EuroFire

Unit EF2: **Training: Apply Techniques and Tactics to Control Vegetation Fire**

Introduction:

These training materials support the EuroFire Level 2 competency standard **EF2 Apply Techniques and Tactics to Control Vegetation Fire.**

This document is an introduction to wildfire behaviour and the techniques and tactics that may be applied to suppress a wildfire or perform a prescribed burn, for people who assist in the management of vegetation fires.

It is for situations where: the fire management operation is simple, the level of risk, complexity and fire behaviour is low and the operator is under direct supervision.

All national and local laws relating to fire management techniques must be followed. In addition local landowners may need to be consulted or give their approval before operations takes place.

The training for this unit may be delivered through a combination of formal training, mentoring and coaching. Self-learning should be restricted to knowledge and understanding of the material and not practical application, which must only be carried out under direct supervision.

The nominal/notional/guided learning hours for this unit is 40-50 hours.

EuroFire is a pilot project. The training material will be evaluated as part of an on-going process. A feedback form can be found at www.euro-fire.eu

The target audience for this material are the people who work in fire services, farming, forestry, game management, conservation, range land and recreation management who have a role assisting with the management of vegetation fires, either on a full or part-time basis.

Relationship with EuroFire competency standards and risk management

Reference to the EuroFire competency standards should be made to understand the full range of expected learning outcomes. The sections of the standards are: unit title, element title(s), about this unit, key words and phrases, what you must be able to do, this element covers, and what you must know and understand.

The support materials for all the EuroFire competency standards are designed to support a flexible approach to training delivery. They can be adapted or modified to suit a particular target audience. The learning material for this unit should be used with the support materials for other units to ensure all learning outcomes in the standards are covered.

There are various European Union Safety Directives which have been enacted as specific Health and Safety legislation in each country in the EU. This legislation is designed to improve workplace safety and health and reduce work related accidents and diseases. All necessary safety legislation, risk management policies and procedures, for your location, agency or organisation must be followed.

Complimentary (co-requisite) learning:

EF 1 - Ensure that your actions in the vegetation fire workplace reduce the risks to yourself and others

Subsequent learning:

EF 3 - Communicate within a team and with supervisors at vegetation fires (to be developed)
EF 4 - Apply hand tools to control vegetation fires
EF 5 - Control vegetation fires using pumped water (to be developed)
EF 6 - Apply Vegetation Ignition Techniques

Learning objectives:

On completion of learning you should be able to:

1. Understand wildfire behaviour

2. Apply suppression techniques to control vegetation fires

Keywords and phrases:

Bays, Control Line, Crown Fire, Direct Attack, Flank, Fingers, Fire Behaviour, Fire Hazard, Fire Weather, Fire Perimeter, Fire Risk, Fuels, Fire Intensity, Fire Support Office, Fire Type, Flame Length, Flanking Attack, Ground Fire, Head, Heel, Indirect Attack, Origin, Rate Of Spread, Smouldering Fire, Spot Fires, Surface Fire, Topography, Wildfire

I. Understanding Wildfire Behaviour

Wildfire

Wildfire is an uncontrolled fire that occurs in both rural and urban areas that burns vegetation, agricultural resources and human structures. It includes peat, grass, shrub (scrub) and forest fires.

Before undertaking wildfire suppression activities, it is important to have an understanding of the basic physical processes that cause fire to occur and the environmental factors that influence fire behaviour.

The Fire Triangle

The Fire Triangle illustrates the three elements that must be present for a fire to occur. If one of these elements is removed a fire will go out.

- Oxygen is a component of air which is necessary for fuel to burn and is readily available in a wildfire environment. Air, in the form of wind, plays a critical role in shaping wildfire behaviour.

- Heat is the energy needed to make flammable material give off vapours that mix with the oxygen in the air to cause fire. Fuel can be heated in numerous ways to reach an ignition point.

- Fuel is any flammable material or vegetation that is readily available to burn. The type, quantity, arrangement, distribution and moisture content of the fuel will influence fire behaviour.

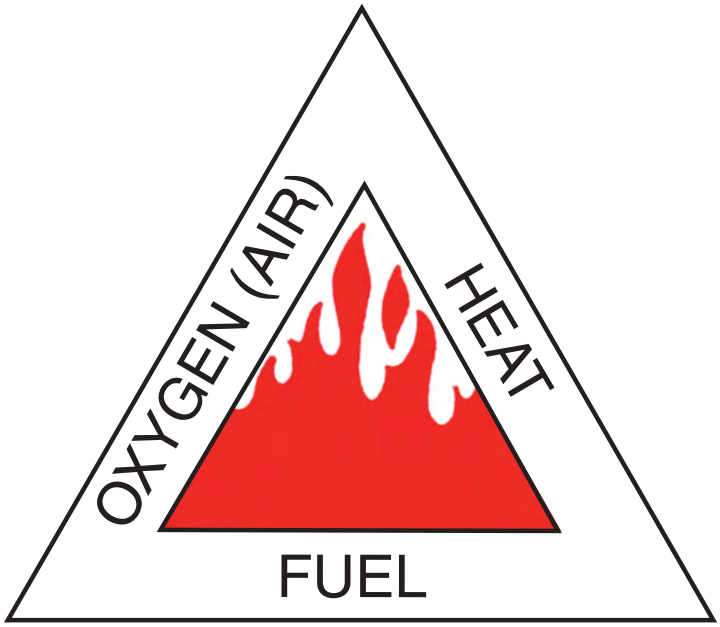


Illustration 1.1 The fire triangle

Heat Transfer

A fire's heat can be transferred to other fuel through convection, radiation and conduction.

- **Convection** is the movement of heat through air. In wildfire terms, convection is the heat that is both rising and moving sideways with the air in front of the flames. Convection is the most important form of heat transfer for wild land fire fighters because the superheated gases preheat fuels in front of the fire which can cause the rapid expansion of wildfire.

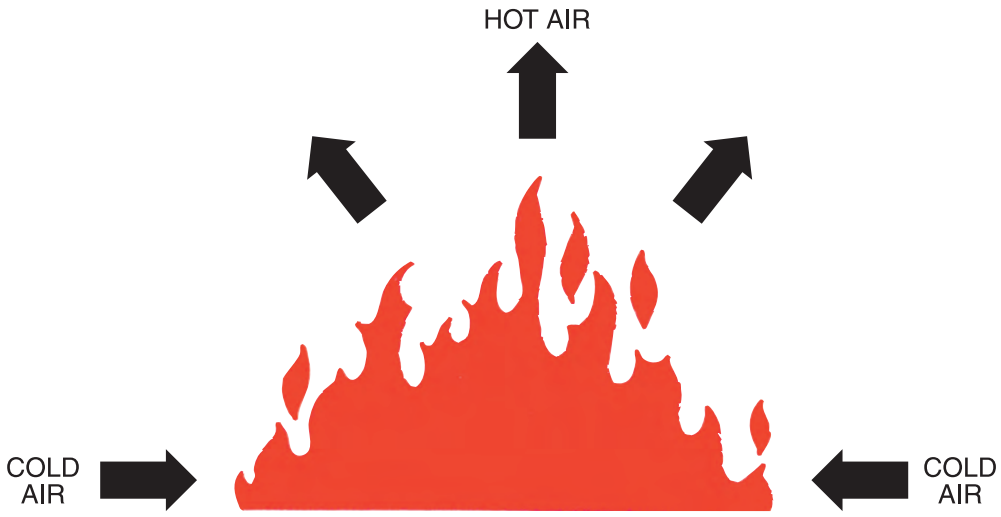


Illustration 1.2 Convection

- **Radiation** is heat that moves from a single source in all directions in the form of waves or rays. Burning fuels will radiate heat in all directions and contribute to the preheating of un-burnt fuels. The sun is another source of radiant heat.

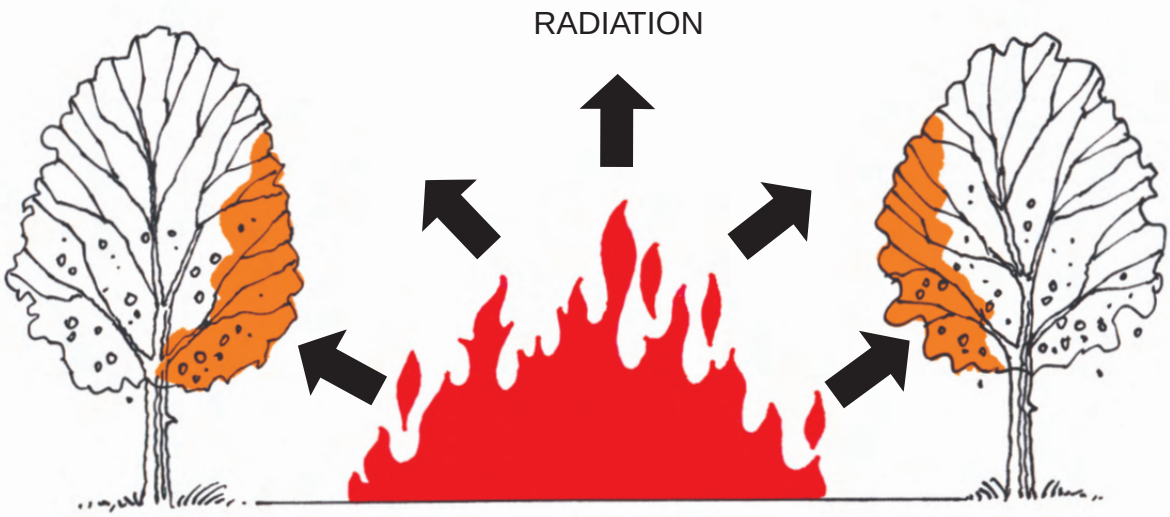


Illustration 1.3 Radiation

- **Conduction** is the transfer of heat through a solid object from a region of higher temperature to a region of lower temperature. It is transferred by direct contact from one object to another. The makeup of the receiving object will determine the speed of heat transfer. Conduction plays a minor role in wildfire because wood, like many other forms of vegetation, is a relatively poor conductor of heat.

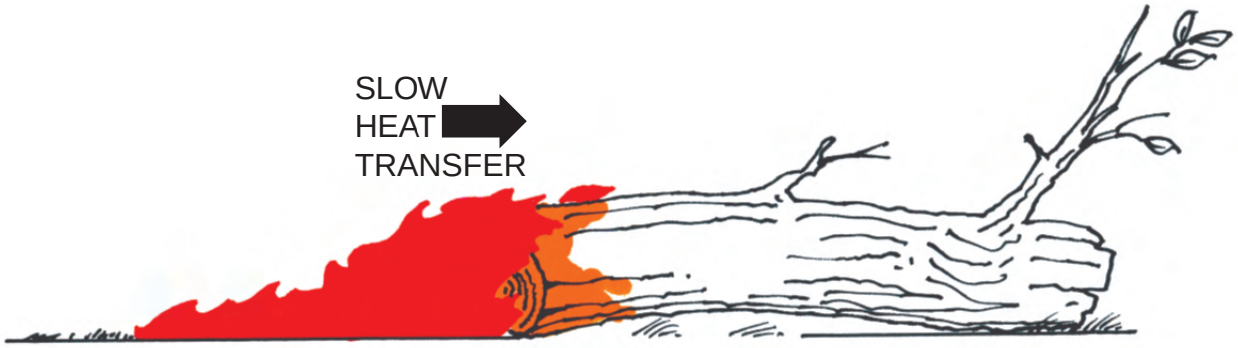


Illustration 1.4 Conduction

The Fire Environment

The fire environment includes all of the surrounding conditions that determine fire behaviour. A fire's rate of spread and intensity are determined by these environmental factors. The fire environment consists of three major components: fuel, weather and topography.

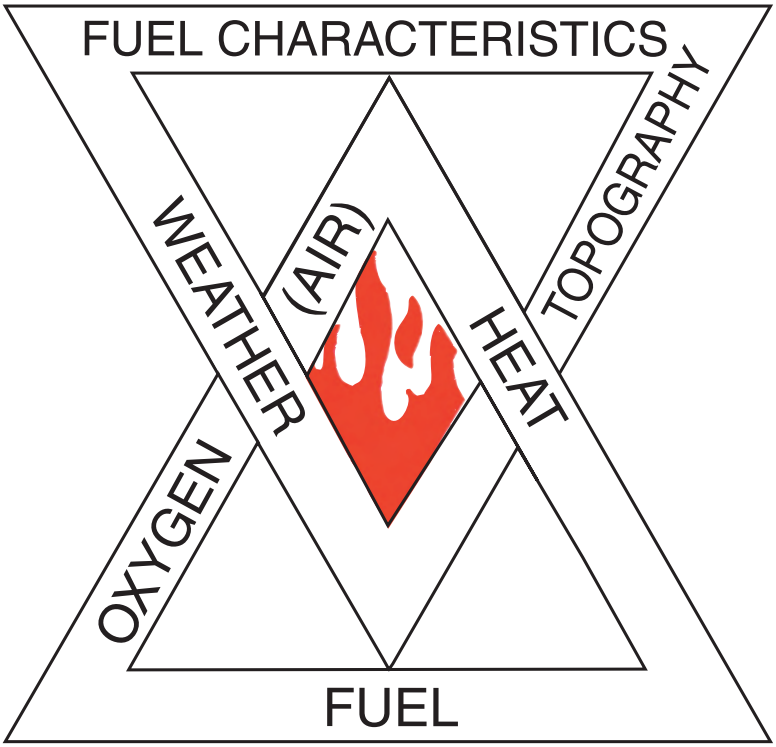


Illustration 1.5 The fire environment

1. Fuel

Fuel is one of the most important factors to consider when analysing a fire environment. Fuels will directly influence fire behaviour based on their:

- Class
- Type
- Size and Quantity
- Arrangement
- Moisture Content

Fuel Class

i. **Ground fuels** are organic materials below the surface litter, including duff, roots, peat, or other buried organic material. Fire behaviour in this fuel class is limited to smouldering or very low intensity burning, but can be sustained for days, weeks, or even months.

ii. **Surface fuels** are the combustible vegetation lying above the duff layer between the ground fuels and the crown fuels. Examples of this type of fuel include dead logs & branches, brush, grass, heather, young trees, etc. Surface fuels will always play a large part in determining fire intensity and rate of spread.

iii. **Crown (Aerial) fuels** are standing and supported fuels that are not in direct contact with the ground. This class will include ladder fuels and the upper levels of forest or scrub canopies. Wildfire intensity will be extreme in order for the fire to reach and spread through the crown fuels.

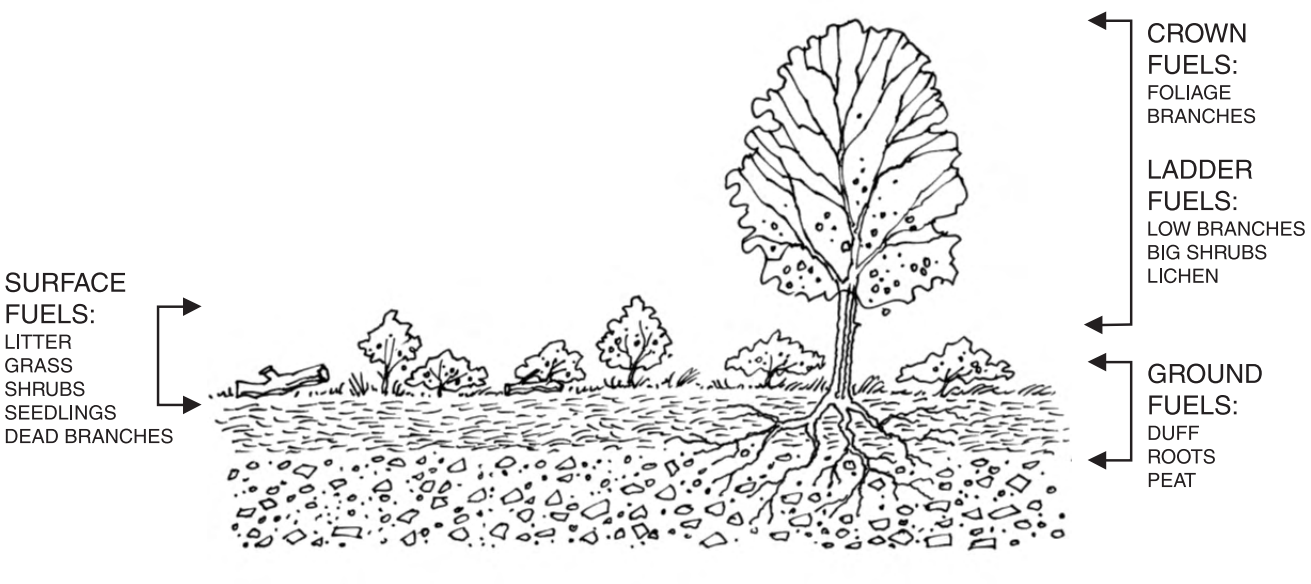


Illustration 1.6 Fuel classes

Size and quantity

There are two main categories of fuels:

i. Fine fuels are small fuels like twigs, grass, or leaves. These fuels are quick to dry out and ignite. They are often the main influence on fire intensity and rate of spread.

ii. Heavy or coarse fuels are large diameter logs or branches. These fuels often continue to burn long after the passing of the flame front.

The *quantity* of fuels readily available to burn will affect the fire intensity and rate of fire spread. A large quantity of fine fuels will result in intense fire behaviour at a flame front, while a large quantity of heavy fuels will result in a low intensity fire lasting long after the passing of the flame front.

Arrangement

Fuels can be arranged both horizontally and vertically.

i. Imagine a forest with varying types and quantities of trees and woody debris in both close and distant proximity to each other – this is **horizontal arrangement**. Scattered fuels will burn at a relatively low intensity, while a large amount of loosely stacked material will burn at a high intensity.

ii. **Vertical arrangement** refers to the quantity and distribution of fuels from the ground fuel level to the level of the crown fuels.

Fuel Moisture Content

The amount of moisture stored within a piece of vegetation will affect how easily it will burn and at what intensity it will burn. Environmental factors that influence fuel moisture are relative humidity, precipitation, air temperature, and to a lesser degree shade, aspect, slope, elevation, etc.

A fuel with a high moisture content, as a result of a recent rain, high humidity, or proximity to a water source, will require more preheating before it will burn. Fuels with low moisture contents will burn with very little preheating, at a high intensity, and with a fast rate of spread.

Table 1.1 Fuel moisture content

Fuel Moisture Content	
Fuel	*Moisture Content*
Fine Fuels	Lose moisture and dry out easily, quickly becoming available to burn
Heavy Fuels	Do not lose moisture rapidly, requiring more time and heat energy to become available to burn then the finer fuels
High Moisture Content Fuels	Require a longer period of preheating as well as a great degree of heat energy
Low Moisture Content Fuels	Quickly dry out and become available to burn, burn rapidly and with a high intensity

2. Weather

Weather is the most variable component of the fire environment, changing rapidly over the course of a wildfire. Weather can be extremely unpredictable and its influence on fire behaviour should not be underestimated. The key weather elements are:

- Relative Humidity
- Air Temperature
- Wind
- Precipitation
- Day/Night Variation

Relative Humidity

Relative Humidity (RH) is a measure of the moisture content in the air. A number of assumptions can be made when considering the effect of RH on wildfire behaviour:

i. RH directly effects fuel moisture content in *dead and fine* fuels, while *live* fuels will not be affected to the same extent by changes in RH.

ii. If RH levels are *high*, then dead and fine fuels can be expected to have a *higher* fuel moisture content level and will not readily burn. Conversely, if RH levels are *low*, then dead and fine fuel can be expected to have a *lower* fuel moisture content level and be readily available to burn.

iii. In weather forecasts, *low* RH levels are a good sign that fire behaviour will be *more intense*, while *high* RH levels generally mean that fire behaviour will be *less intense.*

iv. RH levels will almost always rise and fall according to a known pattern (See Illustration 1.7 below). RH levels will be at their highest in the morning and evening and at their lowest in the afternoon.

v. As a general rule, a fire will burn at its greatest intensity in the afternoon when RH is at its lowest and air temperatures are at their highest.

vi. A relationship between relative humidity and air temperature can be seen in the table below.

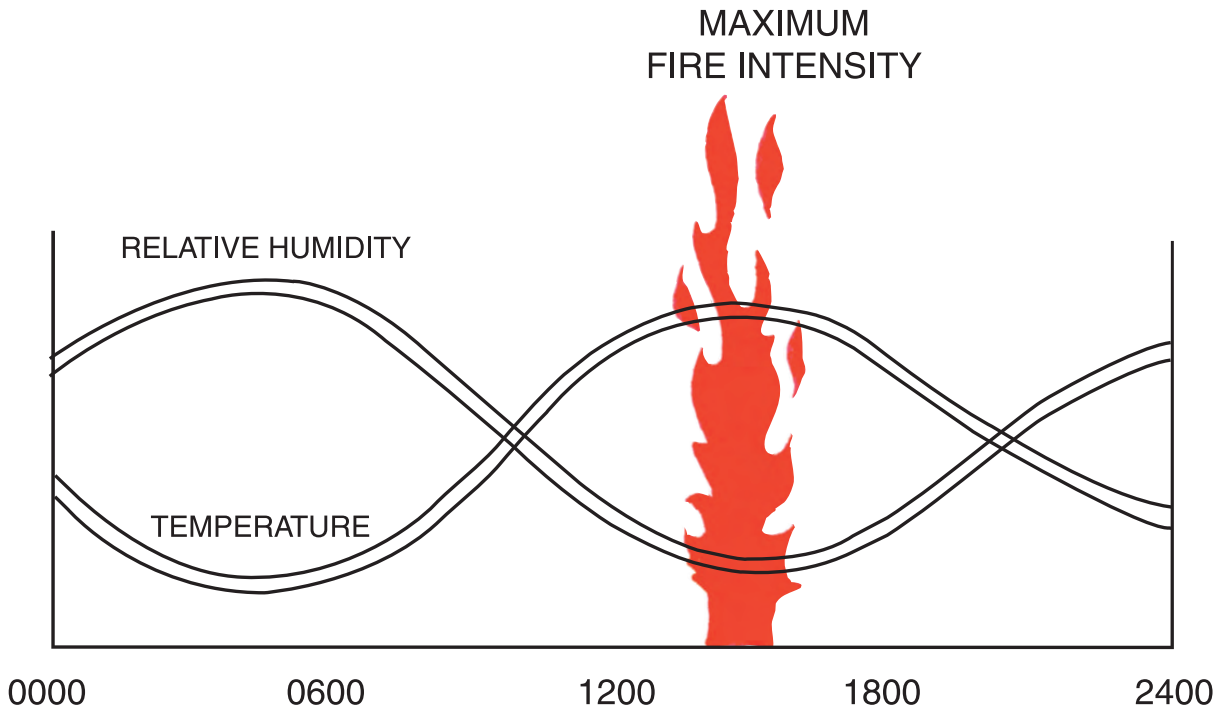


Illustration 1.7 Relative humidity level/fire intensity

Air temperature

Air temperature directly affects both relative humidity and the moisture content of fuel. An increase in air temperature will have two effects:

i. Relative humidity will decrease, resulting in an increase in fire behaviour.

ii. Fuel moisture content will decrease which will allow the fuels to dry out and ignite at a quicker rate.

Therefore we can assume that higher air temperatures will cause fuels to be hotter, drier and more easily ignited.

Wind

Wind has the greatest impact on fire behaviour of all the weather factors. Wind directly affects the rate of spread and direction of the fire. A strong wind will result in an intense and fast moving fire. Wind will contribute to fire behaviour in the following ways:

i. Wind supplies more oxygen (air) to a fire which causes the fire to burn at a greater intensity.

ii. Wind will greatly influence the direction of a fire.

iii. Wind will flatten (or bend) the flames of a fire over the fuel ahead of the fire increasing the rate at which those fuels will dry out and ignite as well as increasing the intensity at which fuels will burn.

iv. Wind will lift burning embers and ash ahead of the main fire causing new fires called “spot fires”.

Illustration 1.8 Effect of wind on wildfire

There are a number of other factors to consider about wind and its relationship to wildfire:

i. Wind direction refers to the direction the wind is coming from (i.e. a southern wind is a wind that originates in the south and moves in a northerly direction across the land).

ii. Land characteristics (topography) can influence the direction and speed of wind. For example, winds could be channelled through a canyon or a valley at a slightly different direction and at a greater speed.

iii. Wind direction and speed is extremely variable and can change at any moment to a great degree. This change can be attributed to the passing of weather systems like thunderstorms or the affects of local wind characteristics.

iv. The variability of wind is an extremely important consideration for fire fighters because it can rapidly change the direction and intensity of a wildfire. This is important to consider when working anywhere on a fire ground, but especially for teams working on the flanks or head of a fire. As can be seen with the effects of the wind shift shown below in illustration 1.9.

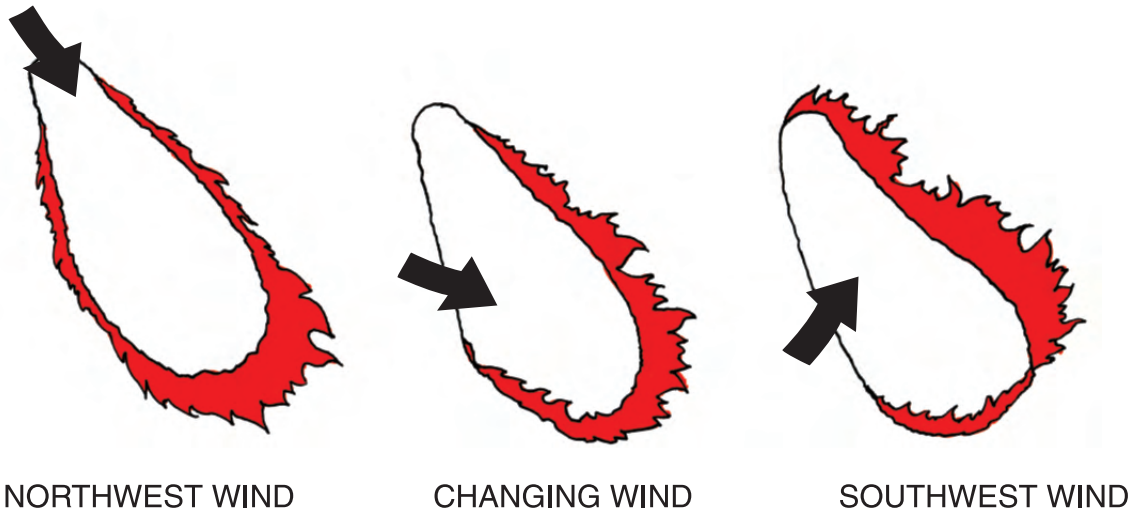


Illustration 1.9 Effect of a wind change on a fire

v. Wildfires can create their own wind. As hot air rises through the convection column of a fire, strong in-drafts of cold air will rush into the fire from all sides. The influx of wind will heighten fire behaviour.

Precipitation

Rainfall will have a dampening effect on a wildfire, although the degree to which rainfall will impact the fire behaviour can vary greatly depending on the amount and duration of the rainfall:

i. When there is steady, continuous rainfall over a long period of time, fuels will absorb more moisture and will not be easily ignited.

ii. Heavy rain over a short period of time will not greatly affect the fuel moisture content of surface fuels, leaving them readily available to burn.

Day & Night Variations

Wildfire behaviour during the night is enormously different than that of day time. Fire activity is often (but not always) relatively low throughout the night and can sometimes present excellent opportunities for wildfire suppression efforts.

3. Topography

The shape and aspect of terrain can vary significantly over the course of a wildfire. It will play a large part in determining the fire's direction and rate of spread. Weather factors like wind can be modified depending on the shape of the landscape. The key topographic features that contribute to fire behaviour are:

- Slope
- Aspect
- Terrain

Slope

A fire burning upslope generates more convective and radiant heat that preheats the unburned fuels ahead of the fire at a faster rate than on level ground. The steeper the slope, the greater this affect. The opposite is true for a fire travelling down slope. The general rules to consider when considering the affect slope will have on fire behaviour are:

i. For every *10° increase* in slope, *double* the rate of fire spread.

ii. For every *10° decrease* in slope, *halve* the rate of fire spread.

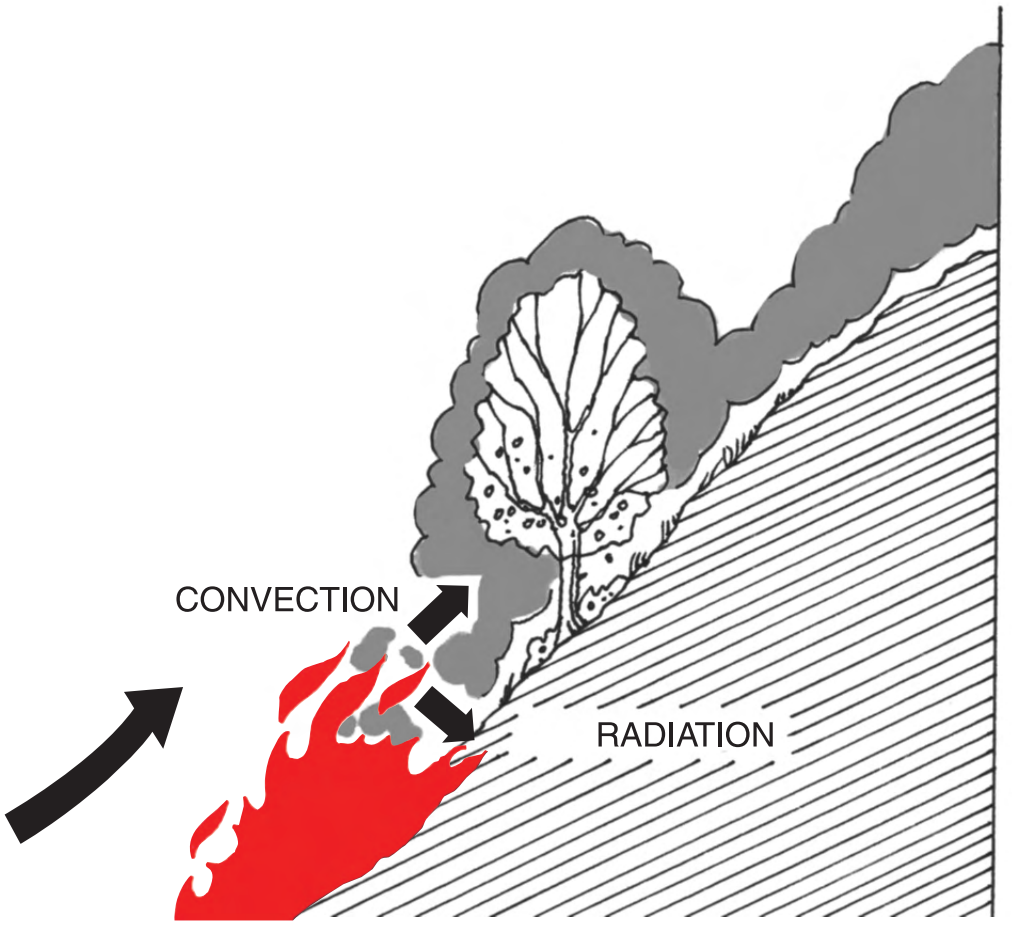


Illustration 1.10 Upslope effect on fire behaviour

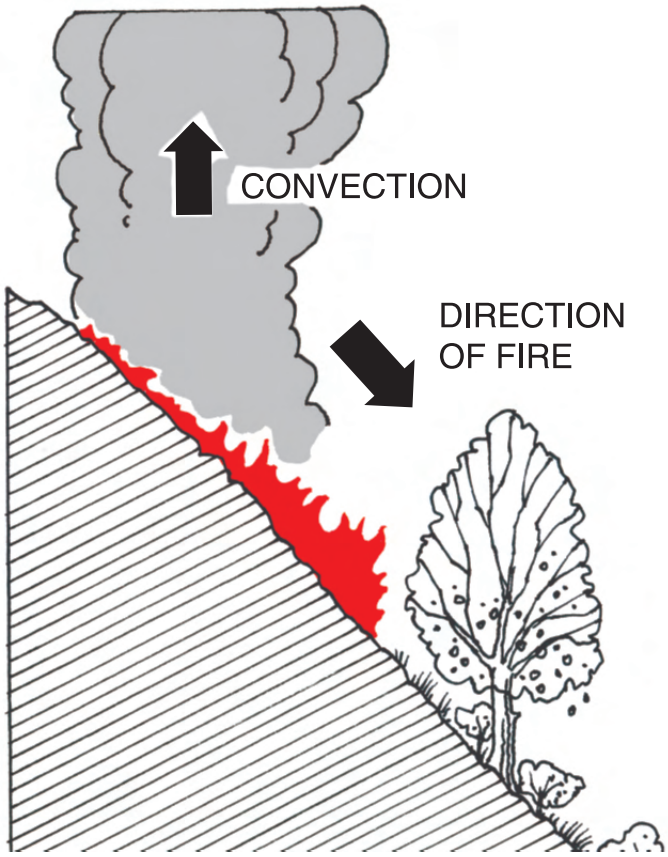


Illustration 1.11 Downslope effect on fire behaviour

Aspect

The aspect of a slope is the direction it faces – north, east, south or west. Aspect effects wildfire behaviour in two ways:

- Pre-heating effect
- Vegetation effect

i. Pre-heating effect

- Fire behaviour will be affected in the short-term (over the course of a day) by the aspect of the slope terrain in which it is burning. A south facing slope will receive more sunlight over the course of the day which will increase the preheating of the fuels. In contrast, a north facing slope will receive less sunlight over the course of the day and fuels will remain cooler. As a result, fire behaviour will be more intense on the south facing slope then the north facing slope. The conditions of the east and west facing aspects will vary, but fall somewhere in between the level at which south and north facing slopes are affected.

ii. Vegetation effect

The type and amount of vegetation is partially determined by aspect. In the northern hemisphere:

- South facing slopes will generally be sunny and dry with light vegetation.
- North facing slopes will be shadier and moist with a greater quantity of heavier vegetation.
- The condition of the east and west facing slopes will fall somewhere in between the environment of the south and north facing slopes. These slopes will be greatly determined by their geographic location and local weather conditions, varying from one location to another.

Wildfire behaviour will be affected by the aspect because of the variability of sunlight, vegetation and moisture content from one aspect to another.

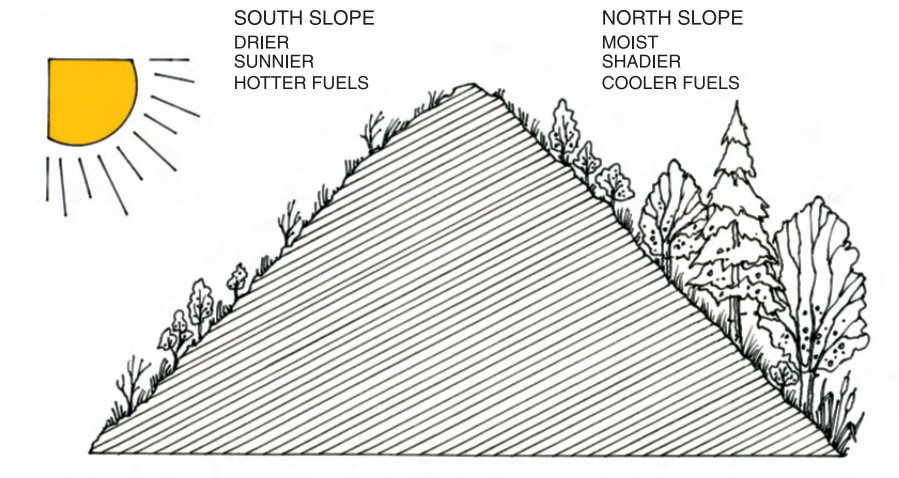


Illustration 1.12 Effect of aspect on fire behaviour (northern hemisphere)

Terrain

Terrain is the physical features on the surface of an area of land. The shape of land forms will affect fire behaviour. Valleys, ridges, canyons, mountains or flat land can all have different influences on the wildfire's direction, speed and intensity.

i. Wind & Terrain

Terrain will affect wind direction and speed. Like water, wind flows along the lowest and easiest path, following the contours of the land. Some examples of this relationship are:

- In the mountains or hills, winds tend to flow up or down valleys and gullies, irrespective of the general wind direction.
- Local winds can be generated by the terrain. An upslope wind during the day could become a down slope wind during the night.

• The leeside of a ridge (i.e. the side facing away from the wind) may have turbulent winds blowing in the reverse direction of the prevailing wind.

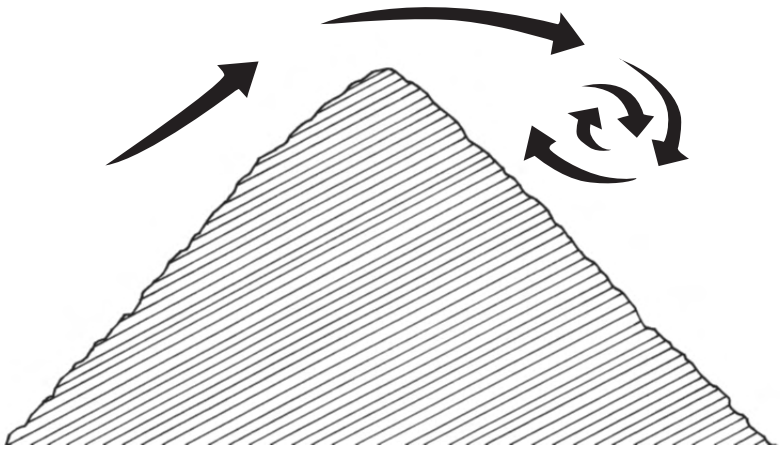


Illustration 1.13 Lee slope turbulence

ii. Ridges

Fire approaching a ridge top can increase in speed and intensity and behave erratically.

iii. Canyons, Gullies, & Saddles

Narrow gullies, saddles and canyons can channel the fire into a narrow, fast moving path. In this circumstance the shape of the land is funnelling both the fire and the wind into an area where the maximum effect of these factors, in terms of fire behaviour, will occur. This is also known as the chimney effect. A fire being influenced by the chimney effect will display extreme fire behaviour and move rapidly through the narrow terrain.

Illustration 1.14 The chimney effect

Wildfire Development

It is important to know the characteristics of the different types of wildfire, as well as how the different parts of a wildfire are defined. It is also critical to understand the way that fire develops from an ignition point to an active wildfire and what forces drive the fire's development.

1. Types of Fires

Wildfires are commonly referred to by the class of fuel (ground, surface, or crown) in which they are burning. Having an understanding of the different types of wildfires is crucial because each will require different suppression methods. There are four types of wildfire:

- Ground
- Surface
- Crown (Aerial)
- Spot

i. A **Ground Fire** burns in the organic materials under the surface litter and in the root systems. Fire will burn in organic material such as peat, humus, roots, and other buried combustible material such as landfill waste. Characteristics include:

- Smouldering with no flame and little smoke
- Fires may burn unnoticed for weeks or months and could potentially re-ignite surface fuels
- Occur in any area with a deep soil layer or large amounts of organic material
- commonly occur in peat fires

ii. A **Surface Fire** involves the burning of vegetation like forest litter and undergrowth, grasses or shrubs, or other vegetation lying at or slightly above ground level. Characteristics include:

- The most common type of wildfire
- Fire behaviour can vary from very low to extreme
- Heavily influenced by the forces that drive fire behaviour (Weather, Fuel and Topography)

iii. A **Crown (Aerial) Fire** burns in the tops of trees above and ahead of an intense surface fire. Convective and radiant heat from an intense surface fire will ignite the tree tops and a crown fire will burn independently of the surface fire. Characteristics include:

- Display the most extreme form of fire behaviour, fastest moving type of wildfire and highly destructive of the natural environment.

- Intense surface fire will follow shortly after the passing of a crown fire.

- Spot fires will appear in great numbers and some may occur well in advance of the main fire.

- Normally only travel short distances supported by either a strong wind or steep slope.

iv. **Spot Fires** are new fires that have been ignited in front of the main as a result of fire brands, or burning debris that has been lifted by hot air through the smoke column and then deposited in front of the main fire.
Characteristics include:

- Each spot fire is independent of the main fire and their spread and fire intensity will be vary greatly based on their location.

- Spot fires are a good indicator of the presence of, or the growing potential for extreme fire behaviour.

- Spot fires are extremely hazardous to the fire manager because of their unpredictability and potential to become a second or third rapidly growing fire independent of the main fire.

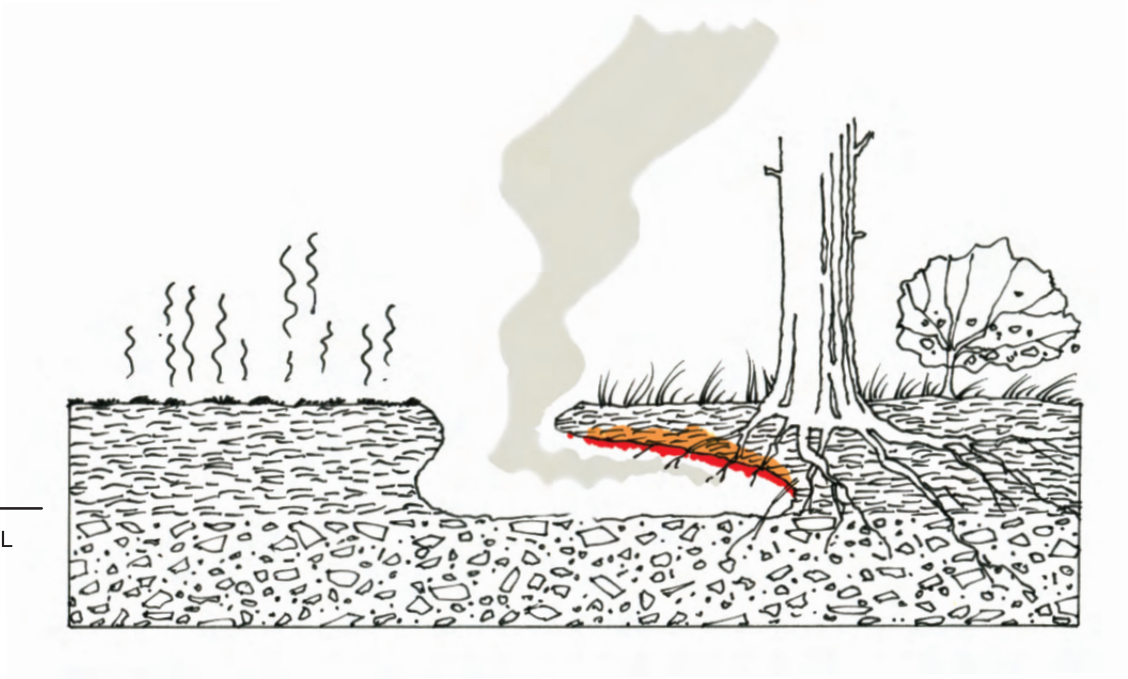


Illustration 1.15a Types of wildfires – ground fire

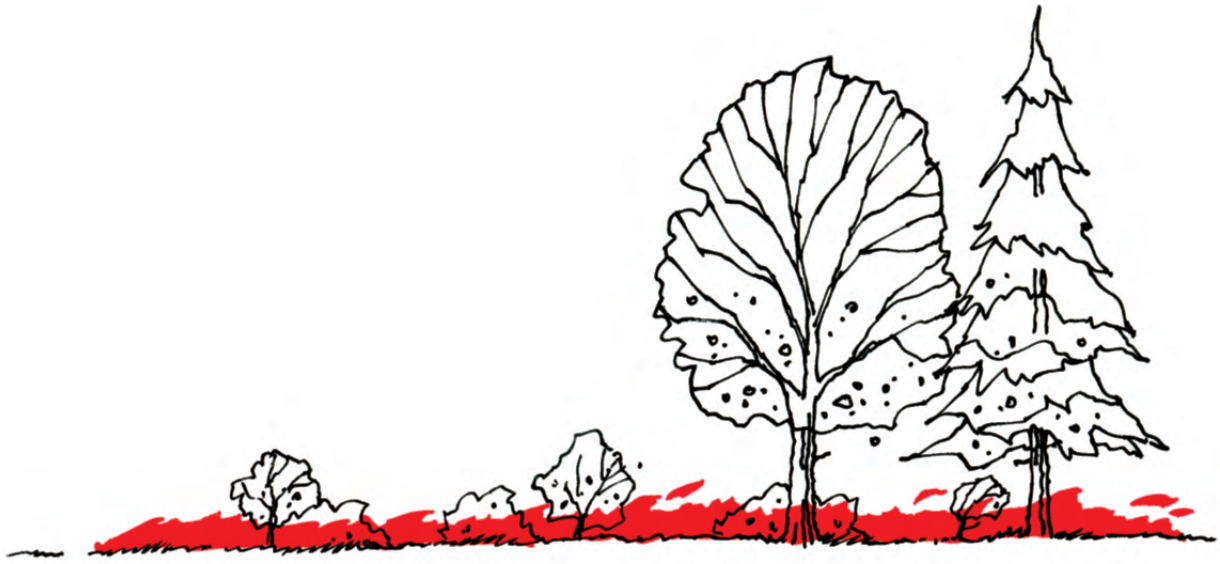


Illustration 1.15b Types of wildfire – surface fire

Illustration 1.15c Types of wildfire – crown fire

2. Parts of Wildfires

There is a set of common terminology used to describe the parts of a wildfire. An understanding of the basic parts of a wildfire will be essential for effective communication on a wildfire incident. Parts of wildfires include:

- Origin
- Heel
- Flanks
- Head
- Fingers
- Bays
- Perimeter
- Spot Fires

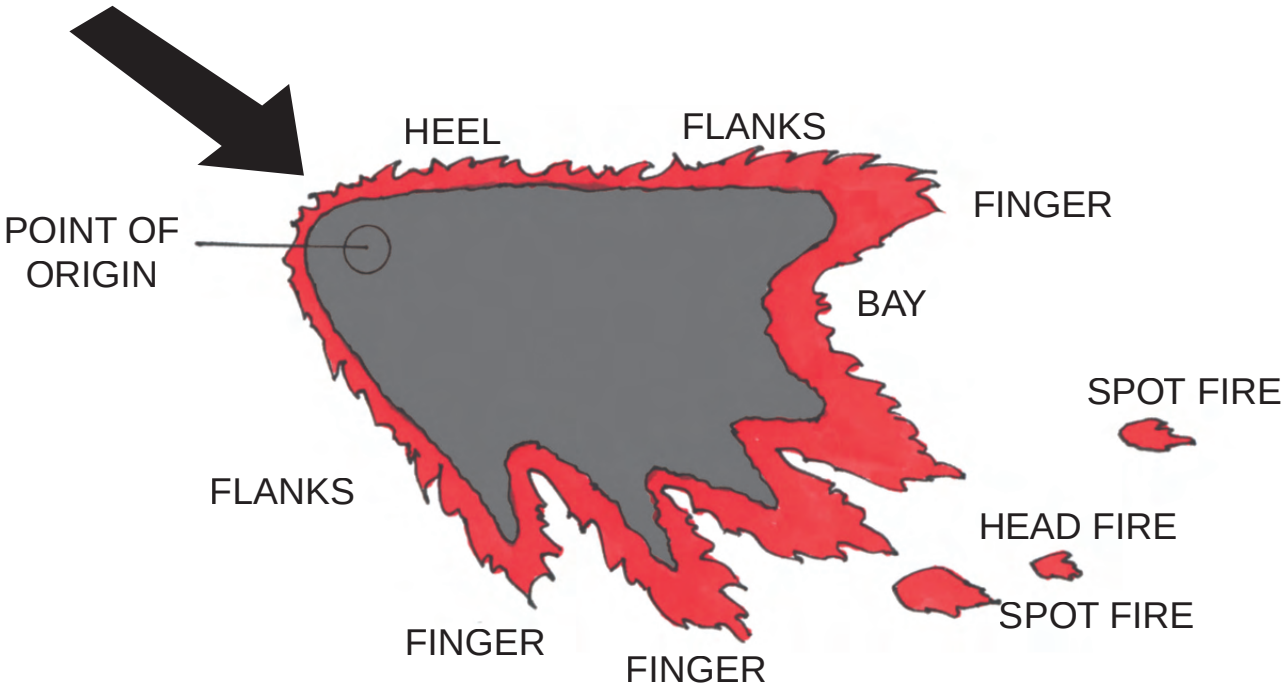


Illustration 1.16 Parts of wildfires

i. The **Origin** is the place where the fire starts. This may or may not be easily identifiable.

ii. The **Heel** of a fire is the rear of the fire starting at the origin.

iii. The **Flanks** are the sides of a fire, often areas of low to moderate fire behaviour.

iv. The **Head** is the front of the fire which will display the greatest fire intensity and the fastest rate of spread.

v. The **Fingers** are narrow slivers of advancing fire that extend beyond or alongside of the head or flanks.

vi. The **Bays** are the areas in front or alongside of the head fire, between fingers of fire, where you may have fire on three sides.

vii. The **Perimeter** is the outside edge of the fire.

viii. **Spot Fires** are new fires ignited ahead or away from the main fire by embers or other burning material.

3. Wildfire Spread

Wildfire spread will depend on the characteristics of the weather, topography, and fuel that determine fire behaviour. In wildfire terms, **alignment** occurs when the forces of weather, topography, and fuel are all in the fire's favour. Wildfires that are in alignment will exhibit extreme fire behaviour and can be highly destructive.

Within the general categories of weather, topography and fuel, the forces of wind, the shape of the land, and the arrangement of the fuel will have the greatest affect on the shape or spread pattern of a wildfire. The illustrations below show the basic effects that these factors will have on wildfire spread.

i. Fire spread with little or no influence of wind or slope

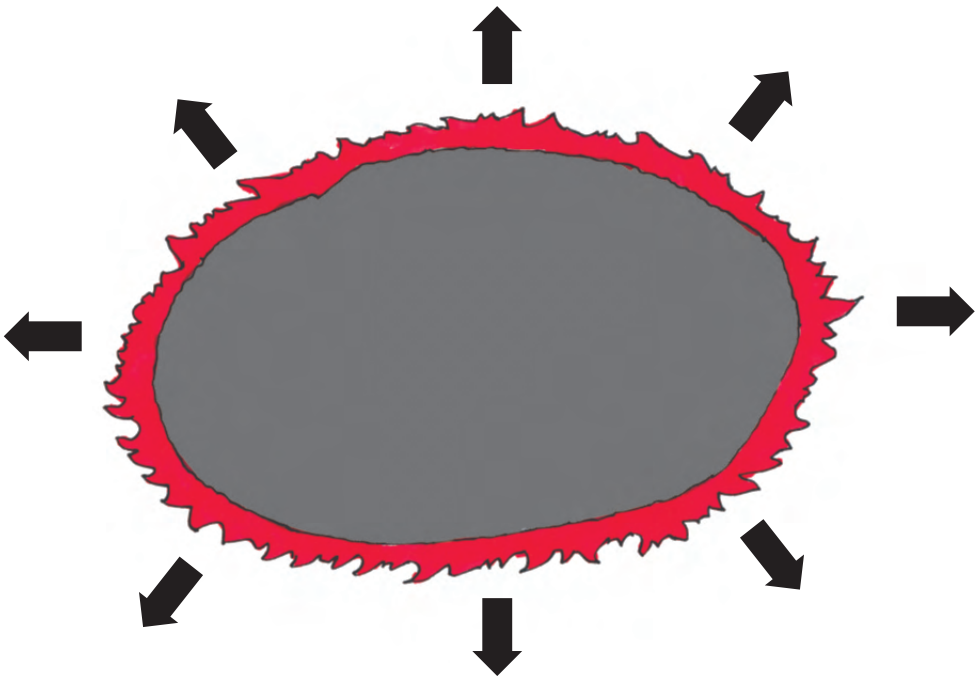


Illustration 1.17 Fire spread with little to no influence of wind or slope

This type of fire spread will occur when a fire starts on flat ground, with a relatively even fuel distribution on a calm day. The fire perimeter will move out evenly from the ignition point in a circular pattern and fire spread will be slow.

ii. Fire with moderate wind and/or topographical influence

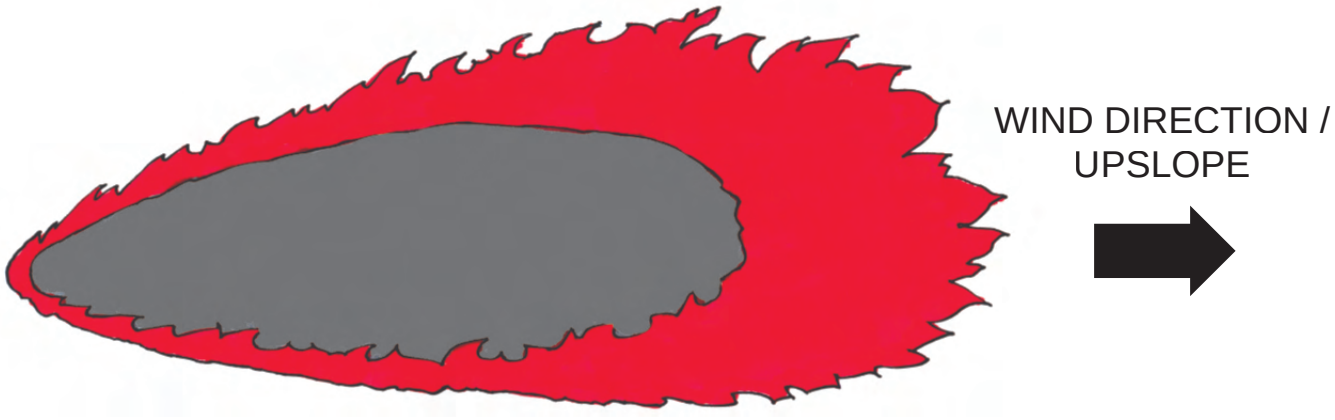


Illustration 1.18 Fire with moderate wind and/or slope influence

Under the influence of a moderate wind the fire's convection column is driven over the head of the fire and contributes to the heating of un-burnt fuels. A moderate slope will contribute to the increase in heating of un-burnt fuels in the same manner. The diagram shows this increase in fire behaviour and the resulting pattern of fire spread.

iii. Fire with strong wind and/or topographic influence

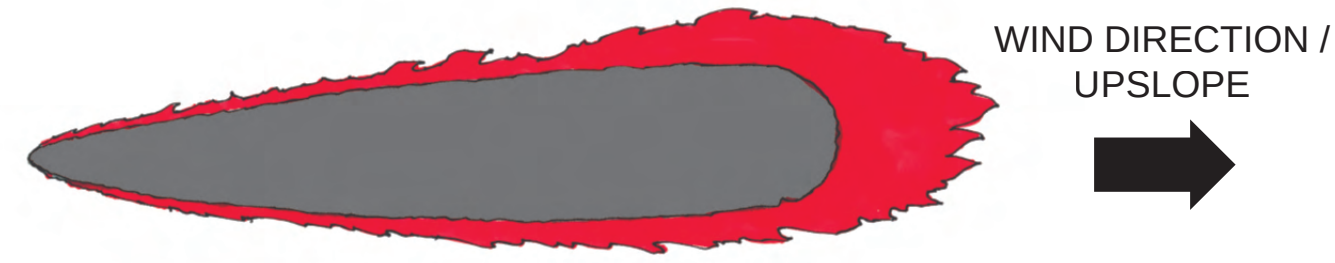


Illustration 1.19 Fire with strong wind and/or slope influence

Under the influence of a strong wind or steep slope the pattern of fire spread will resemble an elliptical shape because the intensity of the head fire (which is most affected by the factors in alignment) will be extreme compared to those intensities seen on the flanks and at the heel. The forces at work are the same as in illustration 1.18, but to a greater degree.

II. Control Vegetation Fires

Approaching a Wildfire

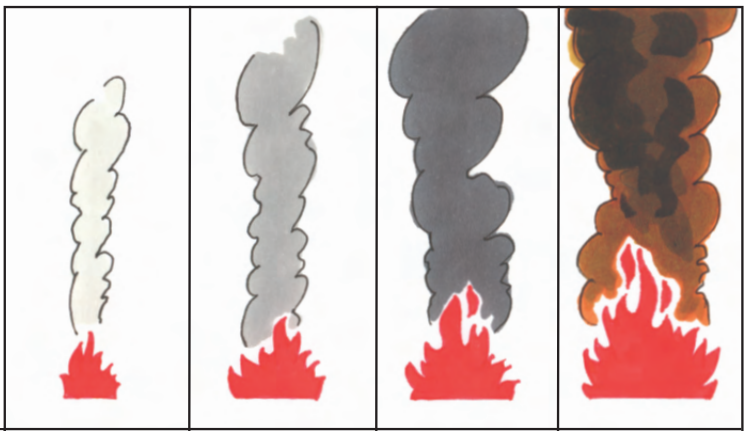
The initial response to a wildfire incident is crucial to the success of wildfire suppression. An effective response depends on correctly identifying the location of the fire, understanding the fire behaviour signs that can be identified prior to arrival and choosing the most efficient route to the fire without compromising the safety of yourself or others.

When Fire is reported:

- Be sure you understand the exact location of the fire, or if only a general location is known, identify a safe vantage point in the area to obtain a more precise location
- Refer to maps or aerial photographs to identify a safe and direct route
- Collect all relevant information from the reporting party

En route to the fire ground:

- Consider weather conditions - current and expected
- Consider the indicators of fire behaviour that can be perceived on approach of the wildfire. What can you discern from the shape, colour, and size of the smoke column?



SMOKE COLOUR	DENSE WHITE	GREY	BLACK	BLACK COPPER - BRONZE
FUEL MOISTURE	VERY MOIST FUEL	MOIST FUEL	DRY FUEL	VERY DRY FUEL
FIRE INTENSITY	LOW	MODERATE TO HIGH	HIGH TO VERY HIGH	EXTREME

Illustration 2.1 Four different smoke columns

- Consider your understanding of the fire area. What are the vegetation types in the area? What are the most common topographic features? Are there any special local weather factors to consider?

Methods of Extinguishment

The removal of one of the three elements that makes up the fire triangle, or “breaking the fire triangle”, will successfully suppress a fire. There are a number of common fire fighting strategies that all aim to remove one element of the fire triangle.

1. Remove the Oxygen Supply

This can be done by throwing soil on a fire or beating out the fire along its edge using a “fire beater”. Foam also removes the oxygen supply.

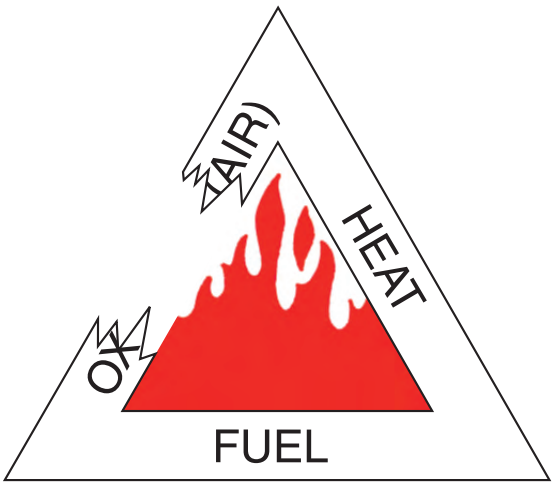


Illustration 2.2 Broken fire triangle (oxygen)

2. Remove the Heat

Water absorbs heat energy through steam. The application of water is a very effective way of extinguishing a fire. Water must be directed at the base of the flames where combustion is occurring.

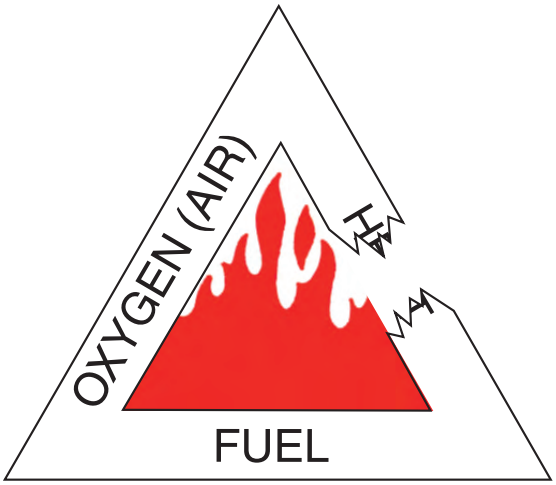


Illustration 2.3 Broken fire triangle (heat)

3. Removing the Fuel

Techniques which involve the removal of fuel are known as “dry fire fighting techniques”. Using hand tools to create a control line or using machinery to create “fuel breaks” are both effective dry fire fighting techniques. Backburns and other burn-out operations are also examples of removing the fuel in front of the fire.

Illustration 2.4 Broken fire triangle (fuel)

4. Combination of Methods

In many cases, it will be a combination of techniques that successfully extinguishes a wildfire. Removing the oxygen supply by adding dirt to the fire is better suited for the “mop-up” stage of the wildfire, while removing the fuels in front of fire might be used to knockdown the head of the fire and gain control of the wildfire.

Wildfire Suppression

The tools used in wildfire suppression vary greatly depending on the geographical environment. It is important to understand when and where the different types of wildfire suppression tools should be used in order to be effective.

Wildfire suppression tools may include:

- Hand tools
- Power tools
- Water equipment
- Ignition equipment
- Heavy machinery
- Air resources

1. Hand Tools

Use:

- Direct, Parallel and Indirect Attack
- Fire line and fuel break construction

Considerations:

- Some hand tools have multiple uses, while some are intended for specific tasks only.
- Depending on the geographic area or fuel type, some tools may be better suited then others for certain tasks.

Basic Hand Tool Examples:

- Axe
- Shovel
- Spade
- Hoe
- Mcleod
- Rake
- Mattock
- Gorgui
- Pulaski
- Slasher
- Brush Hook
- Knapsack
- Fire Beater
- Sprayer

*For a more in depth look at hand tools refer to training module **EF4 Apply hand tools to control vegetation fires**

2. Power Tools

Use:

- Create a fuel break by cutting back trees, shrubs or limbs
- Often used to create a path for the construction of hand line or to clear fuel from an existing firebreak (i.e. road or stream)

Considerations:

- Power tools must only be used by trained and qualified personnel
- Personal Protective Equipment must be worn

Power Tool Examples:

- Brush-cutter
- Chainsaw

3. Water Equipment

Use:

- Used in Direct and Parallel Attack
- Can be applied directly to the flames, used to build wet line, cool down a controlled burn line and putting out hot spots.

Considerations:

- Water Supply/Sources
- Resources are often limited so water conservation is critical
- There are multiple types, brands, styles of water fire fighting equipment (i.e. hose, hydrants, fittings, water appliances, etc) depending on the geographical area

Water Equipment Examples:

- Portable pumps
- Fire appliances/engines
- Knapsack

4. Ignition Equipment Use:

- Parallel and Indirect Attack
- Burnout operations or burning out unburned fuel within the control line perimeter Considerations:
- Using ignition equipment introduces new hazards
- Suitably qualified personnel should be in charge of all burn out operations
- Burn out operations should be carefully planned and executed

Ignition Device Examples:

- Drip torch
- Diesel burner

* Gas Burner *For a more in depth look at ignition devices & techniques refer to training module **EF6 Apply vegetation ingnition techniques**

5. Heavy Machinery

Use:

- Direct, Parallel and Indirect Attack
- Used to build large fire lines or fuel breaks in a short amount of time
- Transport fire fighting teams

Considerations:

- Adhere to safe working practices around heavy machinery

Heavy Machinery Examples:

- Bulldozer
- Tractor & swipe
- Grader
- Transport vehicles

6. Air Resources

Use:

- Direct, Parallel and Indirect Attack
- Support ground units
- Knock down hot spots, support tactically important areas, or attack areas of intense fire behaviour

Considerations:

- Aircraft operating alone are not effective fire fighting tools.
- Fire fighters must work in conjunction with the supporting aircraft while observing safe protocol when working with aircraft on a wildfire

Aircraft Examples:

- Airplanes
- Helicopters

Control Line & Fire Line

Control line is a comprehensive term used for all of the constructed or naturally existing fire barriers used to control the fire. Some examples of existing control lines include; streams, lakes, ponds, rock slides, areas of sparse fuels, roads, canals or previously burned (cold) fireline.

Fireline refers to any cleared strips or portion of a control line from which flammable material has been removed by scraping or digging down to mineral soil.

A fireline is constructed for two purposes:

- To create a “safe strip” from which to start burning out to remove fuels between the fireline and advancing fire.

- To isolate the burned area from the unburned area.

Any control line must be commenced at an *anchor point*. This is an existing area of low fuel (i.e. a road or track, rocky area, substantial stream or already burnt ground) that will prevent the fire burning around the end of the constructed control line.

* For a more in depth look at control lines refer to training module **EF4 Apply hand tools to control vegetation fires**

Wildfire Suppression Techniques

The strategy(s) used to control a wildfire depends on a number of factors including the rate of spread, intensity, values at risk, size, location, type of available resources, and other factors. There are two broad categories of wildfire suppression techniques:

- **Offensive Strategies** are used when the fire can be safely and effectively attacked or suppressed. Wildfire suppression activities may include one or a combination of strategies.

- **Defensive Strategies** are used when the fire is too intense to be safely attacked, fire fighting resource is limited, or areas of high importance are at risk.

Offensive Strategies

1. Direct Attack

i. Used mainly on low intensity wildfires that can be easily and safely reached by fire fighters.

ii. Control efforts, including line construction, are done at the fire perimeter, which becomes the control line.

iii. Suppression efforts should focus on the flanks of the wildfire, starting from the rear and working towards the head of the fire.

iv. Begin fire line construction at an anchor point, (i.e. a road, stream or burned area to minimize the chance of being flanked by the fire).

Methods

- Construct hand line or beat out the fire edge using hand tools, power tools and/or heavy machinery
- Apply water to flames using fire appliances, hose lays or knapsacks
- Use aerial units to apply water or fire retardant on the fire edge

Advantages

- Safest place to work (can keep one foot in the black or burned area)
- A minimal amount of area is burned
- Immediately reduces potential for fire spread
- Eliminates the need for more complex fire suppression strategies

Disadvantages

- Fire fighters can be exposed to heat and smoke because of their proximity to the fire edge
- Irregularly constructed control line
- Doesn't take advantage of natural or existing barriers

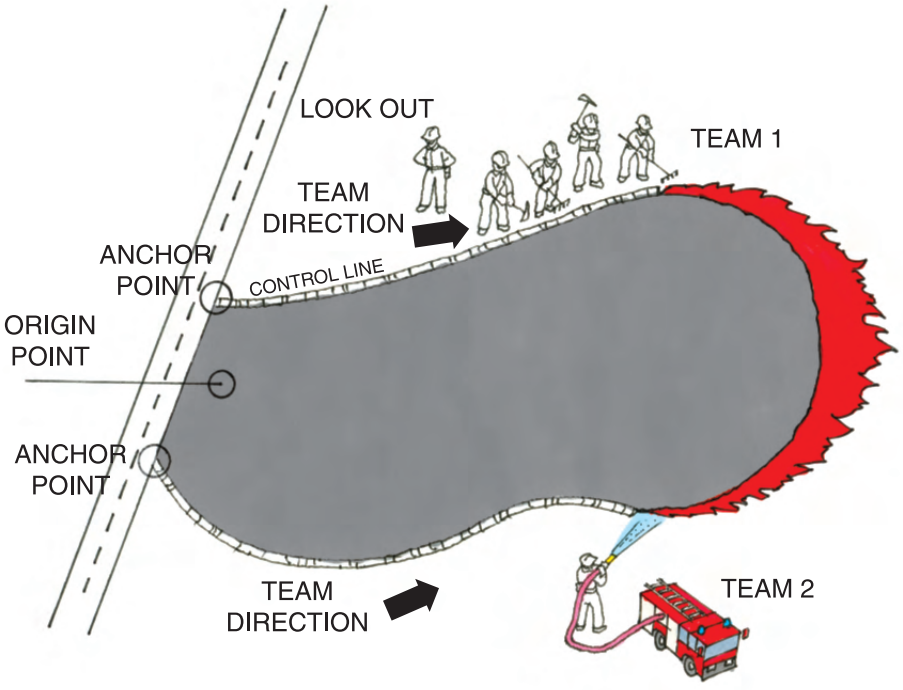


Illustration 2.5 Direct attack (flanking)

2. Parallel Attack

i. Used on *low to moderate* intensity wildfires that may be too intense to attack along the edge of the fire, to make use of a natural existing barrier to act as a control line, and to easily incorporate unburned bays or pockets into the control line.

ii. Control lines are built a short distance from, but parallel to the fire edge.

iii. The distance that the control line is built from the fire edge will depend on the fire behaviour, current and expected weather conditions, terrain, and the type of fuel between the fire edge and the proposed control line.

iv. The area between the control line and the fire edge can be "burned-out" after the construction of the control line to secure it.

v. Fire must be carefully monitored for changes in direction or behaviour.

vi. Requires an experienced supervisor.

Methods

- Construct control line using hand tools, heavy machinery, or existing barriers
- Burn-out vegetation using ignition devices
- Use water to cool control line after burn-out operations

Advantages

- Direct and more secure control line
- Teams are not working within heavy smoke and intense heat
- Makes use of pre-existing natural barriers

Disadvantages

- Added complexity of burn-out operations
- Potential for new fires to escape or increase fire behaviour
- Total fire area is intentionally expanded
- Unburned fuel remains between the fire and teams

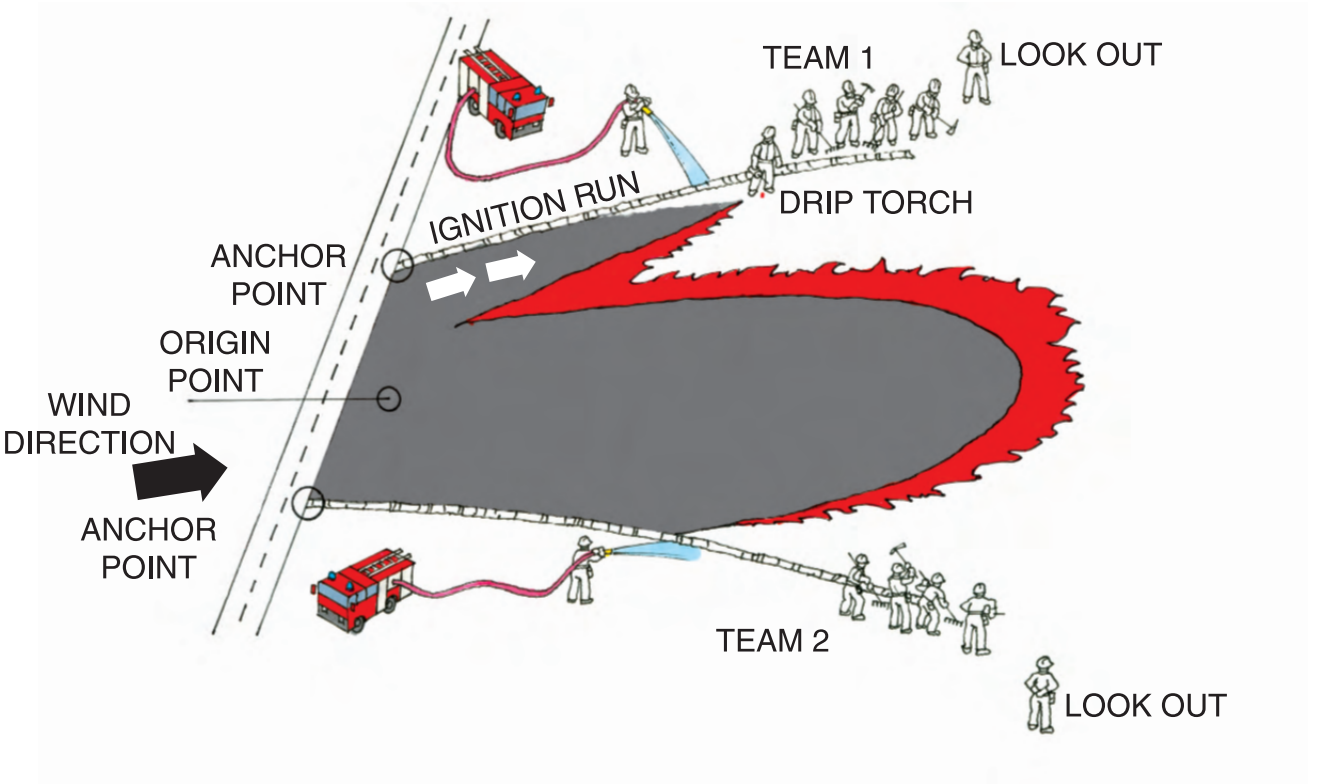


Illustration 2.6 Parallel attack

3. Indirect Attack

i. Used for wildfires of great intensity, large physical area, or those with limited access.

ii. This strategy often involves the use of fire (i.e. Backburning) as an offensive strategy.

iii. Uses an existing natural barrier or constructed control line that is a good distance from the fire.

iv. The distance that the control line is built from the fire edge will depend on the fire behaviour, current and expected weather conditions, terrain, and the type of fuel between the fire edge and the proposed control line.

v. Two methods of ignition can be used in an indirect attack. One, the vegetation between the main fire and the control line is “burned out”, removing the fuel from the main fire. Two, in accordance with the correct terrain and weather conditions, a “back burn” is lit to slowly burn away from the control line towards the main fire and thus removing the fuel from the main fire.

vi. Requires an experienced supervisor.

Methods

- Construct control line using hand tools, heavy machinery, natural barriers
- Burn-out vegetation using ignition devices
- Use water to cool control line after backburn is completed

Advantages

- Control line can be placed in favourable topography
- Uses natural or existing barriers
- Teams work out of the heat and smoke
- Allows time to build a control line and undertake burn out operations without responding quickly to changes in fire behaviour

Disadvantages

- Increases overall fire size
- A back burn could potentially get out of control due to unforeseen changes in weather conditions
- Line construction and backburning operations may not be completed before the main fire reaches the control line
- Complexity of operation is increased
- Intense fire behaviour may occur when the main fire and back fire collide, increasing the potential for spotting

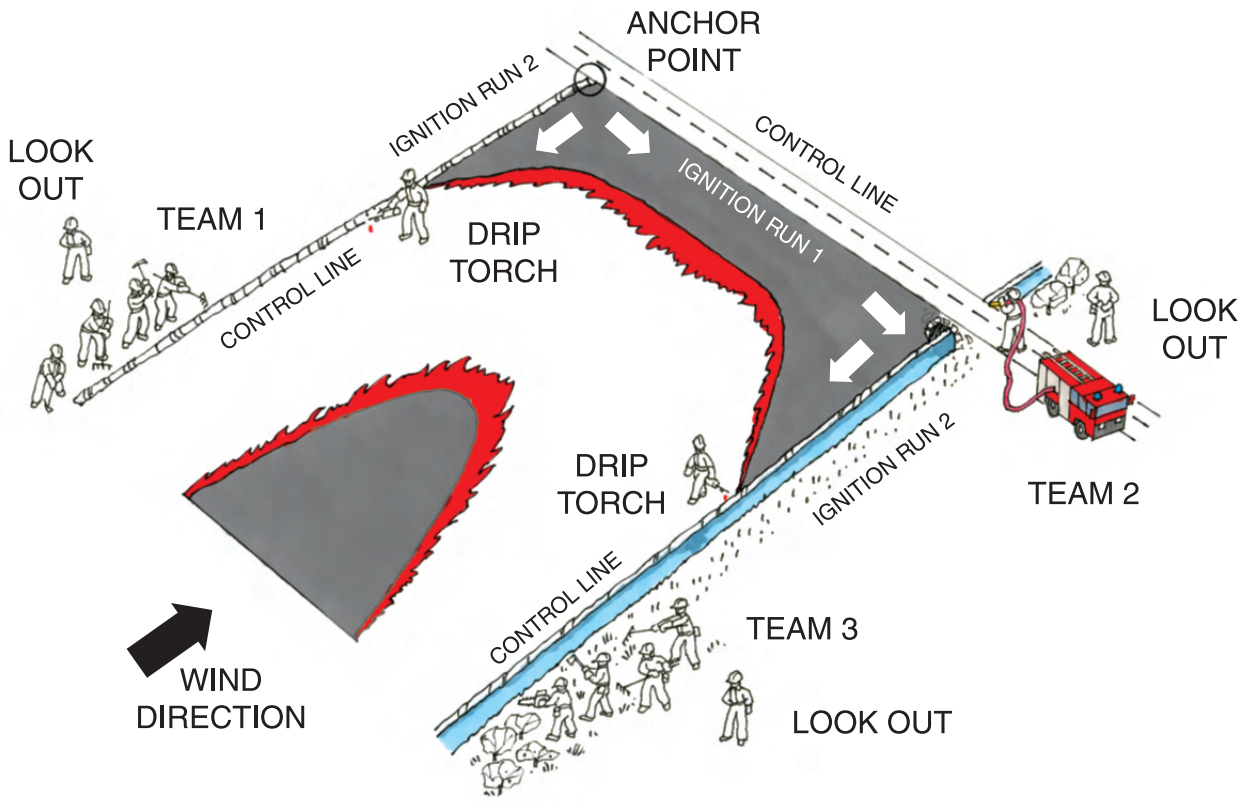


Illustration 2.7 Indirect attack

4. Combination of Methods

A combination of techniques is if often used to obtain control of a wildfire. Deciding on which technique to use on a wildfire, or part of a wildfire, depends on:

- Rate of fire spread
- Intensity of the fire
- Fuel ahead of the fire
- Terrain
- Available resources
- Access to the fire
- People or assets threatened

A wildfire will not burn at the same intensity on every part. A wildfire may be big enough to burn in many different vegetation types. Weather, terrain and aspect may be affecting one side of a fire in a different way then another side. As a result of this, it is common to use many a combination of offensive strategies to suppress a wildfire.

Defensive Strategies

These may be used in times where the main fire is too intense to safely attack, or the fire is remote and it is difficult to deploy sufficient resources. Examples of defensive strategies include:

- The creation of defensible space around structures, settlements, or other areas of high importance.

- An individual or a team burning out a defensible area in order to protect themselves from an encroaching wildfire.

- Only observing the movements of a major wildfire in a remote area.

Choosing a Suppression Strategy

Fire behaviour directly influences the strategy to be used in suppression operations. This relationship can be interpreted by the following table:

Table 2.2: Flame length, tools, techniques and strategies

Flame Length (m)	Significance
0 – 0.5	Fires generally self extinguish
0.5 – 1.5	Fire intensity low Hand tools can be used in direct attack to control the fire
1.5 – 2.5	Fire too intense for direct attack with hand tools Pumped water or bulldozers may be needed Flanking / parallel attack recommended
2.5 – 3.5	Fire too intense for direct attack from control line Helicopters & fixed wing aircraft drops may be needed Flanking / parallel attack depending on local flame length
3.5 – 8	Very intense fire Backburning and backfiring may knockdown the head fire Flanking / parallel and indirect attack recommended depending on local flame length
8m+	Extreme fire behaviour Defensive strategies recommended

*The highlighted box indicates the range of flame lengths that offensive strategies can be used to control a fire

Teamwork

Teamwork is essential to the success of wild land fire fighting. Almost every job in fire suppression is done as a part of team. As a member of a team you must stay in contact with other team members either in person or via radio during wildfire suppression operations. Some essential points to remember are:

- Assure that you understand your instructions and they relate to the instructions of other team members
- Communicate frequently with your team members and supervisor
- Understand the overall objective of your team's work
- Respect the needs of your team members
- Assure that both you and your team members know your team's escape plan in the case of an evacuation

Phases of Wildfire Suppression

There are four phases of fire suppression that will occur on any wildfire incident. These phases are commonly known as knockdown, containment, control, and mop up and patrol.

- **Knockdown** is the initial suppression work aimed at reducing the fire's intensity and slowing or stopping fire spread. Implies that the foreseeable danger of the wildfire has been significantly reduced.

- **Containment** is attained when a control line has been established around the perimeter of the fire and stopped further growth.

- **Controlling** a fire means that the control lines have been improved and secured to the degree that there is no foreseeable chance of the fire escaping.

- **Mop up and Patrol** commences after the fire has been controlled and involves extinguishing the burning area until there is no possibility of re-ignition. Patrolling the perimeter of the fire will help to ensure that the fire will not escape outside of the control lines. A fire can be called "out" after the completion of this phase.

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