one hour. Heavy fuels are not affected as much since they gain or lose moisture more slowly. Green living leaves gain and lose moisture according to the transpiration habits of their species, so it is not unusual to see "green" trees burning in a wildfire.

A large amount of precipitation in a short time will not raise the fuel moisture as much as lesser rainfall over a longer period of time where the fuels can absorb more moisture before it runs off. Moisture in fuel will not burn. It must be converted to steam by heat and driven away before combustion will take place.

Large fires can make their own weather. Large convection updrafts cause air currents along the ground toward the fire and sometimes cause down drafts beyond the fire perimeter. Smoke clouds may shade the sun and alter the temporary radiation of solar heat toward and away from the earth.

Fuel

Fuel is any combustible material. Wildland fuels are basically live and/or dead plant material. These vary from one area of the country to another with the ecosystem. Fuels are important to study in fire management because they are the one component of the fire triangle humans can influence the most. Wildland fuels are grouped into four major types based on the primary fuel that carries the fire. These are *grass, shrubs, timber litter* and *logging slash.*

Grass is found in most ecosystems, but it is more dominant as a fuel in desert and range areas. It can become prevalent after a fire in forested areas. Fires in grass spread rapidly but burn out quickly.

Shrubs are also found throughout most areas. Palmetto and gallberry are highly flammable shrubs in the southeastern United States. As you go westward, sagebrush and chaparral are the highly ignitable shrubs.

Timber litter is leaves, pine needles, small twigs and limbs you find on the forest floor especially in mountainous areas.

Logging slash is the debris left after timber harvesting or silviculture operations such as pruning, thinning or shrub cutting. It includes broken understory trees or shrubs, stumps, bark, branches, chunks or logs.

Regardless of the type of fuel, fire behavior is dependent on characteristics such as *fuel* *moisture, size and shape, fuel loading, horizontal continuity* and *vertical arrangement.* We have discussed the role weather plays in *fuel moisture*. Different species have different moisture holding capacity. Dry fuels, will of course, ignite and burn more easily than the same fuels when they are wet. As fuel moisture increases, the amount of heat required to ignite and burn that fuel also increases.

The *size and shape* of fuels also determine their ability to burn. *Light fuels* which have a diameter of one-half inch or less, dry out quickly, ignite quickly as they are surrounded by plenty of oxygen, burn quickly and are easily extinguished. Light fuels include grasses, shrubs, leaves, twigs, and pine needles. *Heavy fuels* are larger such as limbs, logs and tree trunks which dry out more slowly, heat more slowly and usually have bark or some protective mechanism to prevent moisture loss.

Fuel loading refers to the quantity of fuels in an ecosystem. However, this does not necessarily mean the fire will burn with great intensity. There are many factors that affect the availability of fuel for combustion, such as the size and shape, fuel moisture, the arrangement of moisture and the proximity of fuel particles to one another in respect to the free movement of oxygen around the particles. Hemlock needles on the ground will be less flammable than pine needles or oak leaves at the same place and time because the finer needles are too compact to allow enough oxygen for rapid combustion.

Horizontal continuity is the way fuels are spread over an area. Uniform fuels are the same type that form a network connecting each other to provide a continuous path for a fire to spread. Patchy fuels are distributed unevenly over the area with breaks or barriers such as rock outcroppings, bare mineral soil or less flammable species.

Vertical arrangement is the way fuels are spread vertically over an area. This arrangement includes *ground fuels, surface fuels* and *aerial fuels*. *Ground fuels* are the combustible materials arranged vertically in the ground such as tree roots, deep duff or thick peat. Ground fires burn the organic and combustible fuel beneath the surface such as a peat fire.

Surface fuels are combustible materials lying immediately above the ground including grass, shrubs, timber litter and logging slash. Surface fires burn this fuel.

Aerial fuels are the green and dead materials located in the upper canopy including tree branches and crowns, snags, hanging moss and vines and tall shrubs. Crown fires burn through the tops of trees or shrubs and can progress with or independent of a surface fire.

Topography

The lay of the land is the most stable of the three environmental elements and easier to predict its influence on weather and fuel. Topographic factors that affect the start and spread of wildland fire are *aspect, slope, shape of the area, elevation*, and *barriers*.

Aspect is the exposure of a slope to the sun. It usually determines the amount of heating the land gets from the sun. North of the equator the sun's rays shine most directly upon the south and southwest slopes. Southeast and western slopes receive about the same amount of heating and northern slopes receive the least exposure. This starts a chain of reactions that result in differences in soil and vegetation regardless of the parent soil material. Southern slopes generally have light fuels, higher temperatures, lower humidity, lower fuel moisture and are most critical in terms for the start and spread of fire. Northern slopes have heavier fuels, higher humidity, cooler temperatures and higher fuel moisture.

Slope is the degree of incline of a hillside. Fires burn faster uphill than downhill because the fuels above the fire are brought into closer contact with upward moving flames. The steeper the slope, the faster the fire burns. Convective and radiant heat help the fuel catch on fire easily. A fire near the bottom of a slope will spread more rapidly during daytime conditions than a fire near the top of the slope because it has a greater uphill run. Burning material also can roll downhill and ignite fuel below the main fire.

Shape of the country influences the direction, intensity, and rate the fire will spread. Canyons, ridges and saddles are topographic shapes that influence weather especially wind direction.

<u>Box canyons</u> have steep walls and a generally flat floor. Air will be drawn in from the canyon bottom much like a wood burning stove or fireplace creating strong up slope drafts (the chimney effect) and rapid spread of fire. This can result in extreme fire behavior and be very dangerous.

<u>Narrow canyons</u> also have steep walls with a narrow floor that can best be described as "V" shaped. Wind direction will normally follow the direction of the canyon and fire can easily spread to fuels on the opposite side by radiation and spotting. Wind eddies and strong up slope air movement can be expected at sharp bends in a canyon.

<u>Wide canyons</u> have the same characteristics as box and narrow canyons except the floor is much wider so there is less danger of fire spotting across to a different slope. The prevailing wind will not be deflected by sharp up or down drafts. There will also be strong differences between fire conditions on the north and south aspects of a wide canyon.

<u>Ridges</u> are the long narrow edges or the crest of a hill. Fires burning along lateral ridges may change direction when they reach a point where the ridge drops off into a canyon. This is caused by the flow of air coming from the canyon. Sometimes a whirling or eddying fire may result around the point of a ridge.

<u>Saddles</u> are the ridges connecting two higher elevations such as a mountain pass. Wind is channeled through narrow or constricted areas and spreads out on the leeward or downwind side with eddying action.

Elevation or the height above sea level plays a large role in both the amount of fuel available and the condition of the fuel. Fuels at lower elevation dry out earlier in the year than fuels at higher elevations due to higher temperatures. At extremely higher elevations there may be no fuel. Elevation also affects the amount of precipitation received, winds and its relationship to the surrounding terrain.

Barriers are natural and man-made obstructions to the spread of fire. Natural barriers include rivers, lakes, rock slides, some fuels whose moisture content or other characteristics prevent them from burning as well as other fuels in the area. Man-made barriers include roads, highways reservoirs and the fireline built to control the fire.

Nature's danger signals

Ability to recognize the signs warning of potential dangerous conditions is very important in fire management. Turbulent air movements near the ground create a serious hazard to life and property as well as difficulty in controlling fire. It is important to be able to determine wind direction. Wind direction is the direction the wind is blowing *from,* i.e. a north wind means the wind is blowing from the north. Ability to identify the types of clouds in the area also helps to determine developing weather conditions that usually bring strong winds. These weather conditions are:

High and low pressure systems are strong general winds that are usually influenced and modified in the lower atmosphere by terrain. These systems may also have gradient winds that occur 1,500 feet above mean terrain height. They flow parallel to the isobars or contours and have a speed such that the pressure gradient and centrifugal forces of the area are in balance.

Cold fronts in the northern hemisphere have southeasterly to southwesterly winds *ahead* of the front and westerly to northwesterly winds *behind* the front with cooler air. These winds are generally 10 - 20 miles per hour for 12 to 24 hours. A cold front is the boundary line between a cooler air mass which replaces a warmer air mass. The heavier cold air may cause the warm air to be lifted. If the lifted air contains enough moisture, cloudiness, precipitation, and even thunderstorms may result. If both air masses are dry, there may be no cloud formation.

Foehn winds pronounced "fern". Foehn winds are a type of general wind that occurs when stable, high pressure air is forced across and down the lee slopes of a mountain range. The descending air is warmed and dried as it passes due to compression. These winds are known by local names such as Santa Anna and Mono of California, East wind of the Pacific Northwest and Chinook on the east side of the Rockies.

Thunderstorms are violent local storms produced by cumulonimbus clouds accompanied by thunder, lighting, strong gusty winds and sometimes hail. They seldom last over three hours for any one storm. A tall, building cumulus cloud is an indicator that a cumulonimbus cloud is forming. The cloud resembles cauliflower and has a dark flat base. The top is usually anvil shaped and is well above the freezing level. The direction of thunderstorm movement is generally the direction the anvil shaped top is pointing. Down draft winds from thunderstorms spread radically in all directions when they hit the ground but they are always away from the thunderstorm. Velocities can be as high as 60 miles per hour. Surface winds will be the strongest in the direction the thunderstorm is moving. Lightning is caused by the equalizing of positive and negative electricity at the upper and lower limits of the cloud. Sometimes lightning flashes from cloud to cloud which helps dissipate the electrical tensions and sometimes it strikes earth often igniting fires.

Whirlwinds, dust devils and mirages are indicators of unstable air. Wildland fires burn hotter and with more intensity when the air is unstable. There is usually good mixing of air with upward motion when the air is unstable. Smoke will rise straight up and often to great heights; cumulus type clouds will form; visibility is usually good and gusty winds are present. Dust devils are small whirlwinds that form usually around mid day when the sun has heated the surface air to the point the air expansion is out of balance with the density of the air above the ground. When conditions are right for dust devils to form, a wildfire “blow-up” can occur over a smoldering fire and the whirling air can spread flames in its path. Dust devils can range from 10 feet to over 100 feet in diameter with heights from 10 feet to 4,000 feet. Wind speeds are often up to 50 miles per hour. The same unstable air conditions that produce dust devils can produce lake mirages.

These “lakes of water” illusions disappear as one approaches or changes the observation point. The illusion is caused by the bending of light rays through layers of air of different density The lake mirage is probably the reflected sky. The presence of whirlwinds, dust devils and mirages are extremely dangerous to firefighters.

Inversions take place under stable air conditions. They are easy to recognize because they trap smoke, impurities, and gases resulting in poor visibility especially in valleys. An inversion is a layer in the atmosphere where the temperature increases with altitude. Smoke and other impurities will rise only until their temperature equals that of the surrounding air, then will flatten out and spread horizontally. The rupture of the inversion boundary under pressure spells trouble for fire management.

The *thermal belt* is also stable air associated with mountainous slopes. This belt is the area with the least variation in daytime temperatures, the highest average temperatures and lowest average relative humidity. They are usually found on the mid-portions of slopes. Within the thermal belt, wildland fires can remain active throughout the night.

In a wildland fire, keep an eye on the smoke column. This will give you an idea of the direction the fire will spread, location of spot fires and changes in fire intensity. Danger signals to watch for are small groups of trees or brush beginning to torch, simultaneous fires starting or smoldering fires picking up in intensity. Also be aware of firewhirls developing inside the main fire and fires in the treetops.

A basic knowledge of fire behavior is essential in both wildland fires and prescribed fires to insure human safety and to determine suppression methods.

Different Types of Fires

Objectives

1. Identify the basic types of fire.
2. Identify fire characteristics that determine damage.
3. Recognize toxic fires.
4. Analyze effects of fire on wildlife, water quality, soil and air.

Types of Fire

There are different types of fires, each with its own characteristic behavior, often requiring different fire fighting techniques. These are segregated mainly by the types of fuels which have similar burning tendencies. These are *ground fires, surface fires, crown fires* and *spot fires.*

Ground fires burn below the earth's surface in layers of organic material such as peat, tree roots or deep duff. These fires are slow smoldering, have little or no flame and little smoke.

Although these fires are rare, it is difficult to control them once they get started.

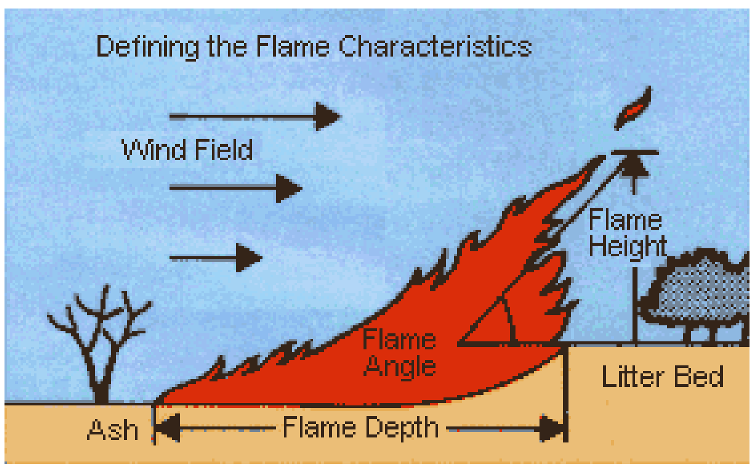
Surface fires burn lower levels of vegetation such as grass, timber litter, understory shrubs, and logging slash. Often in dry weather or high wind conditions, these are considered flashy fuels as they are easily ignited and consumed quickly.

Crown fires burn through the tops of trees. They are particularly dangerous because they are unpredictable. They may burn at the same rate as the surface fire below or may race through the crown ahead of the surface fire depending on topography, wind, moisture, and species. Tree tops can also be considered flashy fuels.

Spot fires are started by wind carrying burning bark and leaves ahead of the main fire igniting other areas. This is an indicator of unstable weather conditions and requires special fire fighting operations.

Fire Characteristics

Flame height, depth, angle and *scorch height* are characteristics that determine the degree of damage a fire will do. Add *intensity, the season of the year* and *frequency of fire occurrence* and you have an even better tool to determine environmental impact.



Flame height is measured vertically from ground level. This measurement does not take into account short, upward flashes of flame.

Scorch height is the height at which leaves are killed by the heat of the fire. The scorch height increases faster than flame height due to increased heat intensity.

Flame depth is the width of the zone within which continuous flaming occurs behind the fire edge. The depth of the fire is an important factor in the survival of the larger animals caught in a fire. Research suggests that in severe fires, some animals will double back onto already burned ground if the flame height and depth is not too great.

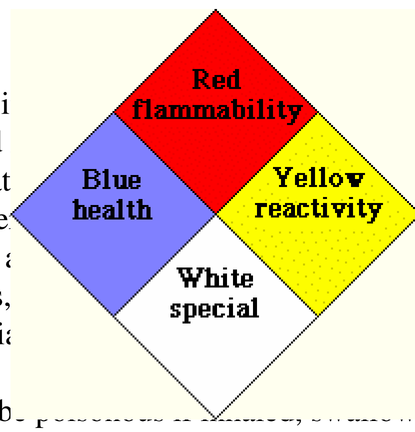
Flame angle is measured from the horizontal in front of the fire. A vertical flame is 90 degrees while a leaning flame has an angle of less than 90 degrees. A fire burning up a steep hill is particularly dangerous as it pre-dries and heats the fuel before the flames actually reach it.

Intensity is the rate at which energy is released (measured in kilowatts) while the fire is burning. The intensity is proportional to the amount of fuel available. Fire intensity quadruples each time the amount of fire fuel doubles. A prescribed fire may have a flame height of 2 feet and a low intensity of about 300 kw while a wildfire can have an intensity between 2,000 kw per meter and up. Ability to control a fire is greatly reduced when the intensity is above 3,000 kw per meter.

Frequency is the average number of years between fires. Records of fires are kept with such details as climatic conditions, how the fire started and the amount of destruction. This gives an indication of fuel build-up on the forest floor and how often fire occurs in a region.

Season of the year often determines amount of moisture in vegetation and forest floor litter. For most of the United States more moisture is present in the spring and less in the fall.

Toxic Fires



Technology has brought many changes i ... growing number of hazardous materials that may catch fire and ... ods and precautions. *Hazardous materials* are defined as any mat ... s that may produce serious health, fire or explosive danger. Eve ... nd rural areas contains some hazardous materials. Examples a ... lothing, home and office furnishings, cleaning supplies, paints, ... torage and transportation of large amounts of hazardous materi ... case of fire.

Toxic materials are substances that can b ... ed, absorbed, or introduced into the body through cuts or breaks in the skin. Often hazardous materials produce toxic fumes in the presence of heat or fire. An international identification system has been developed to recognize the presence of hazardous material and the danger it poses. These are identified by a standard diamond symbol with colored background and numerical ratings. **Blue** indicates a *health hazard*; **red,** a *fire hazard,* **yellow** is *reactivity hazard* and **white** indicates *additional information is needed to identify the hazard.*

The diamond-shaped symbol will also have a number from 1 to 4 which indicates the degree of hazard. These are:

4 = Severe Hazard

3 = Serious Hazard

2 = Moderate Hazard

1 = Slight Hazard

0 = Minimal Hazard

All hazardous materials are required to be labeled with descriptive placards. You see these on pesticide containers, gasoline, railroad cars, ships and trucking vehicles carrying these materials. Hazardous materials are further identified by marking systems developed by the country's military or the most widely used *United Nations Classification System*. This system divides hazardous materials into nine categories or classes. The class number will appear at the bottom of the diamond-shaped placard. Accompanying the background color, and class number is a four-digit identification number which must be used with the *Emergency Response Guidebook* to further identify the product and degree of hazard it poses.

The U.N. System divides hazardous materials into the following classes:

Class 1	Explosives
Class 2	Gases
Class 3	Flammable Liquids
Class 4	Flammable Solids
Class 5	Oxidizers
Class 6	Poisons and Infectious Substances
Class 7	Radioactive Substances
Class 8	Corrosives
Class 9	Other Hazardous materials not otherwise identified

The red placard indicates the material presents a flammable hazard. The "3" indicates the class of hazard is a flammable liquid and the 4-digit number 1090 must be "looked up" in the *Emergency Response Guidebook* to identify the flammable chemical, its dangers and how to handle it.

In this case, the *Emergency Response Guidebook* identifies 1090 as Acetone. Acetone has still another code (127) which one must look up for more information. Chemicals assigned code 127 should be approached with the knowledge given in the *Emergency Response Guidebook* and printed here as an example.

POTENTIAL HAZARD

FIRE OR EXPLOSION

Highly Flammable: Will be easily ignited by heat, sparks or flames.

Vapors may form explosive mixtures with air.

Vapors may travel to source of ignition and flash back.

Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks).

Vapor explosion hazard indoors, outdoors or in sewers.

Some may polymerize (P) explosively when heated or involved in a fire.

Runoff to sewer may create fire or explosion hazard.

Containers may explode when heated.

Many liquids are lighter than water.

HEALTH

Inhalation or contact with material may irritate or burn skin and eyes.

Fire may produce irritating, corrosive and/or toxic gases.

Vapors may cause dizziness or suffocation

Runoff from fire control may cause pollution.

PUBLIC SAFETY

Call Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.

Isolate spill or leak area immediately for at least 25 to 60 meters (80 to 160 feet) in all directions.

Keep unauthorized personnel away.

Stay upwind.

Keep out of low areas.

Ventilate closed spaces before entering.

PROTECTIVE CLOTHING

Wear positive pressure self-contained breathing apparatus (SCBA)

Structural firefighters' protective clothing will only provide limited protection.

EVACUATION

Large Spill

Consider initial downwind evacuation for at least 300 meters (1000feet).

Fire

* If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (l/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

FIRE

CAUTION: All these products have a very low flash point: Use of water spray when fighting fire may be inefficient.

Small Fires

Dry chemical, CO_2, water spray or alcohol-resistant foam

Large Fires
Water spray, fog or alcohol-resistant foam.
Do not use straight streams.
Move containers from fire area if you can do it without risk.
Fire Involving Tanks or Car/Trailer Loads
Fight fire from a maximum distance or use unmanned hose holders or monitor nozzles.
Cool containers with flooding quantities of water until well after fire is out.
Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank
Always stay away from the ends of tanks.
For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
SPILL OR LEAK
ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
All equipment used when handling the product must be grounded
Do not touch or walk through spilled material.
Stop leak if you can do it without risk.
Prevent entry into waterways, sewers, basements or confined areas.
A vapor suppressing foam may be used to reduce vapors.
Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers.
Use clean non-sparking tools to collect absorbed material.

Large Spills
Dike far ahead of liquid spill for later disposal.
Water spray may reduce vapor; but may not prevent ignition in closed spaces.
FIRST AID
Move victim to fresh air. Call emergency medical care.
Apply artificial respiration if victim is not breathing.
Administer oxygen if breathing is difficult.
Remove and isolate contaminated clothing and shoes.
In case of contact with substance, immediately flush skin or eyes with running water for at lest 20 minutes.
Wash skin with soap and water.
Keep victim warm and quiet.
Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

Recognizing the warning placard is the first safety measure in identifying the potential for a hazardous material fire. There are over six million unique substances listed by the Chemical Abstract Services of which 75% are listed in hazardous material literature. Many of them are known by different names. The *Emergency Response Guidebook* lists about 2,400 chemicals and classes of chemicals with the same type of information described in the *acetone* example so it is impossible for one to learn all the hazards, and exactly what to do without referring to the *Guidebook*.

While some toxic fires do produce warning signs such as unusually dark or light smoke, odors, etc. others do not. One must NEVER rely on sight, smell, taste, or touch to detect the presence of leaking or spilled hazardous materials. If these materials are there they propose a potential hazard. The location of significant quantities of hazardous materials and the type of materials stored, transported or manufactured in an area should be reported to the fire department annually. Fires threatening or burning hazardous materials should be immediately reported to the appropriate authorities who are trained and equipped to handle such fires.

Certain plants growing in the forest also produce toxic fires. The oils in Poison Oak, Ivy and Sumac are carried in higher concentrations when burned in smoke. These not only can cause annoying skin rashes and irritations, but can be fatal if the smoke is inhaled into the lungs. Learn to recognize these plants. They are part of the forest ecosystem and burn along with forest floor litter and the trees. Take precautions not to inhale smoke from any fire.

Effects of Fire

Wildlife is affected by the type of fire and type of vegetation being burned. Fire, where heavy fuels exist, tends to burn intensely and kill more animals, especially invertebrates and micro-organisms. Generally, vertebrates are rarely killed in fires, but when a deer, rabbit, squirrel or other animal dies in a fire, it usually has little effect on the population of its species. Wildfires that burn hotter also tend to kill more vegetation including overstory trees. Fires are more damaging to wildlife if they occur during nesting and denning season when young animals have a harder time avoiding intense heat and smoke.

Fire releases minerals into the soil which stimulates plant growth. Wildlife, in turn, benefit from additional minerals when they eat the new plant growth or the charcoal and ash. Some rabbits and white-tailed deer have been observed eating the charred bark or ash after a fire. Wildlife with flexible habitats and diets thrive while those who eat foods found only in mature or old-growth conditions, decrease. Burning helps remove the heavy litter layer on the forest floor making seeds more accessible to wildlife. It also creates an opening for dusting used by species such as bobwhite quail, wild turkey, and ruffed grouse.

The diversity of vegetation tends to increase when an area is burned. Burned areas often "green-up" faster in the spring thus providing early food and cover for many species of wildlife. Forbs and legumes such as beggarweed, partridge pea, and butterfly pea are quickly established after a fire. They provide nutritious, succulent forage (both vegetative and reproductive (fruit) tissues are consumed) for a variety of wildlife. Seed production is stimulated. Roaming animals such as deer and bear will find new pathways for moving to and from water, breeding areas and summer/winter ranges by following the burn pattern.

Invertebrates and their eggs are often killed by flames and heat. Flying insects are attracted to heat, smoke and to dead or damaged trees. Populations of certain species of insects may increase during and after a fire. Wildfire destroys the sap that keeps bark insects away. These insects soon move into a burned forest followed by woodpeckers and other birds who nest in cavities.

Fire can have negative effects on aquatic life. Leaf packs are the source of energy for stream food chains. When a fire burns streamside vegetation, it reduces the amount of leaves that eventually reach the stream. This results in a reduction of the amount of aquatic life the stream can support. The loss of streamside vegetation removes the "buffer" that prevents eroding sediments from entering the stream. These sediments can reduce productivity for phytoplankton, reduce the size of fish spawning beds and resting places as sediment fills up pools, and can smother fish and aquatic insect eggs. Smothering prevents oxygenated water from reaching the egg surface and kills newly emerged fish fry by covering the gills with fine materials.

Burning streamside vegetation also raises stream temperatures by removing overhanging canopy allowing more sunlight to penetrate the water surface. It can also increase turbidity (a measurement of the amount of suspended particles in water such as silt, clay, phytoplankton, zooplankton and organic matter). Increased turbidity causes fish to have trouble seeing their food and may crush or dislodge eggs. Higher stream temperatures will decrease oxygen content and increase incidence of fish disease and kill or drive away fish species that require cooler water temperatures. Less mobile insects may also die when water temperatures increase. Nutrient loading will proliferate algae production resulting in a more diverse population of insect larvae which is beneficial to fish if toxic levels are not reached.

Water quality responses to fire involve turbidity and sediment. Sediment is the soil that gets in the water of the stream and then settles in the stream bed. Concentrations of various nutrients often increase after a fire. Some of these such as nitrogen often exceed drinking standards for short periods of time. Streams usually return to pre-fire levels of these nutrients quickly. Concentrations of a particular nutrient are usually reduced as the stream mixes with tributaries and groundwater flow.

The effect of a fire on water quality is often unpredictable as a number of factors come into play. Site differences in topography, soil characteristics and moisture content, variation in fuel moisture and fuel loads, density of vegetation, microclimates associated with a given slope, aspect and topographic position, and variations in weather patterns before, during and after a fire effect turbidity and sedimentation. As a general rule, the volume of water in a stream increases after a fire due to a reduction in plant cover.

A reduction in plant cover increases the susceptibility of nutrients to erosional losses. Nutrient uptake by plants is then reduced, which further increases the potential for nutrient loss by leaching.

Soils change as a result of fire whether the fire is a prescribed burn or a wildfire. When forests burn, the form, distribution and amount of elements or nutrients in the forest ecosystem change. Nutrients are continually cycled within and among the various organic components of the soil. When burn temperatures reach 100° C., fungi and bacteria are lost. Nitrogen loss begins to occur at 200° C., sulfur at 375° C and phosphorus and potassium at 774° C. Severe or stand replacing fires may burn the duff and the top layer of soil so that only ash remains on the surface and the mineral soil is "cooked" and discolored by a chemical change. Other elements such as calcium and manganese are vaporized at temperatures that reach more than 1000 degrees C.

Moist, thick duff will protect the soil from heating by fire. If the litter layer is thin, dry or partially burned the underlying soil can be heated substantially. The degree of heating depends on the type of fuel, intensity of the fire, the thickness, packing and moisture content of the litter layer and the properties of the soil itself such as water content, texture, and organic matter present. Destruction of micro-organisms in the soil may account for the increased plant growth after a fire as competition for nutrients is reduced but they quickly recover.

Nitrogen fixing plants also grow prolifically after a fire and may restore lost nitrogen. Nitrogen becomes available when it is cycled through soil organisms, oxidized by fire, precipitated or added in the form of nitrogen fertilizer. Bacteria also recover quickly as the conditions for their growth and reproduction are favored by the decreased soil acidity, optimal temperature, moisture and nutrient-rich ash.

Air quality is affected by fire. Smoke can reduce visibility on roads and airports as well as in the forest itself. Over 90 percent of forest smoke is water vapor and carbon dioxide. The major problem with smoke is the small particles that can't be seen with the naked eye. These particles can be inhaled into the lungs and compound any respiratory problem. Smoke can irritate the eyes, nose, and throat, and make breathing difficult. It can also spoil fresh paint jobs and laundry hung outside to dry for at least two miles downwind.

Fire Suppression

Objectives

Determine when to suppress a fire.
Know how fires are detected.
Know the causes of fire.
Understand how fires are suppressed in Georgia.
Know fire safety standards.
Understand interagency cooperation.

Fire Policy

Determining when to suppress a fire depends on the resource management goals and potential destruction of resources and property. At the turn of the 20th century, all fires were fought because fire was perceived as an enemy. Today we know all fires are not bad. Wildfires are always suppressed especially when threatening human life and property. Fire "under prescription", on the other hand, is allowed to burn within the limits defined in a fire plan. In some areas and with some agencies, this would include lightning caused fires where it has been determined that such fire would be beneficial to the ecosystem. This includes congressionally designated wildernesses.

Increased development in and around forests presents challenges to resource management and protection of human lives and property. House design, building material, site topography, landscaping, road design, accessibility for emergency vehicles, and availability of water are factors that should be considered when building a home in a wooded area. These factors greatly affect suppression efforts not only for defending homes but in controlling and conducting prescribed burns to achieve ecological objectives.

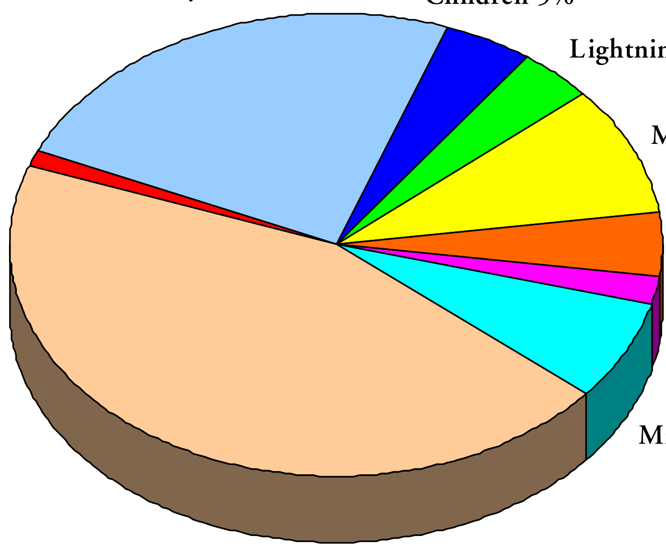
Fire detection is the key to effective forest protection. Most forest fires are reported by local citizens. Other fires are detected by air patrol and fire towers. Air patrols and fire towers are used sparingly until dry, windy conditions warrant increased detection efforts. Fire season refers to the time of year when most forest fires occur. Most forest fires in Georgia occur during the dry and windy months of February-April
and October - November. In some years, hot, dry weather and high winds can change the season and make it earlier, later or longer.

Causes

There are two basic causes of wildfires. One is *natural* (lightning) and the other is *people*.

Natural fires are often started by lightning. Lightning accompanies thunderstorms and is a short-lived, bright flash of light produced by electrical discharges as powerful as 100 million volts. Of the three types of lightning recognized —— *cloud-to-ground*, *cloud-to-cloud*, and *cloud-to-air* —— the form most likely to generate fires on the ground is ***cloud-to-ground.*** Cloud-to-ground lightning occurs when the electrical charge travels between a negatively charged cloud base and the positively charged ground. When a lightning bolt strikes, the electrical energy changes into heat. Temperatures in the path of a lightning bolt can reach as high as 50,000 degrees Fahrenheit (28,000 degrees Celsius), five times hotter than the surface of the sun.

The color of lightning indicates the content of the surrounding air. The flash will appear *red* if rain is in the cloud, *blue* if hail is present and *yellow* if a significant amount of dust is in the



atmosphere. *White* lightning indicates an absence of moisture in the air and as a result is more likely to generate a ground fire. Not all lightning strikes start fires. It must combine with local weather and vegetation to produce fire.

Humans are responsible for most wildland fires most of which are avoidable. These fires stem from activities and actions both intentional and accidental. The following is a list of the causes of wildfires from human origin.

<u>Debris Burning</u> is a fire set for burning brush or debris such as land clearing, yard waste, weeds, grass, trash, garbage, etc. Debris burning requires a burning permit and should be done only with control in mind and safety practiced. **Note: Burning garbage in Georgia is illegal.**

<u>Incendiary</u> is the name given to a fire caused by anyone willfully setting fire to vegetation or property not owned or controlled by him and without consent of the owner or his agent. Known as arson, this is a felony crime and punishable by fines, imprisonment, or both.

<u>Smoking</u> causes fires either by a smoker's match, lighter, or by burning tobacco in any form.

<u>Campfire</u>s started for cooking, heating, providing light or mood may cause wildfires if left unattended, improperly built or inappropriately fueled.

Machine use is the category of fire caused by mechanical equipment or its operation.

Children who are 12 years of age or younger may play with matches, experiment, or accidentally start fires.

Railroads are the source of fires caused by equipment or personnel engaged in the construction, maintenance, or operation of this common carrier mode of transportation.

Miscellaneous is the category of fires caused by specific means that cannot be properly classified under any of the other causal categories. Examples of causes are fireworks, structure fires, powerlines, and spontaneous combustion.

Causes of Forest Fires in Georgia (Fiscal Years 1989-1998)

Suppression

The heart of the fire fighting team is the firefighter with a tractor/plow unit. This consists of a crawler tractor and accompanying fire plow. As the crawler moves through the woods, the plow removes the forest fuels by creating a firebreak of bare ground four to six feet in width. The size of the firebreak could increase depending upon the size of the fire. Because different regions of the state have different fuels, weather, and topography, tractor/plow units may be large or small, depending on the need.

Ground crews equipped with hand tools such as shovels, chainsaws, and pulaskis (combination of ax and mattock) are used to create fire breaks where terrain is steep, hard-to-reach, or inaccessible to heavy equipment. Roads, bodies of water, rock outcroppings and bare soil areas are incorporated as part of the fire break when possible.

Air patrol is used to help with fire fighting. The pilot can radio information to fire fighters on the ground about how to get to the fire, fire behavior, and lay of the land. A pilot saved the lives of several firefighters in North Georgia by advising them that they were completely surrounded by fire. They used their tractor and plow to create a safety zone by the time the fire reached them. Airplanes and helicopters are also used to dispense water and fire retardant (a combination of chemicals and water).

Fire personnel are available 24 hours a day, 7 days a week, 365 days a year. Local, state and federal dispatchers are available to take fire calls around the clock. Usually, people call their local fire department and their dispatchers contact the agency responsible for the fire's suppression. An elaborate radio communication system allows fire personnel to talk to each other, to air patrol, towers, and other fire suppression agencies. Once dispatched to a fire, firefighters can evaluate and report the fire's progress and request additional support if needed.

Agents of the Georgia Forestry Commission have the right to go on any land to suppress, control, or prevent forest fires without being held liable for trespassing.

Fire Safety

Fighting fire is an inherently dangerous occupation. Certain guidelines have been established to insure the safety of fire personnel These are known as the *10 Standard Fire Orders:*

FIRE ORDERS

Fight fire aggressively but provide for safety first.
Initiate all action based on current and expected fire behavior.
Recognize current weather conditions and obtain forecasts.
Ensure instructions are given and understood.

Obtain current information on fire status.
Remain in communication with crew members, your supervisor and adjoining forces.
Determine safety zones and escape routes.
Establish lookouts in potentially hazardous situations.
Retain control at all times.
Stay alert, keep calm, think clearly, act decisively.

In addition, a checklist of *situations* that signal possible dangers are:

SITUATIONS

1.. Fire not scouted and sized up
2. In an area or country not seen in daylight
3. Safety zones and escape routes not identified
4. Unfamiliar with weather and local factors influencing fire behavior
5. Uninformed on strategy, tactics and hazards
6. Instructions and assignments not clear
7. No communication link with crew members/supervisors.
8. Constructing line without safe anchor point
9. Building fireline downhill with fire below
10. Attempting frontal assault on fire
11. Unburned fuel between you and the fire
12. Cannot see main fire, not in contact with anyone who can
13. On a hillside where rolling material can ignite fuel below
14. Weather is getting hotter and drier
15. Wind increases and/or changes direction

16. Getting frequent spot fires across line
17. Terrain and fuels make escape to safety zones difficult
18. Taking a nap near the fireline

Interagency Cooperation

There was a time in Georgia when forest fires were fought by forest rangers and house fires were fought by firemen. Rarely did a forest fire threaten a house, because there were not many houses. It was during this time that families lived close together, in groups. Houses were built in clearings and the dirt yards were swept clean daily, removing any debris that might carry fire or become habitat for unwanted animals.

Today the landscape is covered with houses. The popular trend is to build in and around the much loved forest. But there is fire in the forest and forest rangers meet much too often with firemen as both forest and houses burn together. These situations are very intense and complicated requiring full cooperation from all involved. Interagency Cooperation is the term used to describe how many agencies work together to protect public health and property.

The Georgia Forestry Commission is responsible for suppression of forest fires in the State of Georgia and the USDA Forest Service is responsible for suppression on the National Forests. This does not mean however, that the agencies necessarily do the job alone. Both rural and city fire departments are charged to protect their community. Private companies that grow timber, so that we can have paper and wood products, must also protect their valuable forests. In addition to the US Forest Service, federal land managers such as the U. S. Fish and Wildlife Service, National Park Service, Bureau of Land Management and Bureau of Indian Affairs are also charged to manage fires on nationally owned lands. All of these agencies may work together to suppress a fire. If a fire threatens safety on a roadway, the Department of Transportation, Georgia State Patrol, and county Sheriff may help to direct traffic. The worst forest fires may even require help from the military. If the governor declares a state of emergency, all resources are required to work together to protect life and property. Agencies like the Salvation Army and the Red Cross may provide food and shelter for firefighters and for displaced citizens. An organization called the Georgia Emergency Management Agency is tasked with coordination of all of the above agencies whenever the job gets too big and too complicated for local government to handle and the Federal Emergency Management Agency helps with disasters that overwhelm the states.

The fire job remains in control of the agency having primary jurisdiction. The fire officer will use all of the above resources, through a process called Interagency Cooperation, to get the job done. Interagency cooperation starts before a fire occurs. Fire personnel meet with the fire department chiefs to get acquainted with everyone that helps when a forest fire occurs. They get together often and talk about all of the jobs to be done to suppress a fire and to protect the public. When the fire does occur, everyone has a job to do, and the pieces of the fire suppression job fall together like a jigsaw puzzle.

There are national standards that have been developed to standardize interagency cooperation across the entire United States. Called the NIIMS, National Interagency Incident Management System, the system integrates common communication terminology, training, fire fighting qualifications, informational publications, and supporting technology, to insure that the cooperation we have been talking about can work nearly anywhere for any type of problem. We are talking mainly about fire, but a hurricane, tornado, flood, hazardous material spill, or other type incident may require the same type of interagency cooperation. The backbone of NIIMS is the *Incident Command System*.

The Incident Command System provides an organizational chart of all of the jobs that may become necessary to suppress a fire. For instance, every fire must have a qualified Incident Commander. This could be the forest ranger driving a tractor/plow unit on a small forest fire, a fireman with a fire truck on a grass fire, or the head of an entire agency on a large forest fire. If the incident is small, the organizational structure is small. As a fire increases in size and complexity, the Incident Commander may need support such as someone to provide meals and repair equipment (logistics), someone to plan for needed resources (planning), someone to be in charge of the ground forces (operations) and someone to keep up with expenses and personnel work time (finance and administration).

INCIDENT COMMAND SYSTEM

INCIDENT COMMANDER

PLANNING OPERATIONS LOGISTICS FINANCE/ADMINISTRATION

Interagency cooperation plays an important role in filling all of these positions. The Georgia Forestry Commission may provide the incident commander and the other positions may come from the fire department, forest industry, federal agencies, etc.

The most important part of the Incident Command System that deals with interagency cooperation is the concept of Unified Command. A fire may have become so large that it crosses jurisdictional boundaries. If the fire is burning on the National Forest and on private property both inside the city limits and in the county, several agencies have major responsibilities. Each agency may have different policies and various goals to achieve. You might think that everyone would agree that the fire should be suppressed immediately at all costs. But some agencies may decide that the fire is beneficial or that the suppression method chosen would do more harm than good. How can the incident be organized to meet the needs of so many different people? Unified Command places representatives from each jurisdiction on a panel to discuss how to best handle the incident for all involved. This panel sets priorities like protection of life first, protection of property second, protection of natural resources third, until all the different agencies involved are somewhat satisfied. This way, everyone affected by the fire has some input into how the incident is handled.

You might say that all this organization could result in confusion and indecision. The trick is for everyone to work together all the time, not just when an emergency occurs. That way we all know what to expect from one another and who can best perform which jobs. Interagency cooperation is like teamwork. Practice makes perfect.

Agencies may work together on worthwhile projects like fire prevention and education about natural resources. This type work keeps interagency cooperation alive and ready for serious fire suppression work.

Interagency cooperation brings much needed manpower and equipment to the fire scene. A highly trained and coordinated team of people can work smarter than one person alone.

Fire Prevention

Objectives:

1. Know the history of Smokey Bear.
2. Know how fire prevention is organized in Georgia and the fire danger ratings.
3. Understand the burning permit system in Georgia.
4. Describe management objectives of prescribed burning.
5. Know what factors to consider when prescribed burning.
6. Understand the various burning methods for prescribed burning.
7. Analyze the effects of prescribed burning on other natural resources.

History

Fire can be friend or foe depending on whether it is under control or out of control. It has earned a reputation as a dangerous and notorious adversary when out of control. One of the most destructive fires in the United States occurred on October 8, 1871, in Peshtigo, Wisconsin. When it was over, millions of forest acres had burned and 1500 people had lost their lives. National Fire Prevention Week, occurring in the United States during the second week of October, continues today in commemorating the 1500 people who lost their lives during this fire.

Currently an estimated 30-32 million acres of forest land burn out of control each year worldwide.

Smokey Bear is the national symbol for forest fire prevention. How this came to be is an interesting story. During the 19th and early 20th centuries burning of the woods was done routinely to control insects, enhance grazing for farm animals, and clear land. Often these fires got out of control, burning much more than had been intended. Trains also ignited forest fires as did hunters and careless campers. An effort was needed to encourage people to be careful with fire in the forest. Before the United States entered World War II, the Japanese launched incendiary balloons from ships off the California coasts igniting prime timberland. The forest fire prevention message grew into a necessity with this threat and World War II. Timber was a primary commodity for battleships, gunstocks, airplane propellers, packing crates and hundreds of products in support of the military and war effort. The War also took the firefighters into the military so few men were left to suppress wildfires. Fearing that an enemy attack could destroy our forest resources at a time when wood products were vitally needed resulted in the organization of the Cooperative Forest Fire Prevention (CFFP) Program in 1942 by the USDA Forest Service. The Forest Service asked the War Advertising Council for assistance in conveying the message to citizens to help the war effort by doing what they could to prevent forest fires. The Council produced an appealing poster featuring Walt Disney's "Bambi" character asking, "Please, Mister, DON'T BE CARELESS." The Council found that an animal of the forest was the best messenger to promote the prevention of accidental forest fires, but Bambi was already spoken for by Disney.

Harry Rossoll, an illustrator with the USDA Forest Service in Atlanta, Georgia first drew Smokey Bear in the early 40's for the "Smokey Says" column that appeared in the Atlanta Journal and the Atlanta Constitution. Harry's Smokey, however had a stout, severe look that was not adopted as the symbol. In 1944, noted animal illustrator, Albert Staehle, was given a description by the Forest Service and the Council from which to paint a forest fire prevention bear. In the 1945 campaign, the public was introduced to Smokey Bear with a poster depicting Smokey pouring water on a campfire with the caption, "SMOKEY SAYS – Care will prevent 9 out of 10 forest fires". Smokey's signature slogan, "Remember… Only YOU can prevent forest fires," was seen and heard for the first time in 1947. Rudy Wendelin, a USDA Forest Service illustrator with the Washington, D.C. headquarters, refined Smokey into the rounded nose, blue-jean wearing cartoon character we know today.

After World War II, the War Advertising Council dropped the word War from its name and became simply the Advertising Council. Smokey's campaign broadened to appeal to children as well as adults. In 1952, Congress passed Public Law 359, or the "Smokey Bear Act", to guard against the misuse of this fire prevention symbol. During the same year a licensing program was started which continues to this day to control the manufacturing and sale of items using the Smokey Bear symbol. Royalty proceeds are collected by the Forest Service and returned to the CFFP Program for use in furthering the forest fire prevention message.

A significant chapter in Smokey Bear's history occurred in 1950 when a bear cub was found clinging to a tree after a wildfire destroyed over 17,000 acres of the Lincoln National Forest in Capitan, New Mexico. Taken in and cared for by local forest fire fighters and veterinarians, the recovery of the burned cub was monitored by the American public. The cub became a living counterpart to the CFFP's fire prevention symbol that had evolved six years earlier.

The Smokey Bear of New Mexico died in 1976 at the National Zoo in Washington, D.C. and was returned to Capitan for burial. When the second Smokey died in 1990, the living symbol was laid to rest.

New challenges are making Smokey's task increasingly difficult. Although Smokey's mission has always been to educate people in what they can do to prevent *accidental* forest fires, some feel the message leaves no room for using fire as a tool in ecosystem management. Increasing numbers of people are living in the wildland-urban interface where accidental forest fires can spread to nearby residences. Demand for our dwindling natural resources continues to grow as does the population. Obviously the need to prevent accidental wildfire will be greater than ever, and Smokey helps to remind us, "REMEMBER… Only YOU can prevent forest fires!"

Fire Prevention in Georgia

Georgia is the largest state east of the Mississippi River, with a total land area of 37 million acres. Sixty-five percent, or 24 million acres, is forested. Forestry is Georgia's number one industry contributing close to 20 billion dollars to the economy as of 1998. Protection of the forest from destruction by wildfire is still a primary thrust of the Georgia Forestry Commission, USDA Forest Service and the forest industry.

State headquarters for the Commission is located at the Forestry Center in Macon, Georgia. The State Forester, J. Frederick Allen, is Director of the Commission and supervises a staff that includes the Chief of Forest Protection. There are 12 forest protection districts across the state with approximately 13 counties in each district. Forest rangers working for the chief ranger, suppress the fires with crawler/plow units. All newly hired fire control personnel are required to attend a four week training period at the Georgia Forestry Academy and graduate with a minimum score of 70 on each of the weekly exams.

The Georgia Forestry Commission also administers the Rural Fire Defense (RFD) Program. Initiated in 1968, the RFD program equips, trains, and assists rural communities for fire control. In return, the Commission is provided with a back-up force of personnel and equipment for emergency forest fire use.

Money to fund forest protection in Georgia comes from county and state governments. Each county government pays four cents per forested acre in its boundary and the State pays the remainder of the cost. This money is used to pay salaries, provide funds for operating costs, purchase equipment and for maintaining offices and shops.

Fire Rating

The Georgia Forestry Commission's daily agenda depends heavily on the weather forecast. Fire behavior is directly related to weather conditions making it important for forest rangers to know the daily weather forecast. The Commission employs a forestry meteorologist at the headquarters in Macon. He produces a forecast twice a day that helps the rangers plan ahead for fires. Not only is the normal forecast produced for each district, but a set of fire danger ratings is given to indicate how severe a fire might burn on a given day. Fire danger ratings are on a scale from class 1 to class 5. *Class 1* is a low danger of fire, *Class 2 and 3* is a moderate danger, and *Class 4 or 5* indicates a high danger of fire where any fires ignited are likely to escape control. The forest rangers can provide weather conditions when you call for a burning permit and are available to help with outdoor burning by being present at the burn with a tractor/plow unit. This is done on a first-come, first-served basis.

Over the years, careless debris burning has been the leading cause of wildfires accounting for 40% of the total fires. Nearly every one in Georgia eventually has something that they want to burn. Too many people, though, do not take the proper precautions to control their fires.

Wood arson is the second leading cause of forest fires. This accounts for one in every four of Georgia's forest fires. Arson is considered a felony crime. The Commission has several investigators who are trained to determine the cause of forest fires and conduct investigations if necessary.

Burning Permit

The "Forest Fire Protection Act" of 1942, referred to as the permit system, has been a valuable fire prevention tool. This law requires that notification be given to the county ranger prior to starting a fire. It has helped in promoting safe burning and in the understanding and perception of prescribed burning as a forest management tool.

Permits are given by the forest ranger from the county in which the burn will occur. A permit number corresponding to a permanent record at the office will be issued if weather conditions are right for burning. Your request for a permit could be denied if it is determined that smoke from the fire will cause a problem or obstruction of highway visibility, or the fire rating is high. In 1998, the Governor of Georgia declared by Executive Order the *Voluntary Ozone Action Plan* for the counties of Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Henry, Paulding, and Rockdale. Implemented from May 1 through September 30, the policy is an effort to be in compliance with the Clean Air Standards for Atlanta. It requests that such activities as re-fueling of vehicles and lawn maintenance be done after 6:00 P.M. The issuance of burning permits is restricted in these counties during this time frame.

A permit is good from dawn to dusk on the day the permit is issued. The applicant must specify the burn location, the size of area to be burned, and what is being burned.
Debris to be burned must originate from the area being burned. Burning garbage and dimensional lumber (treated wood) is not allowed. The permit provided by the county forest ranger is in addition to any notice, permit or requirement for burning by a local county or municipality law, ordinance, or resolution. There is no charge for permits issued by Georgia Forestry Commission.

Prescribed Burning

Prescribed burning is "the controlled application of fire to wildland fuels in either a natural or modified state, under specified environmental conditions which allow the fire to be confined to a predetermined area and at the same time produce the intensity required to attain planned resource management objectives." The phrases prescribed burning and controlled burning are often used incorrectly. The difference consists in the need for a written prescription.

With a prescribed fire, a written burning plan is prepared by a knowledgeable person for each area to be burned. The plan is completed before the burning begins. It serves as a checklist to insure that some aspect or potential impact of the fire has not been overlooked. Controlled burning, such as a campfire or debris burning, is a systematic prearranged burn which is confined to a specifically designated area. It does not require a written prescription but may require a permit.

Our understanding of fire's role in the ecosystem continues to grow. With the success of fire prevention and its exclusion from the forest, natural fire cycles have been disrupted in ecosystems dependent upon or adaptive to fire disturbances. Increased tree densities, understory growth, and accumulation of flammable forest fuel have led to larger and more severe wildfires. The Yellowstone fires of 1988 are considered by some as a high profile example of such a wildfire. Since the 1980s, large wildfires in dead and dying forests have accelerated the rate of forest mortality. Susceptibility of trees to insects and disease has increased and many fire dependent species are threatened with extinction due to the exclusion of fire in their ecosystem. Many forest managers have come to recognize how essential fire is in certain forest ecosystems.

Longleaf pine once covered nearly 70 million acres of the southeastern coastal plain of the United States. Today, less than 5 million acres of this southern pine type remain Longleaf pine forests are among the most fire dependent forest types in the world. Most original longleaf forests were regularly burned on a natural frequency of 2-7 years ignited by lightning. The suppression of wildland fires in longleaf stands is thought by many to have seriously affected the integrity and health of this ecosystem.

During the past several decades, prescribed burning has become an accepted forest management practice for southeastern pine woods. When foresters first used this tool in the 1940s it was viewed as a means to an end and not as a natural part of the ecosystem. Commercially valuable pine stands were competing with encroaching hardwood species and prescribed fire was used to control this encroachment.

Today the sustainability of a forest is measured by forest productivity, diversity, resiliency and the maintenance of ecological processes over large land areas. As it turns out one of the best ways to fight fire is with fire.

Management Objectives

Foresters and land managers may use prescribed burning for numerous reasons including one or more of the following:

Fuel Reduction. One of the most important reasons for prescribed burning is to reduce naturally occurring fuels within the forest area. Reduction of forest fuel build-up reduces the risk of intense, uncontrollable wildfires that threaten life, property, and economic timber losses. It is one of the most cost effective elements of any fire prevention program when compared to suppression and damage costs. Complete coverage is not necessary when prescribed fire is used to reduce fuel accumulation. The objective is to break up fuel continuity. This can usually be achieved satisfactorily by burning about 75% of the area. Unburned patches continue to provide cover and food for wildlife.

Southern pine stands of the Coastal Plain can accumulate a dangerous level of combustible fuel over a five to six year period. Plantations are often burned for the first time when they are 15 to 20 feet tall. Subsequent burns usually occur on a three to five year cycle, but each area to be burned must be evaluated individually based on factors such as stand size, species composition, drought years, amount and arrangement of fuels.
Cool, damp conditions with some wind and closely spaced ignition spots are a must to avoid crown damage. Fuel reduction burns are usually conducted in the winter.

Insect and Disease Control. Prescribed burning helps control the fungal infection, brown spot needle rust, in longleaf pine seedlings. Longleaf pine is a tree species that has adapted to allow fire to be utilized at an early stage in its life. Once fire consumes the diseased needles on young pines, the seedlings can continue to store carbohydrates in their roots which aids with growth acceleration. Prescribed burning also helps to control insects such as the white pine cone beetle (Conophthorus coniperda) . Problems from the fungal disease, Fomes annosus root rot, seem to be reduced where prescribed fire has been used.

Maintenance of native species in fire-adapted ecosystems. Certain natural systems are dependent upon periodic fire for maintenance of their biological diversity. Many plants have structural adaptations, specialized tissues, or reproductive features that favor a fire-dominated ecosystem. Fire is essential for the longleaf-bluestem forest ecosystem occurring from Mississippi to east Texas and for the longleaf-slash, pine-wire, grass-saw palmetto ecosystems found in south Georgia and much of Florida. Without fire in these ecosystems, shade tolerant species invade the sites, displace the grasses and surpass the growth of pines. Plants, such as orchids and pitcher plants, are benefited by fire. The interval between fires as well as the fire intensity need to be understood for each species before a fire can be prescribed to benefit that species.

Wildlife Management. Where loblolly, shortleaf, longleaf, or slash pine is the primary overstory species, prescribed burning is highly recommended for habitat management. A mosaic of burned and unburned areas tend to maximize “edge effect” which promotes a large and varied wildlife population. Fruit and seed production is stimulated. Yield and quality increases occur in herbage, legumes and browse. Openings are created for feeding, travel and dusting.

Game species that benefit from the effects of prescribed burning are deer, quail, dove and turkey. Endangered species include the Florida panther, gopher tortoise, indigo snake and the red-cockaded woodpecker.

Site Preparation. Prescribed fire is useful for the regeneration of planted southern pine by controlling competing vegetation until seedlings become established, hastening the return of nutrients to the soil for use by the young trees, improving visibility of tree planting hazards such as stumps and allowing easier access and movement by planting crews. With natural regeneration, any burning should be done several weeks PRIOR to seed fall.

Disposal of logging debris. Unmerchantable debris leftover from logging is an impediment to both people and planting equipment. Broadcast burning is preferable to windrow, or pileup, burning due to smoke management problems and the potential for site degradation. If overstory pines are left as seed trees, more care is needed during burning to insure their protection.

Factors To Consider When Prescribed Burning

As with wildland fire, *weather, fuel and topography* are factors to be considered with prescribed fire.

The weather forecast for the day of the burn, the following night and a 2-day outlook is necessary for a successful prescribed burn. Weather observations should be made at the prescribed burn site immediately before, during and after the burn. Four sources for weather information are: National Weather Service, State Forestry Agencies, Local Observations, and Private Weather Forecasting Services. The best source of information is generally the local office of your State forestry agency.

Weather changes by the minute and these changes can directly affect fire behavior. Wind is recognized as the most important variable to be considered when using prescribed fire. A steady wind, both in direction and speed, is desired. Winds vary with the density of the stand and crown heights. Speed should be a minimum of 3-miles per hour and a maximum of 8-10 miles per hour under normal conditions assuming other weather factors are favorable.

Winds from the northwest and northeast, are preferred. These winds usually coincide with other favorable weather factors. Easterly winds are generally unreliable. Proper burning is possible, however, with wind from any direction provided it is steady and other factors are favorable. Any sudden change in wind direction is undesirable.

Relative humidity greatly affects fuel moisture and fuel moisture affects the prescribed burn. Preferred relative humidity for prescribed burning varies from 30% to 50%. When humidity is 25% or lower, prescribed burning is dangerous. When humidity is greater than 60% the burn may not be hot enough to accomplish the desired result.

Low relative humidity means dry fuels and high relative humidity means damp fuels. The preferred range of actual fuel moisture is from five to ten percent. Burning when fuel moisture is below 5% may result in serious damage to young growth, overstory, and even soil. When fuel moisture is high, fires tend to burn slowly and irregularly and are often incomplete.

Be familiar with the area you are burning beforehand. Know what roads are in the area and their status of use. Roads are essential in planning travel routes to and around a fire and can be utilized as control lines in some cases. Be familiar with cross country barriers such as creeks, swamps, and cliffs. Know the location of steep slopes, ridges, and water sources that will affect the behavior of the fire as well as suppression tactics. Know the best access to any and all area of land being burned and where to establish control lines and fire barriers. Know where areas of excess fuel buildup are and be prepared to handle any increase in heat intensity. Always be alert to the fact that a change in topography can cause a change in the behavior of fire.

Burning Methods and Applications

Three types of fires are used for prescribed burning. Based on behavior and spread, fires either move against the wind (*backing fire*), at right angles to the wind (*flanking fire*), or with the wind (*heading fire*). Each one is used only after an adequate fuel free zone is established at the downwind boundary of the area to be burned. Fire lines should be carefully planned and plowed before the fire, but not so far in advance that freshly fallen debris poses a hazard.

Backing fires, or backfires, are set on the windward side of a control line. These fires burn into the wind at rates of one to three chains per hour (one chain= 66 feet). These are the easiest, safest and least intense types of fires to use as long as windspeed and direction are steady. When a large area is to be burned, interior lines are often plowed at 5 to 15 chain intervals and additional backfires set along them. Backfires are often used to reduce heavy rough. This fire type is also used in young stands with a minimum basal diameter of three inches and when the air temperature is below 45 degrees.

In-stand winds of 1 to 3 mph are desirable with backing fires. These conditions prevent heat from rising directly into tree crowns and helps dissipate the smoke. The cost of using backfires is relatively high because of additional interior plow lines and an extended burning period due to the slower movement of the fire.

Flanking fires are set by treating an area with lines of fire set directly into the wind. The lines spread perpendicular, or at right angles, to the wind. Land slope has an effect on the rate of spread similar to that of wind. Fire intensity with this kind of fire is intermediate. It is best used in medium-to-large sawtimber. This fire type requires considerable knowledge of fire behavior, expert crew coordination and timing, and effective radio communication. Wind direction must be steady. Fuel loading should be light to medium (less than 8 tons per acre) and a downwind base line should always be secured first.

Heading fires, also known as headfire or strip-heading fire, run with the wind into a prepared firebreak. A series of lines of fire are set 1 to 3 chain lengths apart to prevent a high energy fire level. This distance can vary depending on several variables. A backing fire is generally used to secure the base line while the remainder of the strip area is treated with a headfire requiring fewer interior plow lines. Headfires permit quick ignition and burnout needing just enough wind to give direction, generally 1-2 mph in-stand. Winter use is best (below 60 degrees Fahrenheit) to help avoid crown scorch where lines of fires burn together and fire intensity tends to increase.

This type of fire is used in medium-to-large sawtimber and for annual plantation maintenance after initial fuel reduction has been accomplished. Cost is lower than the other two fire types because fewer interior plow lines are required and fire progress is rapid.

Smoke Management

When using fire there will be smoke emissions into the surrounding air. In addition to air quality concerns during burning, smoke can also decrease visibility on roads and in the surrounding environment. This is a primary concern with respect to prescribed burning.

For smoke management, the most important tool of prescribed burners is the forecasted weather information. These forecasts are needed to project the trajectory and dispersion rate of the smoke. Burning at night is often discouraged because the wind often dies down and the smoke tends to stay near the ground and accumulate in hollows. Burning fuels with low moisture content, scattered rather than piled debris, and using backfires where possible are practices that tend to minimize smoke.

The amount of smoke generated depends on weather conditions, type of fire used, amount and type of fuel being burned, its moisture content and the size of the area being burned. Minimizing adverse environmental effects, especially near populated areas, hospitals, and airports should always be of primary concern to the burner. If information is incorrect or conditions become dangerous the burn must be discontinued.

Environmental Effects of Prescribed Burning

Effects on Vegetation

Survival and susceptibility of vegetation from prescribed burning is dependent on a combination of factors such as fire intensity, length of exposure to high temperatures, plant characteristics such as bark thickness and stem diameter, temperature of the air at the time of burn, season of the year, and the interval between prescribed fires.

Hardwood trees are more susceptible to fire injury than are pines. Prescribed fire is generally not used in the management of hardwoods once a stand is established. Pines such as the longleaf are *fire-dependent* species and depend upon fire as part of their ecosystem survival. *Fire-tolerant* species are able to withstand fire but are not dependent upon it for survival. Pine trees three inches or more in ground diameter have bark thick enough to protect the stems from damage by most prescribed burns. Cambial damage can occur if the duff around the root collar smolders for an extended period of time. This kind of damage is more likely in mature, previously unburned trees where a deep organic layer has accumulated. As a rule, plants are more easily damaged by fire when they are actively growing.

Streamside (riparian) vegetation is excluded from prescribed burns to protect associated plant and animal habitat and water quality. A control line should be put in to protect this kind of vegetation during a prescribed burn if an adequate buffer zone is not present.

Effects On Wildlife

Fire effects on wildlife are complex. They are often indirect, affecting habitat more than individuals. Fire is beneficial to some species and detrimental to others. Many species are attracted to the presence of fire due to the availability of prey. The major effects to wildlife from prescribed burning pertain to animal habitat: food, cover, and water. Burning can improve habitat for species such as quail, deer, turkey, birds and other animals by increasing food production and availability and by diversifying cover choices.

The deleterious effects of prescribed burn on wildlife include destruction of nesting sites and killing of wildlife from being trapped. Fortunately, prescribed burns can be planned at times when nests are not being used, and by allowing ample escape routes for wildlife by avoiding the practice of ring firing – lighting all sides of a burn area. Most plants and animals living in a fire dependent ecosystem are well equipped to deal with fire. Small mammals and reptiles burrow underground, while larger mammals and birds simply flee the area until the fire has moved past.

The endangered red-cockaded woodpecker presents a special challenge in a habitat historically maintained by fire. By using short flame lengths and raking the fuel away from the cavity trees, the likelihood of igniting the dried resin that flows from the nest cavity toward the ground is decreased.

There are studies showing prescribed burning adjacent to trout streams changes the ph making streams less acidic thus enhancing the aquatic insects and food for trout. An improperly done burn however, can cause sedimentation to streams and rivers if erosion from the site occurs.

Effects On Water

In the South a properly planned prescribed burn will not adversely affect the quality or quantity of water. Increase surface runoff, sedimentation and ash accumulation in water sources will occur, though, as well as leaching of minerals into the ground water if burns are not properly conducted.

Effects On Air

Smoke consists of small particles of ash and partly consumed fuel and liquid droplets. Gases such as carbon monoxide, carbon dioxide, hydrocarbons, oxides of nitrogen and sulfur are other combustion products in smoke depending on the amount and type of fuel being burned and the rate of fire spread as determined by timing and type of firing technique used. The greatest problem associated with prescribed burning, though, is visibility. Atmospheric stability and windspeed are the main factors determining the rate of smoke dispersal. Weather and smoke management forecasts are available from local weather stations and fire management units. These factors must be considered before a burn takes place. The burner could be held liable if accidents occur as a result of the smoke from a prescribed burn.

Effects On Soil

How fires affect surface runoff and soil erosion is a major concern of the forest manager. Little danger of this exists in the Lower and Middle Coastal Plain sites in Georgia when part of the forest floor is left intact after burning. In the Upper Coastal Plain and Piedmont some soil movement is possible due to the steeper topography. In these areas and the mountains, burning should not be done if exposure of highly erosive soils is likely. In the mountains burning should be completed by mid-September to allow herbaceous plants time to seed in and provide a winter ground cover.

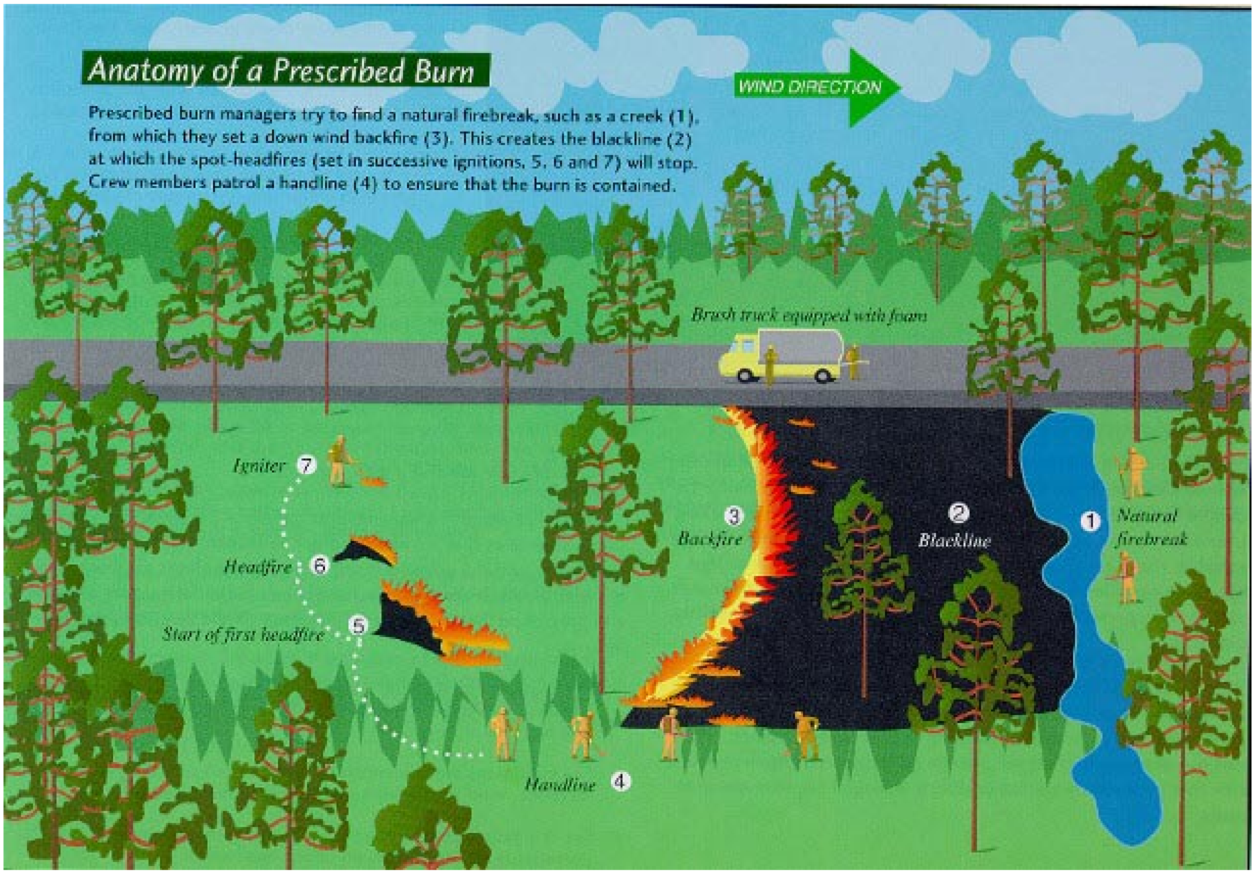
At the time of burning, soil should be wet or damp to ensure that an organic layer will remain and the microenvironment of the forest floor remains viable.

Effects on Human Health and Welfare

Drift smoke from prescribed burning is more often than not more of an inconvenience than a health problem. High smoke concentrations can pose particular risk to people with respiratory illnesses and the elderly. Fire management personnel exposed to high concentrations of smoke often suffer eye and respiratory irritations and need to be aware of continued exposure to carbon monoxide gases that could result in impaired alertness and judgment. On a prescribed fire this is virtually non-existent.

One group of compounds carried in smoke that can have an immediate effect on individuals is those found in poison ivy and poison oak. Breathing smoke with these compounds in them can cause severe reactions in people, especially anyone allergic to these plants.

Conclusion


Anatomy of a Prescribed Burn
Prescribed burn managers try to find a natural firebreak, such as a creek (1), from which they set a down wind backfire (3). This creates the blackline (2) at which the spot-headfires (set in successive ignitions, 5, 6 and 7) will stop. Crew members patrol a handline (4) to ensure that the burn is contained.
WIND DIRECTION
Brush truck equipped with foam
Igniter 7
Headfire 6
Start of first headfire 5
3 Backfire
2 Blackline
1 Natural firebreak
Handline 4

FIRE MANAGEMENT MANUAL

WILDLIFE MANAGEMENT SERIES

WWF

FIRE

MANAGEMENT

MANUAL

These guideline booklets are based on field experience and original research reports which are available from the WWF - SARPO in Harare. WWF wishes to acknowledge the important contribution made by the Rural District Councils and their constituent communities in the development of the series. The methods presented in the manual have been tested by the Support to CAMPFIRE Project over the last five years with different communities in a number of districts and wards.

In addition, WWF wishes to acknowledge the use of Lowveld Environmental Awareness Programme (LEAP) newsletter entitled “Veld Fires” which provided many useful ideas and diagrams for this manual.

The Norwegian Agency for Development Co-operation (NORAD) is funding the WWF Resource Management Support to CAMPFIRE Project which produced this guideline manual. The work undertaken here is part of a collaborative programme with the Department of National Parks and Wild Life Management.

Editing, illustration, design and production: **Action**

ACTION

WWF

This publication was also made possible through support provided by the office of USAID Harare under the terms of project 613-0241 and grant 690-0251-4-9001-00. The opinions expressed herein are those of the authors and do not necessarily reflect the views of USAID. This material has been produced by the authority of and for the use of the CAMPFIRE programme in Zimbabwe for information purposes only.

Published in January, 2001 by WWF - Southern Africa Regional Programme Office (SARPO), Harare, Zimbabwe.

CONTENTS

The use of a road as an effective fire break and/or as a fire break from which back-burning may be carried out.

INTRODUCTION TO THE FIRE MANAGEMENT GUIDELINE MANUAL

What is the objective of this manual?

Under the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) rural communities participate and benefit from the management of their wildlife and other natural resources. Over time, fire has played an important role in shaping our natural **landscapes**. In rural areas, and especially in community wildlife areas, fire is still an important aspect of management.

The purpose of this manual is to explain how fire may be used by communities to improve the management of their wildlife areas. It provides some general background on wild fires in Zimbabwe and then shows how fire can be used as a management tool in wildlife production. The methods described are simple, reliable and easily implemented at little cost. Importantly these methods focus on preventing the damage caused by hot late season wild fires rather than trying to control or put them out once they have started. These methods can be refined and improved over time by the participants as they become more confident and experienced.

These methods have been designed and tested by producer communities and Rural District Councils as part of the first phase of the WWF Support to CAMPFIRE Project.

How is this manual organised?

Chapter 1: introduces fire as a natural agent, provides a background to the causes and effects of fire and outlines broad issues of fire management in Zimbabwe.

Chapter 2: describes the ways in which fire can be used as a management tool, with particular reference to CAMPFIRE.

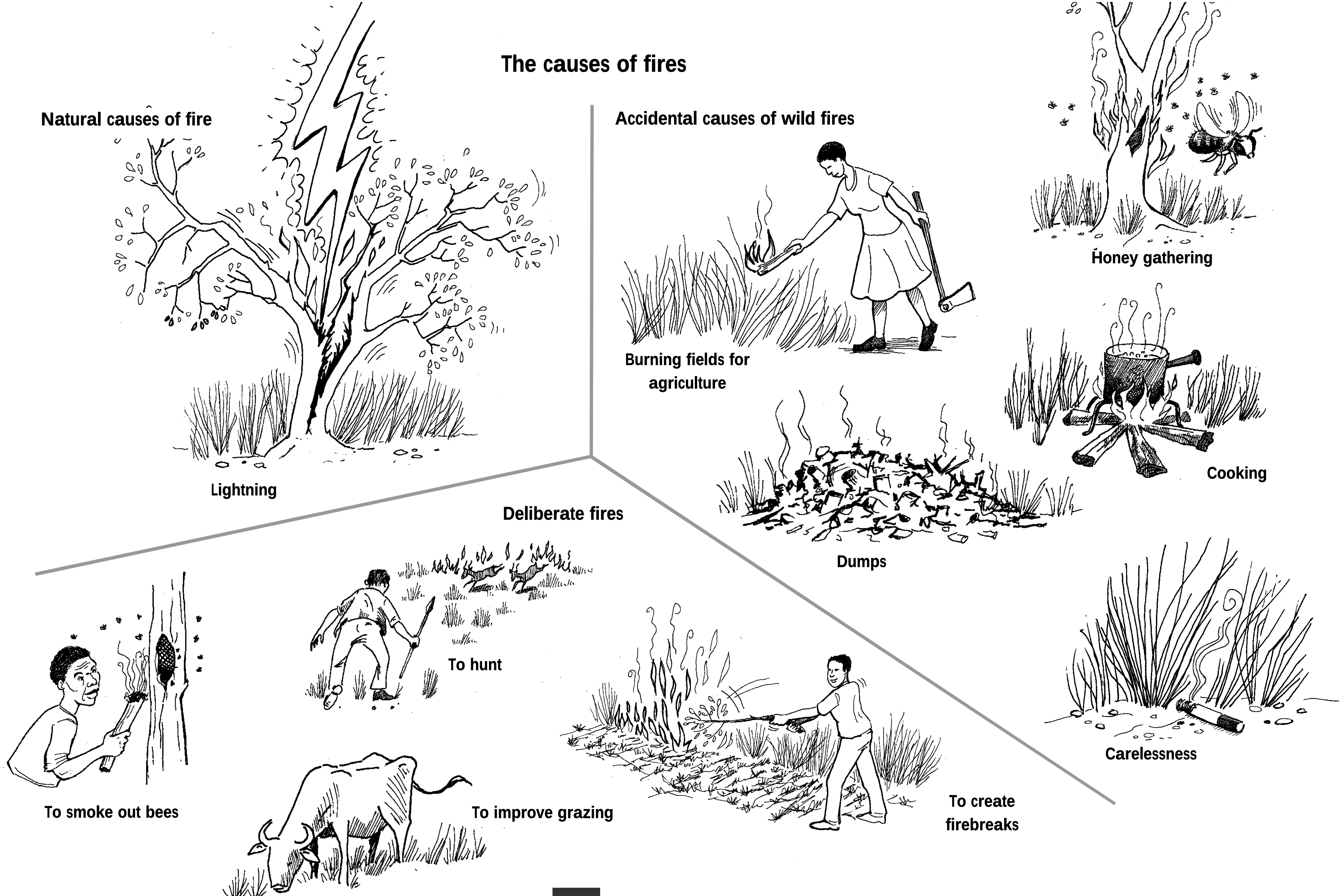
Chapter 3: deals with some practical issues such as setting up a reporting system for fires and practical advice for putting out wild fires such as back burning.

Chapter 4: covers the planning and implementation of early burning programmes.

Chapter 5: provides a case study of an early burning programme in Kanyurira Ward, Guruve District and the important lessons that can be learned from it.

In Appendix 1, there is a glossary which explains the technical words highlighted in the text. Appendix 2 gives the contact details of organisations which can assist with the development of fire management plans. Appendix 3 gives the vegetation characteristics of the three fire regions defined in the manual.

The causes of fires



CHAPTER 1

BACKGROUND TO FIRE MANAGEMENT

Is fire a natural agent?

Wild fires, usually caused by man or lightning, have always been a part of the African landscape. Most of the natural vegetation that we see around us has been shaped by the effects of fire. For example, the characteristic mix of trees and grass found in most of Zimbabwe's natural vegetation often is the result of wild fire. For this reason, fire should be seen as a natural element, to be used for its beneficial effect, rather than eliminated altogether.

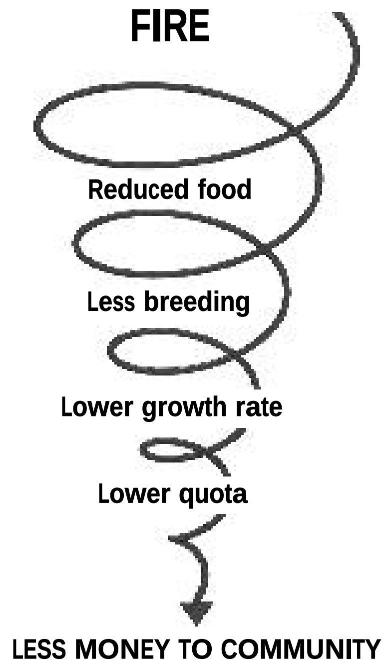
Why is fire important in wildlife management?

Wild fires are a common feature during the dry season throughout rural Zimbabwe. These wild fires can cause a severe reduction in wildlife habitat and production. In turn this can effect wildlife-based activities such as tourism and trophy hunting. This will reduce the revenue which are the incentives for Rural District Councils and wildlife producer communities to manage their wildlife and wildlife areas. On the other hand, it is also possible that total protection from fire can result in vegetation becoming less productive. This will also effect wildlife production and reduce the revenue earned from wildlife.

With a few relatively simple and inexpensive procedures, such as early burning, it is possible to:

- reduce the negative impact of fires, and
- enhance their positive effects.

This way fire can become a valuable tool in wildlife management.



How are fires caused?

There are several causes of wild fires.
Natural causes of fire are:

- lightning at the beginning of the rains

Accidental causes of fire are:

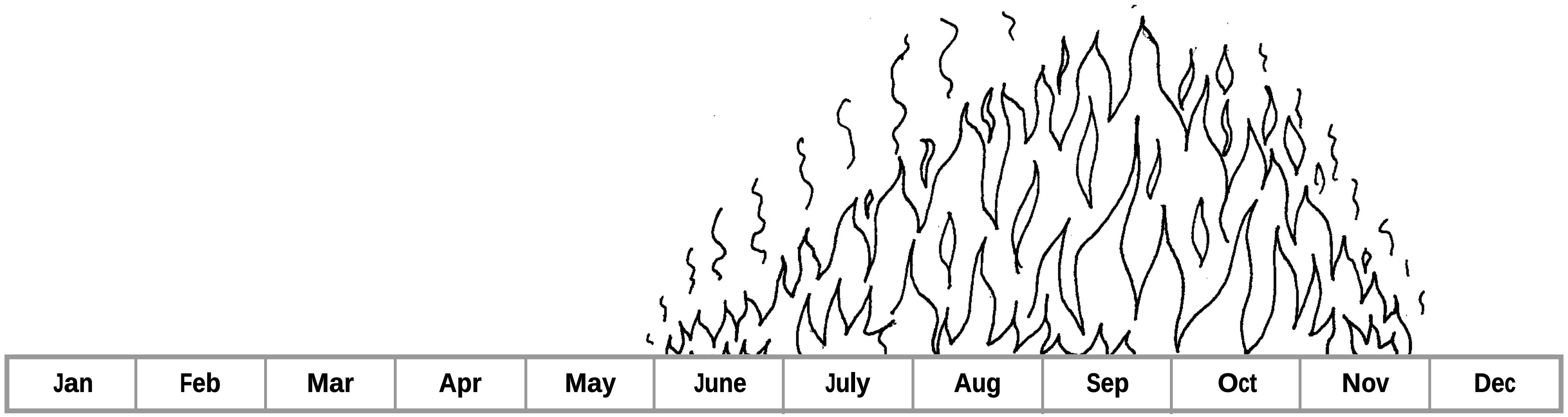
- cooking or camp fires at overnight stops, e.g., bus stops
- cigarettes carelessly thrown into the bush
- fires which escape during honey collection
- fires which escape during land preparation
- rubbish dumps around homesteads, hunting camps and mines

Fires are deliberately set to:

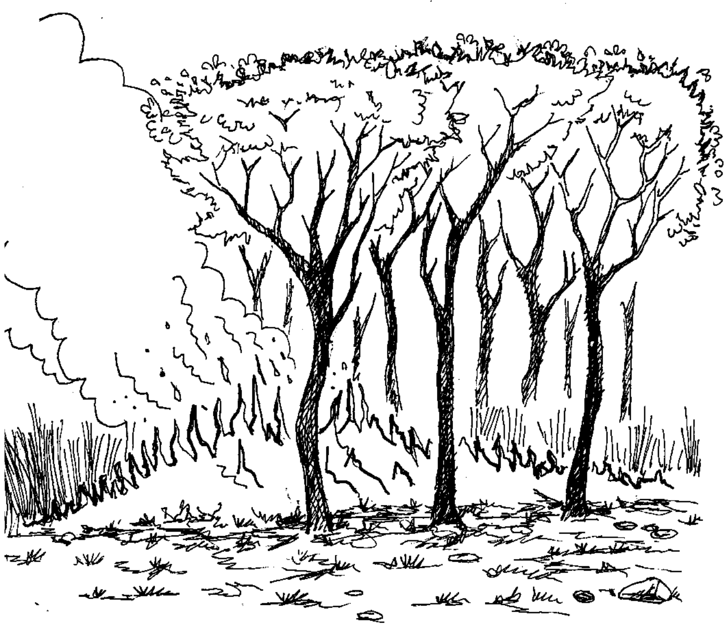
- improve grazing,
- clear land for cultivation,
- drive wild animals when hunting,
- make smoke in order to collect honey,
- reduce the negative impact of wild fires (early burning, back burning, burning fire breaks)

When do most wild fires occur?

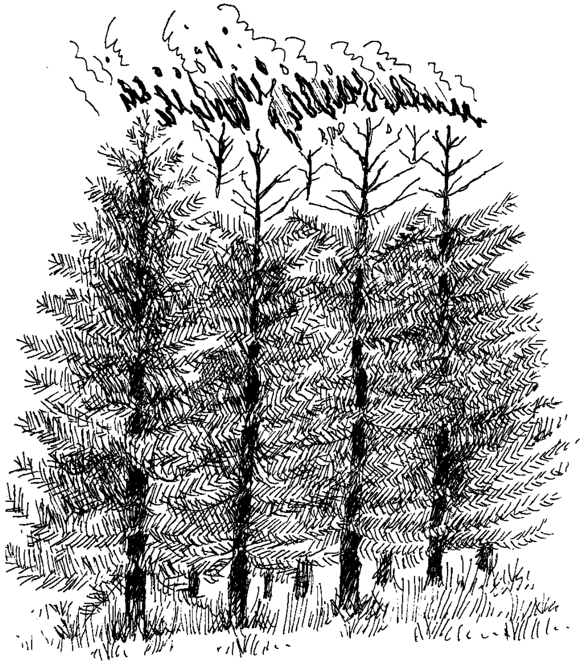
Wild fires start early on in the dry season, in about May or June. Most fires however, occur between August and October and sometimes November. The exact time of year at which fires start and finish depends on the past rainy season and the start of the rains in the current season.



Ground fires occur in mixed mopane woodlands with little grass cover



Crown fires occur in the timber plantations of the Eastern Highlands



Ground and crown fires occur in typical savannah woodlands in many parts of the country

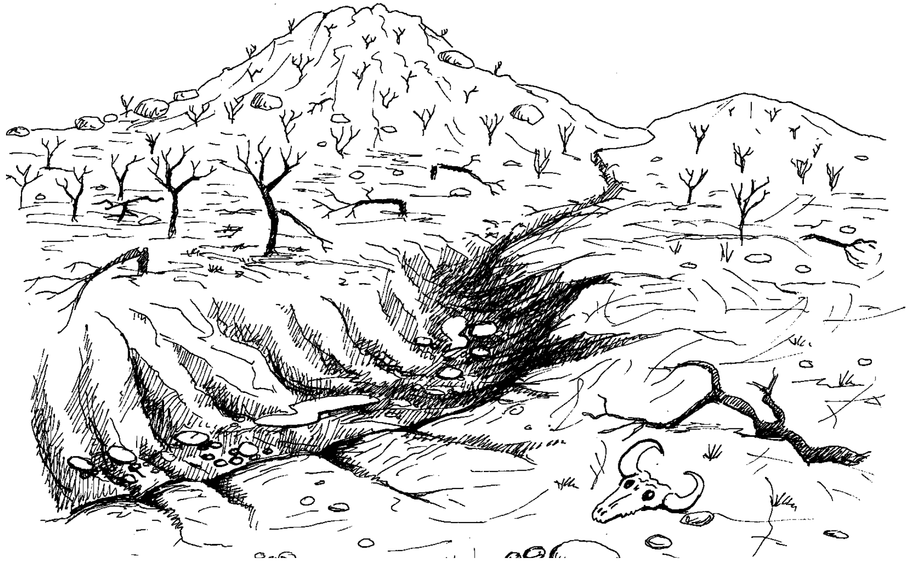
What are the different types of wild fires?

Wild fires are normally classified by where they are burning and the temperature of the fire.

- **Where they are burning:** There are two types of wild fires. These are surface fires which burn along the ground and crown fires which burn the upper parts of trees. Many late season hot fires are a combination of surface and crown fires.
- **The temperature at which they are burning:** More importantly in the Zimbabwean situation, wild fires are classified as either cool fires or hot fires. Cool fires usually occur early in the dry season when there is still moisture in the grass and leaves. Hot fires usually occur late in the dry season when the grass and trees are very dry. These fires are often made hotter and more destructive by the windy conditions in August, September and October.

Cool, early season fires produce a mosaic of burnt and unburnt areas which reduces the damaging effect of hot, late season fires

Hot, late season fires can remove most of the ground cover, leading to increased soil erosion



What are the general effects of wild fires?

The effects of a wild fire will depend on where it burns and at what temperature.

- **Cool, early season fires:** Earlier in the dry season (May to July), before the grass becomes completely dry, fires tend to be cooler and slow burning. This creates a patchwork of lightly burnt and unburnt areas. These fires are mostly ground fires.
- **Hot, late season fires:** Later in the season (August to October), just before the first rains, fires are hotter and may burn fiercely, covering vast areas and reducing everything to ashes. These fires tend to be combined ground and crown fires.

What are the effects of fire on wildlife?

The effects of wild fires on wildlife will depend on what kind of fire it was and the reaction of different species to the fire.

- The effect of cool, early season fires on wildlife: The patchwork of burnt and unburnt areas created by the cool early season fires generally has very little impact on wildlife populations as they will just move into the unburnt areas. After the first rains some species will be attracted to the new grass on the burnt areas.
- The effect of hot, late season fires on wildlife: After a large, hot late season fire most large mammals will move away from the burnt areas. Because these fires cover large areas, this might have a big impact on the use of wildlife for hunting or tourism purposes.

Different animal species respond to the effects of fire in different ways. For example:

- very selective grazers such as sable antelope may move to wetlands (**vleis or dambos**) where the growth of new green grass has been caused by fire;
- coarse roughage grazers, such as buffalo may move to unburnt stretches of land still good for grazing.

What factors determine the effect of fire?

There are many factors which determine the effects of wild fires, such as rainfall, vegetation types, the recent history of wild fires in the area, levels of settlement, cultivation and grazing. These factors, especially vegetation type, will determine a district or community's fire management strategy.

- **The rainfall and the vegetation type:** The type of vegetation and the amount of rain which falls in any given season have a marked influence upon the effects of fire. Not all vegetation types (habitats) will burn. In CAMPFIRE areas supporting wildlife, there are three broad environmental regions. In each area fire can be expected to behave differently:
    - **The Zambezi Valley, escarpment and foothills:** There are four main vegetation types found in this region. The incidence and effect of fire will vary between each vegetation type (see Appendix 3).

      Mopane woodlands are found in the low lying and low rainfall areas. They do not usually present major fire problems because they contain very little grass.

      Jesse thickets are found on the deep sandy soils. They do not usually present major fire problems because they contain very little grass.

      Riverine woodlands are found along the major rivers. The incidence and the effect of fire will depend upon the amount and condition of the grass they contain.

      Mixed woodlands are found in the higher rainfall, hilly escarpment areas of the Zambezi Valley. These well-grassed and wooded areas are most sensitive to hot late dry season fires. The negative effects of fire in these areas can be reduced by using early burning fire management strategies.
    - **The Lowveld and Matabeleland:** The two main vegetation types over much of the south-eastern lowveld and Matabeleland are Mopane woodland and the mixed Combretum / Acacia woodlands. In years of very low rainfall, wild fires in this region are less likely as there is little grass to burn. In better rainfall years when there is a lot of grass, there is a high risk of hot late season fires. Under these conditions it is important to protect this valuable food supply for wildlife, so prevention and fire control strategies may be very important. Early burning programmes are not recommended in these areas.

The Natural Regions (NR) of Zimbabwe are mainly defined by rainfall which is the main factor affecting landuse systems. The recommended landuse systems for each Natural Region are given in the Key (see map on page 13)				
	Rainfall	**Altitude**	**Temperature**	**Proportion of the country**
NR 1	>1,000mm	High	cool	2%
NR 2	750 - 1,000mm	high - medium	warm - hot	16%
NR 3	650 - 800mm	medium	hot	18%
NR 4	450 - 650mm	low	hot - very hot	37%
NR 5	<650mm	very low	very hot	27%

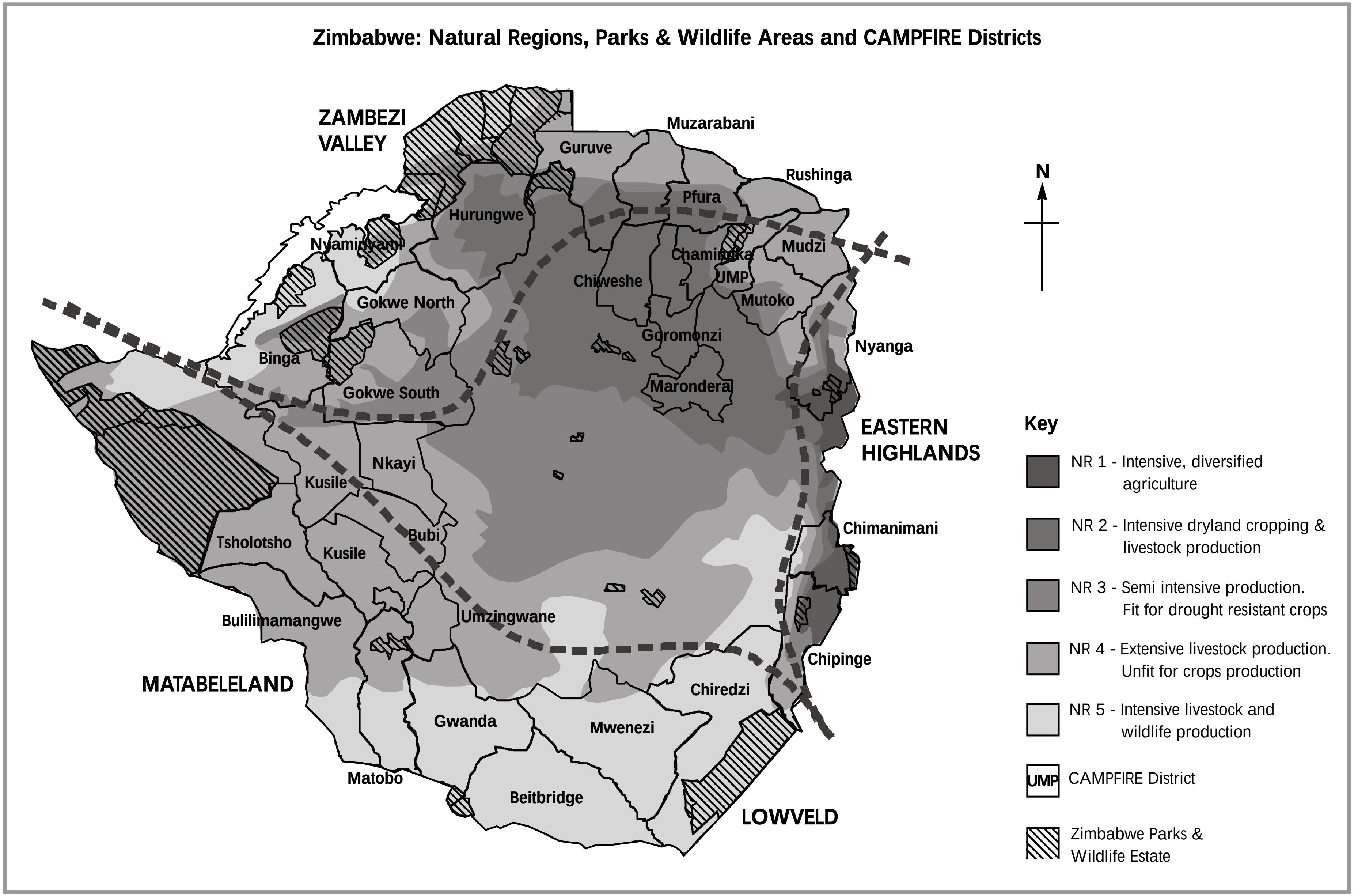
- **The Eastern Highlands:** In the Eastern Highlands there are three major vegetation types. These are the natural forests / woodlands, grasslands and the **exotic** timber plantations. The natural forests do not have enough dry vegetation to be a fire risk. The grasslands and the exotic timber plantations are extremely sensitive to fire. In these areas it is important to prevent fires. The natural forests can often be scorched and badly affected by the very hot fires on the grasslands. Firebreaks should never be made on the boundary between natural forests and grasslands.

- **The previous seasons rainfall:** In Zimbabwe, the rainfall can vary greatly between seasons and this affects how much plant growth there is. After good rains, there will be more grass and more fuel for fires. After poor or bad rains, there will be less plant growth and less fuel for fires.
- **The incidence and severity of the previous season's fires:** If an area has recently experienced a hot, late season fire, there will be less fuel for a fire. This means that a late season fire will be cooler and have less impact.
- **The pattern of settlement and cultivation:** If an area is fragmented by settlement and cultivation, there will be less fuel for a fire. This will reduce the chances for large hot late season fires.
- **The impact of grazing:** If an area is heavily grazed either by domestic or wild animals, this will reduce the amount of fuel for a fire. This will reduce the chances of large hot late season fires.

What are the positive effects of fire?

The positive effects of fire are generally longer term and less easily seen than the negative effects. They include:

- the growth of green grass which provides grazing for animals in the dry season,
- the removal of old and normally less useful dry plant material,
- the control and reduction of **bush encroachment**,
- the stimulation of germination of some useful species of grass,
- the limitation of **animal parasites (e.g. ticks)**.


Zimbabwe: Natural Regions, Parks & Wildlife Areas and CAMPFIRE Districts
ZAMBEZI VALLEY
Muzarabani
Guruve
Rushinga
Pfura
Hurungwe
Nyaminyami
Chaminuka
Mudzi
UMP
Chiweshe
Mutoko
Gokwe North
Goromonzi
Nyanga
Binga
Marondera
Gokwe South
EASTERN HIGHLANDS
Nkayi
Kusile
Tsholotsho
Kusile
Bubi
Chimanimani
Bulilimamangwe
Umzingwane
Chipinge
MATABELELAND
Chiredzi
Gwanda
Mwenezi
Matobo
Beitbridge
LOWVELD
N
Key
NR 1 - Intensive, diversified agriculture
NR 2 - Intensive dryland cropping & livestock production
NR 3 - Semi intensive production. Fit for drought resistant crops
NR 4 - Extensive livestock production. Unfit for crops production
NR 5 - Intensive livestock and wildlife production
UMP CAMPFIRE District
Zimbabwe Parks & Wildlife Estate

Why has there been so much emphasis on preventing wild fires?

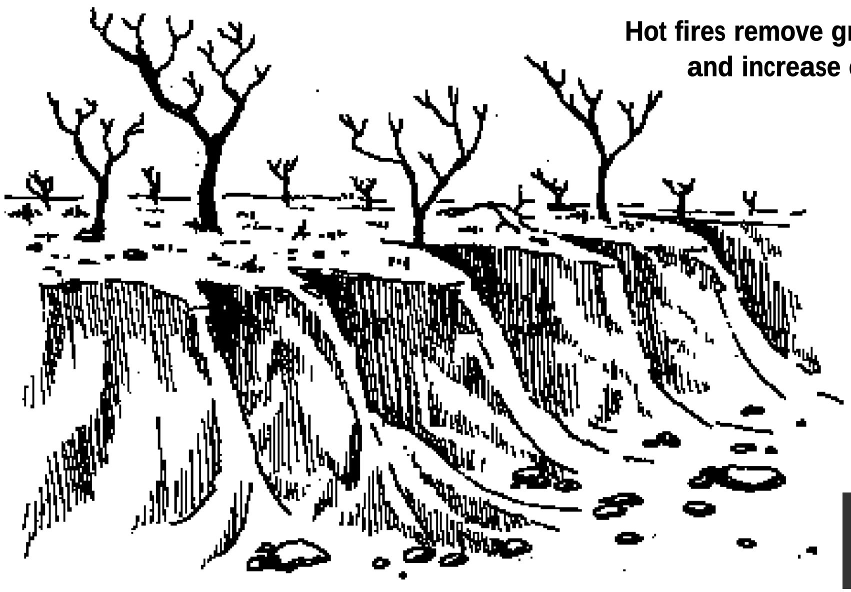
Although fire is part of the natural environment, attempts have often been made to prevent or control wild fires because of:

- the damage to the environment: All fires have the ability to damage the environment by removing important plant cover which leads to increased run-off, increased soil erosion and reduced soil moisture. This can also result in an increase in the rate of bush encroachment in some areas. This can have a negative effect on wildlife and wildlife-based businesses like tourism and safari hunting.
- people's limited understanding of fires: Many people do not understand that fires are an important and natural part of the environment.

As human settlement has expanded into wildlife areas, the frequency and the severity of fires has increased. This has damaged the environment but has also affected the people who use natural products harvested from woodlands.

How have attitudes towards fire changed?

Fire prevention policies were promoted in the commercial and communal farming areas by the Natural Resources Board. In the State protected areas, DNP&WLM adopted a similar approach between 1950 and the 1970's, when it was shown that the prevention of fires in large wildfire areas was not practical or cost effective.



Hot fires remove ground cover and increase erosion

In some cases fires can increase bush encroachment

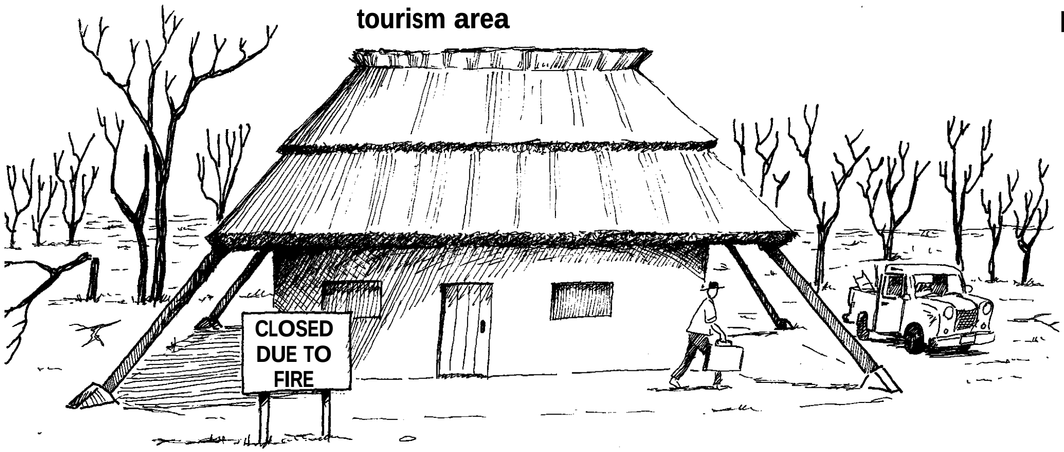
A number of lessons have been learned from the many years of experience gained in fire prevention, control and use in wildlife areas. These are:

- it is very difficult, if not impossible, to prevent wild fires,
- conventional prevention measures (vehicles and equipment) are in most cases not cost effective.
- fire plays an important and positive role in many Zimbabwean **ecosystems**.

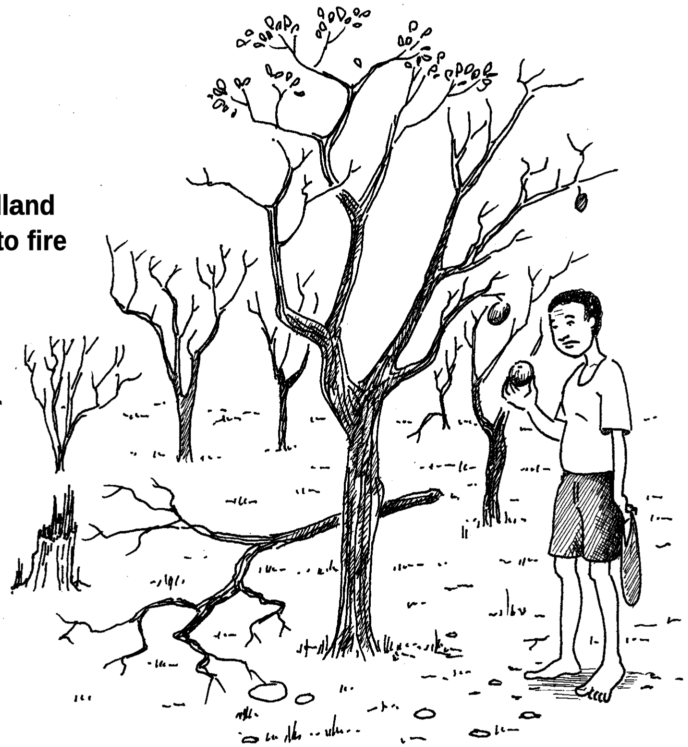
These results have forced people to change the way they think about fire. As a result, fire is now seen as a positive management tool as long as it is used carefully. It can be used as a cheap and effective tool to:

- control the negative effects of hot, late season fires,
- influence vegetation growth, and
- influence the distribution and productivity of wildlife populations.

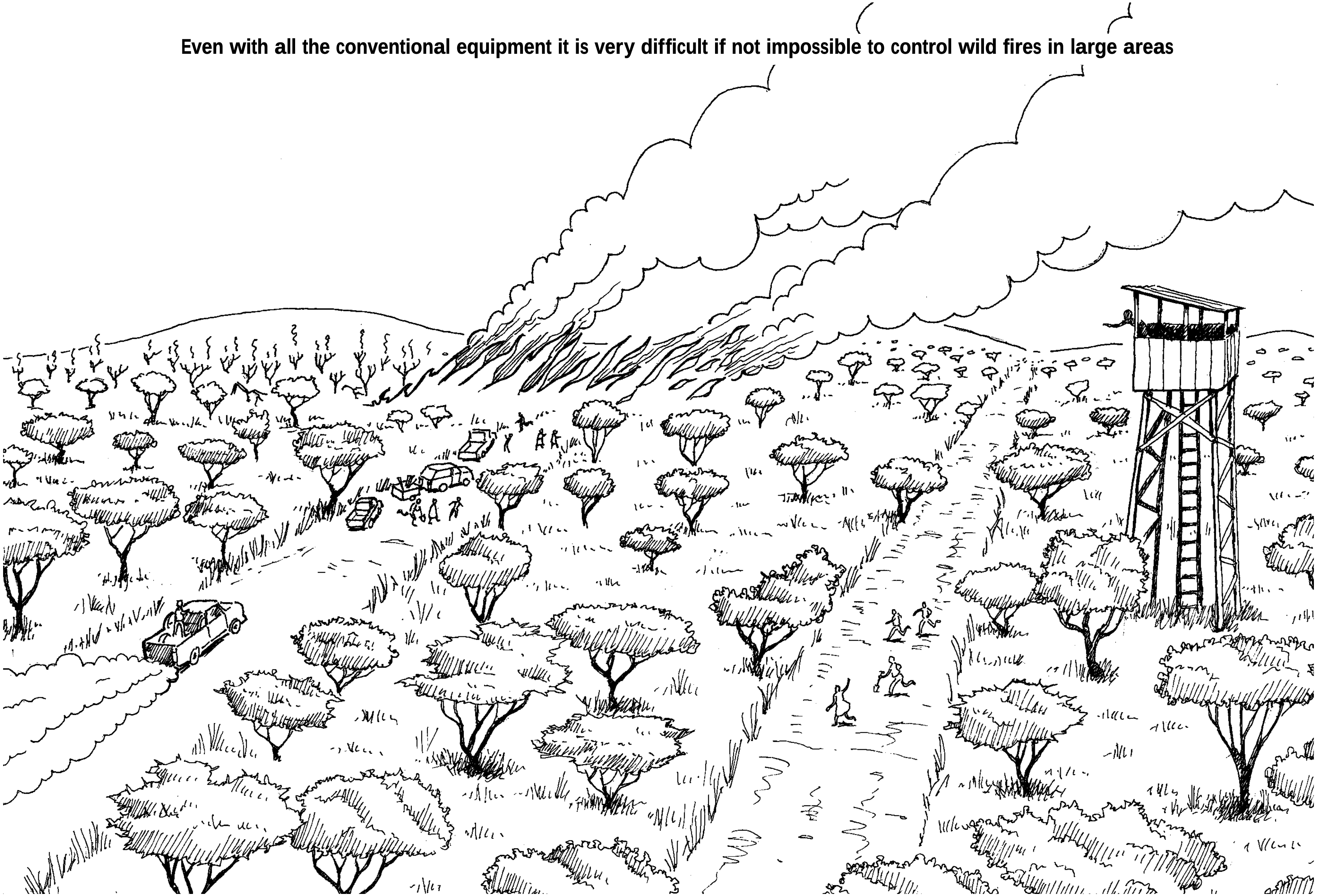
Loss of revenue from fire tourism area

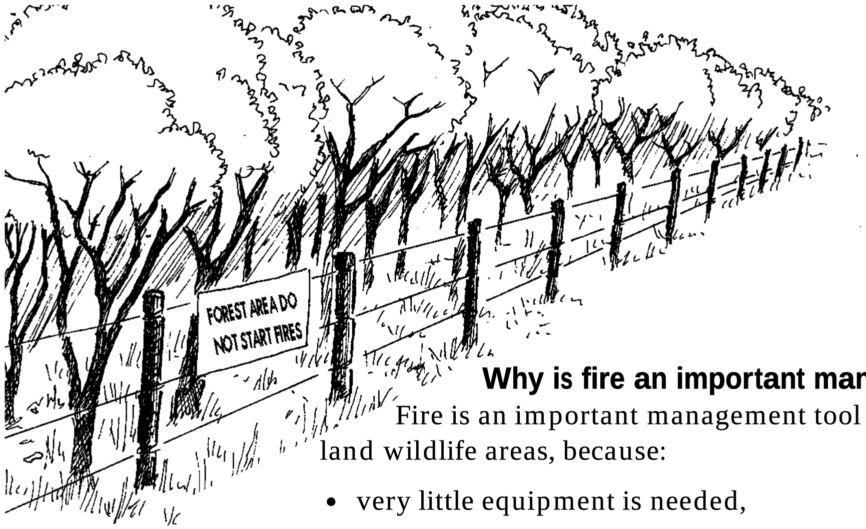


Loss of woodland products due to fire



Even with all the conventional equipment it is very difficult if not impossible to control wild fires in large areas





CHAPTER 2

FIRE AS A MANAGEMENT TOOL

Why is fire an important management tool?

Fire is an important management tool in communal land wildlife areas, because:

- very little equipment is needed,
- it is cheap and simple to use,
- it can be used to improve wildlife production.

For each area, the stakeholders should jointly consider whether it is necessary to prevent fire, control fire or use fire. Importantly, fire can be used as a tool to both prevent and control wild fires as well as achieve certain management objectives.

Under what conditions should fire be prevented?

Preventing fire means that there should be no fires at all in a defined area. There are many situations when this is necessary. These are:

- in areas of settlement,
- in areas like the Eastern Highlands where there are **indigenous** and **exotic** forests which are highly sensitive to fire,
- in isolated, small areas with special plant and animal species that need to be protected,
- to protect or promote valuable grazing and **browsing** resources for livestock and wildlife.

Under what conditions should fire be controlled?

Controlling fire means limiting its use to very specific purposes. These include:

- controlled burning firebreaks to prevent entry of wild fires which are potentially harmful. Firebreaks are used in the commercial farming areas to protect valuable grazing resources for livestock.
- controlled burning of **crop residues** to reduce pests and diseases.

In community wildlife areas and other large wildlife areas, controlled burning requires very careful management, because extensive damage can result if fires escape. CAMPFIRE areas where such prevention and control measures are required include: Beitbridge, and parts of Chipinge and Chiredzi; Matabeleland South (Bulilima-Mangwe, Gwanda, Lupane, Matobo and Tsholotsho) and Matabeleland North (Binga and Hwange).

Under what conditions should fire be used?

Fire can be used to meet certain objectives or overcome certain problems. How fire is used will depend on the objectives for the wildlife area. There are two ways in which fire can be used with good effect. These are:

- **Using early burning to reduce the severity of wild fires**

  Objectives: The most important objective that can be achieved through early burning is to reduce the severity of wild late season hot fires. Early burning creates a patchwork effect of burnt, partially burnt and unburnt areas. This has several advantages:

  - substantial amounts of grass and browsing material remains intact, to support wildlife populations during the late dry season.
  - the ground is not left without **vegetative** cover, particularly if the burning is carefully timed.
  - when hot, late season fires start they are soon checked by the patchwork effect ("firebreaks") created by early burning.

  There are also several disadvantages which need to be considered before an early burning programme is started. These are:

  - fire, of any temperature, is not good for perennial grasses,
  - the soil will be exposed for long periods which can lead to erosion, and
  - fire can destroy or damage other natural resources such as thatching grass.

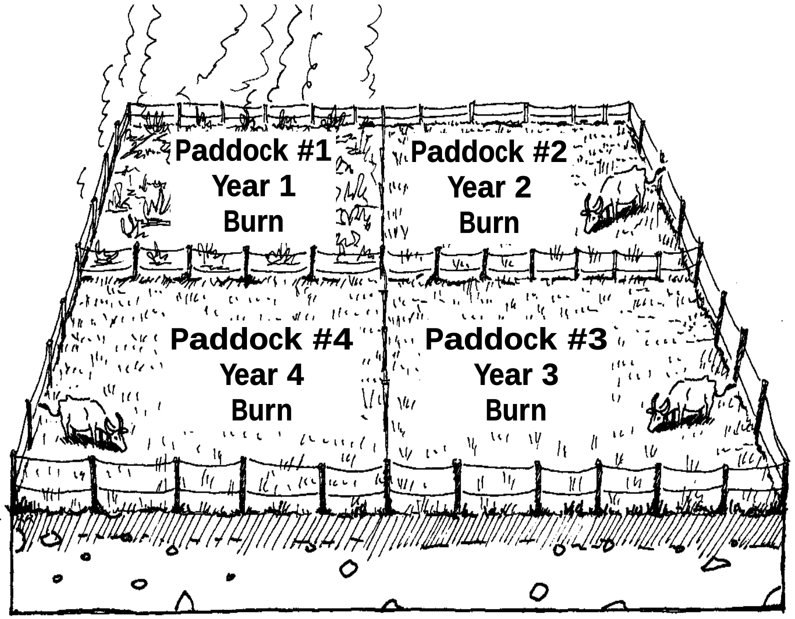
  Early burning has a very important role to play in the higher rainfall areas of the country including the Zambezi Valley escarpment areas. Areas which can use early burning are: Dande (Kanyurira, Chapoto, Chisunga); Muzarabani (Mavuradonha and adjacent wards); Nyaminyami (Sampakaruma, Negande, Nebiri and the Mapongola Hills); North Gokwe (Chireya, Madzivadzvido and Nenyunga); and parts of Binga.

- **Using late burning to improve the quality of grazing**

  Objective: The objective of late burning is to improve the quality of grazing. This is done by removing old plant material, reducing the number of woody plants (bush encroachment) and providing green grass. For example, the **rotational** burning of paddocks or wetland areas stimulates a green flush of new grass growth.

  The success depends on a number of factors, such as:

  - the amount of grass to burn,
  - the level of bush encroachment, and
  - the timing of the fire in relation both to the previous, and to the coming, rainy season.



The complex interaction of all these factors has meant that late burning probably has met with less, rather than more success, over the years.

In most CAMPFIRE areas, late burning should only be used if:

- there is a serious bush encroachment problem, and
- it is part of an integrated grazing strategy, for example, to promote the growth of grass at the end of the winter.

Because late season burning is more risky than early burning, it should only be considered as part of the fire management strategy once a community has gained experience in other areas of fire management, for example: early burning, setting up reporting systems, establishing a fire management committee, implementing community awareness programmes, and applying some of the more easily managed prevention and control strategies.

What are the legal requirements for burning programmes?

The Natural Resources Act and Regulations, which applies to all landholders, makes it a **legal requirement** to inform your neighbours of your intention to burn. So, when planning the implementation of any burning programme, do not forget to inform all those who should be aware of your intentions.

What institutional arrangements are necessary?

Institutional arrangements and associated organisational responsibilities are very important for any kind of burning programme to work properly. The implementation of a burning programme requires careful consideration, involving both logistical and budget planning. This is discussed in more detail in Chapter 4.

What technical support is there to assist with burning programmes?

There are a limited number of organisations who can assist districts and communities develop burning programmes. WWF has the capacity to assist districts and would be happy to do so. Other sources of information are AGRITEX, the Department of Research and Specialist Services and the Department of Biological Sciences at the University of Zimbabwe (see Appendix 2).

ACTION

CHAPTER 3

PRACTICAL FIRE MANAGEMENT

What are the main issues in practical wild fire management?

The main issue in practical fire management is to develop methods which prevent the environmental damage and potential economic losses resulting from hot, late season fires. For example, a fire that burns on a hot day in August or September, with a high wind and lots of dry material, can destroy up to 90% of the vegetation.

Preventing these late season wild fires needs a combination of strategies to:

- prevent fires from starting, and
- react to fires which have started

People who are involved in practical fire management should have:

- a working understanding of how fires burn, and
- some practical tips for putting out wild fires.

What are the best methods for preventing wild fires?

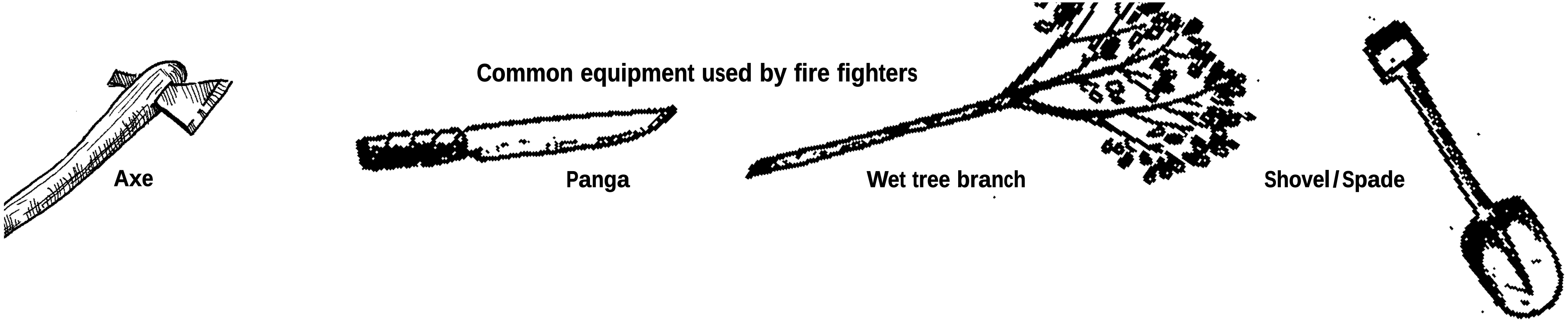
Any fire management strategy must make provision for the prevention of unwanted or uncontrolled fires. Fires can be prevented through:

- improved community awareness and publicity,
- education,
- co-operation between all stakeholders,
- building relations between land users and with the public,
- law enforcement,
- developing fire management strategies (to include fire breaks, reporting systems, early / late burning plans etc).

A lot of money has gone into fire prevention in some parts of Zimbabwe. The money has been used for equipment such as radio networks, vehicles, control towers and the development of firebreaks. This effort has not significantly reduced the incidence and severity of late season fires. Once a late hot fire is burning, it is very difficult, if not impossible, to put it out.

For RDCs and wildlife producer communities, buying equipment is not a cost effective fire management strategy. This is why low cost solutions such as early burning together with community awareness, education and co-operation are now preferred.

Common equipment used by fire fighters



What kind of reporting system is needed for wild fires?

The earlier a fire is reported, the sooner the necessary action can be taken. A reporting system for wild fires requires responsibility and judgement.

- **Responsibility:** Every person who sees or comes across a fire is responsible for taking some action.
- **Judgement:** The person who discovers a fire must use their judgement as to their reaction. Their reaction will depend on the size of the fire:

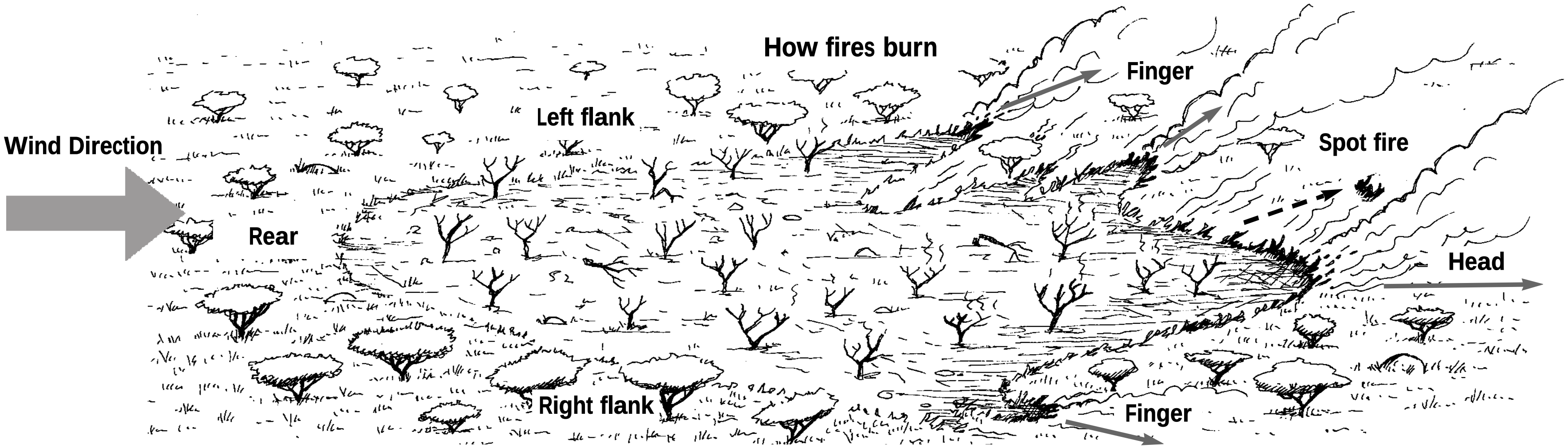
  Very small fire: A fire which has just started, from a carelessly discarded cigarette, can be easily be put out just be standing on it.

  Small fire: If a fire has been burning for a few minutes, it might be possible to mobilise people in the immediate area to put it out.

  Large and very large fires: With large and very large fires, coordinated action is usually needed to put them out. In this case, run to the nearest village to report the fire. In each village there should be one person who is responsible for reporting and one who is responsible for the organisation and management of fire-fighting.

There are some basic principles for a reporting system to fight wild fires. It is ESSENTIAL that:

- one person is in control of the fire fighting team. This person is responsible for mobilising the fire management team and actually trying to put the fire out.
- one person is in control of the reporting team. They must ensure that all the neighbours are informed. This may also mean obtaining additional support from neighbours to help fight the fire. Reporting can be done by the quickest means available: telephone (if available), radio, running, bicycle, or motorcycle. Once a fire has been extinguished, the neighbours should be informed.
- the fire management team should have some basic training in fire fighting techniques (back-burning, etc.) and some basic first aid knowledge. They should also have some basic equipment for fighting fires (beaters, wet sacks, shovels / spades, buckets, pangas, axes and DRINKING WATER).



How does a wild fire burn?

Anyone involved in planning and implementing a fire management programme should understand how a bush fire burns. All fires start very small. It then moves in the direction of the prevailing wind, spreading forwards and outwards in a characteristic way. There are five parts to a typical fire. They are:

- The HEAD is the most rapidly forward-spreading edge of the fire, usually directly ahead of the wind.
- FINGERS are more rapidly burning projections of the fire, usually reaching forwards or sideways behind the head.
- The FLANKS lie behind the head, spreading (usually more slowly) to either side.
- The REAR is the burnt-out back line of the fire, usually opposite the head.
- SPOT FIRES may occur, usually ahead of the main fire when sparks or burning materials are carried by the wind.

Once a fire has started it can generate its own wind, by sucking air into the burning area from around it. By knowing and being able to recognise the different parts of a fire, the person in-charge of the fire-fighting team will be able to:

- estimate how fast the fire might move,
- identify where it might be appropriate to start back burns,
- identify what natural barriers (such as a river) might assist the fire-fighting team,
- determine the width of fire breaks and barriers to stop spot fires from starting,
- avoid wasting resources by fighting the fire in unimportant areas such as the rear.

Fires which are burning up steep slopes or towards the head of a valley can be extremely dangerous and unpredictable. Nobody should ever place themselves above a fire on a steep slope or get trapped in a valley with a fire travelling towards them.

How can a wild fire be put out?

Putting out a wild fire before it does too much damage to the environment requires:

- **an effective reporting and communications system:** Each community (ideally at the village level) should establish a Fire Management Committee to take responsibility for preventing, reporting and organising fire-fighting.
- **a quick and effective reaction to the fire:** Reacting quickly to a fire will increase the chances of putting it out and reducing the damage to the environment. Reacting quickly and effectively to a wild fire needs organisation. People with the right skills need to react and be transported to the site of the fire. Once at the site of the fire their work needs to be directed and coordinated.
- **practical fire-fighting techniques:** It has been shown that buying expensive equipment such as tractors, mowers, water bowsers and watch towers is not cost effective in large wildlife areas. More appropriate, useful and cost effective equipment are axes and pangas which can be used to cut green bushes for beaters.

What are the common methods of fire-fighting that are used?

There are three common methods for fighting fires. These are firebreaks, beating and smothering the fire and back burning.

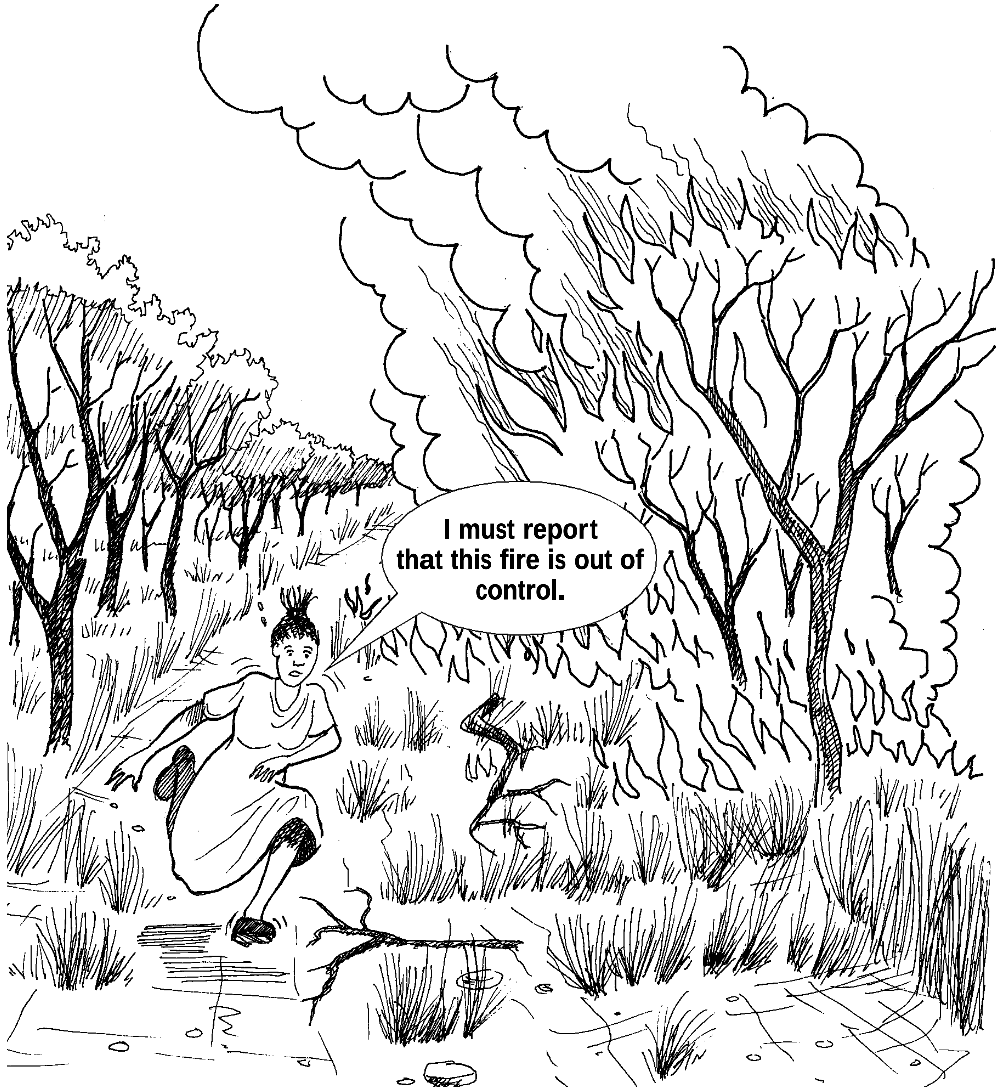
- Firebreaks: Firebreaks can be used either to stop a wild fire entering an area or as a starting point for a back burns to put out a wild fire. Roads, fencelines and rivers can be used as firebreaks, or as their starting point. A firebreak should be no less than 4m wide, in settled or populated farming areas where the area to be protected is small. In extensive, sparsely populated wildlife areas, they should be much wider, possibly up to 100m. It is important that firebreaks are maintained annually. Neighbouring land holders must be informed if the center of the firebreak is going to be burnt.

  When planning firebreaks for a wildlife area, the following points must be considered:

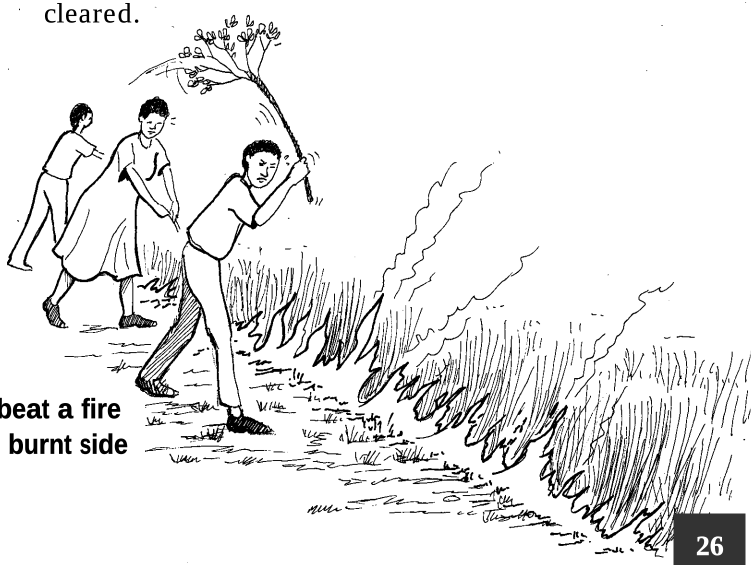
  - the location of the firebreaks. In any wildlife area, the exact location of firebreaks will be determined by the geography, the existing road network and the direction of the prevailing wind. Firebreaks should be located on watersheds to avoid problems with erosion. If possible firebreaks should be planned so that they are diagonal to the direction of the prevailing wind. In large wildlife areas, firebreaks can be placed around the edges to prevent fires entering. Firebreaks can also be used to divide the area into blocks to reduce the area which might be burnt by a wild fire.

A well maintained and effective firebreak

A badly maintained and ineffective firebreak



- the type of firebreaks. Most firebreaks are made by clearing two strips of vegetation and then burning the center. Normally this is done using a grader, a tractor drawing a **harrow** or a mower. Sometimes the vegetation at the edges is cleared by hand. The danger with these methods is that they can sometimes lead to erosion.
- the maintainance of the firebreaks. Firebreaks need to be maintained annually. Maintenance should be done after the rains and before the onset of wild fires. If the center of the firebreak needs to be burnt, this will have to be done when most of the vegetation is dry. Unlike an early burning programme which will leave vegetation standing, the centre of the firebreak should be quite well cleared.

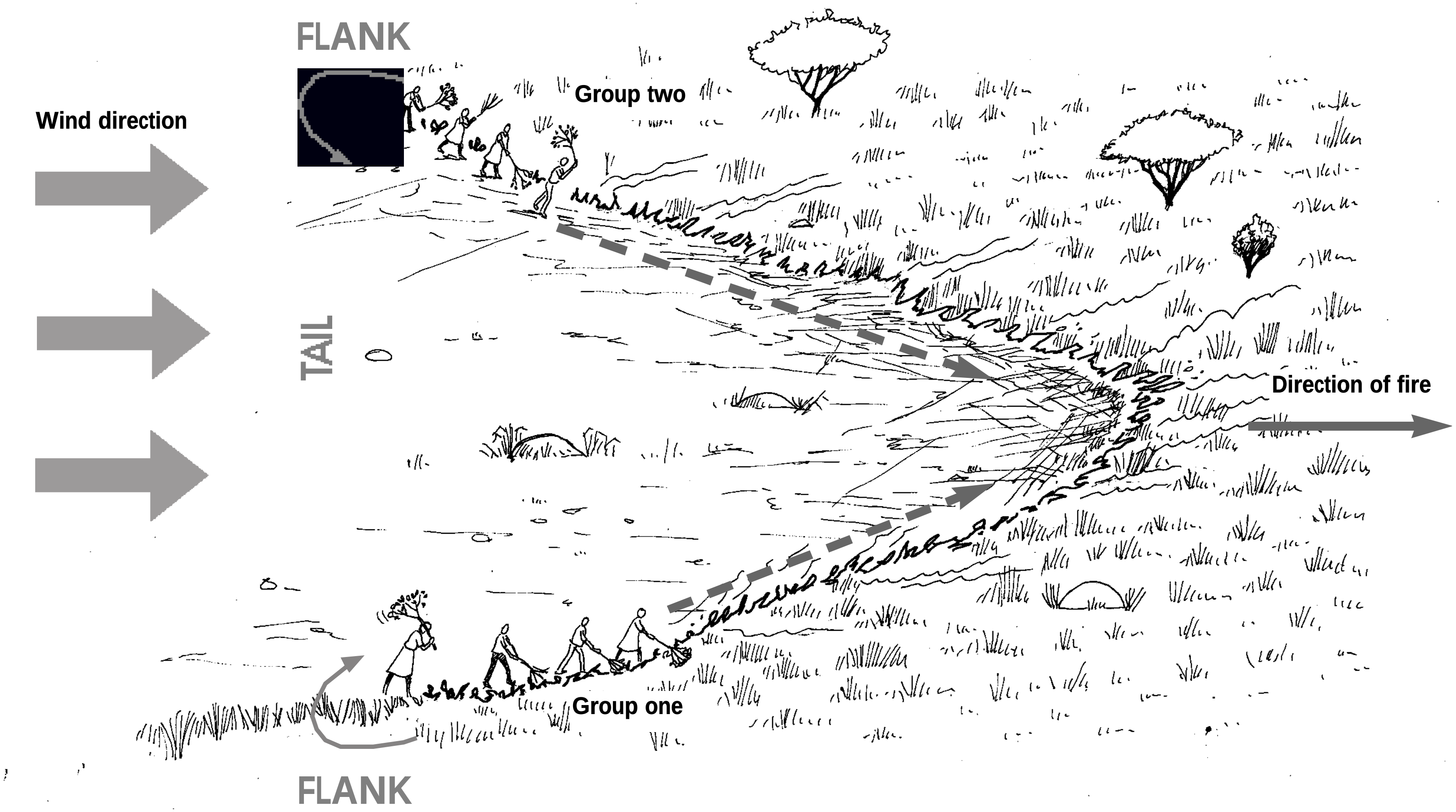


Always beat a fire from the burnt side

- the responsibility for the firebreaks.
  The maintenance of firebreaks is expensive due to the equipment needed. Before an RDC and producer communities start making a network of firebreaks it must be very clear who will pay for the maintenance.

- beating and smothering the fire. Fires can be put out using beaters. Sand can also be shovelled or thrown onto a fire. Putting out large fires can be dangerous so people using beaters and sand should stand on the burnt area and never on the side that the fire is going to. Beaters should try and work together to put out complete sections of the fire. It is always easier to beat out a fire along its flanks rather than trying to put out the head of the fire.
  - making beaters. Beaters are easy to make and every homestead, and every member of the fire management team should have one. A sack or piece of old rubber inner tube can be attached to a sturdy two-metre pole, about the thickness of a broom handle. When fighting a fire with a sack, it needs to be wet, otherwise it may catch fire itself!
- Back-burning: In hot late season fires, back-burning is used to create or widen firebreaks to prevent the wild fire spreading. Back-burning will promote a cooler fire which reduces the impact of strong winds and abundant fuel (see diagram on page 28).

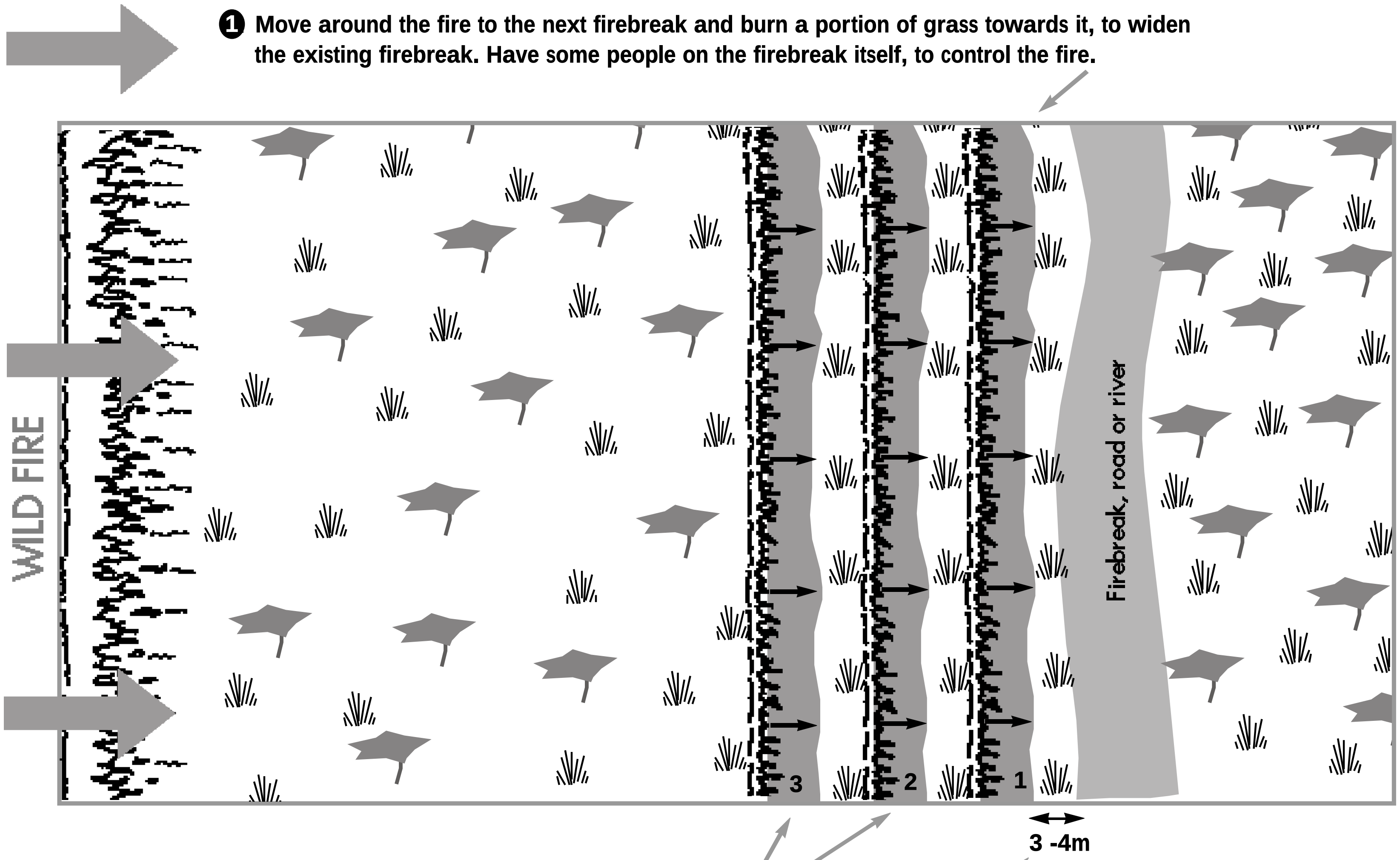
How to beat and smother a fire



Procedures for back-burning

Wind direction

❶ Move around the fire to the next firebreak and burn a portion of grass towards it, to widen the existing firebreak. Have some people on the firebreak itself, to control the fire.



❸ Once the first back burn is finished, it can be followed by a second and third.

❷ Burn a small portion each time, start the first back burn 3 - 4m from the firebreak.

CHAPTER 4

PLANNING AND IMPLEMENTING AN EARLY BURNING PROGRAMME

Why use early burning?

For districts and wildlife producer communities, the most important reason for using early burning is to reduce the environmental damage and the potential financial losses which can result from hot late season wild fires. A well planned early burning programme will remove about 25% of the vegetation compared with a hot wild fire which can destroy between 60% and 90% of the vegetation.

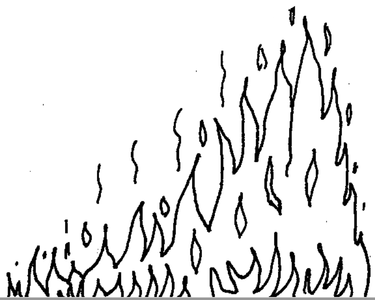
Where should early burning be done?

Early burning is used mostly in the woodlands in the hilly escarpment areas of the Zambezi Valley. These well-grassed and wooded areas are very sensitive to hot, late season fires. Implementing early burning will help conserve plant and animal resources in these woodlands. Early burning should not be used in the Lowveld, Matabeleland or Eastern District areas.

When is the best time for early burning?

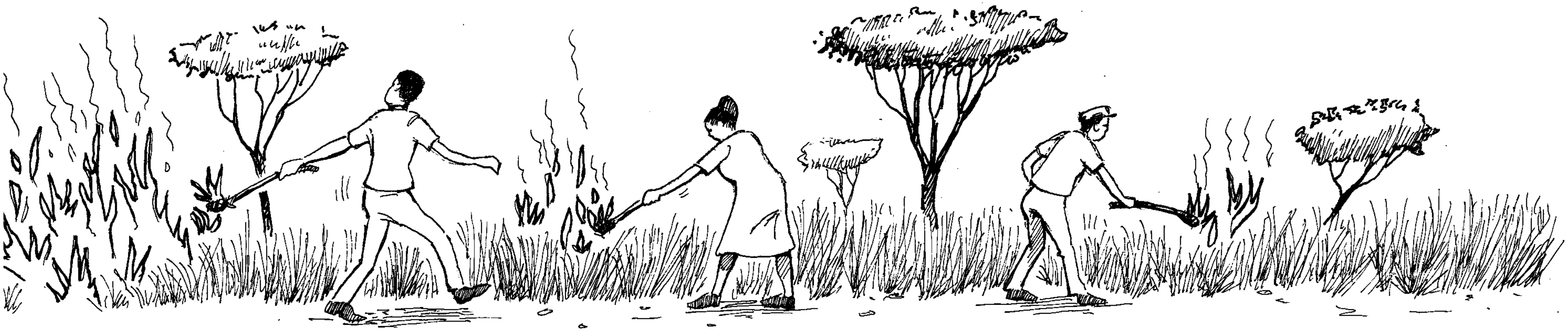
This will vary from year to year and depends mostly on the previous season’s rainfall. From around the month of May onwards, efforts should be made to start fires that will achieve a cool burn. This causes minimal damage and prevents late and hot wild fires from doing further damage.

As a rule of thumb, the longer and the wetter, the previous rainy season, the later the early burning will need to be. Most early burning is successfully accomplished during the month of June. The date of the last rains can provide a good indicator for planning when to start early burning. Early burning must not extend beyond the middle of July. During an early burning programme, the fires should be put out by the cold night air and the dew. If the fires burn through the night it is already too late for early burning.



Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec

Team moving in the bush starting fires with sticks with rag soaked in diesel



How is early burning done?

Early burning fires are simply started by teams of workers or volunteers going into the wildlife area and trying to set fire to the surrounding bush. They should follow roads and tracks in the areas to be burnt. They should start on higher ground, which is generally drier than valleys and depressions. It is important not to give up if at first the vegetation fails to burn. If the grass is too green or moist, they should try again a week or so later. This procedure must be repeated until the early burning is achieved.

With an early burning programme it is not necessary to try and burn the entire area. Ideally, the burning should either be planned so that:

- it removes about 25% to 30% of the dry vegetation over a widespread area, or
- it creates a patchwork effect which will help prevent fires from entering and spreading through the area later in the season.

When doing early burning from roads, participants must walk into the bush (3 - 5m) to start their fires. This is because the vegetation along the edge of the road stays greener from the water running off the road.

What needs to be considered before starting an early burning programme?

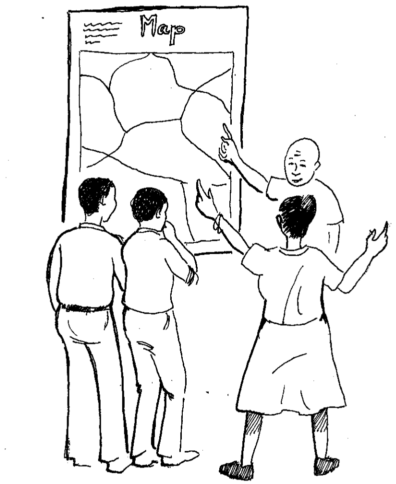
As wild fire can spread easily across many wards of a district, early burning programmes should be planned at a district level. Before any early burning starts, it is essential to have well-planned co-ordination, good communication and clearly defined responsibilities. The CAMPFIRE Coordinator or Manager with the involvement of the Wildlife Committees (WWCs) should take primary responsibility for fire management. In some cases, it may not be possible for individual wards to implement a burning programme in isolation. Good planning, well in advance of the burning, is essential. This could be done during the rainy season when not much wildlife work is going on in the field.

Early burning mark in the wildlife calendar

ACTIVITIES	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Fence maintenance	•	•	•	•	•	•	•	•	•	•	•	•
Wildlife patrols	•	•	•	•	•	•	•	•	•	•	•	•
Wildlife counts						•						
Early burning					●	●	●					
Monitoring / hunting				•	•	•	•	•	•			

Detailed early burning calendar

ACTIVITIES	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Planning		•	•	•								
Test burn					•	•	•					
Burn					●	●	●					
Monitor									•	•		
Report										•	•	



The following major steps need to be taken before starting an early burning programme:

- **Determine the major vegetation types in the district:**
  Use a vegetation map to identify areas of mixed woodland vegetation (msasa / mfuti, mukweza / mugoro and mukonono). These are areas which are most suitable for early burning. Mopane, jesse and riverine vegetation types should not be burnt. District level vegetation maps can be obtained from Forestry Commission or WWF.
- **Decide which roads and tracks can be used in the area to be burnt:**
  The size of the area to be burnt and the network of the roads and tracks will determine whether the burning can be done by people on foot and / or by vehicle. Community wildlife areas which are used for hunting normally have enough tracks to use as access for an early burning programme. Decide which roads or tracks are going to be used in the programme.
- **Decide who will do what and when in the early burning programme:**

  It is important to decide well ahead:
  - who will do the burning,
  - what they will need do the work (manpower, transport, finance)
  - who will be in charge of the programme
  - what role the safari operator will play

  The Safari Operator should be involved in the early burning programme to avoid any conflicts and misunderstandings especially if the hunting starts early. The operator might also be able to assist with transport and communications. If the wildlife area is next to Parks and Wildlife Land, it is important to involve the local Warden in the planning and execution of the burning programme.
- **Decide what equipment is needed:**
  Very little equipment is needed for early burning. The decision of how to get to the areas will determine what transport is needed. If the area is large vehicles might be needed to carry the people to their starting points. Most early burning should be done on foot, once patrols have been put in place by vehicle. If the early burning programme is extensive it is important to make plans for overnight stops for the participants.

An early burning plan

Activity	Responsibility	Timing	Costs	Other resources	Comment
Planning	CAMPFIRE Unit and WWC	February - March	meeting costs only	maps	include all stakeholders
Test burning	Game Guards (RDC or WWC)	April	transport, allowances, matches	vehicles, camping equipment	try, try and try again
Early burning	Game guards, community volunteers	May - July	transport, allowances, matches	vehicles, camping equipment	notify neighbours
Monitoring	CAMPFIRE Coordinator	August - September	transport		
Reporting	CAMPFIRE Coordinator	October	stationary		

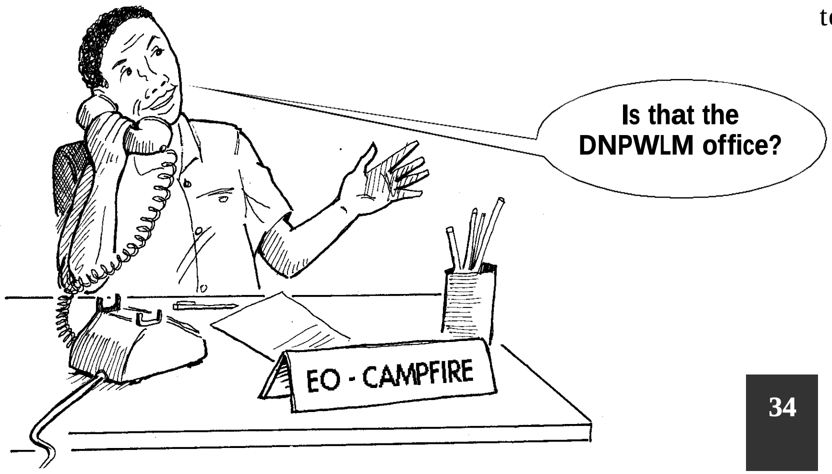
- **Decide how many people will be needed:**
  Early burning should be done by people who know the wildlife area. Most districts have game guards and wildlife monitors who can do this task. They can also do their normal patrol duties at the same time, such as law enforcement and wildlife reporting. If there are not enough game guards then volunteers from the community can be used.
- **Determine how much the early burning programme will cost:**
  An early burning programme should not be a costly activity. A budget should be drawn up for the entire burning programme, which will meet all the expected expenses. Ideally the programme should be paid for by both the wards and the district. It must be clear before the early burning programme starts who will pay for which costs.
- **Determine how long the early burning programme will take:**
  The time taken to implement an early burning programme will depend on the size of the area. There is usually an opportunity when conditions for early burning are perfect, i.e. there is some dry vegetation and no wind. This usually occurs in May and June. During this time those who will be involved should be ready at short notice to start the programme.

How is an early burning programme implemented?

The following steps are given as a guide to implementing an early burning programme:

Step One. Test the vegetation: Once the early burning plan is in place, its implementation will depend on the state of the vegetation. Use a local patrol from the nearest ward involved to examine the bush and vegetation. Does it look as though it would burn or is it still too wet? Try burning a small patch experimentally. If it does not burn because it is still too wet, wait a week or so, then try again. Make sure you do so at the same time of day on each occasion. The ideal fire will burn slowly and will not be too hot, so that:

- the grass cover should only partially be removed, and
- the flames from the fire should reach only the lower leaves of the surrounding shrubs, bushes and small trees. Higher up, above one metre or so, the leaves and branches should remain untouched by fire.



Step Two. Inform neighbours: Remember, it is a legal requirement to inform your neighbours of your intention to burn. So, when planning the implementation of the early burning programme, do not forget to inform all those who should be aware of your intentions.

Step Three. Start burning: When the vegetation is ready, the teams of burners need to be taken to their starting points. They must then walk through the bush starting fires. They should:

- start as many fires as possible in a given area
- let the fires go and do not make any attempt to control them or put them out
- record some basic information about the fires (time, ease of lighting, impact)

Step Four. Burn the selected area: Over a few days, and not usually any longer than a week to 10 days, it should be possible to have set alight much of the selected area. If the timing is correct, the fires will be put out by the low temperatures and dew at night.

Step Five. Implement the monitoring programme:
All management activities should be followed by some form of monitoring and evaluation. For an early burning programme the following information should be collected:

- the area burned - using a 1:50 000 map, calculate the percentage (%) of the total wildlife area burnt.
- the type of fire - was the fire hot or cool; what was the height of flames; how was the vegetation effected; was it easy to start the fires; did they go out easily?
- the climatic conditions - was it calm or windy, was it hot or cold, was there dew at night?
- who was involved - who were the people who did the burning, game guards or volunteers, what training were they given?
- what was the impact later in the year - was there much bare ground, was there still some ground cover, was there sufficient browse towards the end of the dry season?

If this information is accumulated each year and compiled into a simple report, it will assist in the planning and implementation of the following season's burning.

With an early burning programme, remember the following:

✓ **DO** develop the confidence necessary to go ahead and implement what may appear initially to be a drastic activity

✓ **DO** notify your neighbours that you intend to conduct an early burning programme

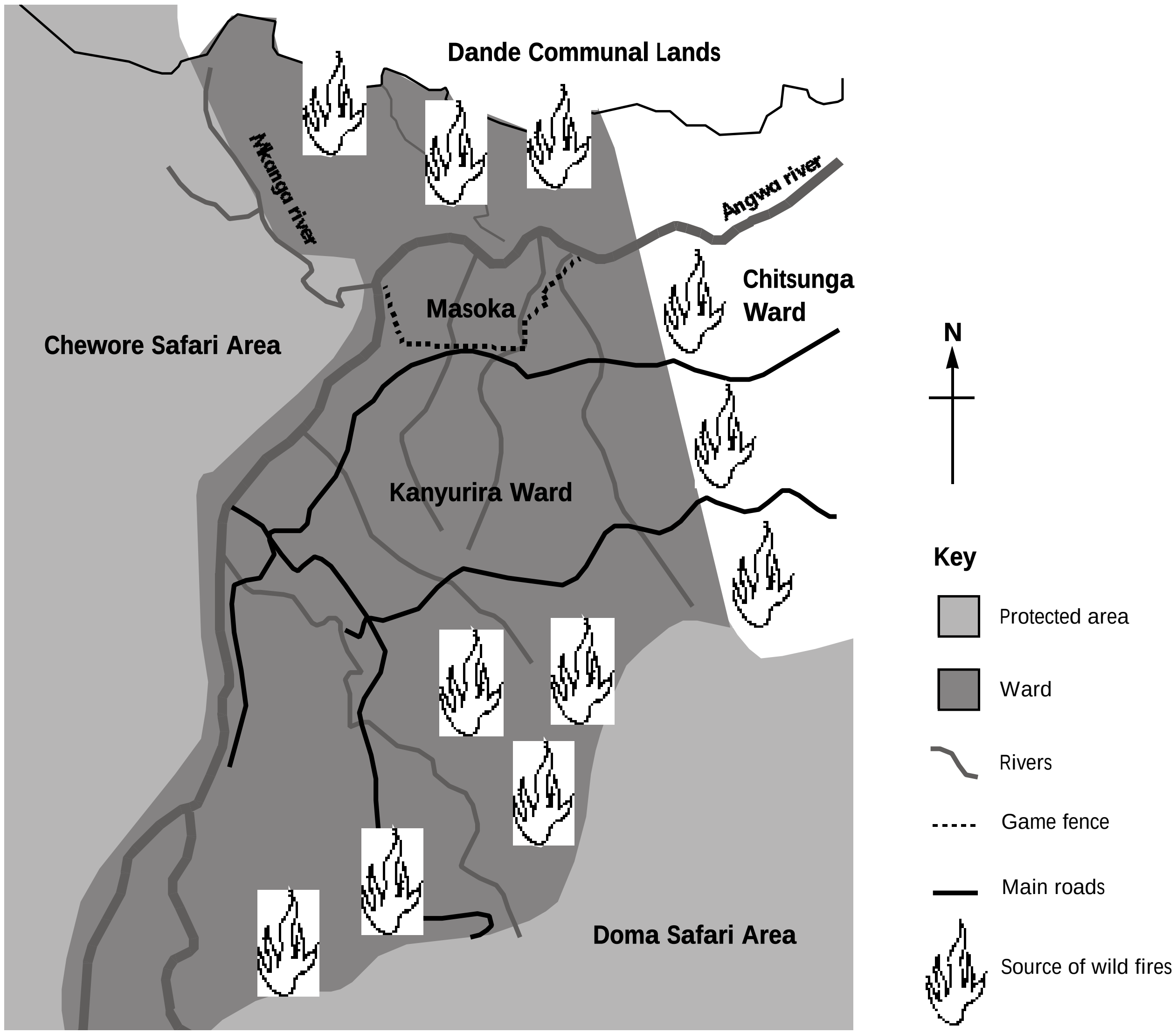
✓ **DO** manage the fire, because early burning is far less disastrous than waiting passively for damaging hot fires that will occur later in the dry season

✓ **DO** discuss fire as part of the environment and as a management tool

✗ **DO NOT** ignore the potential danger of fire and its mismanagement

✗ **DO NOT** undertake early burning after mid July

Map of Kanyurira Ward, Guruve District showing sources of wild fires



CHAPTER 5

A CASE STUDY OF EARLY BURNING IN KANYURIRA WARD

This case study outlines how Kanyurira Ward in Guruve District, has planned and implemented an early burning programme for its wildlife area.

What were the sources of wild fires in the Ward?

An aerial survey facilitated by WWF showed that each year the area north of the Angwa river, together with the southern hilly escarpment areas, were burnt by late hot fires (see map). Local information indicated that fires often came in from the adjacent Chitsungo ward close to the escarpment, when fields were cleared.

What solutions were proposed?

The Ward Wildlife Committee (WWC) proposed the following solutions:

- people would burn their fields at the end of the rainy season. It was agreed that the ward game guards would encourage people to do this and ensure that it was done,
- firebreaks would be made around the settled areas to protect people, their possessions and crops,
- there would be an early burning programme in the foothills of the escarpment and the area north of the Angwa River.

The WWC also proposed that if there was a wild fire, then:

- back burning should be used to prevent the fire spreading to the ward, and
- if a fire started close to the village, then the villagers should try and put it out with beaters.

How was the early burning programme implemented?

Step One. Identifying the major vegetation types: The WWC used their participatory resource survey to confirm if the vegetation in the ward was suitable for an early burning programme. The ward is situated close to the Zambezi escarpment and foothills where the vegetation is mixed msasa / mfuti trees and shrubs. For the fire management plan, they divided the ward into four blocks:

Block 1: This is the fenced area of the ward. The fenceline is cleared, and controlled burning is carried out along the outside of the fenceline. Within the fence, the ward wildlife constitution has a by-law which prohibits the random lighting of fires.

Blocks 2 - 4: These were the northern, central and southern wildlife areas of the ward. They planned to early burn the edges of each block first, followed by the central areas.

Step Two. Using the network of roads and tracks: The committee decided that the existing road and track network was good enough for their programme.

Step Three. Who will do what and when: The WWC planned that the early burning would be done by the game guards, fence minders and some volunteers from the community and that they would be incharge of the programme. Technical advice was to be provided by WWF. Initially there was no plan to involve the safari operator.

Step Four. What equipment was needed: There was no special equipment needed for the early burning programme. The ward's tractor provided transport.

Step Five. How many people were needed: The WWC planned to use about 25 people for the early burning programme.

Step Six. Budgeting for the early burning: The first time there was an early burning programme, no budget was drawn up. In the second year, a budget for the early burning programme was included in the ward's annual budget.

Step Seven. Time needed: The WWC estimated that when the time was right to start the early burning programme, it would take 5 days.

What were the results of the early burning programme?

There are four years of experience with early burning in Kanyurira Ward.

Year 1, 1995: The early burning programme was initiated in 1995 with technical input from WWF and the involvement of the ward game guards, fence minders, WWC members and the community. The plan outlined above and indicated on the map was followed. Reasonable success was obtained.

Year 2, 1996: The exercise was planned and budgeted for by the WWC. Letters of notification were sent to the police, Department of National Parks and Wildlife Management, as well as neighbouring communities (wards) and the resident safari operator.

There appeared to be a conflict of interest. The safari operator was busy hunting and for this reason the WWC felt that early burning could not be undertaken. The safari operator, however did early burning of areas along the escarpment, which were more susceptible to wild fires.

Year 3, 1997: Although some burning was done by the safari operator, nothing was planned for by the ward. As a result, there were a number of uncontrolled wild fires which did a lot of damage.

Year 4, 1998: Early burning in certain escarpment areas was successfully undertaken in May by the game guards working with the safari operator.

Summary of the early burning programme in Kanyurira, Guruve District

Year	Outline of Plan	Involvement	Outcome
Year 1: 1995	Fire management plan developed and initiated according to plan	Technical input: WWF; WWC, game guards, fence minders and community responsible for implementation	Reasonable success
Year 2: 1996	Early burning planned as previously but to include support of safari operator; conflicts of interest arose with safari operator not available except to undertake burning in susceptible escarpment areas	Planned and budgeted for by WWC; Police, National Parks, neighbouring wards and safari operator all informed	Important lesson learned was that all stakeholders had to be involved in the planning and commit themselves fully to actual implementation
Year 3: 1997	No planning done by the ward; some early burning implemented by the safari operator	No meaningful involvement of key stakeholders	A number of uncontrolled wild fires which caused a lot of damage
Year 4: 1998	Early burning planned with safari operator	WWC organised for game guards to work with safari operator	Early burning in escarpment areas undertaken successfully in May

What lessons can be learned from the early burning programme?

There were three important lessons which were learned by all the stakeholders. These were:

- Involve all stakeholders: In the second year, there was a conflict of interest which constrained the early burning programme. This occurred because not all the stakeholders were involved in planning the programme.
- Early burning prevented hot late season fires: In those years and those areas where the early burning was carried out, the incidence and severity of late hot season fires was reduced.
- Long term benefits: The long term benefits will only be achieved if early burning programmes are implemented regularly every year.

Hot fires remove ground cover and increase erosion.

APPENDIX ONE

Glossary of words and phrases

Word / phrase	Meaning	Example
bush encroachment	refers to an increase in the number and density of undesirable woody species	In Matabeleland bush encroachment, caused by overgrazing has reduced the quality of grazing for livestock and wildlife
ecosystems	refers to the interaction of all living organisms and their physical environment	The Mana Pools Flood Plain, with its plants and animals, is a unique ecosystem
crop residues	refers to the remaining plant material after the crop has been harvested	By law, all farmers must destroy their cotton (crop) residues
landscapes	refers to an area of the earth's surface which has a certain type of scenery	The escarpment of the Zambezi Valley is a rugged, but beautiful landscape
vleis or dambos	refers to the shallow wet depressions at the head of the drainage system	Vleis or dambos should be protected because they are an important source of water and grazing in the dry season
indigenous	refers to a species which belongs naturally to a certain area or place	The products harvested from indigenous species of trees are important to communal land farmers. exotic
exotic	refers to a species which has been introduced to the current area from another area or place	The pine and gum trees grown in plantations are both exotic species to Zimbabwe

Continued on page 42..

Word / phrase	Meaning	Example
browsing	refers to animals eating the leaves and the woody plant material	Browsing by elephants can damage woodlands
vegetative	refers to the something which is made up of plants	In Zimbabwe, the long dry winters mean that nearly all vegetation is easily damaged by fire
rotational	refers to moving an activity from one area to another on a regular and managed basis	Some commercial farmers use rotational grazing systems to improve the productivity of the grasslands
harrow	is an an agricultural implement used to break up the soil surface	A disk harrow is used to prepare fields for planting after ploughing or ripping
legal requirement	refers to an action which is required by law	It is a legal requirement to stop at a red traffic light
animal parasites	are organisms which live on or in a live host animal	An infestation of animal parasites (such as ticks or worms) can cause the host animals to loose condition
Natural Regions	these are agro-dimatic zones determined by rainfall. They are used to determine primary landuse	There are five Natural Regions in zimbabwe. Natural Region 1 receives the highest annual rainfall and Natural Region 5 the lowest annual rainfall

APPENDIX TWO

Sources of information on burning programmes

Organisation	Department	Telephone numbers
Government of Zimbabwe	AGRITEX	Harare 707311
	Department of Research and Specialist Services	Harare 704531
The University of Zimbabwe	The Department of Biological Services	Harare 303211
	Institute of Environmental Studies	Harare 302603
Non-governmental organisations	WWF - Southern African Programme Office	Harare 252533 or 252534

APPENDIX THREE

Characteristics of vegetation types

Fire region	**Vegetation type**	**Major species (proper names)**	**Major species (common names)**
Zambezi Valley	1. Mopane woodland	Colophospermum mopane Combretum spp. Terminalia spp.	Mopane Combretum Terminalia
	2. Jesse thickets	Vangueria infausta Holmskioldia tettensis Pteleopsis spp.	Chinese hat
	3. Riverine areas	Trichilia emetica Diospyros mespiiliformis Kigelia africana	Mahogany Ebony Sausage tree
	4. Savannah woodlands	Brachystegia speciformis Brachystegia boehmii	Msasa Mfuti
Lowveld and Matebeleland	1. Mopane woodlands	Colophospermum mopane Combretum spp. Terminalia spp.	Mopane Combretum Terminalia
Eastern highlands	1. Woodlands	Brachystegia speciformis	Msasa
	2. Grasslands	Elyonurus argenteus Themeda triandra Uapaca kirkianna	
	2. Exotic plantations	Pinus spp.	Pine trees

Booklets in the Wildlife Management Series include:

1. Problem Animal Reporting
2. Electric Fencing Projects
3. Marketing Wildlife Leases
4. Managing Safari Hunting
5. Quota Setting Manual
   District Quota Setting Toolbox
6. Maintaining Electric Fences
7. Counting Wildlife Manual
8. Fire Management Manual

This booklet is the eighth in a series of guides on wildlife management and examines various aspects of fire management. It provides background information and guidance to Rural District Councils and should be read along with the other booklets in this series. The WWF Wildlife Management Series provides information and guidance to members of villages, wards and Rural District Councils involved in the management of CAMPFIRE. These booklets are linked to training programmes being undertaken by members of the CAMPFIRE Collaborative Group.

WWF is a member of the CAMPFIRE Collaborative Group supporting CAMPFIRE in Zimbabwe and has provided support and training to communities for the establishment of wildlife management systems.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature by:

- **conserving the world's biological diversity**
- **ensuring that the use of renewable natural resources is sustainable**
- **promoting the reduction of pollution and wasteful consumption**

WWF - SARPO
P.O. Box CY 1409
Causeway
Harare
Zimbabwe

Tel: Harare 252533/4

FIRE SAFETY

INTRODUCTION

Fire safety is the set of practices intended to reduce the destruction caused by fire. Fire safety measures include those that are intended to prevent ignition of an uncontrolled fire, and those that are used to limit the development and effects of a fire after it starts. Fire safety measures include those that are planned during the construction of a building or implemented in structures that are already standing, and those that are taught to occupants of the building. Threats to fire safety are commonly referred to as fire hazards. A fire hazard may include a situation that increases the likelihood of a fire or may impede escape in the event a fire occurs. Fire safety is often a component of building safety.

The staff/employees should have a working knowledge of basic fire science and chemistry. A fire, or combustion, is a chemical reaction. An understanding of the chemical reaction is the basis for preventing fires, as well as extinguishing fires once they initiate. A working knowledge of basic fire science and chemistry is essential for developing and implementing a successful fire safety program.

DEFINITION OF FIRE

A fire is a chemical reaction. There are many variables that can affect a fire. Effective fire safety management programs control the variables that can affect a fire. Therefore, it is imperative to understand the variables. A fire is self-sustained oxidation of a fuel that emits heat and light. A fire requires three variables to initiate: a fuel, oxygen, and heat.

The fire triangle is a well-known representation of the three variables needed to initiate a fire. In order to initiate a fire, fuel, oxygen, and heat are required.

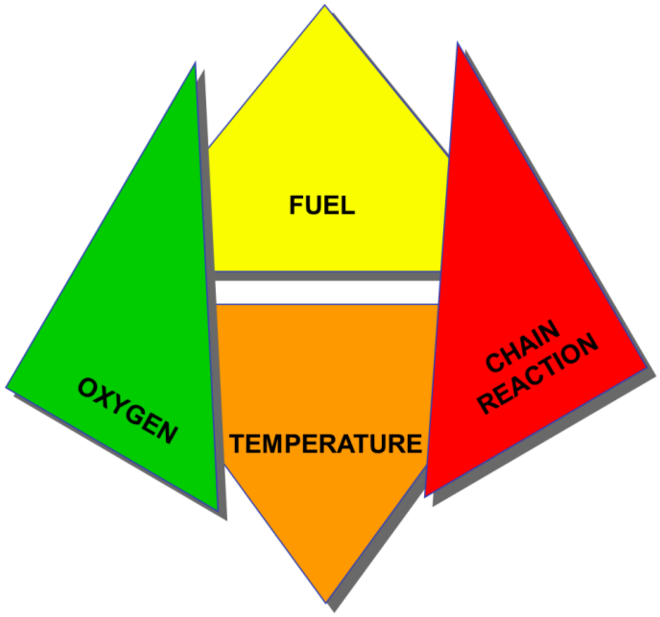
FIRE TETRAHEDRON

Fire prevention is the concept of preventing the variables of the fire triangle from coming into contact with each other to initiate a fire. Once a fire begins, it requires four variables to sustain the combustion reaction. The four variables required to sustain a fire are fuel, oxygen, heat, and chemical chain reactions. These four variables represent the fire tetrahedron.

Chemical chain reactions are a product of the combustion process. The chemical reactions ultimately produce combustion byproducts such as carbon monoxide, carbon dioxide, carbon, and other molecules, depending on the specific fuel. It is these byproducts of combustion found in the smoke that usually affect the safety and health of occupants and fire fighters.

Once a fire begins and is self-sustaining, the goal is to control and extinguish the fire. Fire extinguishment is done by eliminating one of the variables of the fire tetrahedron. By removing the fuel, oxygen, or heat, or inhibiting the chemical chain reactions, a fire can be extinguished. The concept of fire protection assumes fires will occur, and focuses on controlling fires by eliminating or otherwise controlling the variables of the fire tetrahedron. The concept of fire prevention differs from fire protection because fire prevention attempts to control the variables of the fire triangle before a fire occurs.

THE FIRE TETRAHEDRON



To further understand the fire triangle, it is necessary to analyze what influence each side of the fire triangle has in the combustion process. For the safety manager, this analysis is the key for understanding the concept of fire prevention. Fire prevention attempts to prevent fuels, oxygen, and heat from combining to start a fire. Fire prevention strategies include controlling fuels, controlling oxygen sources, and con- trolling heat sources. A discussion of fuels, oxygen, and heat sources follows.

FUEL:

A fuel is a combustible solid, liquid, or gas. Like in any chemical reaction, a source of energy is needed to sustain the heat required. The most common solid fuels are wood, paper, cloth, coal, and so forth. Flammable and combustible liquids include gasoline, fuel oil, paint, kerosene, and other similar materials. Propane, acetylene, and natural gas are some examples of gases that are flammable. Solid and liquid fuels share a common characteristic; they must be converted into a gas in order to support combustion. Gaseous fuels can undergo direct oxidation because the molecules are already in the gas state. Some liquid fuels can undergo direct oxidation because they produce vapors at ambient temperatures and pressures. Other liquid fuels and solid fuels, however, undergo sequential oxidation. This means that a fuel must be heated first to produce sufficient concentrations of gas to support combustion. From a fire safety standpoint, the safety manager should be aware of the different types of fuels located in the workplace.

The ease of ignition of a solid fuel is dependent on several factors. The most important factor is the surface to mass ratio of the fuel. The surface to mass ratio refers to how much of a fuel’s surface area is exposed to the environment in relation to its overall mass. The safety manager should be concerned with two things regarding the surface to mass ratio of a fuel. First, the more surface area that is exposed, the easier it is for a fire to initiate and the more rapidly it can burn. Second, the more mass that a solid fuel has, the more difficult it will be to initiate and sustain combustion. Consider cotton as a fuel in a textile mill. Cotton dusts and lint will burn easier and faster than a tightly bound bale of cotton. Liquid fuels are affected by several factors. The safety manager should be familiar with the terms flash point, fire point, boiling point, and specific gravity. Chapter 4 explores these factors in detail. However, one of the most critical indicators of a liquid's flammability should be mentioned—flash point. The flash point refers to the temperature at which adequate vapors are produced to form an ignitable mixture in air. Therefore, a liquid heated to a temperature at or above its flash point will ignite in the presence of an ignition source such as a spark, cigarette, hot surface, or open flame.

OXYGEN:

The atmosphere contains approximately 21% oxygen by volume. During combustion, the oxygen necessary for oxidation is sufficiently provided from the surrounding air. When the oxygen content of the atmosphere falls below 15%, a free-burning fire will begin to smolder. When the oxygen content of the atmosphere falls below 8%, a smoldering fire will stop burning (Bryan, 1982). Oxygen can also be provided by other sources that release oxygen molecules during a chemical reaction. The safety manager should be aware of these oxidizers in the workplace and segregate them from any fuels.

HEAT:

The safety manager should be concerned with sources of heat commonly found in the workplace. This is a concern because sources of heat provide the energy necessary to initiate combustion. By preventing heat sources from contacting the ignitable fuel-air mixtures, fires can be effectively prevented from occurring. Some common sources of heat for ignition in the workplace are:

- Open flames such as from cutting and welding torches
- Cigarettes
- Sparks such as from electrical equipment, brazing, or grinding
- Hot surfaces such as electrical motors, wires, and process pipes
- Radiated heat from boilers or portable heaters
- Lightning
- Static discharges such as during the transfer of flammable liquids
- Arcing from wires and electrical equipment
- Compression such as hydraulic oil under pressure on a machine
- Exothermic chemical reactions
- Spontaneous ignition from slow oxidation or fermentation combined with proper insulation of a fuel

Heat is transferred by three methods: conduction, convection, or radiation. Conduction occurs when two bodies are touching one another and heat is transferred from molecule to molecule. Convection is the transfer of heat through a circulating medium rather than by direct contact. The medium can be either a gas or a liquid. Radiation is the transfer of electromagnetic waves through any medium. For the safety manager, recognizing how heat can be transferred in the workplace is helpful for preventing fires.

As mentioned, four fire extinguishing principles exist. They are highlighted below:

1. Control the fuel— Controlling the fuel is accomplished by two methods. First, the fuel can be physically removed or separated from the fire. For instance, a fire involving stacks of wood pallets could be controlled by removing any exposed stacks of pallets to a safe location. Another example is closing a valve feeding a gas or flammable liquid fire. Second, the fuel can be chemically affected by diluting the fuel.

2. Control the oxygen— Controlling the oxygen requires that the oxygen be inhibited, displaced, or the concentration of oxygen be reduced below 15% by volume. Smoldering fires should be diluted to an oxygen concentration below 8% by volume. The oxygen supply to a fire can be inhibited by smothering the fire. Smothering a fire places a barrier between the flame and the atmosphere. This can be accomplished with a blanket or applying a layer of foam to form a vapor barrier. Displacing and reducing the oxygen concentration involves applying an inert gas to the fire, such as carbon dioxide. The carbon dioxide displaces the oxygen thus lowering the concentration to a level that cannot sustain the fire. Applying an inert gas to a fire requires that the fire be located in a confined space. Personnel must be aware that displacing the oxygen or diluting the oxygen concentration affects their ability to breathe. Fire extinguishment using this method requires that personnel be absent from the confined area or protected by self-contained breathing apparatus.

3. Control the heat— Controlling the heat requires that the heat be absorbed. Combustion is an exothermic chemical reaction. If the heat emitted by the reaction can be absorbed faster than the reaction can produce the heat, then the reaction cannot be sustained. Water is the most common extinguishing agent. Water is also the most efficient extinguishing agent because it has the capability to absorb immense amounts of heat.

4. Inhibit the chemical chain reactions— Inhibiting the chemical chain reactions requires that a chemical agent be introduced into the fire. Certain chemical agents can interfere with the sequence of reactions by absorbing free radicals from one sequence that are needed to complete the next sequence. Dry chemical extinguishing agents commonly used in portable fire extinguishers have this ability.

CLASSES OF FIRE

Fires are classified based upon the type of fuel that is consumed. Fires are classified into categories so personnel can quickly choose appropriate extinguishing agents for the expected fire and associated hazards. Fires are classified into five general classes. Each class is based on the type of fuel and the agents used in extinguishment. The five classes of fire are described next:

• **Class A—** Class A fires involve ordinary combustibles such as wood, paper, cloth, rubber, and some plastics. Water is usually the best extinguishing agent because it can penetrate fuels and absorb heat. Dry chemicals used to interrupt the chemical chain reactions are also effective on Class A fires.

• **Class B—** Class B fires involve flammable and combustible liquids and gases such as gasoline, alcohols, and propane. Extinguishing agents that smother the fire or reduce the oxygen concentration available to the burning zone are most effective. Common extinguishing agents include foam, carbon dioxide, and dry chemicals.

• **Class C—** Class C fires involve energized electrical equipment. Non-conductive extinguishing agents are necessary to extinguish Class C fires. Dry chemicals and inert gases are the most effective agents. If it can be done safely, personnel should isolate the power to electrical equipment before attempting to extinguish a fire. Once electrical equipment is de-energized, it is considered a Class A fire.

• **Class D—** Class D fires involve combustible metals such as magnesium, sodium, titanium, powdered aluminum, potassium, and zirconium. Class D fires require special extinguishing agents that are usually produced for the specific metal.

• **Class K—** Class K fires most often occur where cooking media (fats, oils, and greases) are used, and most of the time are found in commercial cooking operations. Class K fire extinguishers are required in any location that cooks oils, grease, or animal fat. Any location that fries must have a Class K fire extinguisher. Every commercial kitchen should have a Class K extinguisher located in it to supplement the suppression system.

THREE STAGES OF FIRE

Fires evolve through several stages as the fuel and oxygen available are consumed. Each stage has its own characteristics and hazards that should be understood by safety managers and fire-fighting personnel.

INCIPIENT STAGE:

The incipient stage is the first or beginning stage of a fire. In this stage, combustion has begun. This stage is identified by an ample supply of fuel and oxygen. The products of combustion that are released during this stage normally include water vapor, carbon dioxide, and carbon monoxide. Temperatures at the seat of the fire may have reached 1000°F, but room temperatures are still close to normal.

FREE-BURNING STAGE:

The free-burning stage follows the incipient stage. At this point, the self-sustained chemical reaction is intensifying. Greater amounts of heat are emitted and the fuel and oxygen supply is rapidly consumed. Room temperatures can rise to over 1300°F. In an enclosed compartment, the free-burning stage can become dangerous. Because of the heat intensity, the contents within a compartment are heated. At some point, if the compartment is not well ventilated, compartment contents will reach their ignition temperature. A flashover occurs when the contents within a compartment simultaneously reach their ignition temperature and become involved in flames. It is not uncommon for room temperatures to exceed 2000°F following a flashover. Human survival, even for properly protected fire fighters, is difficult if not impossible for a few seconds within a compartment following a flashover.

SMOLDERING STAGE:

The smoldering stage follows the free-burning stage. As a free-burning fire continues to burn, the chemical reaction will eventually consume the available oxygen within the compartment and ultimately convert it into carbon monoxide and carbon dioxide. This causes the oxygen concentration within the compartment to decrease. When the oxygen concentration decreases to 15% by volume, the chemical reaction will not have sufficient oxygen to support free-burning combustion. Visibly, the flames subsist and the fuel begins to glow. A smoldering fire is identified by a sufficient amount of fuels and lower oxygen concentrations. Smoldering fires, especially when insulated within a compartment, can continue the combustion process for hours. Room temperatures can range from 1000–1500°F. The byproducts of combustion also fill the compartment and human survival is impossible. During the smoldering stage, an extreme hazard, called a backdraft, can develop. A backdraft occurs when oxygen is introduced into a smoldering compartment fire. The immediate availability of sufficient oxygen in the presence of sufficient fuel, heat, and chemical chain reactions causes flaming combustion again. In some cases, the backdraft is so violent that an explosion will occur. Human survival, even of properly protected fire fighters, is usually not possible.

IDENTIFICATION OF HAZARDOUS MATERIALS

In the past, chemical manufacturers labeled their products with the warnings "Caution," "Danger," and "Handle with Care." The terms were vague and did not indicate specific hazards associated with particular chemicals. The U.S. Department of Transportation labeling system contains requirements for the shipping, marking, labeling, and placarding of 1400 hazardous materials.

The objectives of this standard are to
(1) Provide an immediate warning of potential danger;
(2) Inform emergency responders of the nature of the hazard;
(3) State emergency spill or release control procedures; and
(4) Minimize potential injuries from chemical exposure.

The standard contains a hazardous materials table listing substances by name, prescribing requirements for shipping papers, package marking, labeling, and transport vehicle placarding. Table shows a comparison listing of

United Nations and DOT classifications for hazardous materials. The classes of hazardous materials that must be labeled and placarded are as follows: explosives, flammable and combustible materials, oxidizers, corrosives, poisons, compressed gases, etiologies, and radioactive materials.

TABLE 1
United Nations and Department of Transportation Classification of Hazardous Materials

United Nations Class	DOT Classification
1	Explosives: Class A, B, and C
2	Nonflammable and flammable gases
3	Flammable liquids
4	Flammable solids, spontaneously combustible substances, and water reactive substances
5	Oxidizing materials and organic peroxides
6	Poisons: Class A, B, and C
7	Radioactive I, II, and III
8	Corrosives
9	Miscellaneous materials which can present a hazard during transport, but are not covered by other classes

TABLE 2
Table of Evacuation (Isolation) Distances

1. Determine if the accident involves a *small* or *large* spill and if *day* or *night*. Generally, a *small spill* is one which involves a single, small package (i.e., up to a 208 liter [55 U.S. gallon] drum), a small cylinder, or a small leak from a large package. A *large spill* is one which involves a spill from a large package, or multiple spills from many small packages.

2. Determine the initial *isolation* distance. Direct all persons to move, in a crosswind direction, away from the spill to the distance specified in meters and feet.

3. Next, determine the initial *protective action distance*. For a given dangerous goods, spill size, and whether day or night, try to determine the downwind distance—in kilometers and miles—for which protective actions should be considered. For practical purposes, the Protective Action Zone (i.e., the area in which people are at risk of harmful exposure) is a square, whose length and width are the same as the downward distance.

4. Initiate protective actions to the extent possible, beginning with those closest to the spill site and working away from the site in the downwind direction. When a water-reactive PIH producing material is spilled into a river or stream, the source of the toxic gas may move with the current or stretch from the spill point downstream for a substantial distance.

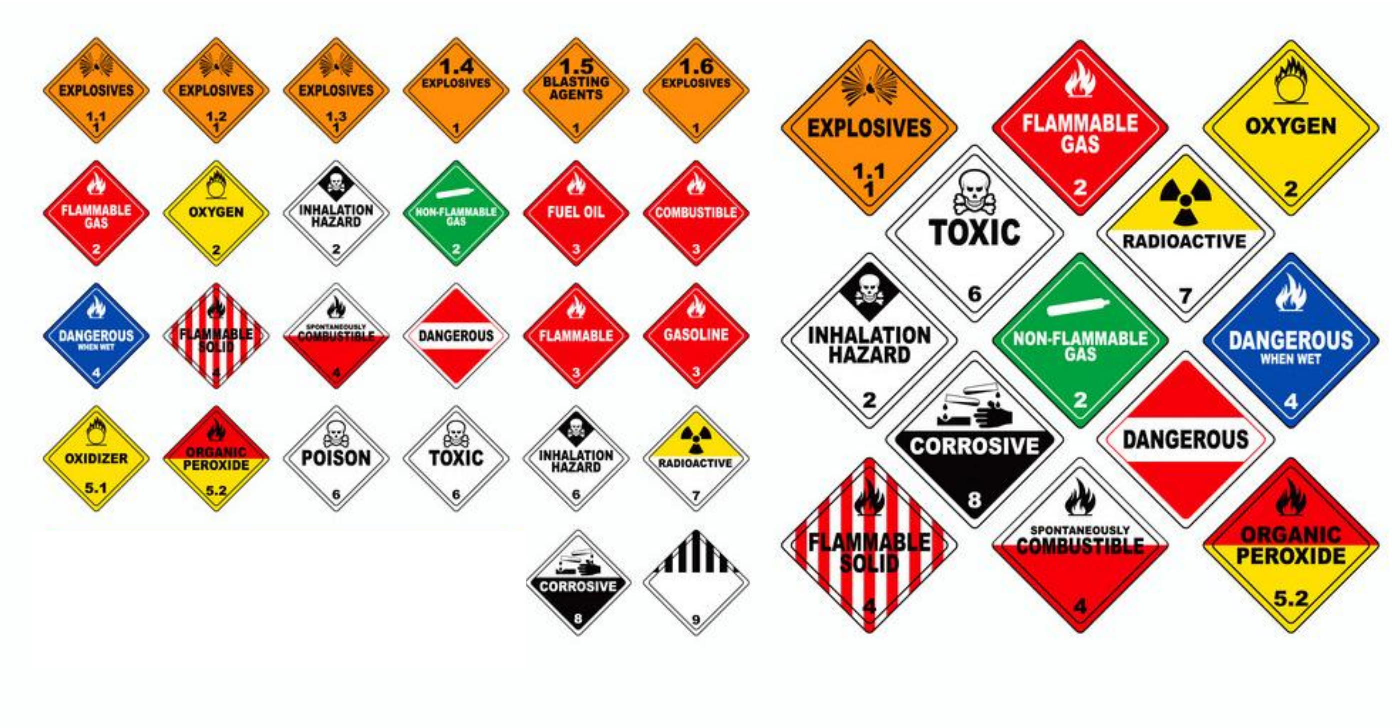


TABLE 3
Classes of Flammable Materials

Hazardous Class	Definition	Examples
Flammable Liquid	Any liquid with a flash point below 37.8°C (100°F).	Gasoline, pentane
Flammable Solid	Any solid material, other than one classified as an explosive, which is likely to cause fire by self-ignition through friction, absorption of moisture, chemical changes, or retained heat. Can be ignited readily and burn vigorously.	Phosphorus, fish meal
Flammable Solid (Dangerous when wet)	Same definition as above, with the additional fact that water will accelerate the reaction.	Magnesium scrap, lithium silicon
Flammable Gases	Any mixture or material in a container having an absolute pressure exceeding 40 psi at 70°F or any liquid flammable material having a vapor pressure exceeding 40 psi at 100°F.	Methane, methyl chloride
Combustible Liquid	Any liquid with a flash point at or above 37.8°C (100°F) and below 93.3°C (200°F).	Pine oil, ink, fuel oil

TABLE 4
Classification of Flammable and Combustible Liquids (*NFPA-30*)

Class I	Flammable Liquids—Flash point below 100°F (37.8°C)
	Volatile Class I Flammable Liquids
Class IA	Most hazardous, having flash points below 73°F (22.8°C) with boiling points below 100°F (37.8°C)
Class IB	Same flash point range but with boiling points at or above 100°F (37.8°C)
Class IC	Flash points between 73°F (22.8°C) and below 100°F (37.8°C)

Class II	Combustible Liquids—Flash points at or above 100°F (37.8°C) and below 140°F (60°C)
Class III	Liquids are included in the combustible liquid classification and are further classified
Class IIIA	Flash point between 140 and 200°F (60–93.4°C)
Class IIIB	Flash point 200°F (93.4°C) or above

NFPA CODE 704:

NFPA 704 provides an easy method of recognizing hazards. The NFPA 704 Diamond indicates the health, flammability, and reactivity (i.e., stability) hazards of chemicals by placing numbers in the three upper squares of the diamond

Health Hazards Are Indicated in the Left Square, Color-Coded Blue

4. Materials which on very short exposure could cause death or major residual injury.
3. Materials which on short exposure could cause serious temporary or residual injury.
2. Materials which on intense or continued, but not chronic, exposure could cause temporary incapacitation or possible residual injury.
1. Materials which on exposure would cause irritation but only minor residual injury.
0. Materials which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.

Flammability Hazards Are Indicated in the Top Square, Color-Coded Red

4. Materials which will vaporize rapidly or completely at atmospheric pressure and normal ambient temperature, or which are dispersed readily and which will burn readily.
3. Liquids and solids which can be ignited under almost all ambient temperature conditions.
2. Materials which must be heated moderately or exposed to relatively high ambient temperatures before ignition can occur.
1. Materials which must be preheated before ignition can occur.
0. Materials that will not burn.

Reactivity (Stability) Hazards Are Indicated in the Right Square, Color-Coded Yellow

4. Materials which in themselves are readily capable of detonations or of explosive decomposition or reaction at normal temperatures and pressures.
3. Materials which in themselves are capable of detonation or explosive decomposition or reaction, but require a strong initiating source, or which must be heated under confinement before initiation, or which react explosively with water.
2. Materials which readily undergo violent chemical change at elevated temperatures, or which react violently with water, or which may form explosive mixtures with water.
1. Materials which in themselves are normally stable, but which can become unstable at elevated temperatures and pressures.
0. Materials which in themselves are normally stable, even under fire expo- sure conditions, and which are not reactive with water.

Special Information Is Indicated in the Bottom Square, Color-Coded White

0. The letter W with a bar through it indicates a material may have a hazardous reaction with water. This does not mean “use no water,” but rather “avoid the use of water.” Note that some forms of water (e.g., fog or fine spray) may be used. Because water may cause a hazard, it is advised that water be used very cautiously until fire fighters have proper information.

1. The radioactive “pinwheel” indicates radioactive materials.
2. The letters “OX” indicate an oxidizer.

HAZARD DIAMOND

TABLE 5
Classes of Oxidizing Materials

Hazardous Class	Definition	Examples
Oxidizer	A substance that yields O_2 readily to stimulate the combustion of organic matter.	Silver nitrate
Organic Peroxide	An organic derivative of the inorganic compound, hydrogen peroxide.	Lauroyl peroxide
Oxygen	An odorless, colorless, gaseous chemical element that supports combustion. At low temperatures the gas liquefies.	Oxygen

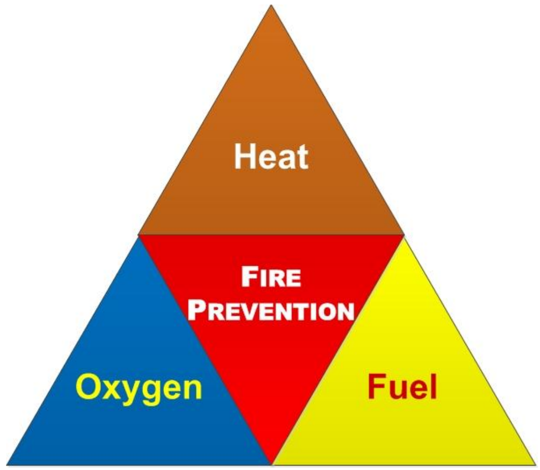
TABLE 6
Classes of Explosives

Hazardous Class	Definition	Examples
Explosive	Any chemical compound, mixture, or device, the purpose of which is to function by explosion, that is, with substantial instantaneous release of gas or heat.	
Class A	A detonating or otherwise maximum hazard.	Black powder, dynamite, blasting caps
Class B	Function by rapid combustion rather than detonation.	Special fireworks, flash powders
Class C	Materials that do not ordinarily detonate in restricted quantities—minimum explosion hazard.	Flares, small arms

FIRE PREVENTION & PROTECTION:

FIRE PREVENTION

Fire prevention requires segregating the three elements of the fire triangle. A fire needs three elements - heat, oxygen and fuel. Without heat, oxygen and fuel a fire will not start or spread. A key strategy to prevent fire is to remove one or more of heat, oxygen or fuel. .



HEAT

Heat can be generated by work processes and is an essential part of some processes such as cooking. This heat must be controlled and kept away from fuel unless carefully controlled. Heat generated as a by-product of a process must be dealt with properly.

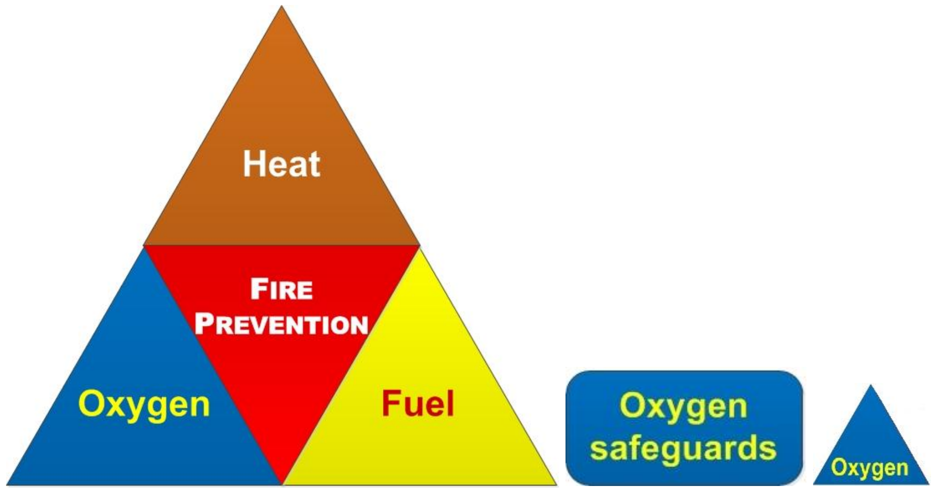
Heat Safeguards

- Ensure employees are aware of their responsibility to report dangers
- Control sources of ignition
- Have chimneys inspected and cleaned regularly
- Treat independent building uses, such as an office over a shop as separate purpose groups and therefore compartmentalize from each other
- Ensure cooking food is always attended
- Use the Electricity Supply Board's Safety webpage
- Have regard to relevant Authority Safety Alerts, e.g. Mobile Phone "*Expert XP-Ex-1*", Filling LPG Cylinders
- Use the Code of Practice For Avoiding Danger From Underground Services

OXYGEN

Oxygen gas is used

- in welding, flame cutting and other similar processes
- for helping people with breathing difficulties
- in hyperbaric chambers as a medical treatment
- in decompression chambers
- for food preservation and packaging
- in steelworks and chemical plants



The air we breathe contains about 21% oxygen. Pure oxygen at high pressure, such as from a cylinder, can react violently with common materials such as oil and grease. Other materials may catch fire spontaneously. Nearly all materials including textiles, rubber and even metals will burn vigorously in oxygen.

With even a small increase in the oxygen level in the air to 24%, it becomes easier to start a fire, which will then burn hotter and more fiercely than in normal air. It may be almost impossible to put the fire out. A leaking valve or hose in a poorly ventilated room or confined space can quickly increase the oxygen concentration to a dangerous level.

The main causes of fires and explosions when using oxygen are

- oxygen enrichment from leaking equipment
- use of materials not compatible with oxygen
- use of oxygen in equipment not designed for oxygen service
- incorrect or careless operation of oxygen equipment

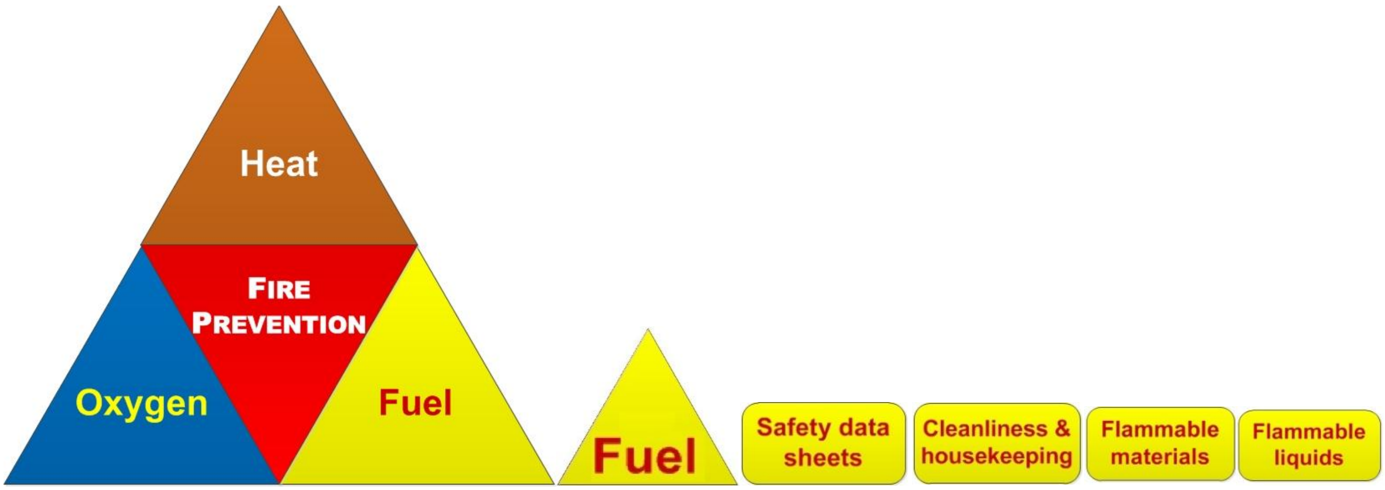
Oxygen Safeguards

- Ensure employees are aware of their responsibility to report dangers
- See safeguards in the Code of Practice for Working in Confined Spaces
- Oxygen should never be used to “sweeten” the air in a confined space
- **Where oxygen is used,**
    - follow safety advice from the supplier
    - follow the safeguards on the safety data sheet
    - keep the safety data sheet readily available
- Be aware of the dangers of oxygen if in doubt, ask
- Prevent oxygen enrichment by ensuring that equipment is leak-tight and in good working order
- Check that ventilation is adequate
- Always use oxygen cylinders and equipment carefully and correctly
- Always open oxygen cylinder valves slowly
- Do not smoke where oxygen is being used
- Never use replacement parts which have not been specifically approved for oxygen service
- Never use oxygen equipment above the pressures certified by the manufacturer
- Never use oil or grease to lubricate oxygen equipment
- Never use oxygen in equipment which is not designed for oxygen service
- Operators of locations storing large amounts of oxidising substances

FUEL

Workplaces in which large amounts of flammable materials are displayed, stored or used can present a greater hazard than those where the amount kept is small.

In relation to fire, fuel consists of flammable material. Flammable material is material that burns readily in a normal atmosphere. Flammable materials include flammable liquids (e.g. petrol), flammable gasses (e.g. propane and butane) and flammable solids (e.g. charcoal, paper). It is important to identify all flammable materials that are in your workplace so that proper controls can be put in place.



Great care is required in the storage, handling and use of flammable materials. Safety Data sheets may provide detailed advice.

Fuel Safeguards

- Identify all flammable materials so that proper controls can be put in place
- Identify use of substances with flammable vapours (e.g. some adhesives)
- Reduce quantities of flammable materials to the smallest amount necessary for running the business and keep away from escape routes
- Replace highly flammable materials with less flammable ones
- Store remaining stocks of highly flammable materials properly outside, in a separate building, or separated from the main workplace by fire-resisting construction
- Provide clearly marked separate storage for flammable chemicals, gas cylinders, and waste materials
- Train employees on safe storage, handling and use of flammable materials
- Keep stocks of office stationery and supplies and flammable cleaners' materials in separate cupboards or stores. They should be fire-resisting with a fire door if they open onto a corridor or stairway escape route.
- This is highly specialised work and a detailed risk assessment must be conducted
- Detailed work instructions must be put in place
- Advice should be sought from the gas supplier as needed
- Workers must be properly trained and supervised
- The quantity of flammable liquids in workrooms should be kept to a minimum, normally no more than a half-day's or half a shifts supply
- Flammable liquids, including empty or part-used containers, should be stored safely. Small quantities (Tens of Litres) of flammable liquids can be stored in the workroom if in closed containers in a fire-resisting (e.g. metal), bin or cabinet fitted with means to contain any leaks
- Flammable liquids should not be decanted within the store. Decanting should take place in a well-ventilated area set aside for this purpose, with appropriate facilities to contain and clear up any spillage
- Container lids should always be replaced after use, and no container should ever be opened in such a way that it cannot be safely resealed

- Flammable liquids should be stored and handled in well ventilated conditions. Where necessary, additional properly designed exhaust ventilation should be provided to reduce the level of vapour concentration in the air
- Storage containers should be kept covered and proprietary safety containers with self-closing lids should be used for dispensing and applying small quantities of flammable liquids
- There should be no potential ignition sources in areas where flammable liquids are used or stored and flammable concentrations of vapour may be present at any time. Any electrical equipment used in these areas, including fire alarm and emergency lighting systems, needs to be suitable for use in flammable atmospheres
- Avoid accumulations of combustible rubbish and waste and remove at least daily and store away from the building
- Never store flammable or combustible rubbish, even temporarily, in escape routes, or where it can contact potential sources of heat
- Position skips so that a fire will not put any structure at risk
- Clean cooking surfaces on a regular basis to prevent grease build-up
- Rags and cloths which have been used to mop up or apply flammable liquids should be disposed of in metal containers with well-fitting lids and removed from the workplace at the end of each shift or working day
- Handle material in accordance with the advice on the safety data sheet
- Keep safety data sheets readily available
- Keep safety data sheets safely available in the event of a fire so that the information is available for emergency services

FIRE PROTECTION

Fire is a chemical reaction that requires three elements to be present for the reaction to take place and continue. The three elements are:

- Heat, or an ignition source
- Fuel
- Oxygen

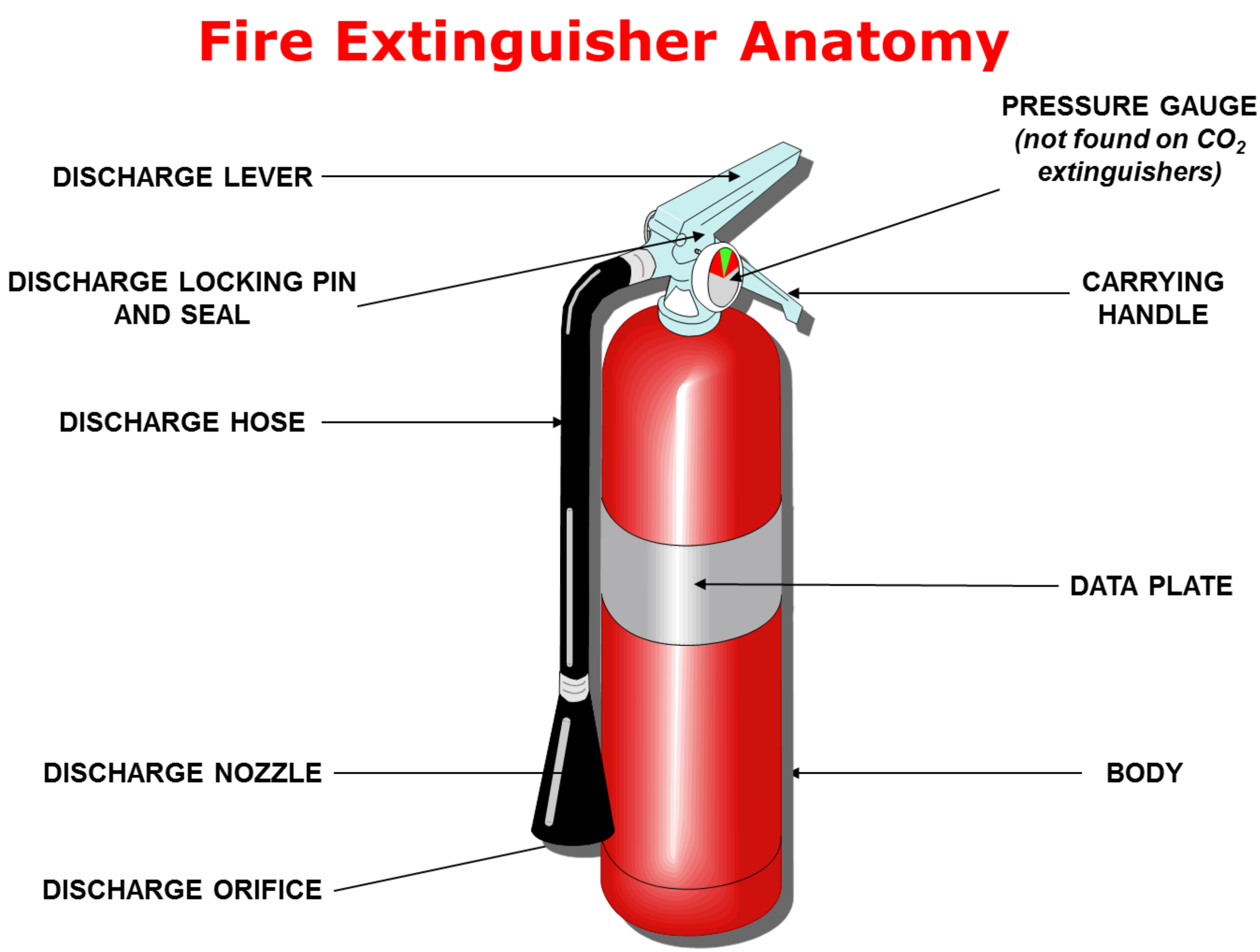
These three elements typically are referred to as the “fire triangle.” Fire is the result of the reaction between the fuel and oxygen in the air. Scientists developed the concept of a fire triangle to aid in understanding of the cause of fires and how they can be prevented and extinguished. Heat, fuel and oxygen must combine in a precise way for a fire to start and continue to burn. If one element of the fire triangle is not present or removed, fire will not start or, if already burning, will extinguish.

Ignition sources can include any material, equipment or operation that emits a spark or flame —including obvious items, such as torches, as well as less obvious items, such as static electricity and grinding operations. Equipment or components that radiate heat, such as kettles, catalytic converters and mufflers, also can be ignition sources. Fuel sources include combustible materials, such as wood, paper, trash and clothing; flammable liquids, such as gasoline or solvents; and flammable gases, such as propane or natural gas. Oxygen in the fire triangle comes from the air in the atmosphere. Air contains approximately 79 percent nitrogen and 21 percent oxygen. OSHA describes a hazardous atmosphere as one which is oxygen-deficient because it has less than 19.5 percent oxygen, or oxygen enriched because it has greater than 23.5 percent oxygen. Either instance is regarded by OSHA as an atmosphere immediately dangerous to life and health (IDLH) for reasons unrelated to the presence of fire. Depending on the type of fuel involved, fires can occur with much lower volume of oxygen present than needed to support human respiration. Every roofing project has all three of the fire triangle elements present in abundance. The key to preventing fires is to keep heat and ignition sources away from materials, equipment and structures that could act as fuel to complete the fire triangle.

Fire Classifications Fires are classified as A, B, C, D or K based on the type of substance that is the fuel for the fire, as follows:

Class A—fires involving ordinary combustibles, such as paper, trash, some plastics, wood and cloth. A rule of thumb is if it leaves an ash behind, it is a Class A fire.
Class B—fires involving flammable gases or liquids, such as propane, oil and gasoline
Class C—fires involving energized electrical components
Class D—fires involving metal. A rule of thumb is if the name of the metal ends with the letters "um," it is a Class D fire. Examples of this are aluminum, magnesium, beryllium and sodium. Class D fires rarely occur in the roofing industry.
Class K—fires involving vegetable or animal cooking oils or fats; common in commercial cooking operations using deep fat fryers.

Fire Extinguishers There are different types of fire extinguishers designed to put out the different classes of fire. Selecting the appropriate fire extinguisher is an important consideration for a roofi ng contractor. The wrong extinguisher actually may make a fire emergency worse. For example, failing to use a Crated extinguisher on energized electrical components may endanger workers by causing the extinguishing material to be electrified by the energiz ed components that are on fire. C-rated fire extinguishers put out the fire by using a chemical that does not conduct electricity.



The following table illustrates the types of extinguishers, fire classes for which each is used and the limitations of each extinguisher.

Fire Extinguisher Type	Class of Fire it Extinguishes	Extinguisher Limitations/ Comments
Dry Chemical (multipurpose)	A, B, C	Generally good for use in roofing industry
Foam—alcohol-resistant and aqueous film-forming foam (AFFF) types	B	Expensive; effective on Class B only; limited shelf life; generally not needed in roofing industry
Water	A	Good only for Class A fires
Metal X	D B, C;	Expensive; must be kept dry; ineffective on A, typically not needed in roofing industry
Carbon Dioxide	B, C	If used in confined areas, will create oxygen deficiency; not effective in windy conditions; can cause frostbite during discharge; typically not used in roofing industry
Halon	B, C	Expensive; not effective in windy conditions; toxic gases may be released in extremely hot fires because of decomposition; generally not used in roofing industry
Potassium Acetate	K	Expensive, wet chemical extinguisher for commercial cooking operations using oils and fats

Remember this easy acronym when using an extinguisher - P.A.S.S.

Pull the pin.

Aim the nozzle.

Squeeze the handle.

Sweep side to side at the base of the fire.

Employees should be instructed that if a fire cannot be extinguished using one full extinguisher, they should evacuate the site and let the fire department handle the situation.

EMERGENCY EVACUATION

Emergency evacuation is the urgent immediate egress or escape of people away from an area that contains an imminent threat, an ongoing threat or a hazard to lives or property.

Examples range from the small-scale evacuation of a building due to a storm or fire to the large-scale evacuation of a city because of a flood, bombardment or approaching weather system, especially a Tropical Cyclone. In situations involving hazardous materials or possible contamination, evacuees may be decontaminated prior to being transported out of the contaminated area.

Evacuation Sequence-

The sequence of an evacuation can be divided into the following phases:

1. detection
2. decision
3. alarm
4. reaction
5. movement to an area of refuge or an assembly station
6. transportation

The time for the first four phases is usually called pre-movement time. The most common equipment in buildings to facilitate emergency evacuations are fire alarms, exit signs, and emergency lights. Some structures need special emergency exits or fire escapes to ensure the availability of alternative escape paths.

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Fires in Structures Under Construction

Richard Campbell
October 2023

Fires in structures under construction

From 2017 to 2021, local fire departments responded to an estimated average of 4,440 fires in structures under construction per year. These fires caused an annual average of five civilian deaths, 59 civilian injuries, and $370 million in direct property damage. Only 1 percent of all the reported structure fires were in structures under construction, but these fires accounted for 3 percent of the direct property damage in structure fires.

- The estimated number of fires in structures under construction has increased since 2014 after declining between 2006 and 2010.
- Three of every four fires (76 percent) in structures under construction involved residential properties.
- Cooking equipment was the leading cause of fires on construction sites, but these fires tended to be minor.
- Fires that were intentionally set caused fewer than one in 10 fires (8 percent) but 45 percent of the direct property damage.
- Fires in structures under construction were highest in January and lowest in October.
- Fires in structures under construction were most common in the afternoon and evening; however, fires that occurred between midnight and 6 a.m. accounted for just over half (51 percent) of the direct property damage.
- The leading factors contributing to the ignition of fires in structures under construction included heat sources that were too close to combustible materials, abandoned or discarded materials or products, and electrical failures or malfunctions.

Property Use

The vast majority of the fires in structures under construction involved residential properties (76 percent) and accounted for the largest shares of deaths, injuries, and direct property damage (see Table A). Another 6 percent of fires involved mercantile or business properties, while fires in outside or special properties accounted for 5 percent but caused 11 percent of the direct property damage.

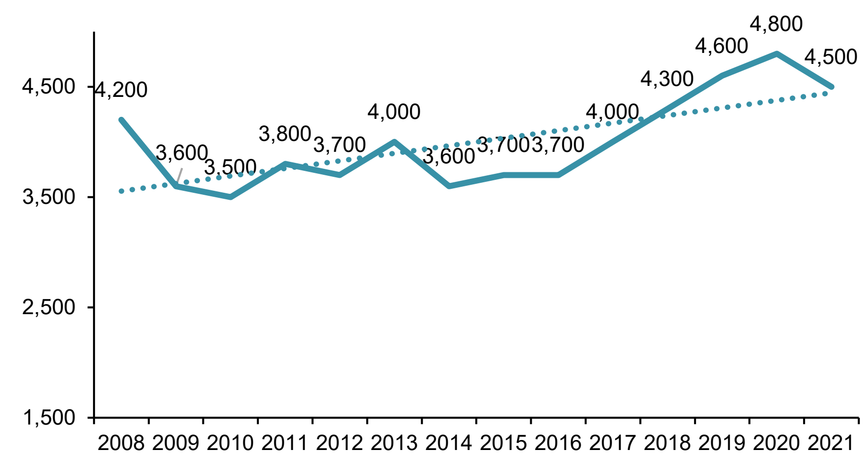
Table A. Fires in Structures Under Construction by Property Use: 2017–2021 Annual Averages

Property Use	Fires	Civilian Injuries	Direct Property Damage
Residential	76%	76%	79%
Mercantile or business	6%	5%	3%
Outside or special property	5%	4%	11%
Assembly	3%	5%	2%
Storage	3%	2%	1%
Health care, detention, correction	2%	7%	2%

Recent trends in fires in structures under construction

Figure 1 shows the estimated number of fires in structures under construction from 2008 to 2021. As the trend line shows, there has been an increase in the number of these fires over this period, particularly in the years since 2015, after declining between 2008 and 2010.

Figure 1. Fires in Structures Under Construction: 2008–2021

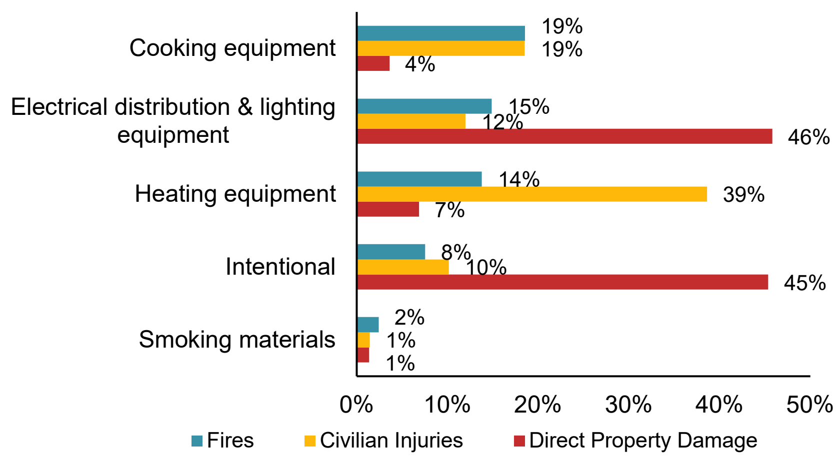


Leading causes of fire in structures under construction

Figure 2 shows that cooking equipment was the leading cause of fires on construction sites. While these fires were usually minor, they accounted for one-fifth (19 percent) of the reported injuries. Electrical distribution and lighting equipment accounted for 15 percent of the fires but nearly half (46 percent) of the direct property damage. Another 14 percent of the fires were caused by heating equipment. Fires that were intentionally set caused 8 percent of the fires but 45 percent of the direct property damage. Smoking materials accounted for 2 percent of the fires and 1 percent of the direct property damage.

It is important at construction sites—where combustible and flammable materials are present—for equipment to be used for its intended purpose. It is also important for temporary heaters to be selected and used with fire safety in mind. The areas around temporary heaters must also be kept clear of combustible materials.

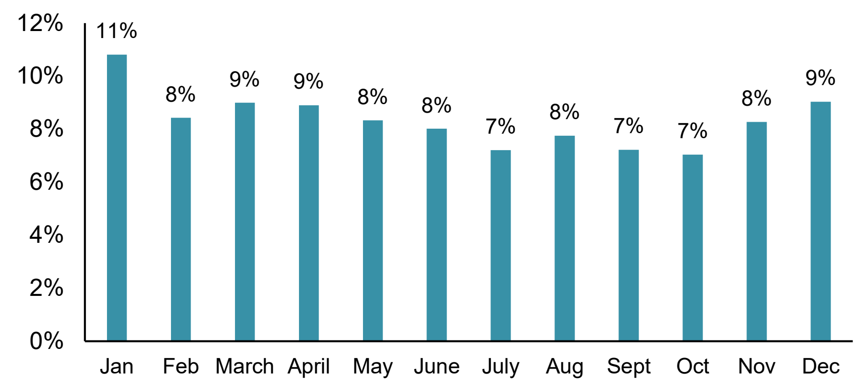
Figure 2. Fires in Structures Under Construction by Leading Cause: 2017–2021 Annual Averages



Timing of fires in structures under construction

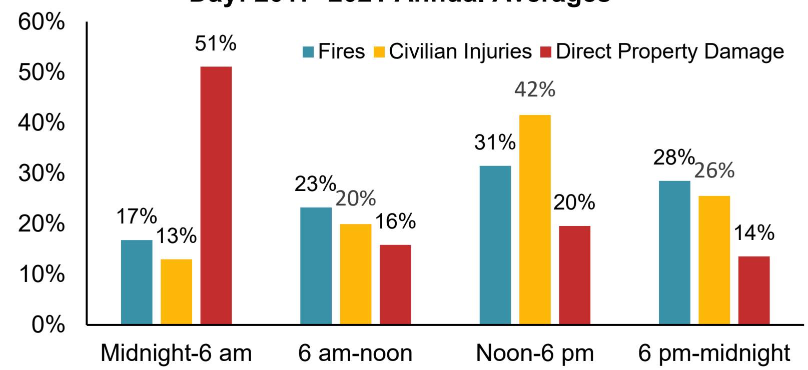
Figure 3 shows that the number of fires in structures under construction was highest in January (11 percent of the yearly total) and was generally higher in cold weather months (December, January, and March). The lowest shares of fires occurred in July, September, and October (each of which accounted for 7 percent of the fires). Fires in the remaining months accounted for either 8 or 9 percent of the annual average.

Figure 3. Fires in Structures Under Construction by Month: 2017–2021 Annual Averages



The peak periods for fires in structures under construction were the hours between noon and 9 p.m. and between 4 p.m. and 8 p.m. (Figure 4). Although approximately one-fifth of the fires (18 percent) occurred between midnight and 6 a.m., these fires accounted for more than half (51 percent) of the direct property damage. Fires may spread more easily undetected during overnight hours when workers are less likely to be at the construction site.

Figure 4. Fires in Structures Under Construction by Time of Day: 2017–2021 Annual Averages

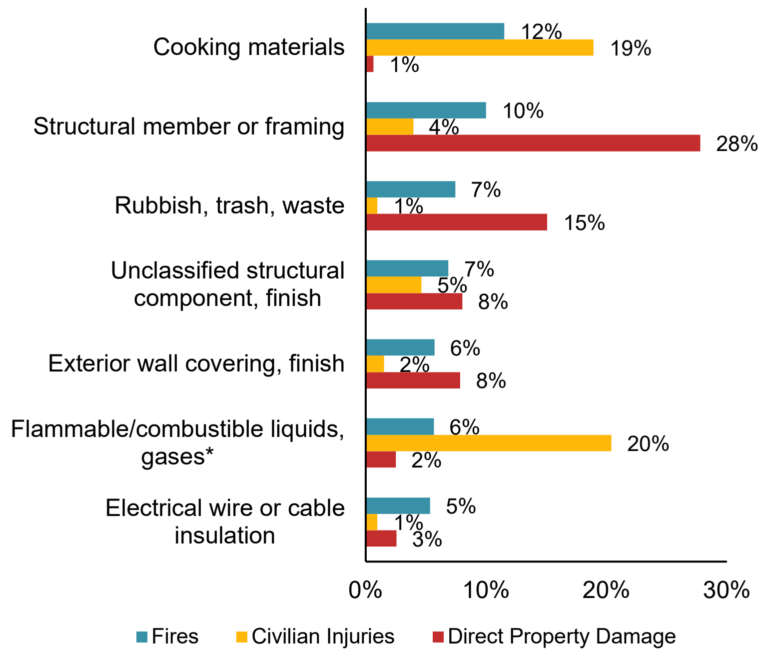


Leading items first ignited in structure fires under construction

Most often, cooking materials were the first items ignited in fires in structures under construction. However, almost one-quarter of the fires involved the ignition of structural elements, including structural members or framing (10 percent), unclassified structural components (7 percent), or exterior wall coverings or finishes (6 percent), as indicated in Figure 5.

Waste materials were first ignited in 7 percent of the fires, but these fires accounted for 15 percent of the direct property damage. The ignition of flammable or combustible liquids or gases, piping, or filters accounted for 6 percent of the fires but one-fifth (20 percent) of the injuries.

Figure 5. Leading Items First Ignited in Structure Fires Under Construction: 2017–2021 Annual Averages



*Flammable or combustible liquid or gas, piping, or filter.

Equipment involved in ignition

Fires in structures under construction most often involved cooking equipment, electrical distribution and lighting equipment, or heating equipment. Electrical distribution and lighting equipment accounted for a disproportionately large share of the direct property damage. Cooking equipment and heating equipment each accounted for the largest shares of injuries (see Table B).

Temporary electrical wiring or lighting can emit heat or sparks if not properly installed or maintained and should be regularly reviewed by qualified personnel to ensure safety.

Torches, burners, or soldering irons were involved in 7 percent of the fires, but these fires accounted for 13 percent of the direct property damage. Hot work activities pose a variety of combustion hazards and should be carried out under a stringent permitting system. For more information on hot work safety, see nfpa.org/Training-and-Events/By-topic/Hot-Work.

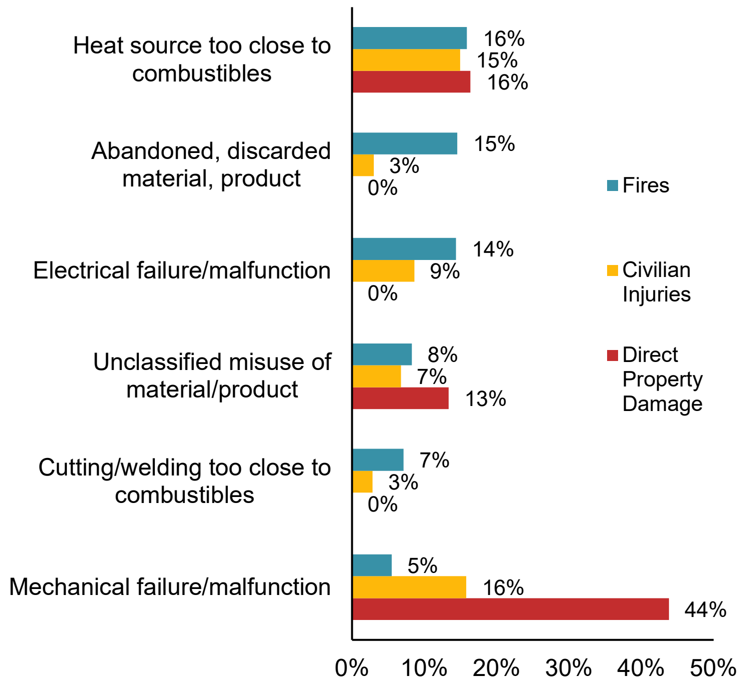
Table B. Fires in Structures Under Construction by Equipment Involved in Ignition: 2017–2021 Annual Averages

Equipment Involved	Fires	Civilian Injuries	Direct Property Damage
Cooking equipment	19%	19%	4%
Electrical distribution and lighting equipment	15%	12%	46%
Wiring and related equipment	10%	10%	13%
Heating equipment	14%	39%	7%
Fixed or portable space heater	6%	29%	4%
Torch, burner, or soldering iron	7%	9%	13%

Factor contributing to ignition

The leading factors contributing to the ignition of fires in structures under construction included heat sources being too close to combustible materials, abandoned or discarded materials or products, and electrical failures or malfunctions, as shown in Figure 6. Other factors contributing to construction fires included cutting or welding too close to combustible materials, unclassified misuse of materials or products, and mechanical failures or malfunctions. Good worksite practices should include regular maintenance for the equipment. Fire safety procedures for the use of powered equipment and combustible materials should also be established.

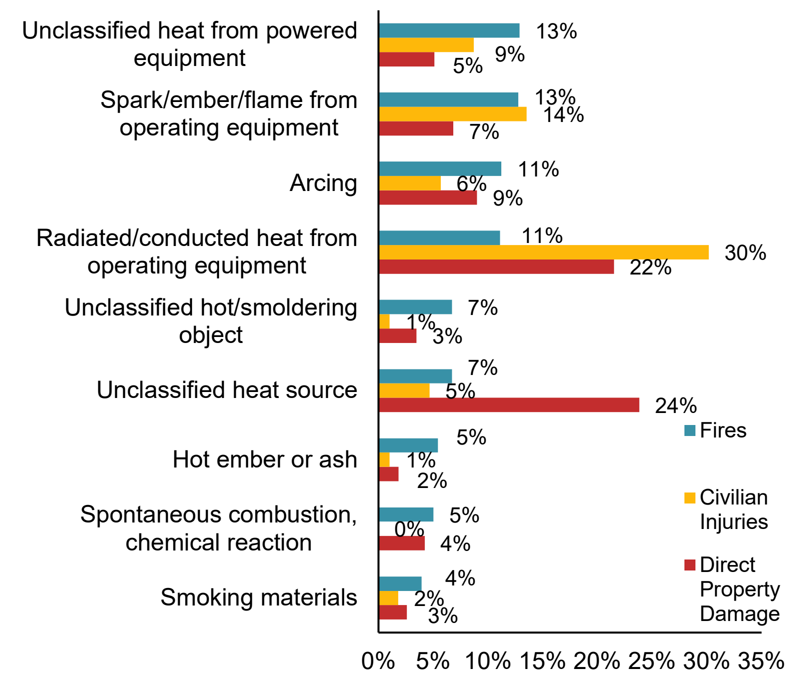
Figure 6. Fires in Structures Under Construction by Factors Contributing to Ignition: 2017–2021 Annual Averages



Heat source

The leading heat sources for fires in structures under construction involved either heat from powered equipment or sparks, embers, or flame from operating equipment, which together accounted for one-quarter (26 percent) of the fires (Figure 7). Arcing and radiated or conducted heat from operating equipment each provided the heat source for 11 percent of the fires, with the latter also accounting for three in ten injuries and 22 percent of the direct property damage. Unclassified hot or smoldering objects accounted for 7 percent of the fires, followed by hot embers or ash (5 percent), spontaneous combustion or chemical reaction (5 percent), and smoking materials (4 percent).

Figure 7. Fires in Structures Under Construction by Heat Source: 2017–2021 Annual Averages

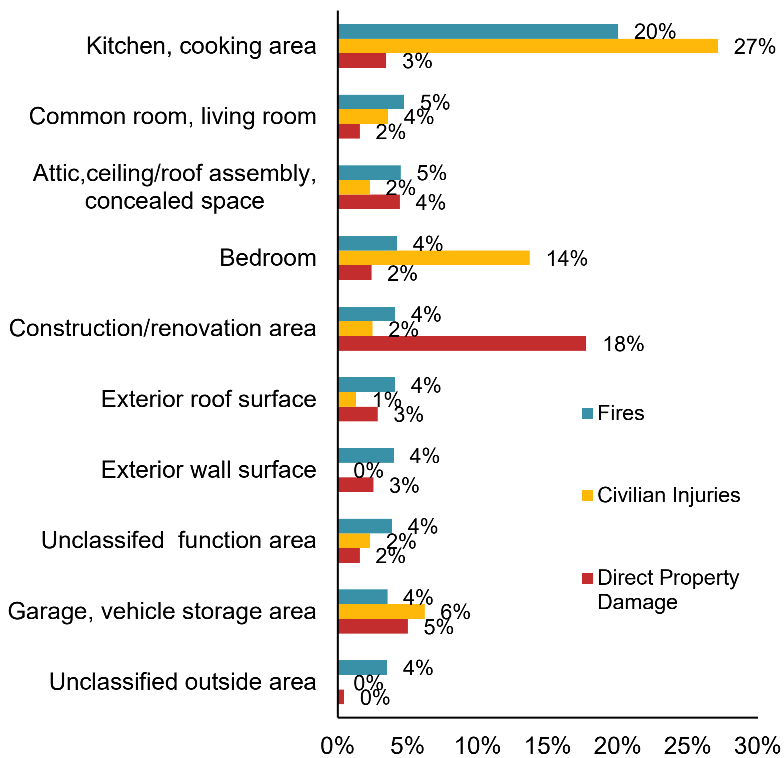


Area of origin

The leading area of origin for fires in structures under construction was a kitchen or cooking area, which accounted for one-fifth (20 percent) of the fires.

Fires that originated in a common or living room and an attic or ceiling/roof assembly or concealed space each accounted for five percent of the fires, while fires originating in a bedroom, construction or renovation area, exterior roof surface, function area, garage or vehicle storage area, and unclassified outdoor area each accounted for four percent of the fires. The fires that originated in a construction or renovation area accounted for nearly one-fifth (18 percent) of the direct property damage.

Figure 8. Fires in Structures Under Construction by Area of Origin: 2017–2021 Annual Averages



Just over one quarter (27 percent) of the civilian injuries occurred in fires that originated in a kitchen or cooking area. Fires that originated in a bedroom accounted for 14 percent of the civilian injuries. See Table 11 in the supporting tables document for details.

Discussion

On average, firefighters responded to nearly 12 fires in structures under construction each day between 2017 and 2021. Fires at such construction sites are a longstanding problem, but their major causes are generally well-established—a good indication that they can be prevented through greater attention to fire hazards.

The most common causes of under construction fires in the most recent five-year period, as well as historically, are electrical distribution and lighting equipment; heating equipment; cooking equipment; a torch, burner, or soldering iron; or an intentional cause. For each of these causes, there are safety protocols that can be utilized to reduce the risk of fire.

The safety protocols can include the following:

- Ensure that the temporary electrical service lighting follows the installation requirements set forth in *NFPA 70*®, *National Electrical Code*®; electrical equipment is maintained and regularly inspected; use of extension wiring is kept to a minimum; and machinery and equipment do not overload available circuits.
- Prohibit the use of temporary cooking equipment (such as hot plates or grills) or the use of improvised heating devices for warming food at the construction site.
- Ensure that unauthorized temporary heaters are restricted from the worksite and that the heaters permitted on the worksite are placed at safe distances from combustible and flammable materials; are used in conformity with their listing and manufacturer instructions; and are regularly checked to ensure that they are being safely operated and do not constitute a hazard (such as being overturned).

- Require a permit system for hot work activities and enforce a thirty-minute (or longer) cool-down interval after torches, burners, or soldering irons have been used.
- Reduce the risk of arson by safeguarding construction sites with fencing or other controls; these controls can include lighting or after-hours security personnel, as needed.
- Have an approved fire prevention program (also known as a fire safety plan) for the construction site.
- Ensure there is a fire prevention program manager to administer the fire safety plan to completion.

Guidance for preventing fires at structures under construction or undergoing renovation is available in NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*.

Acknowledgments

The National Fire Protection Association thanks all the fire departments and state fire authorities who participate in the National Fire Incident Reporting System (NFIRS) and the annual NFPA fire experience survey. These firefighters are the original sources of the detailed data that makes this analysis possible. Their contributions allow us to estimate the size of the fire problem.

We are also grateful to the US Fire Administration for its work in developing, coordinating, and maintaining NFIRS.

To learn more about research at NFPA, visit nfpa.org/research.
Email: research@nfpa.org
NFPA No. Index#2772–2023

1. **Objective**

To provide a guideline for Fire safety practices to be observed in Iron & Steel Industries.

Associated Hazards: Fire, Smoke, Heat, Flame and Explosion.

2. **Scope**

This guideline is applicable to Iron and Steel Industries.

3.0 **Procedure**

3.1 **Definitions**

Fire: Fire is a chemical exothermic reaction in which energy is released in the form of heat and light.

There are four classes of fire depending on the material under ignition. These can be listed as:

1. Class A fire: Fire in solid materials.
2. Class B fire: Fire in inflammable liquids.
3. Class C fire: Fire in gaseous and electrical installation.
4. Class D fire: Fire in metals.

Fire Triangle: Presence of ignition source, material and oxygen called as Fire Triangle, Fire can be extinguished by removing any one.

3.2 Fire Safety arrangement falls into two categories i.e. Fire Prevention and Fire Mitigation.

Fire Prevention

i. Fire Prevention should be included in Design phase.
ii. Fire risk Assessment of the site and Preventive control measures to address the hazard and its elimination.
iii. Fire Incident investigation.

Fire Mitigation

i. Mitigation can be ensured through installation, maintenance and testing of Fire Fighting System & equipment.
ii. Evacuation of the building through emergency escape.

3.3 Fire Prevention

i. Combustible materials should be avoided in the construction or fabrication of new building.

ii. For all premises, fire risk assessment to be done and areas to be classified as per fire risk potential.

iii. Flammable liquids, gases and oxidizing agent must be stored and controlled as per their Material Safety Data Sheet.

iv. Smoking and use of mobile phone shall be strictly prohibited in and around the premises of flammable or combustible material storage area, ignition source, heating surface, cylinder storage area, gas prone area and near cutting/ welding job.

v. Storage area should have proper ventilation to avoid vapour accumulation and it should be away from potential source of ignition.

vi. Flammable material should not be stored near exits, electrical equipment or heating Equipment.

3.3.1 Fire Prevention measures during Cutting and Welding

i. If gas cutting and welding is required on materials which is movable e.g. if two pipes are to be joined or require cutting, then materials should be moved to designated safe location which must be free from combustible materials such as grease, ideally for an area representing an 11 m radius from the point of work.

ii. If the floor is combustible where the welding is done, then the floor shall be kept wet or covered with damp sand to prevent the risk associated with the activity.

iii. If work is done near walls, where openings and cracks in walls are visible and can allow a big spark can pass through, then it shall be sealed to prevent the sparks from going to the adjacent areas.

iv. Hot welding shall not be attempted on metal partitions, walls, ceilings or roofs having a combustible covering, nor on walls or partitions of combustible sandwich-type panel construction.

v. Positive means shall be taken to confine heat, sparks and slag to the welding/ cutting activity working area.

vi. Welding or Cutting not to be done in the presence of flammable/ combustible materials.

vii. Appropriate fire extinguishing equipment shall be immediately available at job place. If normal fire prevention measures are not sufficient enough, additional trained personnel shall be assigned to guard against fire. At least one ABC 4 kg/ 5 kg or Dry Chemical Powder (DCP) fire extinguisher, two dry sand filled buckets, two water filled buckets shall be kept at work place.

viii. Before welding/ cutting, ensure containers are cleaned thoroughly with water.

ix. Welding in centrally air conditioned premise to be avoided. If it is essential to do welding in area catered by centrally air conditioning system, then AC system shall be closed during welding.

(Also refer SG-07: Safety Guidelines for Gas cutting & Gas Welding)

3.3.2 For Cutting/ Welding job on or near Gas Lines

i. Work permit clearance - authorized personal should take permission from the authority before working on or near gas line area.

ii. Local Fire fighting arrangement with fire extinguishers, sand, water and fire hoses shall be kept ready before starting welding / cutting job on gas lines.

iii. Person should be trained on the use of Fire extinguishers and hydrant.

iv. Safety net to be installed below the working zone if the area of operation is in height for easy escape.

v. Potable CO Gas Detector to be provided to the working personnel.

3.3.3 Fire Prevention Measures at Cylinder Storage Area

i. All gas cylinders shall be stored in a designated shed having roof top to protect from direct sunlight. Do not expose gas cylinders to temperatures above 45 ^{0}C. Overheating of cylinders can result in build up of pressure and explosion.

ii. The shed shall be barricaded and proper nomenclature should be displayed.

iii. Do not store gas cylinders with other combustible materials. Flammable substances, such as oil and other solvents, must not be stored in the same area.

iv. The storage area must be well ventilated to prevent accumulation of gas in case of leakage.

v. Flammables and oxidizers must be stored separately in the storage area. The cylinders must be separated by a distance of 6 meters or must be separated by a fire resistant wall of 30 minutes fire resistance.

vi. LPG cylinders must not be stored within 3 m of any compressed gas cylinders (including acetylene).

vii. Within the storage area, Oxygen should be stored at least 3m from fuel gases cylinders. The use of a fire wall may provide the required separation. If volume is greater than 200 m^3, a separation distance of 5 m needs to be executed. Note: Wall must be a minimum of one metre higher than the tallest cylinder.

viii. Compressed gas cylinders are to be secured with clamping or chain/ manila rope or by use of a cylinder stand to ensure they do not fall from their vertical storage position.

ix. Keep cylinders away from any source of heat and ignition.

x. Gas cylinders must be stored in a manner that permits quick removal in case of an emergency. Do not store materials over or around the cylinders.

xi. All fittings shall be of the flame-proof type and wiring shall be in robust conduit to protect it from damage.

(Also refer SG-01: Safety guideline on Storage, Handling & use of Gas Cylinders)

3.3.4 Housekeeping guidelines for fire prevention at work place

i. Accumulation of waste combustible materials such as paper and wood should be checked at the workplace and collected in designated containers.

ii. Combustible materials in trash containers should be covered and emptied on regularly intervals.

iii. Leakage or spillage of flammable materials like oil, grease & flammable liquid near ignition sources/ heat surfaces shall be arrested promptly.

iv. Maintain free access to all Electrical Control points.

v. Chemicals should be stored safely and have proper labels. Material Safety Data Sheet (MSDS) should be provided at the site.

3.3.5 Fire Prevention Measures for Diesel Storage Tank

i. Warning signages and MSDS shall be displayed.

ii. Tank level indicator and capacity of tank should be mentioned.

iii. Fire Hydrants should have adequate pressure and should be accessible.

iv. Spill control measures should be in place.

v. Standard Operating Procedure (SOP) for loading and unloading of oil and emergency preparedness should be in place.

vi. Combustible and flammable materials should not be stored at nearby tank area.

vii. Electrical fittings should be flame-proof.

viii. Ensure proper earthing and bonding.

3.3.6 Fire Prevention Measures for Propane Installation

i. Warning sign should be displayed.

ii. Provision to be made to ensure to discharge Static Electricity.

iii. All Electrical fittings should be flame proof.

iv. Ensure proper earthing and bonding.

v. Fire hydrant & Water Spray system installed should be pressurized all the time.

vi. Do not use mobile inside the plant.

vii. Unloading of bulk Propane transported through bulk tank trucks shall be carried out under the supervision of a responsible person.

viii. The tank truck shall have suitable spark arrestor of make and design approved by PESO (Petroleum & Explosive Safety Organisation), Nagpur properly fixed to exhaust.

ix. Lever indicating close and open status for Quick closing of manifold valve shall be present on the tank truck.

x. All electrical boxes of the tank truck shall be properly sealed.

xi. The electrical wiring of the tank truck shall be insulated and provided with suitable over-current protection.

xii. The cabin of the tank truck shall have a readily accessible master switch for switching-off the engine.

xiii. No hot/ cold work shall be carried out in the vicinity of unloading operation.

xiv. Checks shall be carried out for each Tank Truck prior to unloading of Propane.

xv. Excess flow check valves of the tank shall be functioning.

xvi. Operator should check the connection for tightness.

xvii. Check from Roto Gauge that the level of liquid does not exceed more than 90% in the storage tank by level.

xviii. After making sure that all the valves are closed for liquid and vapour, slowly remove the hose pipe. The liquid hose may have little liquid left in it which will be vented through venting system.

xix. After removing the hoses, mobile tanker should not be started for at least 10 minutes.

3.3.7 **Fire Risk/ Prevention at Overhead Electrified Engine (OHE) on Load Corridor**

i. Provision of Fire extinguisher on Loco Engine to be made to prevent fire from engine, fire on diesel storage tank & on tarpaulin used during rainy season etc.

ii. Remove all dry leaf/ tree branches etc. near OHE area.

iii. Never spray water near overhead power lines. Spray water after getting the power clearance from department.

iv. Do not keep any combustible and flammable materials on loco.

v. Never climb power poles or transmission towers without valid permit.

vi. Never climb trees near power lines & overhead line.

vii. Ensure proper earthing and bonding.

viii. Never drive over a cable lying on ground or under a low-hanging line.

ix. Stay away from power cable lying on ground. Maintain a safe distance from the Danger.

3.3.8 Fire Prevention in Heavy Earth Moving Machineries (HEMM)

i. Oil- bearing hosepipes should be housed separately and away from the hot parts of the engine like turbocharger, exhaust and manifold.

ii. OEM of HEMM should provide suitable type of fire detection and suppression system with periodical testing procedure and maintenance schedule. Maintenance of such fire detection and suppression system should be carried out by the experts / trained personnel.

iii. All high pressure hydraulic hose fitted in the engine room must confirm to the specification as laid down by the OEM and their quality to be ensured. The hoses shall be replaced at the prescribed interval or earlier if there is any sign of deterioration.

3.3.9 Fire Prevention in Coal Chemical Handling

i. Coal chemicals should be stored in an area reserved for highly flammable liquids.

ii. Storage tanks should be situated in the open air and their vent pipes should be fitted with flame arresters.

iii. Tanks should be discharged by means of a pump.

iv. All metal parts of the tank installation should be earthed and earthing terminals should be provided for attaching to tankers during transfer operations.

v. Tanks should be situated well clear of process plant and buildings, any fixed source of ignition and boundary fences.

vi. Naked flames, hot elements and all other ignition sources should be eliminated; smoking should be prohibited; reduced-sparking tools should preferably be used.

vii. The air in the storage and working areas should be regularly sampled with a gas detector in order to check for leaks. In the event of a serious leak, the areas should be evacuated immediately.

viii. Electrical equipment for use in atmospheres which may contain flammable concentrations of chemical vapor should be intrinsically safe.

ix. Metal parts of process and handling machines should be electrically bonded together and earthed to prevent the accumulation of static electricity.

x. Mechanical seal shall be provided for product pumps used for pumping of highly inflammable materials.

3.3.10 **Fire Prevention in Sulphur Handling**

i. Sulphur storage area shall be segregated and sulphur should be stored in a cool well-ventilated space.

ii. Sulphur should not be stored along with chlorates, nitrates, other oxidizing materials, mineral acids or metal powders.

iii. Sulphur powder should be handled in such a way as to avoid formation of dust clouds.

iv. Explosive proof light fittings should be used.

v. Smoking and the use of naked flames should be prohibited in places where sulphur dust may be present.

3.3.11 **Fire Prevention in Sulphuric Acid Handling**

i. Storage tanks should be in the open. They should be protected from external corrosion by coating them with a suitable material such as bitumen.

ii. Storage tanks should be provided with:

   a) A bund capable of retaining the acid in the event of leakage.
   b) A liquid indicator. A glass float indicator or a remote-reading pneumatically operated gauge is recommended.

iii. Sulphuric acid should not be stored with chemicals with which it reacts, or with flammable liquids, gas cylinders, or readily combustible solids.

iv. The vessels should be protected from the direct rays of the sun.

v. All storage vessels and storage areas should be clearly marked.

vi. When there is a danger of hydrogen formation from the acid reacting with metal in processing or in storage:

   a) Rooms should be well-ventilated.
   b) Naked flames, hot elements and all other ignition sources should be eliminated.
   c) Smoking should be prohibited.

3.3.12 **Fire Prevention in Coal Yards**

i. Coal to be stacked up to a maximum height of 15 m.

ii. Stacking to be done in trapezoidal stock pile.

iii. Temperature monitoring of the pile to be done.

iv. Hot spots above 70°C shall be removed.

v. Coal piles shall be segregated from other area.

vi. Coal screening, crushing and other operation shall be done in well ventilated area.

vii. Storage shall be limited for short duration.

viii. Housekeeping shall be of high standard.

ix. Smoking shall be prohibited.

3.3.13 **Fire Prevention in Coal/ Hot Coke/ Hot Sinter handling Conveyors**

i. The belt conveyors installed for handling coal, sinter and other raw materials shall be of enclosed type.

ii. Accumulated heat, dust and muck shall be cleaned regularly and worn out parts shall be immediately replaced.

iii. The major fire hazard is from the ignition of coal dust and from deposits built-up on the internal surfaces, walkways etc. of the conveyor's junction towers, often ignited by maintenance activities.

iv. Care must be taken to ensure that hot coal which may have heated up spontaneously while in storage, is not loaded on the belt. The belt must also not be overloaded.

v. Water spray system may be installed for coal coke and sinter conveyor fire prevention. It is a special fixed pipe water based fire protection system connected to reliable source of water supply and equipped with open type water spray nozzles for specific volumes of water discharge and distribution at surface or area to be protected. Piping system is connected to the water supply through an automatically or manually actuated Deluge Valve, which initiates flow of water through spray nozzles. The actuation of the deluge valve is achieved by operation of automatic detection equipment such as Quartzoid bulb detection systems, electrical linear heat sensing systems.

3.3.14 **Fire Prevention in Conveyor Galleries**

i. Accumulated heat, dust and muck shall be cleaned regularly and worn out parts shall be immediately replaced.

ii. There is also a significant fire hazard associated with the conveyor drive unit due to a combination of brake faults, failure of fluid couplings and overfilling of the drive gearboxes as well as that due to an overheated motor which has become inadequately cooled in service due to the build-up of coal / raw material dust.

iii. The primary causes of conveyor fires fall into following main areas:

  a) Maintenance activities involving the use of electric or gas welding, gas cutting equipment, or similar activities.

  b) Failure of part of the conveyor system (usually and idler or a pulley) can lead to localized overheating and eventually, to the ignition of the coal dust, conveyor belting or lubricating oil and greases associated with the plant.

  c) Rubbing of a belt (running out of center) with steel work resulting in localized overheating and eventually belt catching fire when stopped.

d) From the ignition of a quantity of spilt coal dust, either by self ignition or other causes.

e) Also ignition of the conveyor belt while transporting hot sinter / hot coke without undergoing proper quenching.

iv. Care must be taken to ensure that hot coal, which may have heated up spontaneously while in storage, is not loaded on the belt. The belt must also not be overloaded.

v. Regular maintenance of the conveyor shall be undertaken to ensure freedom from friction due to the spillage of belt over the drive or idle roller and/ or its becoming misaligned or slipping off the roller and becoming jammed.

3.3.15 **Fire prevention in handling of Molten Metal and Slag**

i. Ladle shall not be overfilled.

ii. Alignment of rails used for transportation of hot metal shall be uniform.

iii. Rail cars carrying hot slag and hot metal shall be in good condition.

iv. Refractory of the ladle shall be in good condition.

v. Ladle & thimble shall be heated before pouring of hot metal.

vi. Dumping of molten slag shall be avoided over accumulated water.

vii. Care shall be taken to avoid metal reaction in twin hearth furnace

viii. Standard Operating Procedure (SOP) shall be strictly followed during handling of hot metals.

3.3.16 **Fire Prevention in Transformer Substations**

i. Every oil filled apparatus such as transformer, static condenser, switchgear or oil circuit breaker having an individual or aggregate oil capacity of 200 liters or more shall be housed in a locked, weather and fire resistance building.

ii. A minimum clearance of 750 mm shall be provided between the transformer and other apparatus and enclosing or separating walls.

iii. Substations and switchgear rooms shall only be used to house the intended equipment. Storage of any kind or any repair work shall not be permitted therein.

iv. Cable trenches inside substations shall be filled with sand, pebbles or similar non-flammable materials or covered with incombustible slabs. If a number of cables are taken in the trench, it is desirable that cables are taken on racks.

v. All control gears shall be protected against rodents, reptiles and insects.

vi. All transformers shall be equipped with Over-current relay protection.

vii. Gas pressure type (Buchholz relay), winding and oil temperature protection to give alarm and tripping shall be provided on all oil type transformers of rating 1,000 KVA and above.

viii. Where a sub-station or a switching station with apparatus having more than 2,000 litres of oil is installed, whether indoors or outdoors, following precautions to be taken:

a) the baffle walls of four hours- fire rating shall be provided between the apparatus-

- where there is a single phase transformer banks in the switch-yards of generating stations and sub-stations;
- on the consumer premises;
- where adequate clearance between the units is not available.

b) provision shall be made for suitable oil soak pit. Where use of more than 9,000 litres of oil in any one oil tank, receptacle or chambers involved, provision shall be made for the draining away or removal of any leaked/ escaped oil and special precautions shall be taken to prevent the spread of any fire resulting from the ignition of the oil from any cause and adequate provision shall be made for extinguishing any fire which may occur.

c) Spare oil shall not be stored in the vicinity of any oil filled equipment in any such substation or switching station.

d) All the transformers and switchgears shall be maintained in accordance with the maintenance schedules prepared in accordance with the relevant codes of practice of Bureau of Indian Standards.

e) The transformers of 10 MVA and above rating or in case of oil filled transformers with oil capacity of more than 2,000 litres are to be provided with fire fighting system as per IS – 3034 or with Nitrogen Injection Fire Protection system.

ix. The bushings, insulators and contacts of tap changing gears shall be kept scrupulously clean at all times.

x. The level and dielectric strength of the transformer oil shall be checked at periodic intervals.

3.3.17 Fire Prevention in Cable Tunnels, Cable Cellar, Cable Spreader, Cable Vault, Cable Galleries and other Cable Premises :

Electrical cables are usually insulated with polyvinylchloride, which contributes to the rapid spread of fire. The insulation also give-off highly toxic products combustion including corrosive gases, when it is exposed to intense heat or is involved in fire. Fire in cable runs can spread as fast as 20 m/min.

The critical areas are as under:

- Immediately after end termination or joints up to a length of not less than 1 m in either direction.

- Crossing or T-crossings or joints up to a length of not less than 1 m in either direction.
- Cable passing through high temperature area/ high vulnerable area.

Precautions to be taken are:

i. Ensure HT & LT cable in different racks.
ii. Ensure Temperature monitoring of cables.
iii. Ensure Good forced ventilation.
iv. Compartmentation of cable tunnels to be done.
v. Sealing of entry and exit points of cables to be done.
vi. Use of good quality cable joints to be done.
vii. For cables above 230 Volts, fire resistant coating should be applied just below the end termination up to a length of one meter inside the panel (if space available), just below the panel entry up to a length of one meter, joints up to a length of one meter in both directions and on entire exposed vertical length like connecting different floors etc. Motor terminal box are excluded, but Transformer terminal box included. For cable of voltage 33 kV and above, cable entry to the panel should also be protected with Fire Stop along with fire resistant coating as above.
viii. For all cables, fire protective paint should be applied on entire length if passing through Fire Prone Area.
ix. Cable above 230 Volts in cable tunnels/ cable trays should be painted up to a length of one meter at an interval of every 30 meter. Cable entry into the vault should be protected with fire barrier/ fire stop. If cable below and up to 230 volt (like FO, Control, Instrument, telephone, Power cable etc.) is also passing along the same route within the vicinity of 2 meter from cable >230 Volt should also be treated as above.
x. The wet film thickness of fire resistant coating should be such that after drying 1.6 mm is achieved (Dry film thickness) uniformly on all exposed sides and also there should not be variation in coating across length than specified.
xi. Cables above 230 volts in cable tunnel / cable vaults/ cable trestle should be protected by automatic fire alarm system.
xii. LHS (Linear Heat Sensing cable) may be used as a fire detection system for cable tunnel /cable vault / cable trestle. However, additional fire detection measure as smoke cum heat detectors, flame detector shall also be provided, wherever necessary.
xiii. Fire rated doors shall be installed inside cable premises and at each entry / exit in to the cable premises.

3.3.18 **Fire Prevention in Oil Cellars**

i. Stop valves should be provided at strategic positions to cut-off a dangerous leak of oil.

ii. Self extinguishing grades of oil should be used to minimize fire risk.

iii. Use of flexible piping should be avoided.

iv. Pumps working in oil cellars should be periodically checked for faulty bearings and inadequate lubrication.

v. Either electric or gas welding should not be permitted in the oil cellars.

vi. Leaks from joints and glands should be attended without delay.

vii. Spillage of any lubricants, fuel oil, should be cleared by spraying sand and cleaning the surface.

viii. Spark proof lighting should be provided. Loose wiring or temporary wire connections should not be permitted.

ix. Wooden doors or windows and partitions should not be allowed.

x. Waste cotton should be disposed in the bins filled with water so that the cotton will be wet and therefore will not catch fire.

xi. Smoking should be strictly prohibited. “No Smoking" sign should be displayed at appropriate locations.

xii. The cellars should not be used as store.

xiii. Unauthorized persons should not be permitted to enter in cellars.

xiv. The entry and exit to the oil cellars should not be the same and they should be provided in opposite directions and free from any obstruction.

xv. Multiple criteria type smoke cum heat detector, temperature detectors and flame detectors may be provided for fire detection and alarm system inside oil premises.

xvi. The Oil cellars, oil premises may be provided with Fixed Piping Type High Expansion Foam Flooding System to extinguish fire as per applicability.

3.3.19 **Fire Prevention in Cryogenic Liquids**

i. Outside storage shall be protected against the extremes of weather.

ii. Cryogenic tanks shall be equipped with pressure-relief devices to control internal pressure.

iii. Do not plug, remove, or tamper with any pressure-relief device.

iv. Oxygen must be separated from flammables and combustibles by 20 feet or a half-hour fire wall.

v. Use only oxygen compatible lubricants.

vi. Boiling and splashing always occur when charging or filling a warm container with cryogenic liquid or when inserting objects into these liquids. Perform these tasks slowly to minimize boiling and splashing.

vii. Never touch un-insulated pipes or vessels containing cryogenic liquids.

viii. Use wooden or rubber tongs to remove small items from cryogenic liquid baths.

ix. Cylinders should not be filled to more than 80% of capacity since expansion of gases during warming may cause excessive pressure buildup.

x. Liquid oxygen shall not enter the oxygen gas pipe line.

3.3.20 **Fire Prevention in Gantry Cranes**

i. The control circuit voltage shall not exceed 600 volts for AC or DC.

ii. Electrical equipment shall be so located or enclosed that live parts will not be exposed to accidental contact under normal operating conditions.

iii. Electric equipment shall be protected from dirt, grease, oil, and moisture.

iv. Oil cans, oil soaked jute, extra fuses, and other articles shall not be permitted to store in cranes.

v. Over filling of oil in reducers shall be avoided.

vi. Leakages from reducer shall be arrested.

vii. Housekeeping in cranes shall be of high standard.

viii. 4.0 kg Dry Chemical (BC Type) Powder Portable Fire Extinguishers as per IS: 15683 shall be provided in Operator’s cabin of Gantry Crane.

3.4 **Fire Mitigation**

i. Effective means for detecting an outbreak of Fire and warning people must be established.

ii. Suitable and Sufficient firefighting and escape equipment and devices should be determined through Fire Risk Assessment.

iii. Audit and Fire Risk assessment records should be maintained for the minimum period of 3 years.

iv. Each unit should do internal fire risk assessment audit in an interval of at least three years.

v. Fire risk assessment should be done by a competent person who understands the principal of fire safety.

vi. Fire fighting equipment and evacuation route should be easily accessible and free from obstruction.

vii. Adequate Provision must be made for the evacuation of disabled persons.

viii. Where it is necessary to disable fire Protection & detection system, fire department should be intimated and clearance should be taken from the fire department.

ix. All regular employees shall be educated regarding use of fire extinguishers and available fire fighting arrangements in and around working area.

3.4.1 Fire Extinguishers

There exist different kinds of fire extinguishers for extinguishing different classes. These can be listed as:

i. **ABC Pressurized type Fire Extinguishers:** This type of fire extinguisher is applicable for Class A, B & C type of fire. When extinguisher is squeezed, powder is ejected from the extinguisher**.**

ii. **Foam type Extinguishers:** Gas/ air bubbles are trapped by a foam binding solution in water. These extinguishers are used for fire of Class A & B.

iii. **Dry chemical Powder (DCP) Extinguishers:** Sodium based chemical powders are usually used in these kinds of extinguishers. Fire belonging to Class B & C can be extinguished using these extinguishers.

iv. **CO_2 Fire Extinguishers:** A cylinder is filled with CO_2 gas under pressure which when released displaces the air supporting and surrounding the combustion. These extinguishers are applicable for Class B & C Fire.

v. **Clean Agent:** In this type of fire extinguisher, liquid is stored under pressure that turns to gas on discharge to air. Clean Agent is effective on Class B and C fires typically petrol, oil, etc.

Application of Fire Extinguishers

Class of Fire	**Type of Extinguishers**
A. Fires in ordinary combustibles (wood, vegetable fibres rubber, plastics paper and like)	Gas expelled water type and stored pressure type extinguishers and water buckets
B. Fires in flammable liquids, paints, grease, solvents and the like.	Foam type fire extinguisher, Carbon Dioxide, dry powder type & Clean Agent.
C. Fires in gaseous substances under pressure including liquefied gases and live Electrical.	Carbon dioxide, dry powder types, Clean agent and sand buckets.
D. Fires in reactive chemicals, active metals and the like.	Special type of dry powder extinguishers and dry sand buckets.

N.B. Where energised electrical equipment is involved in a fire, the non-conductivity of the extinguishing media is utmost importance and only extinguishers expelling dry powder or carbon-dioxide (without metal horn) shall be used. Once the electrical equipment is de-energised, extinguishers suitable for class A, B, C may be used safely.

Fire Extinguisher guidelines

i. Fire extinguishers should be placed as near as possible to Exit / Entry doors.

ii. Extinguishers should be placed in such a way that it shall be available within 15 meters at any point of place.

iii. Extinguishers shall be installed on the wall in hanging position. The height of the extinguisher bottom portion shall be 1 (One) mtr. above the floor.

iv. Extinguisher should not be placed in a position where it is likely to be impacted by Direct Heat, Sun Rays, Rain, moisture etc.

v. In a confined space, it is generally advisable to place the extinguisher outside the confined space.

vi. Fire extinguishers should always be accessible.

vii. Floor Plan with location of Fire Equipment and type of extinguishers should be placed at prominent place/entrance of the Plant.

viii. Fire extinguishers should not be placed in the Transformer room. It should be placed just outside the room.

ix. Each and every location allotted for Fire Extinguishers should be marked with Department-wise Serial Number.

   a) The number should start with FE/1 and so on (FE stand for Fire Extinguisher).

   b) The type of Extinguisher should also be marked e.g. DCP, CO_2, W/CO_2, and FOAM.

   c) All letters should be painted by Fluorescent paint of 9 Cm. sizes in White Colour on Red background (30 X 21 Cm.).

x. One copy of the Master list of the Fire extinguishers with location should be available in department and a copy should be submitted to the Fire Brigade.

xi. After refilling the fire extinguisher, inspection card indicating the serial numbers of the extinguishers, date of initial charging and the next due date of refilling should be pasted.

xii. Record of the date of inspection, refilling date, etc., should be maintained.

xiii. Inspection & Maintenance shall be done quarterly as per the guideline.

xiv. The HP test of DCP/ ABC type Fire Extinguisher shall be done once in 3 years @ 35 kg/ cm^2 for 2.5 minutes & the CO_2 Fire Extinguisher shall be HP tested once in 5 years @ 250 kg/ cm^2 for 2.5 minutes.

xv. All employees should be trained on the Operation of Fire Extinguisher with the help of Fire Brigade. Department should ensure that refresher training should be given to the employees time to time.

3.4.2 Fire Hydrant

Fire Hydrant is a discharge pipe with a valve and nozzle at which water may be drawn from the fire water mains.

Hose: A fire hose is a high - pressure hose used to carry water to extinguish fire.

Nozzle: Provides an outlet to the high pressure water coming through the hose and directs it towards the fire.

Hose Pipes and Nozzles

i. Hose boxes/ hose shall be cleaned internally and externally quarterly.

ii. Damaged hoses should be removed immediately.

Hose Reel

Once in a year the hose reels should be completely run out and subjected to operational water pressure to ensure that the hose is in good condition and that the coupling joints are watertight.

Pump & Fire Fighting Pump Room / House

i. Independent water source / Static water tank shall be provided for minimum 2 hrs. continuous fire fighting.

ii. If Pump Room is not manned for 24 hours, then it shall have Fire Detection & Alarm system. 24 Volt battery is to be provided to give back up in case of power failure.

iii. Two (2) independent source of power shall be provided for the Pump operating panel.

Fire Hydrant System

i. At least one hydrant point shall be provided for every 30 M distance (for both ordinary & high hazards)

ii. Necessary Cut-Off / sectionalizing valves shall be provided for easy maintenance of the system.

iii. Height of the hydrant outlet point shall be 1 M from floor level.

iv. For farthest / remotest location (horizontal position), the minimum pressure at all the hydrant outlet shall be 5.5 kg/ cm^2.

v. For highest / top most hydrant point, the minimum pressure at the hydrant outlet shall be 3.5 kg/ cm^2.

vi. Hydrants for the protection of the Fire like combustible/ flammable liquids storage tanks shall be provided as per the respective norms such as per IS and OISD (Oil Industry Safety Directorate) Guidelines.

vii. Fixed water monitors shall be provided for the structures having a height more than 15 M (Hydrogen Vessel, Nitrogen Vessel, Coke Oven Gas Desulphurisation, Furnaces installation etc.) and a site having Propane bullet and for the protection of conveyor belt on the ground.

viii. Fire Hydrant water shall not be used for other purpose like tapping, gardening etc.

ix. Fire hydrant layout plan with Fire Hydrant Number and location shall be available and displayed at prominent places and layout copy to be submitted to Fire Brigade.

Fire Hydrant Inspection, Checks and Maintenance

Hydrant System

i. Availability of proper P&ID diagram, Equipment Layout of Fire Fighting Pump House and Fire Hydrant and Spray Yard Piping Layout of Fire Hydrant System shall be ensured.

ii. Fire hydrant point shall be checked and test quarterly. The record of all such inspections should be maintained.

iii. All hydrant valves shall have wheel, lugs & washer in place, so that it can be quickly connected to hose for firefighting.

iv. Hydrant points shall be kept free from any obstruction as well as Emergency Exists.

v. The Painting (Signal Red) of Hydrant post and Line shall be carried out annually.

vi. All the Hydrant points must be numbered.

vii. All Cut-off / Isolating Valve shall be maintained.

Pumps

i. Pump sets shall be run for at least 5 minutes every week by department representative.

ii. Diesel Pump shall be run for at least 5 minutes once in a week by department representative.

iii. Before running the Pumps, two Hydrant Points shall be open.

iv. Records shall be maintained for the above testing.

v. Fire Fighting Pump Room shall be checked once in a month.

3.4.3 Fire Detection Systems

Fire detection systems are designed to discover fires early in their development when time will still be available for the safe evacuation of occupants. Early detection also plays a significant role in protecting the safety of emergency response personnel. Property loss can be reduced and downtime for the operation minimized through early detection because control efforts are started while the fire is still small. Most alarm systems provide information to emergency responders on the location of the fire, speeding the process of fire control.

Addressable Fire Alarm System: In an analog Addressable system detectors are wired in a loop around the buildings with each detector having its own identity. System may contain one or more loops depending upon the size of the building**.** An addressable fire alarm system provides an exact location of the fire. This minimizes the response time of emergency services and first responder.

Conventional Fire Alarm System: In conventional fire alarm system detectors give information about specific circuits (zones). System is not applicable for large buildings having too many rooms.

Photo electrical smoke detector: Photo electrical detectors are of two types:
A. Photoelectric Light Obscuration.
B. Photoelectric Light Scattering.

A. Photoelectric Light Obscuration Smoke Detection - The principle of using a light source and a photosensitive sensor onto which the principal portion of the source emissions is focused. When smoke particles enter the light path, some of the light is scattered and some is absorbed, thereby reducing the light reaching the receiving sensor. The light reduction signal is processed and used to convey an alarm condition

B. Photoelectric Light-Scattering Smoke Detection - The principle of using a light source and a photosensitive sensor arranged in such a way that the rays from the light source do not normally fall onto the photosensitive sensor. When smoke particles enter the Light path, some of the light is scattered by reflection and refraction onto the sensor. The light signal is processed and used to convey an alarm condition.

Linear Heat Sensing Cables: Linear heat sensing cables detect heat anywhere along the length of the cable. The cable is comprised of two zinc-coated spring steel conductors, individually coated with a heat-sensitive thermoplastic polymer engineered to melt at fixed temperatures. Once the polymer melts, the conductors initiate contact with one another and communicate with the control panel to sound alarms or activate suppressing systems. This detector is suitable for cables galleries and conveyor system.

Auto dialer

An automatic device that can automatically dial telephone numbers to communicate between any two points in the telephone, mobile phone networks. Once the call has been established the auto dialer will announce verbal messages to the called party.

Fire Detectors Installation

The choice of the initiating devices shall be dictated by the application, type and characteristics of fire risks in the protected area.

SN	Type of Building	Type of Fire System/ Detector
1	Office Building- Upto Ten (10) rooms	Conventional/ Addressable detector
2	Office Building > Ten (10) rooms.	Addressable Fire System
3	Electrical installation	Addressable System/ Smoke cum Heat detector
4	Computer Server Room	Addressable System /Smoke cum Heat detector
5	Cable Tunnel, Cable Cellar, Cable Spreader, Cable Vault, Cable Galleries and other Cable Premises	Addressable System/ Smoke cum Heat detector/ Linear Heat Sensing Cables
6	Conveyor System	Linear Heat Sensing Cables
7	Large Halls above 10 m height	Beam Type
8	Cellar (having potential of fume particle generation leading to false alarm phenomenon)	Multi-sensor detector – This type of detectors detects both Heat and Smoke. It combines the characters of two types of detectors, each of which responds to different physical and or chemical characteristics of fire. The purpose of combining sensors in this way is to enhance the performance of the system in detection of fire or its resistance to at least certain categories of false alarms or both. There is significant potential for reduction of many types of false alarm. It is also possible to disable an individual sensor depending on the circumstances at the place of installation.

- Ionization detectors shall not be installed as it contains radioactive element.
- Detectors shall not be in a direct airflow nor closer than 3 ft. (1m) from an inlet or forced ventilation.

Checking & Cleaning procedure for fire detectors:

Persons involved in checking and cleaning of detector shall be well trained.

Checking:

i. Spray the aerosol fluid on the detectors and observe the detector LED, if the LED turns into red or green and alarm is activated then detector is OK. If LED doesn't respond, replace the detector.

ii. Blow hot air on the Heat detector and observe the detector LED. If the LED turns into red or green and alarm is activated then detector is OK. If LED doesn't respond, remove and clean the detector with vacuum cleaner with brush attached to it. Mount the detector on it base and check again through heat gun. If LED blinks then detector is OK, or else change the detector.

iii. Check battery condition with respect to battery voltage. The voltage level shall not fall below the level specified. If the voltage fall below the level specified, corrective action shall be taken and the battery shall be retested otherwise replace the battery.

iv. Detectors which are not having LED, give signal to the panel. Detector will work if an alarm signal comes to the panel.

Cleaning:

i. Remove the detectors (PHS, HT & OSD) from the base and see that its indication as an open fault is coming on the panel or not. The entire detector should be checked one by one.

ii. After removing, clean the detector with vacuum cleaner with brush attached to it. Restore the detector and spray aerosol to re-confirm its correctness of connection. Heat detector should be cleaned same as other detectors.

iii. Disconnect AC supply and ensure that system has been changed over to stand-by (battery) power supply.

iv. Check all the manual call point and see their indication on the panel.

To ensure the healthiness of FDA System, Audit of FDA System should be done by the line manager preferably every 6 months. Evacuation Mock drill can be conducted by activating Fire Alarm System. Line Manager is responsible to maintain the healthiness of the FDA System.

3.4.4 Emergency preparedness

i. Fire Detection & extinguishing system should be inspected, tested and maintained by competent agency at regular frequency as specified in the guideline. For e.g. Fire Extinguisher & Fire Hydrant should be checked on Quarterly basis. FDA should be checked Bi-monthly and quarterly based on the location. Records of same should be maintained.

ii. Persons carrying out checking and maintenance of fire equipment should be certified by the fire department.

iii. Each site/ premise should include risk of fire scenario in their emergency plan and appropriate measure for:

a) Raising the alarm.

b) Evacuation of personnel to the safe area.

c) Containment of fire until arrival of emergency services

References:

1) Tata Steel India Safety Standard: Fire Prevention (SS/GEN-36), Fire Extinguishers standard (SS/GEN-33), Fire Hydrant Safety Standard (SS/GEN-35), New Fire Detection and Alarm System Safety Standard(SS/GEN-37), Fire Safety in Cable Runs (SS/ELEC-09), Compressed Gas Cylinder safety management system Code of Practice (SS/GEN-57).

2) Fire mitigation management in SAIL (Committee's report for framing comprehensive guidelines for Modern, Water Tight Fire prevention, control & response system in SAIL).