Fire and Rescue Service

Wildfire Operational Guidance

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SCOTTISH GOVERNMENT

Fire and Rescue Service

Wildfire Operational Guidance

The Scottish Government, Edinburgh 2013

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Section 1

Foreword

The climate of Scotland, as with the rest of the UK, is changing. Over the last 100 years it has become warmer, precipitation patterns have changed, with drier summers and wetter autumns and winters. There is also evidence of an increase in the frequency of exceptionally heavy rainfall events. The effects of this changing pattern have already been evidenced throughout the UK by the direct impact on fire and rescue service operational responses to large scale wildfire incidents and widespread flooding, both of which could be attributed to the climate we experience. The fire and rescue service, and the public sector in general, plays a crucial role in the delivery of both the mitigation of and adaptation to climate change.

Wildfires can have a devastating impact on internationally important moorland and blanket bog habitat, as well as forests and grasslands. Where peat is ignited, biodiversity can take centuries to recover and significant quantities of greenhouse gases can be produced thereby compounding the problem of climate change.

The fire and rescue service, along with other responding agencies, landowners and managers must work together in order to effectively respond to the change in frequency and intensity of extreme weather events and the consequent impact to society.

Although within the UK the majority of people directly affected by extreme weather events are usually those impacted by flooding, the focus of this manual is wildfire. Fortunately in the UK , unlike areas of the United States and Australia, casualties as a result of wildfire incidents are rare. The greatest impact of wildfire in the UK is on the rural rather than urban community, due to damage to arable crops, livestock or the loss of woodland value.

This operational guidance document for wildfire incidents is the first to be published by the Scottish Government. It has been written to give fire and rescue service personnel an additional understanding and awareness of the phenomenon of wildfire. Examining the hazards, risks and controls relating to Fire and Rescue Service personnel, the personnel of other agencies and members of the public at Incidents of wildfire. Providing a point of reference for those who may be called upon to plan for wildfire events and for those incident commanders and personnel responding to such incidents. Thereby ensuring the development of a consistent approach to pre-planning, response and suppression practices enabling and supporting cross border mutual aid.

As with other guidance documents, this manual offers a starting point for Fire and Rescue Services to conduct their own assessments, produce their own operating procedures and written safe systems of work taking account of their own local circumstances.

The Scottish Government is grateful to all those who helped to produce this guidance.

Section 2

Preface

The objective of the Fire and Rescue Service Wildlife Operational Guidance is to provide a consistency of approach that forms the basis for common planning, response and suppression practices; supporting interoperability between FRSs, land management agencies and other rural sector stakeholders.[1]

These common principles, practices and procedures are intended to support the development of safe systems of work on the incident ground and to enhance local, regional and national resilience.

Operational guidance issued by Fire and Rescue Services Division – Scottish Government promotes and develops good practice within the Fire and Rescue Service and is offered as a current industry standard. It is envisaged that this will help establish high standards of efficiency and safety in the interests of employers, employees, partners and the general public.

This guidance has been compiled using the best sources of information available at the date of issue and is intended for use by competent persons, and does not remove the necessity for appropriate technical and managerial judgement in practical situations with due regard to local circumstances, nor does it confer any immunity or exemption from relevant legal requirements, including by-laws.

It is a matter for each individual FRS whether to adopt and follow this Operational Guidance and to assess the extent to which additional wildfire awareness and training may be required. The onus of responsibility for application of guidance lies with the user. Fire and Rescue Services Division – Scottish Government accepts no legal liability or responsibility whatsoever, however arising, for the consequences of the use or misuse of the guidance.

1 For the purposes of this operational guidance, all references to land management agencies and rural sector stakeholders (or similar) should be taken to refer to any individual or agency, with responsibility for the stewardship, management and conservation of the land whether in private, public or trust ownership.

Section 3

Introduction

What is Wildfire?

3.1 The Food and Agriculture Organization of the United Nations (FAO) describe a wildfire as:

"Any unplanned and uncontrolled wildland fire that, regardless of ignition source, may require suppression response or other action according to agency policy."

3.2 One of the key elements of the FAO definition is the reference to 'wildland'. The term refers to any part of the landscape in which human development or impact is essentially non-existent except for the presence of basic infrastructure such as roads, railways and power lines.

3.3 As the UK has a predominantly managed landscape, the reference to 'wildland' within the FOA definition may prove to be misleading, therefore a more accurate description of wildfire within the UK is:
"Any uncontrolled vegetation fire which requires a decision, or action, regarding suppression."

Although all non-prescribed vegetation fires technically fall into the above definition, there is a requirement for FRS personnel, and other partner agencies, to use their professional judgment to differentiate between a small vegetation fire and a wildfire event.

3.4 For recording purposes, and to assist in drawing distinction between minor vegetation fires and those that can be logically referred to as wildfire incidents, a wildfire event can also be considered as meeting one or more of the following criteria:

- **Involves a geographical area of >1 hectare.**
- **Has a sustained flame length of >1.5 metres.**
- **Requires a committed resource of ≥ 4 FRS appliances.**
- **Requires resources to be committed for ≥ 6 hours.**
- **Presents a *serious* threat to life, environment, property and infrastructure.**

The criteria also allows a differential to be made between 'small' and 'large' wildfire events due to its inherent scalability.

3.5 The criteria listed above are considered appropriate for FRS use as they assist to enable services to assess the significance of wildfires across a wide range of service impactors, including: geographical area, risk to personnel, service resilience, resource implications, associated financial costs, impact on 'business as usual' and risk to their local communities, environment and infrastructure.

3.6 Some methods of assessment will be more relevant than others. For example, in FRSs with a high 'on call' firefighter establishment and limited, dispersed resources covering a large rural area, the number of appliances mobilised to the wildfire may not provide a true indication of the scale and impact of the fire.

3.7 The suite of options, whether used singularly, or in combination, allows for a much more detailed analysis through the national recording systems of the threat, scale and impact of wildfires to be made than has previously been the case.

Are Wildfires a Problem for the UK?

3.8 Whilst wildfires on the scale of the 'mega fires' experienced in other parts of the world are unprecedented in the UK, very large wildfires are not uncommon, and their frequency and intensity are likely to increase given the predictions for climate change in the UK.

3.9 As the UK does not generally have the same degree of wildland/urban interface (WUI) as countries such as the USA, Australia or the southern Mediterranean states, the impact of wildfires is normally confined to rural areas, and does not ordinarily impact urban centres and their communities.

3.10 Nevertheless, evacuations of communities in areas of the UK have taken place; property and equipment has been destroyed and injuries have occurred. It is important not to be complacent about the wildfire threat and, in fact, UK wildfire events should be seen as a serious threat to the safety of attending personnel, communities and the resilience of fire and rescue services, and not as merely a growing, yet infrequent, inconvenience.

3.11 What should also be borne in mind is that the sheer number of vegetation fires during supportive weather periods, which do not fall within the criteria listed within 3.4 but still require a response, can have an equally detrimental and significant impact on FRSs simply because of their volume and frequency.

3.12 In order to demonstrate and contextualise the wildfire threat in the UK, it is helpful to review the two most recent periods when there was a marked upsurge in wildfire events – 2003 and 2011.

3.13 The UK Fire Statistics for 2003[1] published by ODPM show that there were 621,000 fires – 152,700 of which were grassland and heathland, accounting for almost a quarter of all FRS attendances at fires.

3.14 The daily average for January 2003 was 40 grassland and heathland fires per day representing 4.2% of the total daily fire average. If this is compared with March and April, the average daily number of grassland and heathland fires rises to 762 and 1,010 respectively, or 36% and then 39% of the daily averages.

3.15 The figures are notable for a number of reasons:

- **Analysis shows that the daily averages of most other incident types remain fairly static i.e. vehicles, buildings, chimney fires.**
- **The significant increase occurs within a short period of time (4 weeks) indicating that conditions that support a rapid increase in wildfire events can manifest quickly.**
- **The approximately twenty fold increase does not take into account the fact that the additional wildfires would not have been evenly spread leading to a disproportionately adverse impact on local fire cover and resilience on certain days.**

1 Office of the Deputy Prime Minister (ODPM) Fire Statistics, United Kingdom, 2003 ISBN 9781851127757

3.16 The early 2011 wildfire season also saw many FRSs dealing with very significant increases in wildfire events. Statistics for England show that for a 19-day period from 18th April there were more than 7,100 wildfires of which 251 were significant in terms of their size, deployed resources and duration.

3.17 The most significant of the English wildfires in terms of resource commitment, impact and profile occurred at Swinley Forest, Berkshire, and affected an area covering 300 hectares, of which 55% was damaged by fire and forestry clearing operations. The fire was the largest ever dealt with by Royal Berkshire FRS and involved support from another 11 FRSs, Forestry Commission, Local Authority and Police, and the use of a significant number of Fire Service national resilience assets.

3.18 The impact of such a high volume of wildfire events in such a short concentrated period presents obvious challenges to FRSs in responding to the wildfires whilst maintaining their ability to meet other emergency operational demands and manage operational budgets.

3.19 Similar demands were also experienced by FRSs in Northern Ireland, Wales and Scotland. As an example, Highland and Islands FRS deployed over 1,800 firefighters to deal with 70 significant wildfire incidents between 29th April and 5th May, which destroyed approx. 9,200 hectares of moorland and forestry, and resulting in direct costs of over £125,000 to H&IFRS and wider restoration costs estimated at between £7.2m and £26.4m.

3.20 Similarly, Northern Ireland FRS was also faced with an almost unprecedented level of wildfire incidents during the 2011 spring season. 3,177 wildfire incidents were attended from 1st January until 12th June, and at one stage during the first bank holiday weekend in May, the fire service was receiving a call every 45 seconds, the busiest period in its history. The total costs of the wildfires attended by NIFRS during the first six months of 2011 were estimated to exceed £8m.

Section 4

Relevant Legislation and Guidance

Introduction

4.1 Fire and Rescue Authorities (FRAs) need to be aware of the following legislation and guidance. It is relevant to the planning, response and command and control of wildfire incidents whether in the preparedness and pre-planning, operational response or training and exercising environment.

4.2 It should be noted that this section does not contain detailed legal advice about the legislation. The chapter has been produced to provide an overview and summary of the relevant legislation which may be applicable in Scotland, England, Wales and Northern Ireland as applied to FRAs, and land managers.

4.3 It is recommended that each individual FRA satisfies themselves that they are in compliance with all necessary legislation applicable to the area of the United Kingdom within which they reside.

4.4 When considering this framework it is essential to recognise that any definitive interpretation of the legal roles and responsibilities imposed by legislation can only be given by a court of law.

4.5 The adoption of the principles set out in this guidance will assist Fire and Rescue Authorities in achieving suitable and sufficient risk assessments and appropriate corresponding risk control measures such as those referred to in this and other similar documents.

General FRA Legislation and Applicable Guidance

4.6 **Fire (Scotland) Act 2005 (Fire and Rescue Services Act 2004):** this is the main Act which affects FRAs. Amongst other things, it obliges FRAs (in Chapter 2 Section 9 of the F(S)A 2005 and Part 2 Section 7 of FRSA 2004) to (a) extinguishing fires in its area; and, (b) protect life and property in the event of fires in its area by securing the provision of the personnel, services and equipment that are necessary to meet efficiently all normal requirements and also to secure the provision of training for such personnel.

4.7 **Civil Contingencies Act 2004:** Section 2(1) states, among other things, that FRAs shall maintain plans for the purpose of ensuring that if an emergency occurs or is likely to occur the FRA is able to perform its functions so far as necessary or desirable for the purpose of preventing the emergency, reducing controlling or mitigating its effects or taking other action in connection with it.

4.8 **The Civil Contingencies Act 2004 (Contingency Planning) (Scotland) Regulations 2005:** FRAs as Category 1 responders under the regulations, must co-operate with each other in connection with the performance of their duties under Section 2(1) of the Civil Contingencies Act 2004. In addition, the Regulations state that FRAs must co-operate as part of the appropriate Strategic Co-ordinating Group (regulation 3) and may perform duties under Section 2(1) jointly with one another and make arrangements with one another for the performance of those duties (regulations 4-8).

The Civil Contingencies Act 2004 (Contingency Planning) Regulations 2005 set out clear responsibilities for category 1 and category 2 responders and their need to participate in local resilience forums.

4.9 **Department for Communities and Local Government – IRMP Steering Group Integrated Risk Management Planning: Policy Guidance: Wildfire (August 2006).** This document is intended to guide FRAs in the preparation of an IRMP strategy for combating wildfires. The purpose is to assist the Fire and Rescue Service (FRS) in understanding the scope of wildfire considerations in the IRMP process to undertake risk analysis, develop response and prevention strategies, develop delivery mechanisms and to monitor and review and evaluate such activity.

4.10 **Fire and Rescue Service Operational Guidance – GRA 3.4 – Fighting Fires in Open Rural Areas (June 2011)** examines the hazards, risks and controls that relate to Fire and Rescue Service personnel, the personnel of other agencies and members of the public when fighting fires in open rural locations including grass, moor land crop and forest fires.

4.11 **Emergency Workers (Scotland) Act 2005 (Emergency Workers (Obstruction) Act 2006).** The Act makes it an offence to obstruct or hinder an emergency worker or someone assisting an emergency worker who is responding to emergency circumstances. A person found guilty of an offence under the Emergency Workers (Scotland) Act, is liable on summary conviction to a period of imprisonment not exceeding 12 months and/or a fine not exceeding £10,000. There is no custodial penalty under the Emergency Workers (Obstruction) Act.

4.12 **Department for Communities and Local Government – Departmental Adaption Plan (May 2011).** Emphasises that the primary focus of central Government's relationship with the fire and rescue service is now securing national resilience and ensuring public safety against identified national risks.

The Action Plan recognises that local fire and rescue services are already considering the long term risks of climate change and the emergency response to floods and wildfires.

Health and Safety Legislation

4.13 **Corporate Manslaughter and Corporate Homicide Act 2007:** FRAs will be criminally liable for the death of a person if the way in which they manage or organise their activities (for example in relation to the command and control of breathing apparatus):

- **amounts to a gross breach of the duty of care owed to the person, and,**
- **the gross breach causes a person's death (Section 1).**

Any alleged breaches of this act will be investigated by the police. Prosecution decisions will be made by the Crown Prosecution Service (England and Wales), the Crown Office and Procurator Fiscal Service (Scotland) and the Director of Public Prosecutions (Northern Ireland).

4.14 **Health and Safety at Work etc Act 1974:** this Act applies to all employers in relation to health and safety. It is a wide ranging piece of legislation but in very general terms, imposes the general duty on FRAs to ensure, so far as is reasonably practical, the health, safety and welfare at work of all of their employees (Section 2(1)) and to persons not in their employment who may be affected by the FRAs undertaking (Section 3(1)).

4.15 **Management of Health and Safety at Work Regulations 1999:** obliges FRAs, amongst other things, to make suitable and sufficient assessment of the risks to the health and safety of firefighters and others not in their employment who may be affected by the FRAs undertaking, to which they are exposed whilst on duty (regulation 3(1)(a)&(b)); to implement any preventive and protective measures on the basis of the principles specified in the Regulations (regulation 4);

to make arrangements for the effective planning, organisation, control, monitoring and review of the preventive and protective measures (regulation 5) and to provide such health surveillance as is appropriate having regard to the risks to health and safety which are identified by the risk assessment (regulation 6).

4.16 **Provision and Use of Work Equipment Regulations 1998:** obliges FRAs to ensure that work equipment is constructed or adapted as to be suitable for the purpose for which it is used or provided (regulation 4(1)). FRAs must have regard to the working conditions and to the risks to the health and safety of firefighters which exist in the premises or undertaking in which the equipment (including breathing apparatus) is to be used and any additional risk posed by the use of that equipment (regulation 4(2)). The Regulations also contain provisions about maintenance, inspection, specific risks, information and instructions and training regarding work equipment.

4.17 **Personal Protective Equipment at Work Regulations 1992:** obliges FRAs to ensure that suitable PPE (including breathing apparatus) is provided to firefighters (regulation 4(1)). The Regulations contain provisions as to the suitability of PPE, compatibility of PPE, assessment of PPE, maintenance and replacement of PPE, storage for PPE, information, instruction and training regarding the PPE and the use of PPE.

Any PPE purchased by an FRA must comply with the Personal Protective Equipment Regulations 2002 and be 'CE' marked by the manufacturer to show that it satisfies certain essential safety requirements and, in some cases, has been tested and certified by an approved body.

Legislation Regarding Land Management and the Countryside

4.18 **Hill Farming Act 1946 (as amended); The Muirburn Code, The Heather and Grass etc Burning (England) Regulations 2007: the Heather and Grass etc Burning (Wales) Regulations 2008** apply to the burning of heather, grass, bracken, gorse and vaccinium (a range of shrub species including bilberry/blueberry).

The relevant provisions provide that:

- **Burning may only take place in the burning season** (unless under licence, for defined purposes, from Scottish Natural Heritage or Natural England). In Scotland, the burning season is 1 October to 15 April at all altitudes. Burning is permitted during the extended burning season, 16 April to 30 April, where authorised by the landowner. In England, the burning season for upland areas is 1 October to 15 April inclusive. On all other land it is 1 November to 31 March inclusive. "Upland areas" means land in the "Severely Disadvantaged Areas". In Wales, the burning seasons are 1 October to 31 March for upland areas; 1 November to 15 March on all other land.
- **Burning must be conducted safely. Burns must be controlled for their entire duration. All reasonable precautions must be taken to prevent injury to people or damage to adjacent land and property. Burning must not start between sunset and sunrise.**

- **In Scotland, notification of the intention to burn must be given in writing to the land owners and occupier of the land within 1 kilometre of the proposed burn site no later than seven days before burning.**

Further details on the location and timing of burns must be provided on request. These regulations and associated best practice codes (the Muirburn Code in Scotland and the Heather and Grass Burning Codes in England and Wales) outline where burning can be undertaken and where it should not. There should be a strong presumption against burning sensitive areas. Doing so may permanently damage the environmental interest of the land and may be unlawful. In special circumstances, the advantages of burning on sensitive areas may outweigh the disadvantages. Those who feel a sensitive area on their land falls into this category may wish to contact Scottish Natural Heritage, Natural England or the Countryside Commission for Wales for advice.

4.19 **Wildlife & Countryside Act 1981 (as amended)** The scope of the Act provides protection for wildlife (birds, and some animals and plants), the countryside, National Parks, and the designation and protection of Sites of Special Scientific Interest (SSSIs) in England and Wales, and public rights of way.

Scottish Natural Heritage currently defines SSSI as *"those areas of land and water... that Scottish Natural Heritage (SNH) considers to best represent our natural heritage – its diversity of plants, animals and habitats, rocks and landforms, or a combinations of such natural features."*

In addition to sensitive habitats in the wider countryside, SSSIs therefore represent clearly definable areas which may be susceptible to damage from fire directly or indirectly. It is an offence to intentionally or recklessly damage special natural feature on SSSIs.

Caution is needed when burning during the spring as it is an offence to intentionally or recklessly disturb or destroy the nests, eggs or young of breeding birds.

4.20 **The Nature Conservation (Scotland) Act 2004:** imposes a wide-ranging duty on Scotland's public sector to conserve biodiversity and protect the nation's precious natural heritage.

The Act reformed the law relating to Sites of Special Scientific Interest entirely replacing the provisions of the Wildfire and Countryside Act relating to SSSIs in Scotland. In doing so, it strengthened protection for SSSIs with maximum fines for intentional and reckless damage to any natural feature specified on a SSSI notification raised from £5,000 to £40,000.

It is an offence to carry out burning on a SSSI without consent from Scottish Natural Heritage, if burning has been listed as 'an operation requiring consent' on the site in accordance with the Act. Unauthorised development, the removal of plants or animals and damage caused by motorised vehicles may also constitute an offence.

4.21 **The Roads (Scotland) Act 1984 Section 100(c)** – Lighting a fire, or allowing a fire to spread to within 30 metres of a road so as to damage the road or endanger traffic on it without lawful authority or reasonable excuse, commits an offence.

4.22 **Highways Act (1980) Section 161A** – It is unlawful to burn in a way likely to cause injury, interruption or danger to road users.

4.23 **Environmental Protection Act (1990) Section 79** – It is unlawful to cause emission of smoke which is prejudicial to health or causes a nuisance.

4.24 **The Environmental Damage (Prevention and Remediation) Regulations 2009** – The regulations ensure that the polluter pays for the most serious types of environmental damage, supplementing any existing legislation such as The Water Resources Act 1991.

Environmental damage is identified for three areas:

(a) protected species or natural habitats, or a site of special scientific interest (SSSI), (b) surface water or groundwater and (c) land.

For water and biodiversity, the definition thresholds are high. Incidents attended by Fire and Rescue Services where the regulations apply are therefore likely to be rare. Thresholds for land damage are lower and it can be expected that more incidents attended by FRSs where land damage occurs will be covered by the regulations.

There are exclusions to the regulations:

- **acts of terrorism**
- **exceptional natural phenomena**
- **activities which have the sole purpose of protecting against natural disasters and activities which have the main purpose of serving national defence or international security.**

4.25 **Environmental Impact Assessment (Forestry) (England and Wales) Regulations 1999 and the Environmental Impact Assessment (Forestry) (Scotland) Regulations 1999.**

These regulations affect four 'forestry' projects. These are:

Afforestation: Planting new woods and forests. This includes direct seeding or natural regeneration, planting Christmas trees or short rotation coppice.

Deforestation: Felling woodland to use the land for a different purpose.

Forest roads: The formation, alteration or maintenance of private ways on land used (or to be used) for forestry purposes. This includes roads within a forest or leading to one.

Forestry quarries: Quarrying to obtain materials required for forest road works on land that is used or will be used for forestry purposes or on land held or occupied with that land.

The regulations give each of these projects an area threshold. Lower thresholds are given for projects that lie within sensitive areas, e.g. National Park, AONB.

During the consultation process to determine the potential environmental impact arising from any of the four projects, Fire and Rescue Services may be contacted to comment upon the potential for there to be a change to the wildfire risk within the relevant area under consultation.

4.26 **The Conservation (Natural Habitats etc.) Regulations 1994** transpose the requirements of the EC Habitats Directive (and certain aspects of the Birds Directive). It is an offence to intentionally or recklessly damage European Sites (i.e. Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)) which form the pan-EU network of sites known as Natura 2000. Most, but not all Natura 2000 sites in Scotland are also SSSIs.

4.27 **Ancient Monuments and Archaeological Areas Act 1979** makes it an offence to cause damage to a scheduled monument.

Further Reading

Operational guidance on the management of risk in the operational environment has been issued in the past. In particular, refer to:

- **Incident Command – 3rd Edition (2008) – Fire and Rescue Manual – Volume 2: Fire Service Operations.**
- **Environmental Protection, Fire and Rescue Manual – Volume 2: Fire Service Operations (2009)**
- **Fire and Rescue Operational Assessment Toolkit 2009.**
- **Fire Service Health and Safety Guide (volume 1, *'A Guide for Senior Officers'*, volume 2 *'A Guide for Fire Service Managers'*, volume 3 *'A Guide to Operational Risk Assessment'* and *'Dynamic Management of Risk at Operational Incidents'*).**

In addition, the following publications provide further background and understanding of factors which may inform wildfire planning and response.

- **Scottish Government – The Muirburn Code and supplementary guidance (Prescribed Burning on Moorland)**
- **The Common Agricultural Policy Schemes/The Common Agricultural Policy Schemes (Cross-Compliance) (Scotland) Regulations 2011**
- **Forestry Commission – Operational Guidance Booklet No 17 'Planning for the Unexpected' (Section 6)**
- **Arboriculture and Forestry Advisory Group – Fire fighting 803 Health and Safety Executive**
- **Effects of Climate Change on Fire and Rescue Services in the UK (1/2006), Dec 2006 CLG, 06 FRSD 04166**
- **Farmer, B (2003). Fires on Forestry Commission Estate, Information Note. Forestry Commission**
- **Fire Management: Voluntary Guidelines: Principles and Strategic Actions (2006) Fire Management Working Paper FM17E, Food and Agriculture Organisation (FAO):** http://www.fao.org/docrep/009/j9255e/j9255e00.htm
- **Vegetation Fire Risk Management: Toolkit for Practitioners and Advisors.** http://www.forestry.gov.uk/pdf/Vegetation_Fire_Risk_Management_250112.pdf/$FILE/Vegetation_Fire_Risk_Management_250112.pdf
- **Risk Management Control Measure: Toolkit for Practitioners and Advisors.** http://www.forestry.gov.uk/pdf/Vegetation_Fire_Control_Measures_130212.pdf/$FILE/Vegetation_Fire_Control_Measures_130212.pdf-
- **Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora**
- **Biodiversity Action Plan Broad Habitat Classificationw**
- **The National Vegetation Classification (NVC)**

Section 5

Strategic Role of Operational Guidance

Role of Operational Guidance

5.1 Fire and Rescue Authorities, and strategic managers within the Fire and Rescue Service, are responsible for ensuring their organisation and staff operates safely when dealing with incidents involving wildfires. Their legal duties and responsibilities are contained in Section 4 of this guidance.

5.2 This document provides the Fire and Rescue Service with guidance on developing and maintaining a consistent approach to managing, processing and using strategic and tactical operational risk information. This guidance is also relevant to national resilience and interoperability with other Fire and Rescue Services or emergency responders.

5.3 Fire and Rescue Services should continually assess the risk, in terms of the foreseeable likelihood and severity, of wildfire incidents occurring within their areas. This assessment should form part of their integrated risk management plan. The findings will help them ensure they have appropriate organisation, policy and procedures in place for dealing with wildfire incidents.

5.4 Current Fire and Rescue Service practices have been surveyed and used to develop this guidance. Fire and Rescue Authorities may wish to adopt some or all of the principles outlined within this guidance. However, the Scottish Government accepts no legal liability or responsibility whatsoever, howsoever arising, for the consequences of the use or misuse of this guidance.

Status of Operational Guidance

5.5 Operational Guidance does not in itself represent a legal duty on Fire and Rescue Authorities. However, it is seen as the sector benchmark standard for Fire and Rescue Services, and departure from it will require a risk assessed alternative, with supporting control measures, particularly in the event of an accident or injury.

5.6 How do strategic managers know if they are providing, at least, the minimum level of acceptable service or possibly meeting their 'duty of care'? The following principles may assist Strategic Managers when determining the level of acceptable service and whether they are meeting their duty of care:

- **operations must be legal and within the requirements of regulations**
- **actions and decisions should be consistent with voluntary consensus**
- **standards, and nationally recommended practices and procedures**
- **actions and decisions to control a problem should have a technical foundation and be based on an appropriate risk assessment**
- **actions and decisions must be ethical.**

5.7 When responding to incidents involving wildfires the Fire and Rescue Service has strategic multi-agency responsibilities. These are additional, and in the main complimentary, to the specific fire and rescue functions that the Fire and Rescue Service performs at the scene. The strategic objective is to co-ordinate effective multi-agency activity in order to:

- **preserve and protect lives**
- **mitigate and minimise the impact of an incident**
- **protection of the environment**
- **inform the public and maintain public confidence**
- **prevent, deter and detect crime**
- **assist an early return to normality (or as near to it as can be reasonably achieved).**

5.8 Other important common strategic objectives flowing from these responsibilities are to:

- **participate in judicial, public, technical or other inquiries**
- **evaluate the response and identify lessons to be learnt**
- **participate in the restoration and recovery phases of a major incident.**

Operational Guidance Review Protocols

5.9 This guidance will be subject to a review every 3 years.

The following circumstances may also require this guidance to be reviewed at an earlier stage:

- **Enactment of new or updated legislation.**
- **As the result of an investigation.**
- **Following reports of repeated or serious procedural queries/concerns resulting from exercises, training, incident reviews/feedback.**
- **The issuing of an improvement notice by the HSE or other relevant enforcing body.**
- **On advice of Her Majesty's Fire Service Inspectorate for Scotland.**
- **At any other time when any particular aspect of the current Guidance is considered invalid.**

5.10 The Operational Guidance Programme Board may decide that a full or partial review is required within this period.

Section 6

Generic Risk Assessment/s (GRAs)

Introduction

6.1 When attending a wildfire incident, Fire and Rescue Service personnel will be operating in a dynamic and sometimes hazardous environment.

6.2 This guidance presents a framework for a safe system of work for the management, and command and control, of wildfire incidents. It therefore, provides for a consistency of approach across FRSs and forms the basis for common operational practices, which will assist in supporting interoperability between FRSs, other Emergency Services, land management agencies and other partners. The drive toward common principles, practices and procedures supports the development of safer wildfire systems of work on the incident ground and enhances local, regional and national resilience.

6.3 This guidance should be read in conjunction with Fire and Rescue Service Operational Guidance – GRA 3.4 – Fighting Fires in Open Rural Areas (June 2011)[1].

6.4 Clearly, due to the complexity of wildfire incidents, there are a wide range of significant hazards and risks which need to be considered within both national and local GRAs. These may include, but not be limited to, environmental conditions, extreme fire indicators, terrain, fuel types, fuel loading, personal safety, manual handling and heavy physical work. It is incumbent upon individual FRSs to ensure that they are confident that their suites of safe systems of work, which are derived from their GRAs are relevant to their associated local wildfire risks.

6.5 The following risk assessment process steps[2] have been considered in the development of this guidance and should be further considered both by FRSs in the development of their own strategic risk assessment processes and in the operational environment by the Incident Commander.

The Risk Assessment Process

6.6 The five basic principles of all risk assessments are the same:

1. **Identify the hazards.**
2. **Decide who might be harmed and how.**
3. **Evaluate the risks and decide on precautions – note that this might involve selection of the most appropriate breathing apparatus command and control procedures in relation to the task/s to be achieved within a given set of circumstances.**
4. **Record the findings and implement them.**
5. **Review the assessment and update if necessary.**

1 Published by Communities and Local Government ISBN 978011754039.

2 See 'Fire and Rescue Service Operational Guidance: Generic Risk Assessments – Introduction', CLG, August 2009.3 HSE 'As Low As Reasonably Practicable' principle.

6.7 The risk assessment process should include the actions below:

- **Determine the specific activities to be achieved.**
- **Identify the hazards present should these activities be undertaken.**
- **Identify both the likelihood of an injury occurring and its severity arising from exposure to each hazard (i.e. the risk).**
- **Identify the extent of the resources required to complete all or selected elements/tasks of the overall operational plan.**
- **Implement control measures to reduce the risk to a level that can be considered as low as is reasonably practicable, including the most appropriate for the task/s to be completed.**

6.8 This approach provides for a framework for reducing risk to a tolerable level in relation to the task/s to be completed, which correlates to existing risk information, provides for a sound basis for the development of additional control measures (ALARP[3] principle), and is effective in helping FRSs to optimise safety at operational incidents.

3 HSE 'As Low As Reasonably Practicable' principle.

Section 7

Key Principles

Introduction

7.1 This chapter seeks to establish a number of key principles which are contained within the guidance, and, which if adopted will enhance the FRSs wildfire pre-planning, response and resilience of their service.

7.2 FRSs should make an assessment of whether the key principles are applicable to their own circumstances and should ensure local wildfire risk assessments and standard operating procedures (SOP) have been formulated following consideration of guidance contents.

Key Principles

1. There is a need to provide a risk assessed, suitable and sufficient safe system of work to protect firefighters, and external partner agency personnel, deployed to wildfire incidents.

2. It is essential that Fire and Rescue Service and external agency personnel responding to a wildfire event have an understanding and awareness of wildfire behaviour and development.

3. There is a need to provide guidance on standardised safe systems of work in order that personnel attending wildfire incidents may work safely across Fire and Rescue Authority boundaries, with personnel from land management agencies and organisations, and, where appropriate, other emergency services and the military.

4. The LACES protocol should be adopted by FRSs attending any wildfire event. (**LACES** – **L**ookouts; **A**wareness; **C**ommunications; **E**scape Routes; **S**afety Zones). (See Section 8 Part B7)

5. Fire and Rescue Services should ensure that effective liaison with land management agencies and appropriate partners is undertaken to assist in the development of local fire plans, mutual aid support arrangements and resilient safe systems of work.

6. Such an approach will support environmental protection awareness and enhance operational interoperability and local, regional and national resilience.

7. FRSs should utilise the principles of the Wildfire Prediction System (WPS) to ensure, as far as reasonably possible, that the correct personnel and resources are deployed to the correct locations, at the right time, to maximise the available opportunities to manage and suppress a wildfire incident. (See Section 8 Part B6)

8. FRSs should consider utilising indirect, as well as direct, wildfire suppression tactics as a potentially more effective and appropriate, and at times safer, means of dealing with a wildfire incident.

9. The appropriate level of wildfire Command and Control supervision and Safe Systems of Work, as outlined within this Guidance, must be followed at all wildfire incidents being responded to.

10. Incident Command System (ICS) principles and practices must be adhered to at all times[1], although these should be applied in the context of a dynamic, geo-spatial incident.

11. Suitable and sufficient briefing and debriefing of wildfire teams is critical to the effectiveness and safety of fire service operations, the establishment of a safe system of work and firefighter, and external agency, safety. Full and effective briefing and debriefing of wildfire teams should therefore, be undertaken on every occasion that a wildfire incident is responded to. (See Section 8 Part B7)

12. Good communications between the Incident/Sector Commander, wildfire team leader(s), the safety officer(s), Tactical Lookout, and, Command Support are also essential to the effectiveness and safety of wildfire teams and external agency personnel. Accordingly, suitable, sufficient and resilient means of communications should be established and maintained at all times.

13. Wildfire is an incident type which requires the adoption of a situational awareness process and the application of continual analytical risk assessment to ensure the safety of personnel and a satisfactory conclusion to the incident. (See Section 8 Part B7)

14. All personnel assuming a role connected with operating within a wildfire suppression response team must be competent to undertake that role.

15. A robust and resilient decision-making log and analytical risk assessment (ARA) must be maintained throughout the duration of the incident.

16. FRSs should begin to adopt the terminology contained within this guidance and the accompanying Glossary. This will improve communication and safety at a wildfire event; avoid confusion and ambiguity and enhance interoperability and resilience.

1 Ref. Fire and Rescue Manual Vol.2: Fire Service Operations: Incident Command.

Section 8

Fire and Rescue Service Operations

8A

Preparedness, Pre-Planning and Partnerships

Introduction

8A.1 Wildfire events, due to their potential complexity, scale and risk, can be managed much more effectively if FRSs have undertaken wildfire specific preparatory actions prior to an incident occurring.

8A.2 Having robust and resilient preparedness arrangements will assist in ensuring that all potential issues have been considered in advance of an incident and effective control measures have been identified and implemented. Key to this proactive approach is the development of integrated planning and response arrangements with partner agencies.

8A.3 FRS responsibilities to produce Integrated Risk Management Plans (IRMP) and develop, or contribute to, Community Risk Registers (CRR) should ensure that an assessment of wildfire risks within individual FRSs are fully considered.

IRMP and CRR

8A.4 The main aim of an IRMP is to make the fire and rescue service more responsive to locally identified needs and thus better able to deliver their operational response and community fire safety. By moving the service from reactive response to proactive risk reduction across both the operational and community arenas, and by widening the quality and type of services provided, IRMPs hope to deliver:

- **A reduced number of fires and other emergency incidents.**
- **A reduction in loss of life due to fires and other emergency incidents.**
- **A reduction in the number and severity of injuries occurring in fires and other emergency incidents.**
- **Safeguard the environment and heritage.**
- **Provide communities with value for money.**

8A.5 To specifically address the issue of wildfire within local IRMP planning, guidance was produced by the Department for Communities and Local Government in August 2008[1] and made available to FRSs throughout the UK.

8A.6 The guidance is intended to assist FRSs in the preparation of an IRMP strategy for combating wildfires. The purpose is to raise awareness of wildfire as an issue within the FRS to enable services to understand the scope of wildfire considerations in the IRMP process so they are able to undertake risk analysis, develop response and prevention strategies, develop delivery mechanisms and to monitor, review and evaluate such activity.

8A.7 Under The Civil Contingencies Act 2004 Fire and Rescue Services are designated as Category 1 responders. This places a legal duty on FRSs to co-operate with partners from their Local Resilience Forum (LRF) to develop and maintain a Community Risk Register (CRR).

8A.8 The CRR provides an agreed position on the risks affecting a local area and on the planning and resourcing priorities required to prepare for those risks. The purpose of the CRR is to enable each FRS Category 1 responder to:

- **Be fully informed of the risks of emergency in its area;**
- **Benefit from the range of views on risk of all of its partners on the LRF;**
- **Identify collectively the main local emergency plans and capabilities which appear to be needed across all the Category 1 responders;**
- **Decide which of the plans and capabilities should properly fall to it;**
- **Appreciate which of its partners in the LRF acknowledges responsibility for developing plans and capabilities against the various risks.**

8A.9 The CRR should be shared with LRFs with whom a boundary is shared. Category 1 responders should also consider whether there are any specific risks which should be communicated to any LRFs in any other local areas.

8A.10 While the Act imposes a duty on each Category 1 responder to assess risk, it is recognised that requiring each Category 1 responder to perform this duty in isolation would lead to a wasteful duplication of resources. It is more efficient for individual Category 1 responders to fulfil their risk assessment duties by participating in a collaborative exercise that result in a single, collective risk assessment.

8A.11 This ensures that each local risk is only assessed once and allows the workload to be shared between Category 1 responders. It also helps to streamline the relationship between Category 1 Responders and the government departments and agencies that are able to support the risk assessments.

8A.12 Although the level of risk varies, every area of the UK has a wildfire threat. It is clear therefore that through both the IRMP and CRR processes FRSs should be fully considering the potential impact of the wildfire threat upon their services.

1 IRMP Steering Group Integrated Risk Management. Planning: Policy Guidance – Wildfire.

Assessment and Fire Plans

8A.13 As a consequence of undertaking IRMP and CRR assessments, FRSs should ensure that any wildfire risks identified within their areas are subject to a specific and dedicated operational assessment. Not only should this seek to address risk, but also operational and response considerations associated with responding to an incident at that location.

8A.14 It is recommended that FRSs undertake work to produce fire plans which enhance preparedness in advance of a wildfire incident and improve the effectiveness and efficiency of any subsequent operational response.

As a general, but not exhaustive, guide Fire Plans should cover:

- **Estate/Land Owner Contact(s)**
- **Neighbouring Estate Contact(s)**
- **FRS Rendezvous Points**
- **Access and Turning Points**
- **Colour coded roads and tracks indicating those that can be used by different types of vehicle**
- **Available Equipment**
- **Specialist Assistance**
- **Communications**
- **Water Supplies**
- **Identified Hazards**
- **Priority Areas (i.e. SSSI/SPA/SAC and water courses)**
- **OS mapping of area**
- **Digital photography of area**
- **Infrastructure**

An example of a Fire Plan template is included as Appendix 1.

8A.15 Wildfire can have a direct and indirect effect on the environment and the economy. As a result there is a broad spectrum of public and private stakeholders that have an interest in the subject. FRSs face many challenges in their efforts to protect communities from the effects of wildfire, but this interest can be used to establish networks that can be utilised to form a more collaborative approach to preparedness, prevention and response.

8A.16 What is apparent is that to be robust and resilient, Fire Plans must be developed in consultation, and with the collaboration, of the owners and managers of the land under assessment. Whilst land owners have no legal responsibility to co-operate in the production of a Fire Plan, there are obviously significant advantages for them to do so. As well as the benefits of a co-ordinated and orchestrated response, they can be used to identify vulnerable and sensitive areas of landscape and detail the pre-planning required to mitigate any potential environmental damage.

8A.17 Aside from developing a closer working relationship with local FRS personnel to support and enhance the effectiveness of any response, the plans should ensure that the scale of the fire, the resources required to manage it and the economic and environmental loss arising from it are reduced. In addition, disruption will be reduced and there may well be financial incentives available from insurance companies for those owners and estates which enter into the collaborative production of fire plans.

Partnership Working and Fire Groups

8A.18 The concept of partnership working is well established with the UK Fire Service and wildfire is an incident type which particularly benefits from a collaborative approach.

8A.19 FRSs increasingly recognise that without a renewed focus and strategy for dealing with wildfire events, then the likely result will be a significantly increased operational commitment, increasingly stretched resources and greater costs of providing resilient fire cover. Already, FRSs are looking to shift focus from incident response to more effective and robust pre-planning and prevention, and increase the assistance available from partnerships to deliver these changes.

8A.20 It would be impossible for FRSs to attempt to address future wildfire risk in isolation, and there are a number of partnerships which have been developed to bring wildfire stakeholders and practitioners together to improve planning, prevention and response, and at the same time enhancing cross sector liaison and facilitating the sharing of knowledge and best practice.

Photo 8A.1
An example of specialist off road equipment being used at a fire

8A.21 Although FRSs may have limited responsibility or involvement in what happens to an area of landscape post incident, a fire group also offers an opportunity for effective restoration plans to be developed to address longer-term environmental impacts.

Photo 8A.2
Specialist manufacturers can provide purpose built vehicles for land managers and FRSs

8A.22 Local fire groups are an invaluable point of contact, networking and capacity building. They are a particularly useful mechanism for the development of closer links between the FRS and partners (and potential partners), that can provide tactical and logistical operational assistance in the event of a wildfire incident. FRSs should seek to establish a framework that results in a collective response to wildfire emergencies. This support will maximise the effective and efficient use of resources, prevent duplication, and to some degree minimise and share cost.

Photo 8A.3
An Argo-cat All-Terrain Vehicle (ATV) available to Northumberland fire group partners

8A.23 Preparedness, through the development of working relationships with partners can alleviate many of the problems routinely confronted at large wildfire incidents. The success of a Fire Group will depend greatly on good working relationships, trust and a shared belief and demonstration of the mutual benefit of collaborative working. It should be structured in such a way that it empowers partners to play a full and meaningful role in the group.

Photo 8A.4
All terrain vehicles are able to traverse over difficult parts of the landscape

Group Membership

8A.24 The membership of any local wildfire group will depend upon the local circumstances, some will be formed where there are numerous potential partners, and in other areas the opportunities to involve other agencies may be limited.

8A.25 It is recommended that to ascertain the maximum benefits from the establishment and membership of the group a combination of national, regional and local stakeholders should ideally be sought.

As a general guide, governmental and national public bodies may include:

- **Scottish Natural Heritage**
- **Natural England**
- **Scottish Environment Protection Agency**
- **Environment Agency**
- **National Parks**
- **National Trust/National Trust for Scotland**
- **Forestry Commission or Forestry Commission Scotland**
- **Crown Estates**
- **Ministry of Defence**

Non-government organisations include:

- **National Game Keepers Association**
- **National Farmers Union and NFU Scotland**
- **The Heather Trust**
- **The Moorland Association (Scotland Moorland Forum)**
- **Wildlife Trust**
- **Woodland Trust**
- **The Countryside and Business Association**
- **Scottish Land and Estates**

Photo 8A.5
Fire Service, forest workers and land managers take part in an equipment fimiliarisation event

8A.26 Representatives from these organisations, along with FRSs and local land management community representation can form a core membership that will provide long-term local wildfire group resilience.

Photo 8A.6
Demonstrating that there are opportunities for innovative partner support

Features of a Successful Fire Group

- **The group should be a consortium made up of equal partners.**
- **The secretariat of the group should ideally have an understanding of wildfire and links with the rural sector.**
- **The group should have a clear mandate.**
- **There should be a willingness to work together for the benefit of the group.**
- **There should be effective methods of communication between members, meetings should be held when necessary but kept to a manageable number.**
- **The development of local fire plans should be a priority, copies should be held by the local land manager and the FRS.**
- **Standard operational procedures should include active partner involvement, the role of partner agencies within the plan should be fully understood by FRS and other partners.**

Interoperability

8A.27 A collective response depends on alleviating any differences in understanding between partners and in standardising procedures and equipment as far as reasonably possible. Specifically, this should lead to local agreement of the management or operational role(s) that rural sector partners can undertake to support the FRS incident command team.

8A.28 To operate co-operatively it is essential that effective exchange of information and multi agency training systems are established. This can then allow for resilient operational integration between FRSs and land management partners within the group.

Photo 8A.7
A soft track vehicle equipped with a fire fogging system

8A.29 The aims of mutual training should be to:

- **Improve the effectiveness of operational response and incident command.**
- **Provide a rapid and cost effective response which minimises the potential draw on the resources of each group member – particularly the FRS.**
- **Confirm and test the roles of non-FRS partners within the incident command system.**
- **Establish and embed operational interoperability.**
- **Enable resources to act co-operatively.**
- **Utilise all available wildfire resources, expertise and skill to manage the incident.**
- **Shared understanding of safety protocols, partner's roles and responsibilities and response procedures.**

Photo 8A.8
An example of the type of off road vehicles that can be provided by commercial companies that actively support fire groups

National Wildfire Bodies

8A.30 To address national strategic wildfire issues, the Scottish Wildfire Forum (SWF) was formed in 2004, followed by the English Wildfire Forum (now the England and Wales Wildfire Forum EWWF) in 2007.

8A.31 Both forums are unfunded special interest groups which exist to create a strategic forum between fire and rescue services, national land management agencies, environment and conservation groups and other relevant stakeholder agencies in Scotland, England and Wales. The SWF and EWWF are committed to promoting and developing a wider understanding of wildfire, its impact and associated risks.

8A.32 The SWF and EWWF exist to develop and communicate wildfire prevention, protection and mitigation strategies to Government, stakeholders and their wider communities.

8A.33 In recognition of the raised awareness of the risks posed by wildfire incidents, the Chief Fire Officers Association (CFOA) has established an Operational Wildfire Group with membership open to all UK FRSs. The purpose of the CFOA Wildfire group is to:

- **Raise the awareness of risks and dangers of Wildfire incidents within the UK FRS community.**
- **Seek to develop national standards for Wildfire training and suppression techniques.**
- **Seek to identify and establish accreditation for Wildfire training.**
- **Identify and share best practice in relation to Wildfire Incidents.**
- **Seek to support Fire and Rescue Services by developing a resilient and robust mutual aid framework to meet operational, tactical and command and control requirements.**
- **Develop an effective marketing, lobbying and communications strategy to support the activities of the Working Group.**
- **Offer advice and support to Fire and Rescue Services regarding Wildfire pre-planning, prevention and response.**
- **Encourage and support Fire and Rescue Services to work in partnership with local and regional land management agencies to develop more effective planning and response networks, i.e. Fire Operations Groups.**
- **Seek to support improved data quality, collection and statistical analysis of wildfire events from the CLG Incident Recording System and external partners.**
- **Ensure that there is effective liaison and exchange of information between the CFOA Wildfire Group and the England and Wales Wildfire Forum (EWWF), Scottish Wildfire Forum (SWF) and other relevant fora, organisations and agencies.**
- **The Group will commission and co-ordinate work packages to develop policies and procedures.**

National Preparedness

8A.34 Whilst the development of specific and dedicated local wildfire response is becoming more established, there remain opportunities to progress national resilience in regard to wildfire response.

8A.35 As the events of April/May 2011 demonstrated, FRSs face enormous challenges in dealing with large scale and high numbers of wildfire events. The development of nationally co-ordinated and resilient wildfire support response will enable appropriate mutual aid and firefighting/command support to be provided to FRSs which have been significantly affected.

8A.36 In the same way as enhanced capability, resilience and response provision has been developed for the terrorist threat, water rescue and flood response, high volume pumping and urban search and rescue; wildfire can also benefit from the introduction of subject matter advisors (SMAs), interoperable training and equipment, standardised systems of work and central resource management and deployment.

8B Technical Considerations

8B1

The Effects of Fuel

Introduction to Fuel

8B1.01 Within the wildfire environment the main source of fuel is vegetation. The type of fuel, its size and the way the vegetation is arranged across the landscape will inevitably affect the way it burns. Understanding how vegetation interacts with fire is important as such knowledge can be used to understand present fire behaviour, as well as predicting what it is likely to be in the future. This understanding is not limited to fire intensity but can also provide an accurate evaluation of future rate of spread and expected flame length.

8B1.02 The behaviour of a fire in a given fuel source is dependent upon its:

- **Size and Shape**
- **Quantity**
- **Arrangement**
- **Moisture content**
- **Type**

8B1.03 Effective management of wildfire requires that there is an appropriate understanding of how each of these factors affect the way vegetation will burn and the influence they have on fire behaviour.

Size and Shape

8B1.04 The size and shape of the available fuel is important, particularly in regard to their ease of ignition. Smaller fuels, referred to as 'fine fuels', are more receptive to fire, while larger or more coarse fuel types generally rely on their interaction with fires in finer fuels before they will ignite.

8B1.05 The relationship between any given fuel's surface area and its volume, and the fuel's size and shape, strongly influences the ease of ignition. The surface area of finer fuels, such as grass or heather, is much greater than the equivalent volume of coarser fuels such as branches and logs. Fuels with a higher surface area to volume, dry quicker and require less exposure to heat for them to be raised to their ignition point.

Photo B1.1
Heather which provides a plentiful supply of fine fuel

Once an ignition occurs, the shape, structure and the composition of the vegetation – such as the proportion and mix of fine and coarse fuels – will then influence fire development.

Photo B1.2 Conifer trees consisting of fine (needles) and coarse fuel (trunk and branches) in contact with surface fuels

Fine and Coarse Fuels

8B1.06 Fine fuels are considered to be those with a diameter of up to 6mm, and include grass, small stems and the leaves of low lying shrubs such as heather. Fine fuels can also be found in huge quantities in larger plants, i.e. needles on conifer trees.

8B1.07 Fuels that are over 6mm in diameter are described as 'coarse fuel' and include twigs, branches, and tree trunks.

Fine fuels will strongly affect:

- **Fire intensity, particularly at the head of the fire.**
- **Rate of forward and lateral motion of the fire.**
- **Flame length.**
- **Likelihood of extreme fire behaviour events.**
- **Horizontal and vertical fire development.**
- **Aerial fire activity.**
- **Increased ignitions caused by spot fires.**

8B1.08 Fine fuels influence the forward and vertical motion of a fire. Because of their size, they are burnt off quickly resulting in high fire activity and longer flame length at the fire edge – particularly at the head of the fire. The mix ratio of fine and coarse fuels is also important. The amount of fine fuels present will always have a significant impact on fire development and behaviour. It is important to understand that some plants, such as trees and shrubs, consist of both fine and coarse fuel types.

8B1.09 After the finer fuels have burnt, the coarse fuels continue to burn in what is termed 'the flaming zone' which is located behind the fire edge. The fire intensity within the flaming zone is dependent upon the quantity and size of the coarse fuels and their arrangement.

8B1.10 Consideration should always be given to the fact that finer fuels dry out much more readily than coarser ones, and that the intensity of a fire in coarser fuel types may be restricted by their higher moisture content.

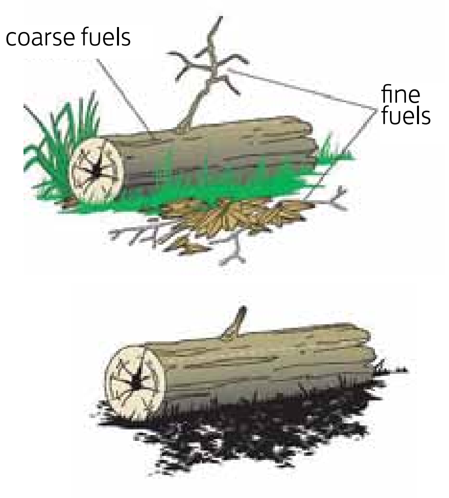


Fig B1.1
This example indicates how fine fuels, burn off quickly and, where the coarse fuel is too large, there is little interaction

Characteristics

Characteristics of fine fuel	Characteristics of coarse fuel
Up to 6mm in diameter	More than 6mm in diameter
Consists of leaves, grass and small twigs either living on the plant or present in the surface litter	Consists of twigs, branches and logs either living or found present in the surface litter
Dries quickly	Dries slower than fine fuel depending on diameter
Rapid loss of moisture when preheated	Slower loss of moisture when preheated
Ignites easily	Depends initially on activity in fine fuels as a source of ignition
Burns readily normally at or near to the fire edge	Burns more slowly sometimes for a considerable length of time
Gives momentum to rate of spread	Active in the flaming zone within the fire perimeter
More fine fuels present will increase rate of spread	Does not have a significant effect on fire spread
Can result in extreme fire behaviour such as torching, crowning and spotting	

Quantity

8B1.11 The proportion of fine and coarse fuels within a fuel arrangement can alter the physical interaction between the two and the subsequent fire behaviour. If there is an abundance of fine fuels, but limited coarse fuels, then the fire will burn with intensity at the fire edge, leaving little, or no fire activity once the fine fuels have been burned.

8B1.12 Whenever there is an appropriate mix of fuels of different sizes then the fine fuels will ignite more coarse fuel and a flaming zone will be left burning within the fire perimeter. The mixture of fine and coarse fuels, and the way these fuels are arranged, will influence the speed, intensity and duration of a fire.

Fuel Arrangement

8B1.13 The way in which fuel is arranged plays an important part in the way fire develops and fire intensity. The principal factors to consider are the continuity of vegetation across the landscape and how the vertical and horizontal fuel arrangement is able to interact.

Fuel Continuity and Uniformity

8B1.14 Fuel continuity is the extent to which the surface of the ground is covered by vegetation, and includes the degree to which the fuel is connected within its horizontal and vertical arrangement.

8B1.15 Fire within the UK wildfire environment mainly travels by radiated heat and flame contact. Therefore, closely arranged fuel will readily support fire development while more disparately spread fuel will limit a fire's movement across the landscape. This is relevant to both the vertical and horizontal motion of the fire.

8B1.16 Another important consideration is uniformity. If fuel is arranged in a uniform way across the landscape, there will be little change to fire behaviour as the fire moves through the vegetation. It is therefore easier to predict fire behaviour in uniform fuels than in a fire that is burning in mixed vegetation types, or fuels that have different arrangements.

Fuel Density

8B1.17 When fuel is tightly compacted there is less exposed fuel surface area and a lack of oxygen, due to restricted air/wind movement through the fuel, available to support combustion. This will impair fire development resulting in a fire of low intensity or smouldering fire. This type of fire behaviour is often found in peat fires or in the duff layer of forest litter such as in needle debris.

Vertical Arrangement

8B1.18 Vertical arrangement describes the way in which fuels are arranged from the ground up to the canopy levels of the vegetation. This arrangement will dictate how easily fire can develop vertically and is normally dependent upon sufficient fine fuels being available to allow an interaction between the different fuel levels. Vertical fire development may be supported by the arrangement of a single plant such as a conifer tree that can sometimes provide an unbroken fuel source from ground to canopy levels, or it may rely on fine fuels of different vegetation types acting as a ladder enabling fire to climb upwards from one fuel source to another.

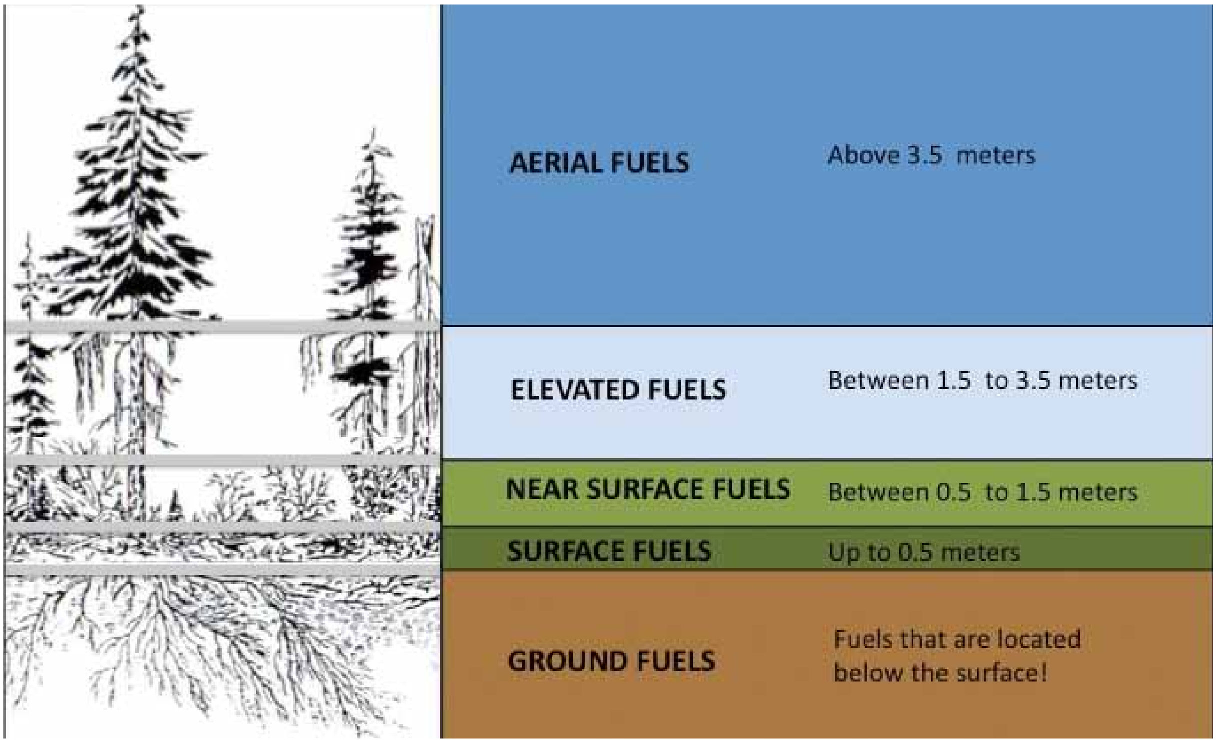


Fig B1.2 A diagram of the vertical fuel arrangement

8B1.19 Fuels that provide a means for the fire to move vertically are known as 'ladder fuels'. The existence of ladder fuels should indicate to personnel that, there is the danger of a significant increase in fire intensity and propagation if the fire is able to penetrate into these fuels.

8B1.20 Fine fuels can exist at various levels within a fuel complex and fire behaviour can increase in intensity as it moves upwards into the aerial fuels. For example in a conifer wood, much of the fine fuel lying on or near the surface may be shaded and, as a result, remain cooler and damper than the fuels above. If the fire penetrates into these warmer and dryer aerial fuels there may be a substantial increase in the amount of fuel available to burn.

8B1.21 Such fire behaviour in the upper canopy or 'crown', may result in a separate and independent fire which can move with great speed and intensity through the finer fuels that have been subjected to preheating from both the sun above and the surface fire below.

8B1.22 The terminology associated with different levels of vertical arrangement can be used to describe fires that burn within them. For example, a fire that is burning in surface fuels should be described as a 'surface fire'. If a fire is active in fuels at different levels of the fuel arrangement it should be described making reference to all of the levels it has involvement with.

Photo B1.3
If the fuel arrangement provides a continuous ladder of fine fuels the fire will be able to move from ground level into the aerial fuels

Photo B1.4
Where ladder fuels are in existence there is the possibility of extreme fire behaviour including torching and crowning

Horizontal Arrangement

8B1.23 Horizontal arrangement is the extent, and continuity, of fuel across the ground. Fire behaviour depends on whether fuel types vary significantly or whether they are uniform. For example. scrub may contain a mixture of vegetation that will support different fire intensities and behaviour, whilst vegetation that grows with more uniformity, such as grass or heather, will burn with more consistency.

Photo B1.5
Heather moorland and coniferous woodland

Vertical Fire Development

Ground Fuels

8B1.24 These are fuels that are present below the surface. They can be the roots of vegetation, buried branches or twigs, or in some situations may be the soil itself. For example, peat can be a primary ground fuel source.

8B1.25 Ground fuel fires may burn for prolonged periods and can prove to be very difficult to extinguish without access to large volumes of water or a means to excavate and expose the burning material.

Surface Fuels

8B1.26 Surface fuels, which include both living and dead fuels, are those that are found on or close to ground level extending to a height of 0.5 metre. As they are close to the ground they are often in the shade of taller vegetation and can be in contact with the ground which may be wet. They consist of grasses and low shrubs, litter such as twigs and branches, logs, stumps and seedlings.

8B1.27 If surface fuels are dry then they can make a significant contribution to fire intensity and fire spread. Most wildfires start in, and are carried by, surface fuels.

Near Surface Fuels

8B1.28 These are fuels that are present above a height of 0.5 metre and up to a height of 1.5 metres. As they are above the surface the vegetation is normally aerated, and therefore dryer, but can consist of less dead fuel than can be found nearer the surface. The presence of Near Surface Fuels often allows the fire to penetrate into the elevated fuels above.

Elevated Fuels

8B1.29 Fuels that exist between a height of 1.5 metres and 3.5 metres including, the upper parts of shrubs, and/or, fuel contained within the lower parts of taller vegetation (such as the lower branches of trees) are described as elevated fuel. These are usually well aerated allowing them to dry quickly, if involved in fire there can be an increase in fire intensity and rate of spread. The flammability of elevated fuel depends on its dryness, and the amount of fine and dead fuels that are present.

Aerial Fuels

8B1.30 Aerial fuels are those that are found above the height of 3.5 metres and extend to the upper most parts of tall vegetation – known as the 'canopy'. Often the most extreme fire behaviour takes place once a fire penetrates into the aerial fuels. How intense an aerial fire becomes is normally dependent on the amount and continuity of fine fuel available to burn.

8B1.31 Where there is a lack of aerial fuel continuity or the trees are widely spaced, this can be described as an 'open canopy' arrangement and will usually result in single or small groups of trees being burnt in a process referred to as 'torching'.

8B1.32 Where aerial fuels are continuous (closed canopy) the continuity may allow for extreme fire behaviour and and prolonged 'crowning'activity.

Moisture Content

8B1.33 Fuel moisture content has a substantial effect on fire behaviour altering rate of spread, intensity and the likelihood of extreme fire behaviour. Both dead and living fuels contain moisture which affects the way they will react during a wildfire.

8B1.34 The amount of fuel moisture is dependent on a number of factors including:

- **Type of vegetation.**
- **Weather conditions.**
- **Condition of the fuel (dead or alive).**
- **Size of fuel.**
- **Moisture content of the soil.**
- **Relative humidity.**
- **Time of year**

8B1.35 Fine and coarse fuels do not dry at the same rate. Fine fuels require only a short-term drying environment; those exposed to strong sunlight may dry in minutes rather than hours. More coarse fuels rely on a longer period of supportive drying conditions, some will dry relatively quickly but others will take days or even weeks to dry out completely. The wetness or dryness of the ground will also impact on the process. Dry soil will draw moisture from fuel while wet soil will prevent moisture from evaporating from it.

The amount of moisture in a fuel will affect:

- **Ease of ignition**
- **Rate of spread**
- **Fire activity**
- **Flame length**
- **Amount of extreme fire behaviour**

Fuel Temperature

8B1.36 Warmer fuels burn more readily and fine fuels are more easily heated than coarse fuels allowing for a rapid loss in moisture content. The amount of solar heating a fuel is subjected to has a major effect on how quickly it dries out and there can be a significant difference in flammability between those that are in direct sunlight (in aspect) and those that are not.

Types of Fuel

8B1.37 The term 'fuel type' used within this guidance does not relate to the species of vegetation, nor should it be confused with the National Vegetation Classification System[1] or the Biodiversity Action Plan Broad Habitat Classification used in the UK. Instead it looks to generically group predominant varieties or mixes of vegetation that can be found on the landscape, and which result in similar wildfire behaviour.

To enable FRs personnel to have a generic appreciation of the differing fuel types within this guidance, they have been arranged using the following classifications.

1. **Grassland.**
2. **Crops.**
3. **Broadleaf and Mixed Woodland.**
4. **Coniferous Woodland.**
5. **Heath, Bogs and Moorland.**
6. **Scrub.**

8B1.38 The weather and the seasons determine the state of vegetation and its susceptibility to fire, but when in a condition that allows combustion to take place, each of the fuel types will demonstrate different fire characteristics. It is also important to understand that interaction between different classifications of fuel also play an important part in changes to fire development and in its behaviour.

1 The National Vegetation Classification (NVC) is one of the key common standards developed for the country nature conservation agencies.

Grassland (Class 1)

Photo B1.6
An area of grassland

8B1.39 Grass is a fine fuel which burns readily when cured and is strongly influenced by alignment with wind and slope. When grass burns fire spread can be rapid which presents a significant hazard. An important consideration when fighting fires in areas of grassland is the speed at which it can carry the fire into vegetation with higher fuel loading such as gorse, heather or trees, leading to a rapid change in fire behaviour.

8B1.40 Grass fires that are wind driven may spread rapidly within the upper parts of the vegetation; it is possible that the fire may not remove all of the fuel to ground level. This may result in sufficient vegetation being left to allow a second burn in the same area should there be a change in wind direction.

8B1.41 Coastal areas of grassland are strongly influenced by sea breezes and the undulation in topography. Personnel need to be aware that this can lead to frequent changes to fire behaviour.

8B1.42 If grass is very green, typically over 50% green, then it is unlikely to support fire spread, as the heat of the fire is used in drying the grass before it is able to ignite. However, when the grass is progressively cured it will support combustion and the rates of spread can increase dramatically.

Characteristics
Light to moderate fuel loading (less than 6 tonnes per hectare – t/ha)
Mostly fine surface fuels
Maximum wind penetration
Low to moderate intensities
Rapid rate of spread
Short residual burning time
Limited short-distance spotting

Crops (Class 2)

Photo B1.7
Uniformity of crops

8B1.43 Arable grassland, such as wheat or barley, can have a much higher fuel loading than that of natural grassland. Crops are densely arranged providing high fuel loads that can result in fires that are very intense. Generally, fires burning in crops are slower moving than those in more natural grassland but wind-driven crop fires can spread quickly.

8B1.44 Although slope still plays a part in fire intensity, its effect is reduced due to the fact that crops are generally planted on more level ground. Crop fuels are characterised by their uniformity in their horizontal and vertical arrangement, this type of fuel consistency means that there is little change to fire behaviour brought about by variations in the fuel formation.

Characteristics
Moderate fuel loading (more than 6 t/ha)
Mostly fine surface fuels
Maximum wind penetration
Uniform fuel
Moderate to high intensities
Moderate rate of spread
Short residual burning time
Limited short-distance spotting

Broadleaf and Mixed Woodland (Class 3)

Photo B1.8
Broadleaf and mixed woodland

8B1.45 Broadleaf and mixed woodland is generally composed of deciduous trees such as oak, beech, sycamore and ash, although there may be pockets of conifer trees used as a nurse crop within the broadleaf woodland. Broadleaf woodland tends to be found in areas which have good soils and a plentiful water supply. Most, but not all, broadleaf trees are deciduous, losing their leaves in the autumn (expect holly). They are normally characterised by wide, flat leaves with veins extending through them. The leaves can be used to identify the individual species of broadleaf tree.

8B1.46 Broadleaf and mixed woodlands will generally demonstrate significantly different fire behaviour to coniferous woodland due to the lower quantities, and greater separation, of fine fuels found on the trees and importantly their leaves containing less flammable chemicals. Under normal spring and summer seasonal conditions, the leaves, which constitute the fine fuels of a broadleaf tree, will have high moisture content and will not readily burn making it more difficult for the tree's coarser fuels to become involved in a fire.

The surface litter, and ground vegetation, plays an important part in fire development and rate of spread in broadleaf woodlands, although this is likely to be very slow. If there are sufficient fine fuels such as leaf litter, fine twigs and grass at ground level then there is a possibility of significant fire spread through other available surface fuels.

8B1.47 Even in periods of drought or extreme weather, where other vegetation can act as ladder fuels, the resistance of broadleaf trees to support continued fire development is greater than that of coniferous woodlands. The resultant fire would be expected to be of lower intensity than a fire found in a coniferous woodland or plantation.

The management aims of broadleaf woodlands ranges from commercial timber production, field sport cover, conservation, landscaping etc. Trees that are not managed for timber production will tend to have a more wider spacing between trees than those found in plantations. Forestry operations such as pruning and thinning can further reduce fuel loadings. Both young and mature broadleaved trees are unlikely to see significant aerial fire activity and sustained crowning with the associated extreme fire behaviour being very unlikely.

8B1.48 Broadleaf and Mixed Woodlands are the most resilient classes to extreme fire behaviour and are regularly used as fire belts to fragment higher risk classes, such as coniferous woodlands, scrub and grasslands etc. Where broadleaved woodlands are naturally occurring in locations such as along streams and valleys, they can further improve the resilience of natural fire breaks.

Characteristics
Moderate to high fuel loading
Trees have a generally rounded shape
Wide and flat leaves rather than slim thin needles
Slow growing
Fine and coarse surface fuels
Mixed fuel variation
Moderate wind penetration at surface level and high wind penetration in aerial fuels
Moderate to high fire intensities
Variations in rate of spread
Moderate to long burning time
Limited spotting, torching and crowning

Coniferous Woodland (Class 4)

Photo B1.9
An example of planted coniferous woodland which contains huge quantities of fine fuels

8B1.49 Coniferous woodland can consist of variety of native species including native Scots Pine, Juniper and Yew and other non-native species such as Douglas Fir, Corsican Pine and Sitka Spruce.

8B1.50 Naturally occurring conifer woodland is usually, but not exclusively, found on acid sandy soil. If the tree canopy is open they will often have a healthy ground layer of other species such as heather, blaeberry (bilberry) bracken and other small shrubs.

8B1.51 The fuel complex within coniferous woodland differs significantly from that found in broadleaf and mixed woodland; a major difference being the amount of fine fuel that is available to burn in the form of live and dead pine needles and the flammable chemical composition of tannings, oils, alcohols and turpentines (similar to gorse) of the needles.

8B1.52 The fuel characteristics found within conifer woodlands vary with the vegetation's age. Increased fire intensity is likely in younger trees which are at the thicket stage. These young trees have branches growing near to the ground which can be ignited by fires burning in surface fuels. The fire can then move vertically through the fine fuel arrangement and into the aerial fuels above. If weather conditions are supportive, extreme fire behaviour is likely and this can include torching, crowning and spotting.

8B1.53 As the trees grow and mature they generally loose there lower branches and gaps can appear between the surface and aerial vegetation. This can reduce the amount of ladder fuels and prevent fire penetrating into the canopy.

8B1.54 It is important to recognise that fire behaviour in coniferous woodland will alter as the fire moves through trees of different age, species and management or where there are different surface fuels.

8B1.55 The majority of commercial timber production in the UK is usually of a single, or a limited number, of coniferous tree species. Trees are normally planted over large areas close together in a regimented formation, and in many plantations, the spacing between trees can be less than 2 metres. The very structure of the trees, and the way they are planted in close proximity to each other, can allow the fire to spread from tree to tree and the likelihood of extreme fire behaviour is significantly increased.

8B1.56 In older trees the connection with surface fuels will be diminished and forestry operations, such as pruning, brashing and thinning, can reduce fuel loadings and fuel ladders. It is important to note that these operations can also create a substantial amount of surface fuels called brash. These can support horizontal and vertical fire spread even in older woodlands with the possibility of an intense surface, or near surface fire, spreading into the canopy fuels. The strategic removal of brash is advised in high risk areas.

Photo B1.10
Torching and crowning is more likely in younger trees as vertical fire development is more probable

8B1.57 In areas where mature coniferous trees have closed canopy there is little light penetration resulting in only a limited amount of live vegetation with little or no shrub growth at surface levels. Again, this widens the ladder fuel arrangement and reduces the likelihood of vertical fire development. In these conditions only slow moving surface fires are likely which burn through the fallen needles.

Photo B1.11
As trees mature the lower branches do not retain their foliage, a gap can gradually grow between the lower branches and the surface fuels nearer to the ground this creates a lack of ladder fuels

8B1.58 Across the UK it is common for coniferous woodlands to be thinned out every 5 years and then finally clear felled when economically viable. Clear felling to harvest timber can leave large amounts of surface fuels in situ, called lop and top. Remaining timber and lop and top can result in very intense fires and it can be difficult for fire fighting water to penetrate the burning mass effectively.

8B1.59 Thinning operations will result in more light being able to penetrate down to the surface which encourages a temporary build up of ground vegetation. As a result there may be the potential for trees and shrubs of various ages grow in the same area; this mixed arrangement can increase the amount of ladder fuels, until the tree canopies close once again.

Characteristics
High fuel loading
Trees have a generally 'pointed' shape
Needles rather than leaves
Fast growing
Fine and coarse surface fuels
Large quantity of aerial fine fuels
Little wind penetration at surface level and high wind penetration within aerial fuels
High to extreme fire intensity
Likelihood of torching and crowning
Likelihood of some spotting as a result of aerial fire activity
Moderate to long term burning time
Age dictates variation in fire behaviour

Heaths, Bogs and Moors (Class 5)

Photo B1.12
A large area of heather moorland

8B1.60 Heath, bog and moor, can be very similar in appearance. All can have similar vegetation and can be found in upland or lowland areas. The main difference is that heath is normally located on well drained sandy soils whilst bog and moorland are found in wetter areas where sphagnum mosses help retain water content and play an important role in the formation of peat.

8B1.61 Heaths bogs and moors support many different plant species, the most abundant being grass, bracken, gorse and small shrubs such as heather.

8B1.62 Unlike other vegetation types, heather and gorse are naturally flammable due to volatile compounds found within them. They may, therefore, burn with more intensity and at times of the year when other vegetation types will not.

8B1.63 Peat is commonly found in moor and heathland areas and is formed over many thousands of years from decomposed surface vegetation and sometimes can be of considerable depth. It is often covered by fuel that is susceptible to fire such as heather or grass. When ignited, these can transfer sufficient temperature into the soil to cause the peat layer to ignite. Once burning, peat can potentially support substantial underground fires that can continue to burn for many weeks, sometimes resurfacing considerable distances from the original point of ignition. Drained peatland areas are more susceptible to the risk of fire, particularly in the springtime, even if there has been significant rainfall through the winter months.

8B1.64 Environmentally, peat is a valuable resource acting as a carbon sink, if involved in a fire large amounts of pollutants and carbon dioxide can be released into the atmosphere.

Characteristics
Moderate to high fuel loading
Fine and coarse surface fuels
Moderate to high wind penetration
Moderate to high fire intensity
Some spotting
Some crowning possible in dense shrubs
Short term burning time except in ground fuels
Potential for intense sub surface fires in ground fuels

Scrub (Class 6)

Photo B1.13
Lack of uniformity in scrub

8B1.65 Scrubland is a classification of fuel type that is common across most of the UK including urban areas. It usually consists of mixed vegetation types including grasses, gorse, shrubs and small trees and has a wide variation of species. A generic descriptive is an area of mixed vegetation found on the fringes of other classifications of fuel types or contained in pockets within them.

Photo B1.14
An area of scrub containing bracken and gorse

8B1.66 Such areas are of high risk as fire behaviour can be erratic with rapid changes to fire spread and flame length. In some areas of scrubland a particular plant species is dominant, for example large areas of gorse or bracken are common. Within these more uniform areas there is more consistency in the fire behaviour and a better opportunity to predict fire development.

8B1.67 Gorse is a common species of scrub across the UK and as it is naturally flammable can produce a particularly intense fire even at times of the year when other fuels may not burn – a swathe of green gorse scrubland may not necessarily act as a fire break. It is important to note that the seasonal nature of the flammability of these fuels is not fully understood and fire behaviour may therefore be erratic in what appears to be benign weather conditions.

Characteristics
Moderate to high fuel loading
Fine and coarse fuels
Moderate to maximum wind penetration
Moderate fire intensity
Rapid changes to fire behaviour
Short term burning duration

Live and Dead Fuels

8B1.68 In the wildfire environment fuel can be further divided into two other main categories and these are ***live*** and ***dead*** fuels. The main difference between the two categories is the way in which they react to changes in the atmosphere altering their potential for involvement in the combustion process.

Dead Fuels

8B1.69 Dead fuels are normally found on the surface of the ground but can also remain on or as a part of living vegetation.

Photo B1.15
Photo of dead surface fuels; note there is a lack of growth both on the lower branches of the trees and on the ground, this is due to little light being able to penetrate through the canopy of the woodland

Photo B1.16
Gorse with dead fuels remaining on the plant

8B1.70 Dead fuels interact with the atmosphere searching for a balance between the moisture contained within the fuel and that which is held within the air. Therefore, when relative humidity is high they will generally absorb moisture, when the moisture content of the air is low they will release moisture back into the atmosphere.

8B1.71 The exchange of moisture, and in particular the drying out process, is also influenced by the size and shape of the fuel. Smaller fuels, particularly fine dead fuels will usually dry out much faster than coarser ones.

8B1.72 There are a number of factors which influence this exchange which include:

- **The size and shape of the fuel**
- **The difference between the moisture contained in the fuel and that of the atmosphere**
- **Whether the fuel is in direct sunlight or is shaded from the sun**
- **How densely the fuel is arranged**
- **The moisture content of the soil the fuel is arranged upon**

8B1.73 The exchange of moisture from the fuel to the atmosphere is a process that is relative to the difference in moisture content between the two. The effect of recent rainfall on heavier fuels will diminish over several days while finer fuels can dry out in hours. It is important to consider how previous weather conditions may have altered the moisture content of the fuel; this will help to understand how the fuel will behave when an ignition source is applied. If heavier fuels are wetter, finer fuels will have less capacity to ignite them, even if ignition occurs their behaviour will be reduced.

Higher moisture content can impair:

- **Ease of ignition**
- **Rate of combustion**
- **Rate of spread**
- **Fire intensity**

Free Water

8B1.74 Dead fuels when saturated can hold free water; this can surround the fuel or soak into its fibre which can slow the drying out process. This free water has to be dried first before the fuel's actual fibre construction can lose its moisture content.

Live Fuels

8B1.75 The atmosphere and weather conditions have a lesser effect on the moisture content retained within live fuels. Living plants although not immune to metrological conditions will regulate their own moisture content and do not readily absorb water. The water content within many plants is much higher than that contained within the air. The main influence of dryer conditions will be on the outer surface of the plant and particularly on the finer fuels contained in plant foliage. Nevertheless, during drought conditions the actual moisture content within live vegetation will diminish and ultimately can result in the destruction of the plant and in these situations fire behaviour can be altered significantly.

8B1 Key Considerations

- Fine fuels – those less than 6mm in diameter – dry out very quickly and are easily ignited.
- It is the fine fuels that are mostly responsible for the level of fire intensity and rate of spread of a wildfire.
- In areas where there are large amounts of fine fuel fire behaviour will be intense or extreme.
- Fine fuels that exist in the vertical fuel arrangement can quickly spread fire upwards into the aerial fuels.
- Fine fuels burn at the fire's edge igniting the coarser fuels, these burn with less intensity but for longer.
- Fires burning in fine fuels positioned on slopes which are 'in aspect' can move with alarming speed.
- Fuels positioned in the upper levels of the vertical fuel arrangement can be much drier and warmer than the fuels at lower levels.
- Dead fuels dry out more quickly and burn with more intensity than live fuels.
- Take note of the fuel type/arrangement you are working in and anticipate the fire behaviour that is likely to occur.
- Remember that fuel will generally become drier and warmer throughout the day leading to an increase in fire intensity.
- Consider the effects of weather and of topography on fuel, and anticipate how these will effect fire development and behaviour.
- The existence of available ladder fuels indicates that there is the potential for extreme fire behaviour.
- Observe and take note of the fire behaviour that occurs in the different fuel types and arrangements, relate this to the environment you are working in.

8B2

The Effects of Weather

Introduction

8B2.01 Weather is a key wildfire factor and has a significant impact on the fuel complex and the broader wildfire environment. Weather influences fire intensities, rates of spread and levels of risk and it is vital that fire service personnel understand how the prevailing weather conditions can change wildfire behaviour throughout the day, even if the fuel type remains the same.

8B2.02 The key factors that bring about changes within the local daily weather cycle are:

- **Changes in temperature which heats fuel and influences the moisture content of the air.**
- **The effect of precipitation and other forms of moisture such as dew.**
- **Local air movements such as katabatic and anabatic winds.**

8B2.03 Whenever weather conditions are supportive, it is likely that Fire and Rescue Services will be called upon to respond to large numbers of wildfire events. It is a misconception to believe that wildfire is reliant on extreme weather conditions, that the threat of wildfire is limited to the summer months, or indeed that it requires a prolonged period of dry weather to create suitable conditions for wildfires to occur. A relatively short period of supportive weather can increase the risk of wildfire significantly and vegetation fires can occur at any time of the year.

The Effect of Weather on Fire Behaviour

8B2.04 Not only does the weather have an effect on the combustibility of fuel, it also has an influence on the combustion process itself. Weather influences fire behaviour by:

- **Raising and lowering the temperature of fuels and the air.**
- **Increasing and decreasing the moisture content of the air.**
- **Changing the moisture content of fuels, particularly dead ones.**
- **Supporting or limiting the development of strong convection plumes.**
- **Curing (drying of) fuel.**
- **Changing the direction, strength and type of prevailing and local winds.**
- **Changing the level of stability in the atmosphere.**

8B2.05 During a wildfire event, changes to weather conditions, in both the short and longer term, create conditions that will result in either the fire situation improving or becoming worse. Understanding and interpreting these weather changes, and what they mean to personnel on the fire ground is of paramount importance to the effective management of a wildfire incident, and in particular, can have a substantial influence on the safety of personnel.

8B2.06 The aim of this section is to give an understanding of the influences that weather can exert on the wildfire environment. Whilst it is not the intention to give in depth detail on the complexities of the broader global climate, firefighters should have a basic understanding of how the global climate functions and its influence on local conditions.

Solar Radiation

8B2.07 The sun is the engine that powers the Earth's climate and weather systems. It transmits its energy in the form of solar radiation and it is this radiation which drives the global climate. When solar radiation reaches the Earth's atmosphere, it passes through the air having only a negligible effect on air temperature. It is only when it reaches the surface of the Earth and the solar radiation is converted to terrestrial radiation, that the surface is heated and the air temperature begins to rise. The air coming into contact with these heated surfaces is then warmed and it is this process which raises the air temperature throughout the day.

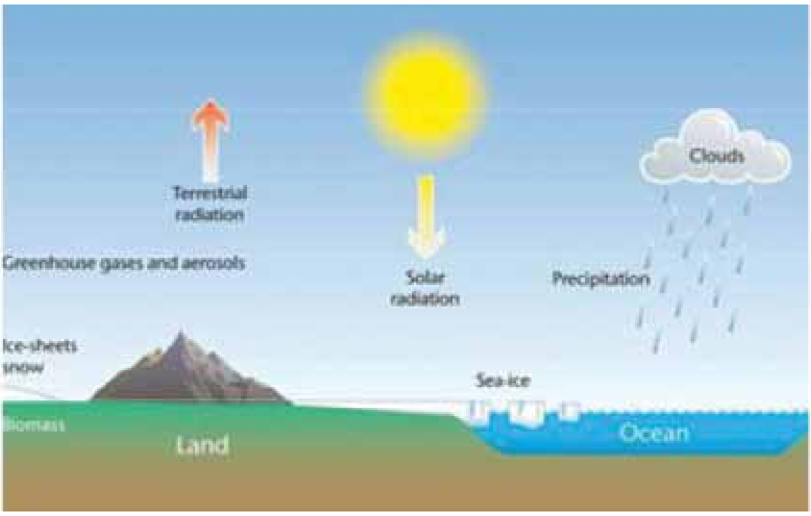


Fig. B2.1
The effects of solar radiation on the atmosphere

Differential Heating

8B2.08 For a number of reasons, the effect of solar radiation on the surface of the Earth is not equal. This causes a variation in the solar radiation's ability to raise surface and air temperatures. This differential in heating causes an atmospheric imbalance which results in the formation of compensating weather patterns.

8B2.09 The sun's energy is concentrated at the Earth's equator, but at the poles the energy is spread over a greater surface area resulting in a reduction in per unit strength.

8B2.10 Higher temperatures over the equator and lower temperatures over the poles create a temperature imbalance across the surface of the Earth. The atmosphere responds by circulating the cold and warm air to compensate for the imbalance. This causes the formation of areas of low pressure known as 'depressions' or what are more commonly referred to as 'lows'.

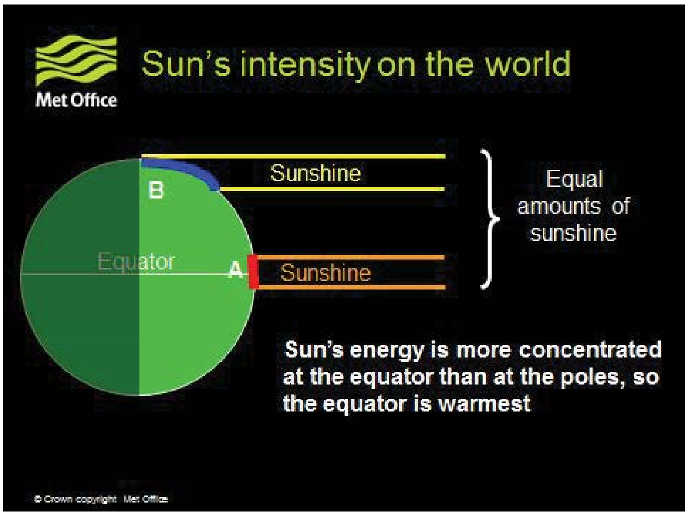


Fig. B2.2
The sun's intensity is concentrated at the equator

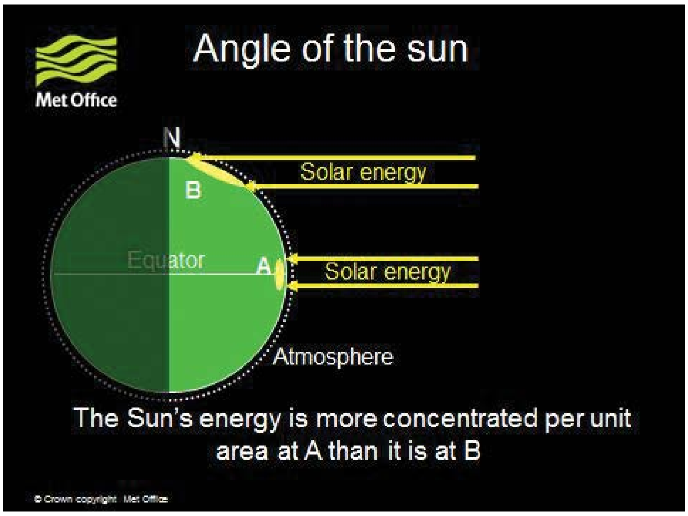


Fig. B2.3
The concentration of the sun's energy at the equator

8B2.11 There are two main areas of rising air. These are in the Tropics and along the Polar Front, and it is here where the greatest average rainfall occurs. There are also two main compensating areas of descending air. These are in the Polar Regions and Sub-Tropical regions, these give rise to the sub-tropical and polar high pressure areas. At these locations there is little rainfall and subsequently the major deserts of the world are found in what is known as the sub-tropical high pressure belt.

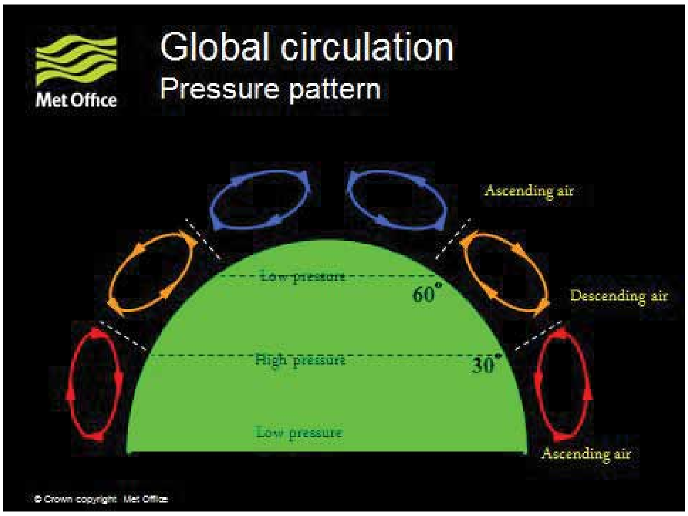


Fig. B2.4
Atmospheric circulation. Descending air marks high-pressure areas; ascending air marks low-pressure areas.

Land and Sea Surfaces

8B2.12 Due to differential heating between land and sea, there is an interaction between the two surfaces that has an impact on the global climate. Land cools more than the sea in the winter and colder denser air over land surfaces leads to the formation of areas of high pressure. Conversely, in the summer the land warms more than the sea, and warmer, less dense air rises, leading to the formation of lower pressure systems.

Surface Heating

8B2.13 Direct heating from the sun has a major impact on the surface of the Earth. The amount of solar radiation absorbed by the Earth depends on a number of factors:

The time of the year

8B2.14 Longer days in the summer result in more exposure to solar radiation. This generally leads to higher temperatures and drier surface conditions. Shorter days result in less exposure to solar heating and longer nights means that the surface temperatures become lower.

The time of day

8B2.15 The sun is weakest in the early morning and late in the afternoon. The sun is generally strongest when it is at its highest trajectory. A lower angle results in less radiation being received by the surface and a corresponding reduction in the surface temperature.

Cloud cover

8B2.16 Cloud cover and air quality will absorb or reflect solar radiation before it reaches the surface. On a humid day the moisture in the air will reduce the amount of solar radiation striking the surface. Pollution will also reduce the amount of sunlight reaching the surface.

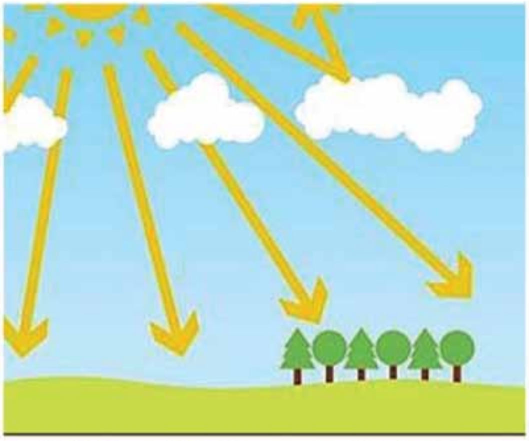


Fig. B2.5
Showing how some radiation is unable to reach the surface of the Earth as it is absorbed or reflected by cloud and pollutants

The shape of the surface

8B2.17 The shape of the Earth's surface is not flat and the shape of the topography arranged across it alters the amount of exposure time and strength of the solar radiation striking the surface.

The angle of the surface

8B2.18 The angle of the surface in relation to the sun's position throughout the day causes variations in surface temperature. This is particularly relevant to slopes, the direction and angle of slope can cause the fuel on them to be much warmer and dryer than those found on other parts of the landscape. In the UK, southerly-facing slopes receive a greater amount of surface heating.

The Effect of Surface Heating

8B2.19 It is the heated surface materials (rocks, vegetation, surface coverings) that warm the air that comes into contact with them. This heated air then becomes buoyant and is replaced by cooler heavier air; this process accelerates as the temperature of the surface increases during the day. This convection process distributes the heat upwards through the atmosphere sometimes to heights of many hundreds of metres. The strength of the solar radiation peaks at about noon when the sun is at its highest. As a result the surface continues to increase in temperature drying out the air until later in the afternoon.

8B2.20 As the air loses its moisture the fuel seeks to remain in balance with the air that surrounds it and also sheds water. This drying process increases the fuels combustibility. This process continues until the effect of the solar radiation begins to diminish and the air begins to cool.

8B2.21 Fuel will be at its warmest and driest about 2 hours after the sun has reached its zenith, with fire behaviour peaking during the spring and summer between 1400-1600 hours.

Atmospheric Moisture Content – Relative Humidity

8B2.22 Relative Humidity (RH) is a measure of the amount of moisture in the atmosphere; this is represented as a percentage. For example when it is raining or foggy, relative humidity could be as high as 100%.

8B2.23 A correlation exists between temperature and relative humidity, it is highest around dawn when temperature is low, and is lowest later in the afternoon when temperatures are likely to be higher. When RH is high, fuel is unable to dry, when humidity levels fall, moisture content within the fuel also reduces. The effect of RH on fire behaviour is significant and is a good indicator of likely fire severity.

8B2.24 When RH falls to critical levels (below 40%) then extreme fire behaviour becomes probable. Fine dead fuels (such as dead grass and litter) respond very quickly to changes in relative humidity.

8B2.25 Later in the day, as temperatures fall, humidity levels will rise producing cooler damper air nearer the surface resulting in lower fire intensity which can aid firefighting operations. Information on humidity should be collected throughout a wildfire event as it is a useful indicator of future fire behaviour.

Dew Point Temperature

8B2.26 The dew point temperature is the temperature to which air must be cooled before moisture condenses from the atmosphere. It is common to find dew forming on vegetation during the night while other surfaces remain dry. Dew is more easily formed on fine fuels because they have a large surface to volume area. This results in rapid cooling, and the formation of dew on the surface reducing the fuel's capacity to burn. Knowing when dew point may be reached can assist firefighting activities during certain times of the day, particularly early in the morning.

The Effect of Shade

8B2.27 Fuels that are in shade are not subject to direct sunlight resulting in them remaining cooler and damper than fuels that are exposed to the full effects of solar radiation. Shaded fuels are more reliant on the general air temperature and the effects of wind to dry them out. Therefore, the position of vegetation within a vertical fuel arrangement is important. Those fuels existing in the canopy generally get most sunlight and are therefore warmer and drier than those existing at lower levels. In denser vegetation which the sun fails to penetrate, fuels that exist at the lower levels, particularly those at ground level, may remain cooler and damper. This is particularly so in fuel that is in contact with the saturated ground which restricts the capacity of the fuel to shed moisture. For this reason there may be an increase in fire intensity when a fire moves from an area in shade to an area where the fuel is in sunlight.

Hot and Cold Fuels

8B2.28 Fuel arranged across the landscape is affected by variations to its exposure to solar radiation. This can be dependent on the following factors:

- **The length of exposure.**
- **The time of day.**
- **Fuel is in or out of shade.**
- **Fuel is in or out of aspect.**

8B2.29 All of these factors will cause variations in the temperature and moisture content present within the fuel bed. Fuels that are subjected to significant amounts of solar radiation will become hotter than those that are not. These are descriptively referred to as 'hot fuels' as their temperature can be increased significantly; hot fuels are therefore more supportive to the combustion processes.

8B2.30 Cold fuels are those that are not positioned favourably and receive less direct sunlight and therefore have a lower temperature, as a result the fuels are normally cooler than those growing in hotter exposed areas.

8B2.31 There may be a substantial difference in fire behaviour in fuels of different temperature, particularly in fires burning within a fuel containing large amounts of fine fuel. Understanding which fuels are hot and which ones are cold is usually best achieved through observations on the fire ground.

The Effect of Cloud

8B2.32 Clouds are formed from particles of water and can be at variable heights above the surface. If there is a cloud covering, less sunlight will reach the surface and temperatures are likely to be lower, as a result the moisture contained within the air and fuels may be higher.

Precipitation

8B2.33 Rainfall has an obvious impact on the wildfire environment and will raise the moisture content of the air, fuel and the soil. If there has been a lack of rainfall prior to the fire the fuel is likely to be much dryer and more responsive to preheating by solar radiation.

8B2.34 There are three main phases that should be considered:

Short term drying environment

A short term drying environment is one that lasts long enough to only dry out finer fuels, mainly those that are exposed to solar radiation or those effected by the circulation of warm air.

Extended drying environment

Prolonged periods without rainfall can result in an extended drying environment that lasts for a number of days/weeks, during which most fine fuels within the fuel arrangement will readily support fire development. As increasing amounts of coarse fuels dry, there will be an escalation in the amount of fuel available to burn; this increase in fuel loading has the potential to drastically affect fire behaviour and intensities.

Long term drying environment (drought)

A long term drying environment, or drought, results in the ground becoming arid and baked. Fuel that exists at ground level, that would have otherwise remained saturated, dries and even fuels that exist below the surface become available to burn. Vegetation becomes dehydrated, parched or can even die off completely, leading to an abundance of available fuels and optimum wildfire conditions.

Wind

8B2.35 Wind plays a key role within the wildfire environment. Its strength and direction will affect fire spread and intensity. Wind can also assist in drying out fuels, a warm wind with little moisture content can accelerate the drying out process and make the fuel more receptive to the combustion process. Not all winds will have this affect and the general direction of the large scale winds is an important factor. Air blowing from continental Europe is usually the driest.

8B2.36 The diagram below gives a general guide of the potential characteristics of winds that are blowing from different directions.

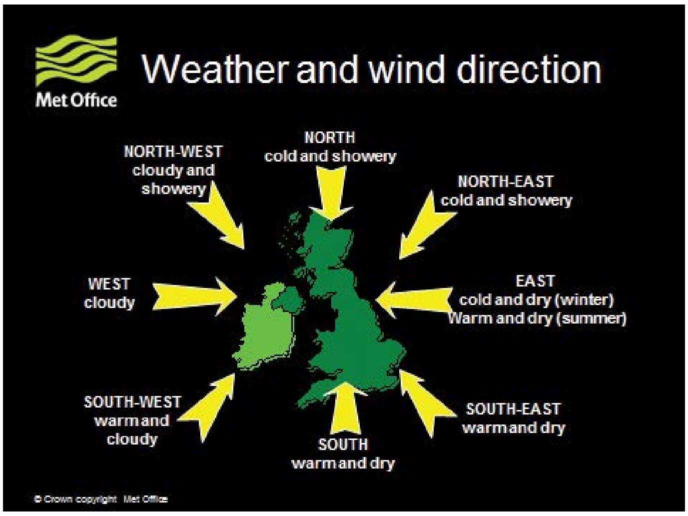


Fig B2.6
Wind direction can have a major impact on fire behaviour as the air temperatures and moisture content may differ

8B2.37 As well as the general wind direction, local conditions can influence the way air circulates across the landscape. This can result in variations to wind speed and its direction which can result in substantial changes to fire behaviour.

Local Winds

8B2.38 Local changes to wind are driven by the day-night cycle. This results in the surface of the Earth heating during the day and then cooling during the night. This process results in the natural movement of air within the local topography, this can have a significant impact on fire behaviour. This can either be in its intensity or direction or rate of spread.

8B2.39 Local wind types should not be confused with topographical winds which are described later in Section B3. It is important that firefighters understand the influence that local winds can have on a fire as they can often result in wind direction or strength changing suddenly.

8B2.40 The four main types of local winds that are likely to impact on wildfire in the UK are:

- **Anabatic or upslope winds**
- **Katabatic or downslope winds**
- **Land breezes**
- **Sea breezes**

Anabatic Wind (upslope wind)

8B2.41 Slopes that are subjected to exposure to solar radiation become heated. Prolonged periods of preheating results in a layer of air near to the land surface becoming very warm and dry. This increases the buoyancy of the air, with the result that the lighter air circulates upslope, producing a general movement of air at surface levels. Anabatic winds may form on what otherwise is a calm day resulting in increases in a fires rate of spread and intensity.

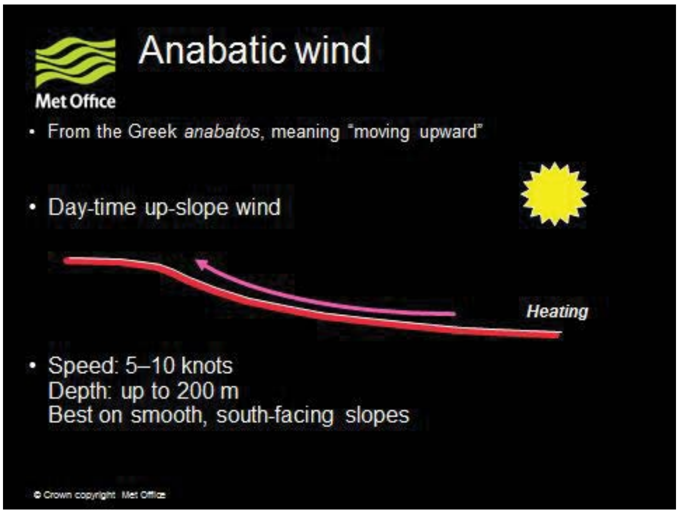


Fig. B2.7
Anabatic winds are formed on slopes that have been heated by the sun

Katabatic Wind (downslope wind)

8B2.42 Katabatic winds are formed after the sun sets and the surface is no longer heated causing the surface and the materials on it to cool down. The air in contact with the surface also cools and becomes denser; this heavier air then flows down slope.

8B2.43 Air that is cooler and damper can impair fire development and as katabatic winds flow downwards, they will generally reduce fire intensity. Where the fire has previously been supported by an upslope wind, and then is subjected to the influence of a katabatic wind, this may force the fire to burn back into previously burnt fuel which can also lower the intensity and rate of spread.

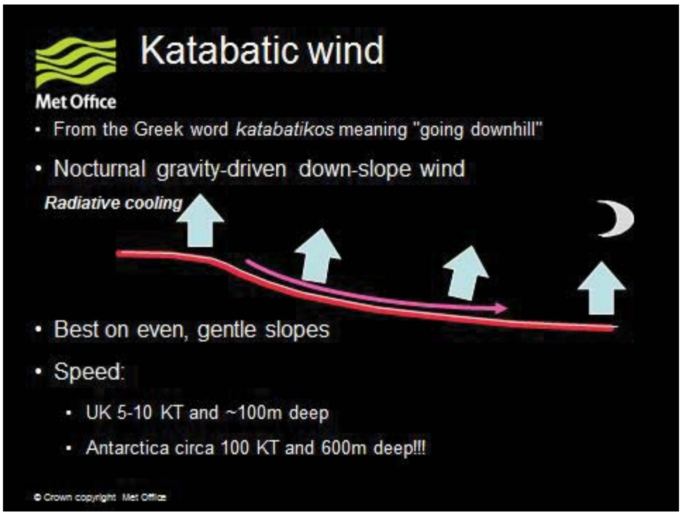


Fig. B2.8
Katabatic winds can form on slopes that cool at night

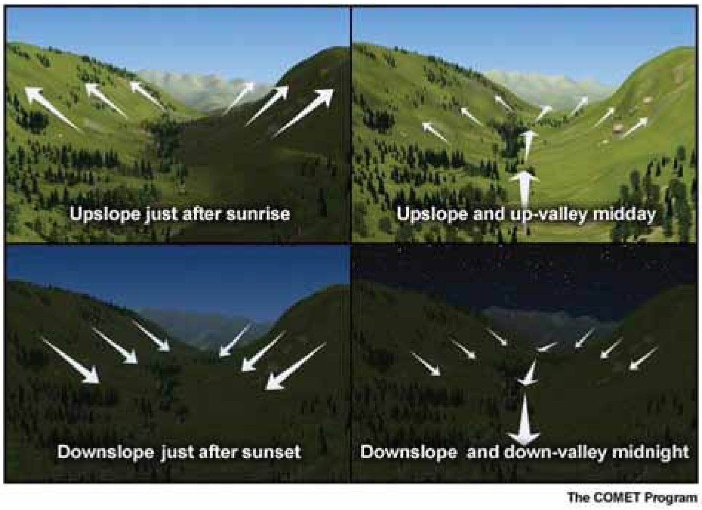


Fig. B2.9
Downslope and upslope winds

A Land Breeze (night time wind)

8B2.44 A land breeze is a wind that blows from the land towards the sea at night. It is caused by the imbalance of temperature between the air above land surfaces and the air above the sea. When the land is no longer being heated by the sun the surface loses temperature very quickly and the air becomes colder and denser. The relatively warm air above the sea rises and the air covering the land moves to replace it.

A Sea Breeze (day time wind)

8B2.45 A sea breeze is a wind that moves from the sea onto the land and is caused by the imbalance between the temperature of the air covering the land and the sea. When the surface of the land is being heated by the sun it heats up relatively quickly. Water on the other hand has a high specific heat capacity; therefore it requires a larger amount of energy to raise its temperature. Much of the heat absorbed by the sea goes into the process of evaporation rather than raising the water temperature.

8B2.46 Once the air above the surface of the land becomes heated it starts to expand and becomes lighter, as it rises the denser, cooler air from the sea is drawn over the land to replace it. Sea breezes are common during the summer and can be quite strong. They can start quite early in the day depending on how quickly the surface of the land is heated by the radiation from the sun.

(Similar effects can take place around large inland lochs and lakes)

8B2.47 The effect of a sea breeze on a wildfire can be significant, and potentially dangerous. They can have the following influences on fire behaviour:

- **Disturbs the movement of air on what otherwise would have been a calm day**
- **Depending on direction it can strengthen an existing wind**
- **Depending on direction it can reduce the strength of an existing wind**
- **Can influence the direction of the general wind**
- **Generally increase the intensity of a fire**

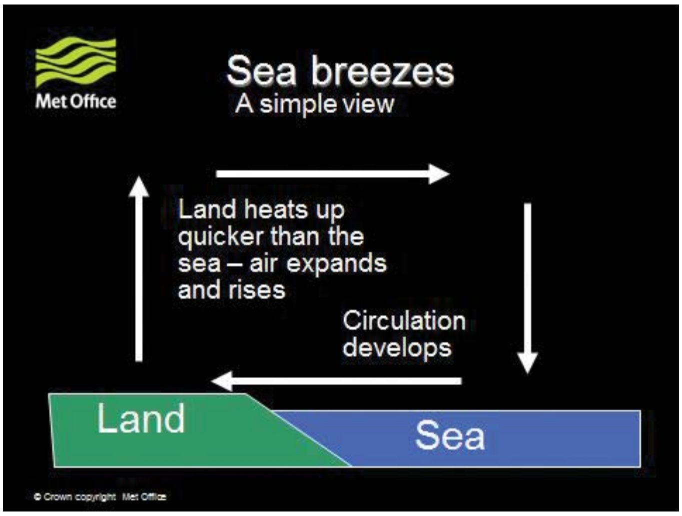


Fig. B2.10
Showing the formation of sea breezes which can be common in the UK

Atmospheric Stability

8B2.48 Atmospheric stability is the resistance of the atmosphere to the vertical or upward movement of air that has been heated nearer to the surface. This resistance is in the form of a boundary layer that can fluctuate in height depending on the time of day and the temperature of the air at different heights within the atmosphere. The degree of stability or instability of the atmosphere will impact on fire spread, fire intensities and the movement of smoke.

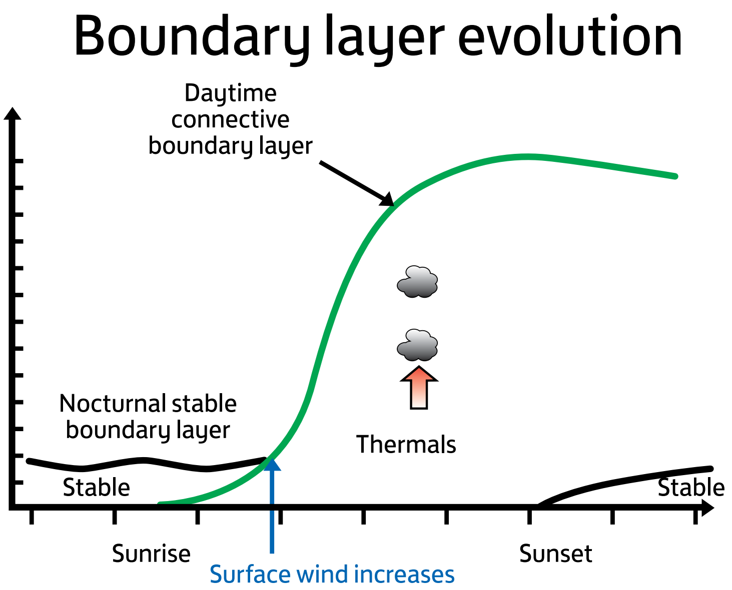


Fig. B2.11
The boundary layer is influenced by changes in temperature throughout the day

Inversions

8B2.49 The temperature of the atmosphere usually falls with a rise in altitude, but when a layer of air in the atmosphere is warmer than the air below, what is known as an inversion is formed. This creates a more stable fire environment by restricting the upward motion of the lower atmosphere and the fire plume.

A Stable Atmosphere

8B2.50 Temperature inversions are commonly formed during the night and early morning when the cooling surface lowers air temperatures. This cold air is denser than the warmer air above and because it is less buoyant remains close to the surface.

8B2.51 During a wildfire, a stable atmosphere tends to prevent the formation of a strong convection column. This restricts fire intensity and fire behaviour is usually predictable. Smoke is more likely to remain closer to the ground.

Stable atmospheric conditions may display the following visual indicators:

- **Low stratus type clouds**

- **Smoke columns drift apart and do not rise to a great height**
- **The vertical movement of air is limited**
- **Hazy lower atmosphere**
- **Possible fog layers particularly in low lying parts of the landscape**
- **The winds are usually light and predictable**

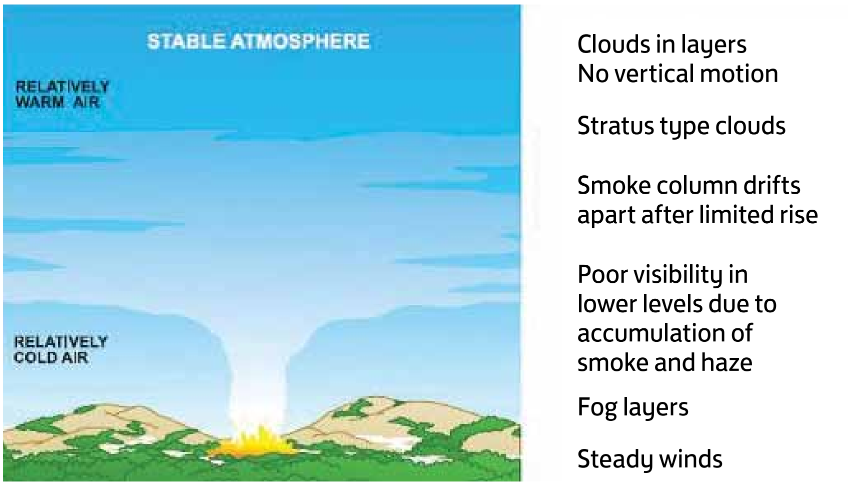


Fig. B2.12
Observations to indicate a stable atmosphere

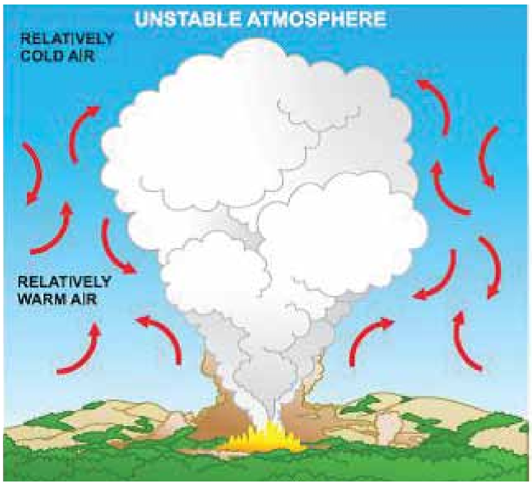
An Unstable Atmosphere

8B2.52 As the surface temperatures near ground level increase during the day, the cooler air warms and the heat differential between it and the inversion above weakens. When the heated air near to the surface becomes warmer than the air above, its buoyancy increases and it starts to rise, cooler air is drawn in to replace it. This vertical movement of air mass or 'updraft', provides a fire with the means to develop a strong convection column which can result in an in-draft of air. This results in a potential increase in fire intensity that makes a fire less predictable and sometimes leads to its behaviour becoming erratic. Gusty winds make smoke movement more unpredictable. If atmospheric stability changes it may be necessary to alter suppression tactics.

Unstable atmospheric conditions may display the following visual indicators:

- **Cumulus type clouds which show noticeable vertical growth**

- **Smoke columns develop vertically and can rise to a great height**
- **Winds are gusty and unpredictable**
- **Thunder storms can develop**
- **There is a clear lower atmosphere**



Clouds grow vertically and smoke rises to great height

Cumulus type clouds

Upwards and downward currents gusty wind

Good visibility

Dust whirls

Fig. B2.13
Observations to indicate an unstable atmosphere

Collecting Weather Information

8B2.53 Firefighters should now be aware that weather is a major factor within the wildfire environment, and one that can bring about significant change to fire behaviour. Usually, weather brings slow and predictable change to fire behaviour, but sometimes the changes are more sudden and can result in extremely dangerous situations.

8B2.54 Globally, sudden and unexpected weather change is a major cause of firefighter fatalities, and it is of absolute importance that the current and predicted weather is closely monitored throughout the duration of a wildfire incident. Regular weather updates should be obtained and onsite intelligence regarding local weather variations should be gathered. This will play an important part in the risk assessment and decision making processes which underpin the tactical fire plan.

8B2.55 Detailed weather information should be included within operational briefings and all personnel should be made aware of any risks posed by the current or future weather conditions. Updated weather information should be communicated to all operational personnel on the fire ground to assist in the maintenance of situational awareness.

8B2.56 Equipment is available that can provide accurate onsite information. Small hand held weather units are particularly useful as these can be used to gather a wide range of weather intelligence including, air moisture content, altitude, barometric pressure, wind speed and wind direction.

Meteorological measurements must be made away from the influence of the fire and in clear terrain unaffected by nearby trees, other obstructions or factors which may result in false or inaccurate readings.

Met Office Support

8B2.57 Weather information provided by the Meteorological Office should form an essential and critical part of any wildfire incident command system. The Met Office can provide accurate information that will assist in defining the affect that weather will have during an incident. This can be provided by utilising a number of metrological services:

Photo B2.1
A wildfire specialist using a hand-held weather unit

General Information

8B2.58 Information on the prevailing local weather conditions, can be provided by accessing the general weather forecast for a local area. The information given is for public use and can be obtained from the Met Office web site www.metoffice.gov.uk/

8B2.59 The pressure systems shown on a weather map are an indication of atmospheric stability. The presence of a high pressure system indicates that a stable atmosphere can be expected, a low pressure system indicates that the conditions will be unstable.

Specific Advice and Information

8B2.60 Recently the Met Office has improved its web-service so that it now provides a single source of decision making information to the emergency response community. This source is known as Hazard Manager, the web-based resource for the emergency response community. This facility provides a single location where the Met Office holds all its environmental intelligence; it can be used to assist decision makers and allows visualisation and manipulation of different data types.

Specialist Advisors

8B2.61 Met Office Regional advisors should be used appropriately and are available to:

- **Assist emergency responders to assess the risk in their particular area from predicted or ongoing severe weather events.**
- **Provide guidance on the use of Met Office services available to emergency responders.**
- **Assist with weather related risk assessments as used within community risk registers.**

8B2.62 If required, advisors can give support during an incident and their role may include:

- **Ensuring that the management team is aware of all the meteorological factors which could impact the incident.**
- **Ensuring that all meteorological information is consistent and that all responders within the Command and Control structure use the correct information.**
- **Interpreting any information for the responders if necessary.**
- **Sourcing other scientific advice available from the Met Office.**
- **Acting as a point of contact between the Met Office and the emergency responders.**
- **If required and appropriate, arranging for routine forecasts and other information to be supplied to aid in the recovery phase of the incident.**

Met Office Fire Severity Index

8B2.63 The Met Office Fire Severity Index (FSI) produces an assessment of the current day and gives a forecast of the coming five days' fire severity. The forecast uses information such as time of year, wind speed, temperature and rainfall. The index values are from 1 to 5 which represent an increasing degree of likely fire severity:

1. **Very Low**
2. **Low**
3. **Moderate**
4. **High**
5. **Exceptional**

8B2.64 The FSI maps display an index on a 10km x 10km colour coded grid square system. The Met Office FSI was primarily developed following the introduction of the Countryside and Rights of Way Act, 2000 (CROW Act). It assists in the management of land, and provides a guide for consideration as to when public access should be restricted during periods when there is an exceptional fire risk.

8B2.65 The FSI is a useful tool for fire and rescue services and land management agencies as it predicts the potential current and future fire risk. Services should access this information regularly and instigate appropriate action relevant to the risk levels indicated by the index.

8B2.66 Currently the Fire Severity Index is not available in Scotland or Northern Ireland. At the time of writing, arrangements to introduce a comparable system for Scotland are under review.

Climate Change

8B2.67 It is widely acknowledged that climate change is occurring and at a rate that many consider to be accelerating. Scientists, including those from Met Office, have carried out a great deal of research into what might be causing the changes to the climate. There is evidence to suggest that increasing amounts of greenhouse gases within the atmosphere are contributing to climate change and global warming. This warming may cause relatively large and long term change, not just to the UK climate, but to the wider natural environment.

8B2.68 Wildfire is influenced by the fuel that is available, the pre and prevailing weather conditions and the topography. If the global climate is changing then it is sensible to accept that this will affect our national weather patterns. Should local conditions change then this will also bring variations to the fuel types and the condition of vegetation.

8B2.69 If there are changes to the UK climate which result in warmer wetter winters and hotter drier springs and summers, then FRSs should be prepared for an increase in the scale and number of wildfires, as conditions become more supportive of a natural increase in fuel loading.

Risk Monitoring

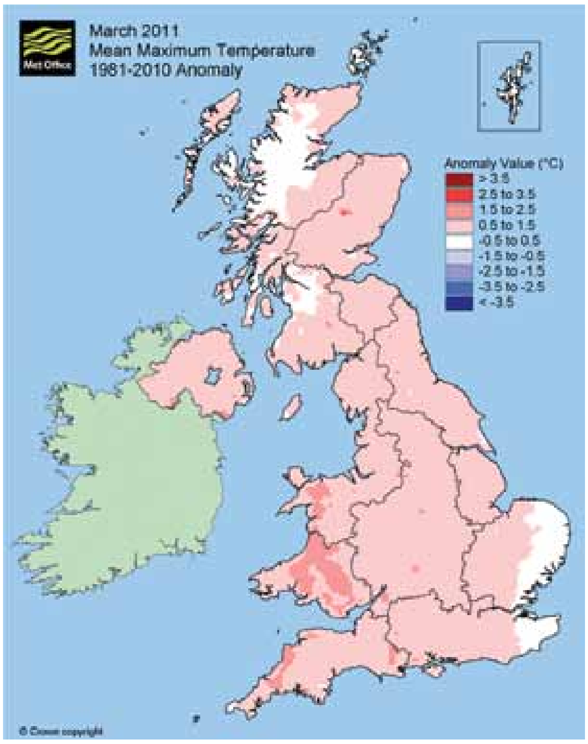
8B2.70 The effects of climate change on the UK is uncertain but evidence and trends suggest that at least in the short term, temperatures are increasing. This coupled with a suggested decrease in the amount of rainfall during the spring and summer months, could have a substantial impact on the UK wildfire environment.

8B2.71 It would be beneficial if fire and rescue services gather information on the weather and its consequential impact on the number and frequency of wildfire incidents. This information will be invaluable in developing response projections. This data can also be fed into other scientific research projects including the development of a more response orientated FSI system.

Case Study

8B2.72 During the spring of 2011, FRSs across the UK responded to a large number of wildfire events. The diagrams below give an overview of the prevailing conditions during this period and can provide some explanation for the increase in the number of occurrences.

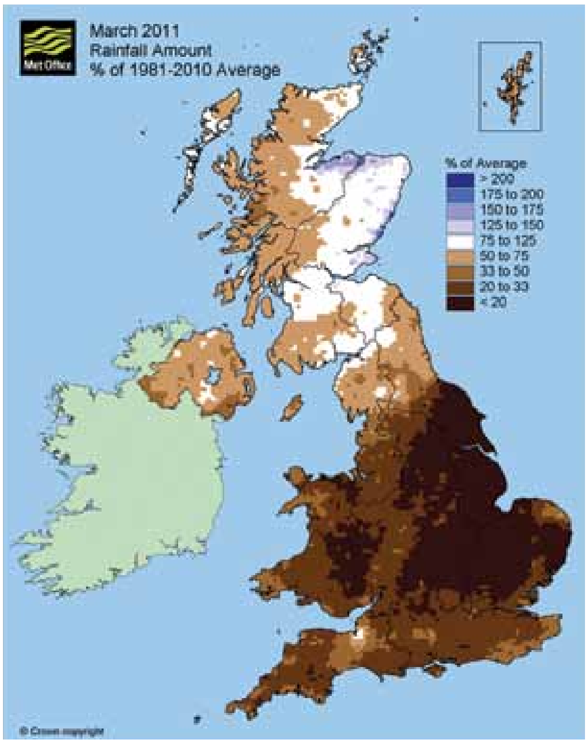
8B2.73 The diagrams show that March was very dry and warm while April had very high mean temperatures. The poor physical condition of the vegetation following the rather harsh winter and unseasonably warm spring provided substantial amounts of wildfire fuels.



Anomaly Value (ºC)

- >3.5
- 2.5 to 3.5
- 1.5 to 2.5
- 0.5 to 1.5
- -0.05 to 0.5
- -1.5 to -0.5
- -2.5 to -1.5
- -3.5 to -2.5
- <-3.5

Fig. B2.14
The mean temperatures during the early spring of 2011 were much higher than the average



% of Average

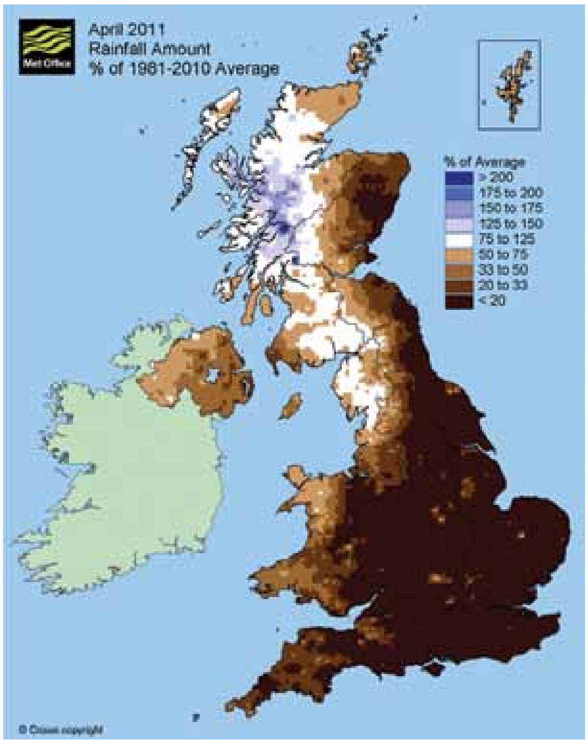
- >200
- 175 to 200
- 150 to 175
- 125 to 150
- 75 to 125
- 50 to 75
- 33 to 50
- 20 to 33
- <20

Fig. B2.15
Low rainfall during March 2011 contributed to a rise in fires across the country

Anomaly Value (ºC)

- >3.5
- 2.5 to 3.5
- 1.5 to 2.5
- 0.5 to 1.5
- -0.05 to 0.5
- -1.5 to -0.5
- -2.5 to -1.5
- -3.5 to -2.5
- <-3.5

Fig. B2.16
Low rainfall and high temperatures gave supportive conditions to vegetation fires during the spring of 2011

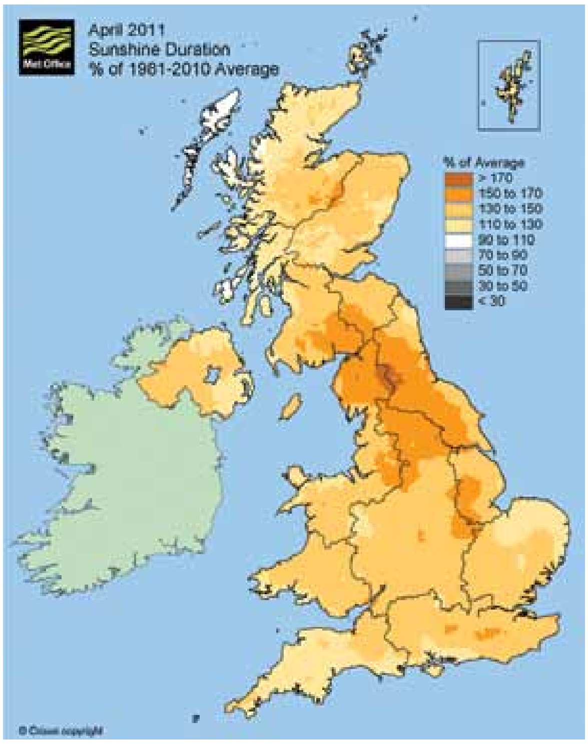


% of Average

- >200
- 175 to 200
- 150 to 175
- 125 to 150
- 75 to 125
- 50 to 75
- 33 to 50
- 20 to 33
- <20

Fig. B2.17
Continued low amounts of rainfall led to increased activity during April and May 2011

This final diagram shows how clear the skies were during April 2011 . This would have a significant impact on the amount of solar heating fuels received and would affect its combustability and increase the intensity of any fire.



% of Average

- >170
- 150 to 170
- 130 to 150
- 110 to 130
- 90 to 100
- 70 to 90
- 50 to 70
- 30 to 50
- <30

Fig. B2.18
Clear skies during April 2011 had a significant impact on the moisture content of fine fuels

8B2.74 FRS risk managers should assess whether sufficient consideration is being given to weather and climate, and its effect on their services. Consideration should also be given as to whether the vast amount of weather data that is already available is being used to its full potential.

8B2.75 Weather and climate assessments can be used by FRSs to judge the potential impact that weather patterns and climate change will have on their organisations.

8B2.76 UK FRSs should begin to assess through their integrated risk management plans and community risk registers, how a changing climate may place different challenges and demands on their services.

8B2 Key Considerations

- Weather conditions that support a drying environment will progressively increase fuel availability and fire intensity. It is therefore important to understand how supportive the weather conditions have been in the days leading up to the event.
- The cumulative effects of the daily weather cycle (on the drying process and on fire behaviour) will peak during mid to late afternoon.
- During extended or prolonged drying environments, it should be anticipated that increases in fire intensity will occur much earlier in the day.
- Wind strength and direction has the predominant effect on fire spread and intensity.
- A fire that is burning in fuel which has been preheated by solar radiation will burn with more intensity.
- An unstable atmosphere will make fire behaviour more dangerous and erratic.
- The approach of a cold front can create unstable atmospheric conditions.
- The levels of moisture in the air should be monitored; relative humidity readings can be used to explain current, and indicate future, fire behaviour.
- The collective effect of high wind (above 30km/h), high temperature (above 30°C) and low relative humidity (≤30%), known as the 30–30–30 rule, can result in extreme fire behaviour and intensity.
- Obtain frequent weather forecasts and specific updates on predicted air humidity, temperature and wind speed.
- At prolonged incidents advantage should be taken of periods when weather is less supportive to fire development, such as early morning, in the evening or during the hours of darkness.

8B3

The Effects of Topography

Introduction

8B3.01 Topography can be described as the configuration of the Earth's surface, including its relief and position of natural and man-made features, arranged across the landscape. In the wildfire environment topography plays an integral part in determining how a fire will develop and spread across a landscape. In wildfire terms, it is the space in which a fire can move comprising the physical shape and positioning of the features within that space. These influences will have a direct and indirect impact on fire behaviour, and if the topographical influences are understood, fire officers can use this knowledge to determine the likely fire severity at different points across the landscape.

Photo B3.1
The shape of the terrain will influence fire behaviour

Topographical Influences

8B3.02 Topography should be considered to be a fixed or known factor that will influence variables such as fuel types, quantities, relative humidity, wind speed and direction, and the potential size and shape of the fire footprint. In addition, topography plays an important part in fire intensity, direction and rate of travel.

8B3.03 The shape of the landscape has a direct effect on the ability of the surface to interact with the sun, allowing some areas to become warmer and dryer while others remain cooler and damper. These variations can affect localised areas or cover larger parts of the landscape; in some situations this can cause rapid changes to fire behaviour.

8B3.04 Water drainage has also altered the shape of the landscape forming re-entrants such as valleys and gullies. These influence wind speed and direction, also providing habitats that alter the types and quantities of fuel within them.

The Profile of the Landscape

8B3.05 The shape of the landscape will influence wildfire behaviour in a number of important ways and consideration should be given to the following:

- **Orientation and angle of slope in relation to the position of the sun**
- **Steepness of slopes**
- **Shape of the topographical features**
- **The effect of topography on the types and amounts of vegetation**
- **Water drainage features**
- **The effect of topography on wind direction and its strength**
- **Barriers to fire travel such as tracks, roads, streams, rivers, wetlands and other fire obstacles**

Photo B3.2
Showing changes that can occur across the landscape

The Effect of Aspect

8B3.06 Aspect can be described as the direction the surface of the ground is facing in relation to its orientation with the sun. Generally, southerly-facing slopes become warmer and drier throughout the day, whilst northerly-facing slopes remain cooler and damper.

8B3.07 Although the angle of a slope is fixed the amount of solar radiation received will vary depending on the time of day and the position of the sun.

8B3.08 The amount of solar radiation the surface absorbs has a direct influence on the temperature and humidity of the air and therefore the combustibility of available fuels. As a general rule, fires that occur in fuels that have been subjected to more solar preheating will be more intense.

8B3.09 The diagram B3.1 above shows the direct relationship between temperature and relative humidity, as the temperature rises the relative humidity falls, this effect on the general landscape peaks in the afternoon but the timing of this will vary depending on the time of year.

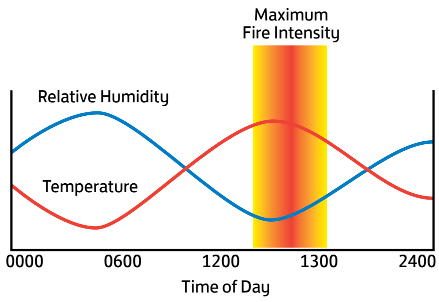


Fig. B3.1
Diagram of how flammability of fuels can change throughout the day

The Sun's Position

8B3.10 South-eastern-facing slopes will be warmer in the morning, drying out the fuels earlier in the day. South-western-facing slopes warm later when the sun moves into alignment. Fuels on these slopes are likely to continue to increase in temperature during the day until late into the afternoon.

Photo B3.3
Showing the south-westerly-facing slope being warmed during the afternoon

The Effect of Slope

8B3.11 Slopes can assist or hinder fire development in a number of ways, they can be in or out of aspect which will affect air and fuel temperature and the steepness of a slope also influences fire spread and intensity.

8B3.12 When a fire moves across level ground or downslope most of the heat generated by the fire (in the absence of wind) will be lost to the atmosphere.

8B3.13 When a fire moves onto an upslope, the slope will assist the fire's development and increase its efficiency, accelerating the combustion process. The fuel is brought closer to the flame by the angle of the slope and this is then subjected to more preheating. The steeper the angle of the slope the more preheating the fuel is subjected to.

8B3.14 Depending on the actual gradient of the slope, the convection plume will penetrate into more of the vegetation ahead of the fire front, drying out the air and also raising the temperature of the fuels, particularly the finer ones. This preheating of the vegetation is not limited to the surface fuels, but can also include aerial fuels, particularly those in the canopy; this can greatly increase the ease of ignition of these fuels. The longer and steeper the slope, the more influence this process will have leading to an increase in intensity. Fires on steep slopes will normally develop a narrower and more intense head fire.

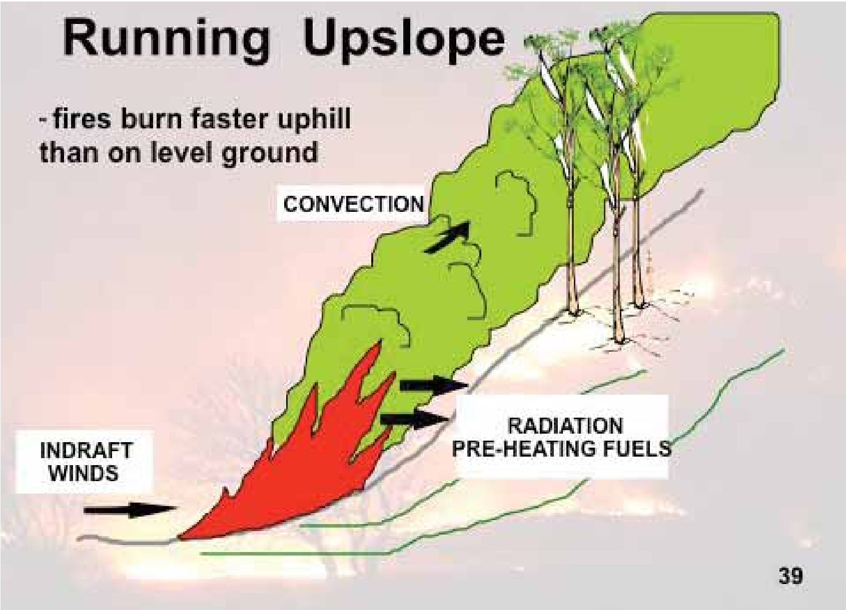


Fig. B3.2
A Fire that is burning upslope is able to transfer its energy to the un-burnt fuel and is classed as being in alignment with the slope

Fire Position on a Slope

8B3.15 The position at which a fire starts on a slope is important; generally fires that start nearer the base of a slope become more intense. This is due in part to the fire remaining in alignment with the slope for a longer period; this allows the fire more time to heat up the fuel and air in the fire's path. A fire moving upslope will generally increase in speed and intensity, as it progresses up the gradient, the steeper the slope the faster the acceleration.

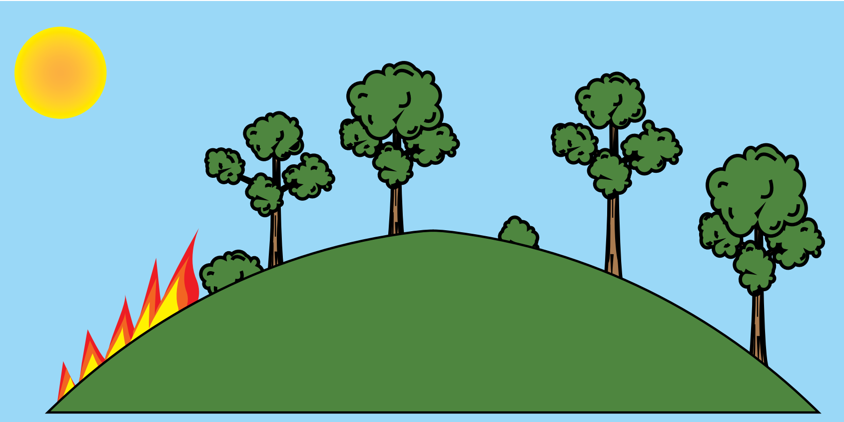


Fig. B3.3
Fire that is burning upslope will burn faster and with more intensity

Fires Burning Downslope

8B3.16 When a fire burns downslope the process is almost reversed with a widening of the gap between the available fuel and the fire, the movement of the fire will slow and its intensity will reduce.

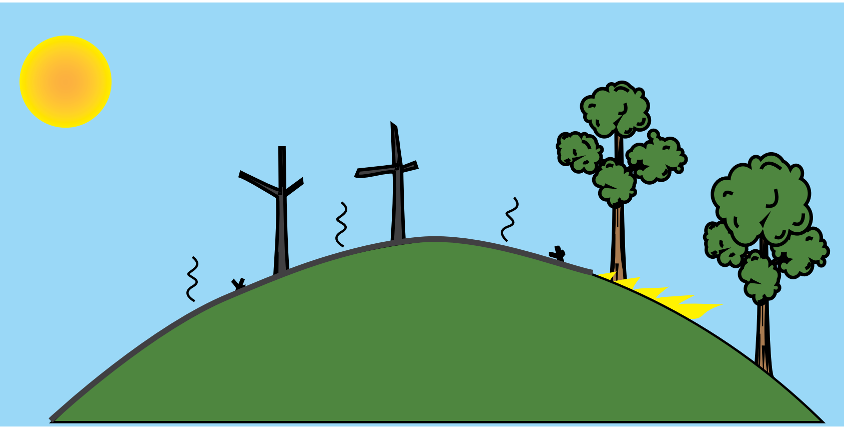


Fig. B3.4
Fire that is burning downslope is not able to transfer energy to unburnt fuel as effectively as an upslope burn and will burn with less intensity

8B3.17 A significant hazard for firefighters working on a slope in un-burnt fuel is burning material may roll down hill and ignite fuels behind them, with the result that they can become trapped between the two fires.

Slope Reversal (upslope to down slope)

8B3.18 Slope reversal is a term used to describe a situation where a fire changes its alignment with slope. This can happen when a fire that has been moving upslope reaches the top of a hill and then starts to move downslope. Once burning against the slope the fire changes its behaviour, and unless supported by a strong wind will normally significantly reduce its intensity. Most of the heat generated by the fire is lost to the atmosphere and the change in fire alignment causes a significant reduction to the fire's rate of spread.

Photo B3.4
A pre-slope reversal low-intensity fire

Slope Reversal (downslope to upslope)

8B3.19 This second scenario is much more dangerous and occurs when a fire that is backing downslope reaches a point where it can start to turn and burn upslope. This change can result in a dramatic and sudden increase to the intensity and speed of the fire, this type of reversal should be considered to be particularly hazardous.

Photo B3.5
Showing a significant increase in fire intensity due to the fire now burning upslope

8B3.20 Another, and possibly more dangerous situation, is where a fire is backing downslope and moving against the wind. The appearance of the fire can be very deceptive – sometimes demonstrating very limited intensity. Should any part of the fire move into a position where it finds alignment with the slope and wind, then it may make a run back upslope through any unburnt fuel. This can result in a rapid and high intensity head fire that can develop in the opposite direction of the backing fire which may compromise the safety of firefighters that are positioned upslope.

8B3.21 Dangerous locations where these changes may occur should be proactively identified and used as trigger points (indicators) to highlight the necessity to review safety issues and operational tactics.

The Shape of Slopes

8B3.22 The shape and angle of a slope will affect the ease in which the fire is able to transfer heat to existing vegetation.

Slopes are termed to be:

- **Straight**
- **Concave**
- **Convex**

Straight Slopes

8B3.23 A straight slope has a near constant angle that results in a more predictable rate of spread. Any increase in speed or intensity will be due to the effect of preheating of fuels or changes to vegetation or its arrangement.

Personnel at the top or at the base of the slope should have an unobstructed view of the slope's surface and the fire unless this is limited by other factors such as vegetation.

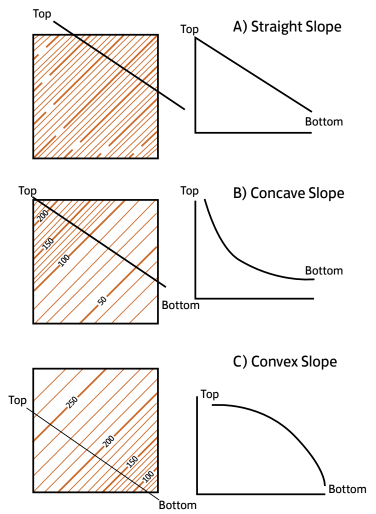


Fig. B3.5
The shape of slopes can affect fire spread and intensity

Concave Slopes

8B3.24 Concave slopes are ones that have an increased angle of slope nearer the summit; this can result in a significant increase in fire intensity as the fire moves upslope. A fire moving downslope will gradually increase in intensity as the angle of the slope decreases nearer the bottom where more heat can be transferred to the unburnt fuels. A concave shaped slope should not affect line of sight when standing at the bottom or top of the slope.

Convex Slopes

8B3.25 Convex slopes have a steeper angle at the base compared with the summit; therefore the fire is likely to be more intense at the base of the slope. As the fire moves upslope the angle of slope lessens and the amount of heat transferred to the unburnt fuel is reduced.

8B3.26 If a fire is moving downslope the angle between the fire and the fuel is increased resulting in a decrease in potential fire development. Due to the shape of this type of slope, personnel may have their view of the fire obstructed. In particular personnel at the base or at the top of the slope may not be able to observe the fire at all.

Photo B3.6
The feature shown in the photograph has all three types of slope in evidence

Topographical Features

8B3.27 The shape of the landscape can influence fire behaviour in a number of significant ways. One of the most important topographical influences is on wind which can be channelled and funnelled through and along features of terrain; this may alter its direction and strength.

Hills

Photo B3.7
Showing a hill

8B3.28 The slopes forming the sides of a hill will either support or hinder fire development depending on whether a fire is burning up or down slope.

On the ground definition:

"A hill is an area of high ground. From a hilltop, the ground slopes down in all directions. A hill is shown on a map by contour lines forming concentric circles. The inside of the smallest closed circle is the hilltop."

Saddles

Photo B3.8
A saddle is shown in the foreground

8B3.29 Saddles are identified as a curvature in the landscape formed between two areas of higher ground. The wind passing within saddles tends to concentrate and can fluctuate or alter direction.

On the ground definition:

"When in a saddle and facing forward there will be an uphill slope in front of you, an uphill slope behind and downhill slopes to your left and right. On a map the contour lines might look something like an hourglass."

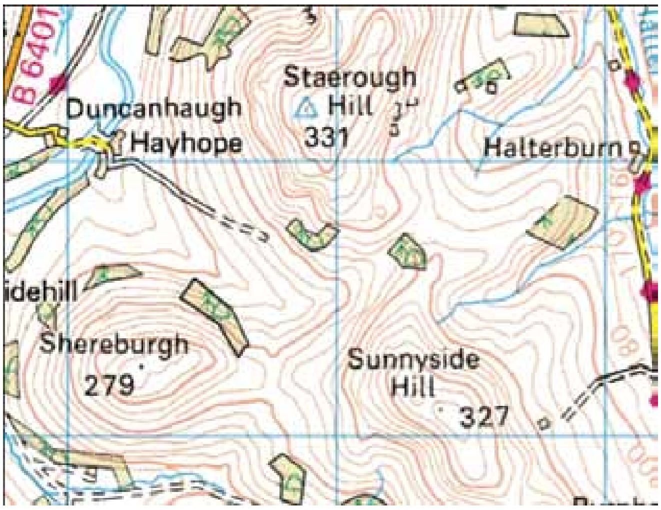


Fig. B3.6
Showing how hills and saddles are represented on an OS map, the shape of this terrain could easily alter wind direction and strength

Spurs

8B3.30 Spurs are often steeper than the slopes that surround them and this may alter a fires speed, direction and intensity.

On the ground definition:

"When heading up a valley spurs will often look like steeper ground sticking out of the surrounding slope, at the end of which will be a steep slope dropping into the valley. From above, spurs will not seem as steep as the surrounding slope and have increasingly larger slopes running downhill to the left and right of it, with a steep slope at its end."

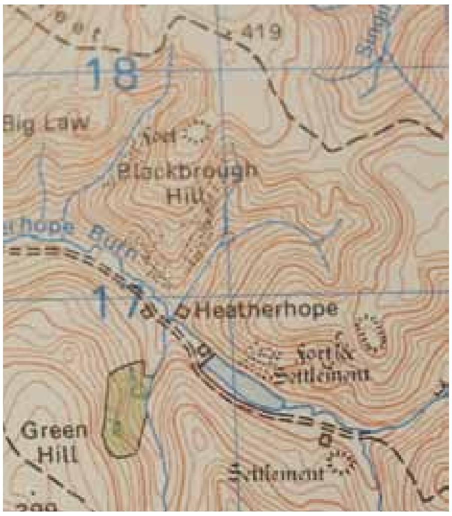


Fig. B3.7
The contours on the map show a number of spurs on the landscape formed between re-entrants

Ridges

Photo B3.9
Showing several ridge lines

8B3.31 Ridges are features formed between two opposing slopes. They are sometimes the most suitable locations to construct a fire break because when the fire reaches the ridge line it loses alignment with the supporting slope and its intensity and rate of spread will reduce.

On the ground description:

"When standing on the centre-line of a ridge, you will normally have low ground in three directions and high ground in one direction with varying degrees of slope. If you cross a ridge at right angles, you will climb steeply to the crest and then descend steeply to the base. When you move along the path of the ridge, depending on the geographic location, there may be either an almost unnoticeable slope or a very obvious incline."

Water Drainage Features

Re-entrants

Photo B3.10
A number of re-entrants formed by drainage features

8B3.32 Re-entrants are normally drainage features with slopes on either side. They can have a significant effect on fire behaviour as they can act as a chimney channelling the wind and concentrating its strength. They are often critical points on the landscape allowing fire to alter its direction and speed of travel.

On the ground description:

"When facing up a valley there will be smaller valleys running uphill to your left and right. These will become smaller and may look like folds in the landscape the higher up the valley you go."

Gullies

Photo B3.11
Showing a steep-sided gully

8B3.33 A Gully is a re-entrant feature that has been formed by running water which can cut sharply into the ground, often the sides can be very steep. This type of feature can cause what is termed to be the chimney effect acting as a funnel for winds to follow and in certain situations concentrate its strength. This can increase fire intensity and rate of spread along these features substantially.

8B3.34 In narrow gullies, as a fire moves down one side the heat generated can preheat the fuel on the opposite side resulting in a much more intense fire if slope reversal occurs.

On the ground description:

"Having already gone up a slope there will be a steeper, narrowing in front of you, and steeper uphill slopes on either side. There may be water running down the gully and some scrambling or climbing might be needed to get up it."

Photo B3.12
Steep-sided gully

Valleys

Photo B3.13
A narrow valley

8B3.35 The main effect of valleys is in the way they can alter the direction and strength of the general wind, normally the wider the valley the less concentration of wind strength although this might increase as the wind moves upwards where the valley is narrower.

On the ground description:

"Valleys drop from higher ground and generally become broader as they lose height. When standing in one they can have steep, even slopes, narrower near the end of a valley, though they can also be wide, with a gentle curve on either side getting slowly steeper."

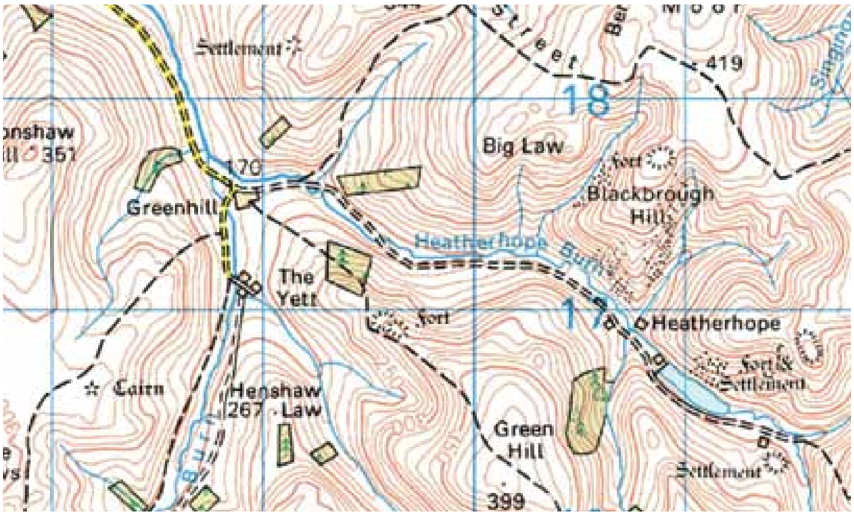


Fig. B3.8
An example of how valleys are shown on a map

8B3.36 Contour lines forming a valley are either U-shaped or V-shaped. To determine the direction water is flowing, look at the contour lines. The apex of the contour line (U or V) always points upstream or toward high ground, and contour height numbers are always orientated up the slope.

The Effect of Topography on Vegetation

Photo B3.14
Changes in the direction a slope faces can influence fuel arrangement and continuity

8B3.37 The orientation of a slope affects the amount of sunlight it will receive. In the short term this can affect the temperature and moisture content present within available fuels. In the longer term it can influence even the type and condition of fuels growing on different slopes. Southerly facing slopes are normally warmer and dryer while northerly facing slopes are cooler and damper.

8B3.38 These variations create microclimates that can influence the species that will colonise different parts of the landscape. The soil found in re-entrants is normally damper and this encourages more vegetation growth which may lead to heavier fuel loading.

Wetter areas of the landscape can often be identified by the vegetation types that grow on it.

The Effect of Topography on Wind

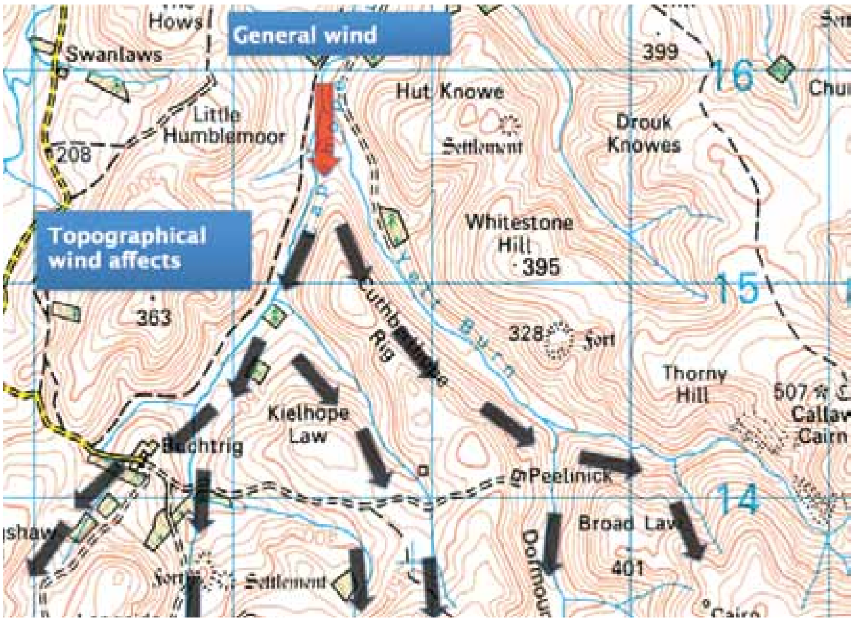


Fig. B3.9
This shows the way in which the shape of the terrain can influence wind direction and strength

8B3.39 The illustration above demonstrates how the wind can be influenced by the lay of the land. The terrain can channel wind along valley's and re-entrants sometimes causing it to significantly change its direction. Narrow valleys and gully's can funnel and accelerate the wind increasing its influence on fire behaviour.

Photo B3.15
Terrain will affect the direction and strength of wind

Barriers to Fire Travel

8B3.40 A landscape may contain areas that will restrict fire travel. A barrier is any area where there is a break in the horizontal fuel arrangement that prevents fire spread. Natural or man-made features can cause this break in continuity. Barriers to fire spread should, wherever possible, be taken advantage of within any suppression plan.

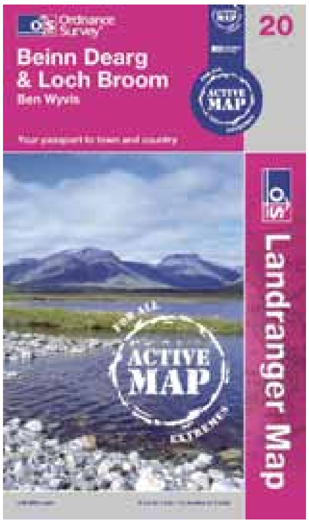
8B3.41 Common barriers to fire spread include:

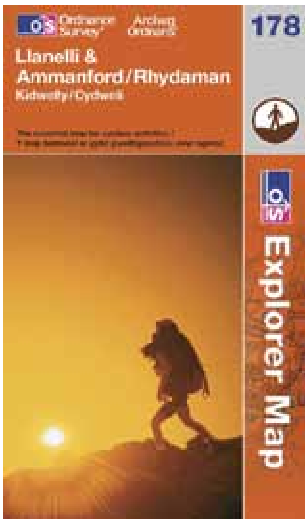
- **Rock outcrops or cliffs and bare patches of land.**
- **Lakes, rivers, streams and wet areas of land.**
- **Changes to the fuel type, its condition or moisture content. An example of this might simply be an area of wet, green grass.**
- **Roads, tracks or other man-made barriers that prevent fire spread.**
- **Tactical control lines either dug into the soil or burnt into the vegetation.**

Photo B3.16
An outcrop of rock that has broken fuel continuity and could prevent fire spread

8B3
Key Considerations

- The shape of the topography has a direct impact on the drying environment; fuel that is in direct sunlight will be warmer and dryer than fuels that are not.
- Warmed air will move upslope during the day and cool air will fall downslope during the night.
- Slope has a major impact on fire behaviour and an upslope will cause a fire to increase its intensity and speed.
- The steepness of a slope has an incremental effect on fire behaviour and its speed.
- Fire intensity and rate of spread normally reduces when fires are burning downslope.
- When constructing fire breaks look to take advantage of reverse side of ridges whenever possible.
- Gullies and Re-entrants can be dangerous – having personnel working in them should be avoided due to the danger of the ‘chimney effect’.
- Barriers such as rivers, rock outcrops and roads can often prevent fire spread and, whenever possible, should be incorporated into the tactical fire plan.
- Parts of a fire burning downslope may find an alignment that allows it to make a run back up the slope presenting a danger to personnel working above the fire in unburnt fuels.
- The shape of the terrain will have a significant impact on fire behaviour; plan to take advantage of areas where intensities will be low and avoid areas where fire intensities will be high.
- Topography will influence wind speed and direction, be aware of local conditions and remain alert to possible change.
- Southerly-facing slopes will generally be warmer and dryer than those that face towards the north.
- Eastern-facing slopes warm early in the day; western-facing slopes are warmer in the afternoon.





8B4

The Understanding and Use of Topographical Maps

Introduction

8B4.01 Some of the wildfire issues that UK FRSs are required to address are complex; others such as acquiring an appropriate standard of map reading and navigational expertise are simpler. One thing is certain however, without the basic skills to operate effectively within a spatial environment, operational capabilities at a wildfire incident will be limited.

8B4.02 Maps are not only a navigation tool, they can also be used to improve the incident command system, address safety issues and assist in formulating a more complete understanding of the operational environment. Unless FRS personnel are trained in the basic skills necessary for them to operate at incidents that take place within the wider rural environment, there will be an inherent weakness in FRS response capability. In addition, Section B7 shows how maps can also be used to assist the Incident Commander to effectively sectorise a wildfire incident.

The Use of Maps at Wildfire Incidents

8B4.03 Wildfires usually occur in more rural or even remote rural areas. As a result the use of maps during these incidents is both necessary and unavoidable. All FRSs should provide personnel with training that is appropriate to the identified risk, thus ensuring that these invaluable aids are used to their full potential.

Maps can be used as:

- **A navigation tool**
- **A safety tool**
- **A planning tool**

Maps as a Navigation Tool

8B4.04 An Ordnance Survey (OS) map is a useful navigation tool that can be used to identify features on the landscape, such as roads, tracks, buildings and structures, different vegetation types and the lay of the land. All of these can be used as points of reference to identify what is actually seen on the landscape and the features' position on it.

8B4.05 Importantly, maps can be used to measure or estimate distance and travel times. When used in conjunction with a compass they provide an accurate method of navigation.

8B4.06 An understanding of how to use maps as a navigation tool, provides personnel with the expertise to safely move across the landscape, and allows officers to identify any hazards that may pose a risk to the personnel they have responsibility for. At a wildfire, or indeed at other types of spatial incidents, it is essential that individuals have skills that allow them to quickly travel to the scene of operations. FRSs should have sufficient numbers of personnel that have appropriate navigational skills.

Maps as a Safety Tool

8B4.07 A map is an accurate representation of an area of ground, providing risk critical information that can be used to improve safety at a wildfire incident. Maps show the shape of the terrain and give important information on locations where fire behaviour may alter. This might include such things as the steepness of slopes, changes in vegetation types, or locations where fire alignment may change. Maps therefore play a crucial part in identifying the risks that may be encountered during a wildfire event.

8B4.08 The information contained on a map can assist in maintaining a high level of understanding of the operational environment and help establish a raised level of situational awareness. The ability to read maps plays an important role within the risk assessment and the decision making processes. This guidance also encourages the use of the LACES safety protocol (see Section B7) at wildfire incidents; having an understanding of maps is an integral part of this safety system. Maps provide essential information for lookouts, assist in the communication process and can be used to help plan escape routes and safety zones.

Maps as a Planning Tool

8B4.09 At a wildfire incident maps must be utilised as a planning tool as they are an indispensable aid to effective incident command. The effective use of maps within the planning processes will assist in the formulation of an effective suppression plan. Personnel on the incident ground can also use their understanding of maps to relay important intelligence to incident commanders.

8B4.10 Maps can be used to assist in deciding what tactics should be used at a wildfire incident. Information provided on a map includes intelligence on the following:

- **Changes to fuel**
- **Critical points**
- **Steepness of slopes**
- **Aspect**
- **Windows of opportunity**
- **Fuel breaks**
- **Areas of habitation**
- **Natural or man-made control lines**
- **Other obstacles to fire travel**

8B4.11 These can be used to identify changes to fire behaviour as it moves over the landscape, and by applying the Wildfire Prediction System (see Section B6) to a map, it is also possible to construct a fire footprint that will identify likely fire travel.

Map Reading and Navigational Skills

8B4.12 FRSs managers must consider the risks posed to operational personnel by local geography, and ensure that suitable training is provided. It would, however, be impractical to suggest that every firefighter should be trained to an accredited standard of navigation.

8B4.13 Nevertheless, if FRS personnel are expected to operate at incidents that take place in rural or remote areas, they should be provided with appropriate expertise relevant to their role. They should also be supervised by well-trained officers who have the expertise to effectively manage resources during a spatial incident.

Essential Understanding of Maps and Navigation

8B4.14 Firefighters who may have to operate at spatial incidents should understand:

- **Map scales, contour lines, symbols, and grid squares**
- **How to give a four- and six-figure grid reference**
- **How to orientate a map to the landscape**
- **How to recognise features of terrain**
- **Cardinal directions**
- **How to estimate distance**
- **How to follow paths and tracks on the landscape that are identified on a map**
- **How to understand the use of the Global Positioning System**
- **Mobile data**

Advanced Navigation

8B4.15 If it is necessary to leave recognised paths and tracks it is essential that personnel possess, or are supervised by individuals that have more advanced navigational skills. These should have the expertise to:

- **Take a compass bearing from a map**
- **Use a compass to follow bearings accurately over short distances of open ground**
- **Accurately estimate distances and travel time**
- **Accurately measure distance using double pacing**
- **Plan and follow a safe route over short distances**
- **Understand how to use features of terrain as reference points**
- **Select an appropriate speed of travel**
- **Lead groups of people that operate on the ground**

Specialist Navigation

8B4.16 Officers with specialist knowledge of navigation can provide additional support at incidents that pose higher levels of risk.

These should have the expertise to:

- **Use landform features as a method of navigation**
- **Use contour information to understand the positioning of landscape features**
- **Use a compass to navigate across long distances of open ground**
- **Use compass bearings to navigate across intricate terrain**
- **Use a compass to move around obstacles that force a deviation from a planned route**
- **Navigate in darkness**
- **Use back bearings to confirm position**
- **Use contour information to confirm personal position and as a method of navigation**

Ordnance Survey (OS)

8B4.17 Ordnance Survey (OS) is a non-ministerial government department and an Executive Agency responsible to the Secretary of State for Communities and Local Government. OS has a number of agreements with the public sector including the One Scotland Mapping Agreement, and the Public Sector Mapping Agreement for England and Wales. There are various types of maps including, digital and paper based, which can be utilised by FRSs under the public sector agreements. This guidance provides information on the use of OS paper maps which provide accurate geographical information.

Topographical Maps

8B4.18 A topographical map is a simplified bird's-eye view of a piece of ground, drawn to scale and showing physical and man-made features present on the ground. Information is presented in a unique format, through the use of symbols depicting various features, which are explained in the map legend, colours and shading, and contour lines which join points of equal height defining the shape of the terrain. OS maps also give direction, as all maps are orientated towards the north and have a positioning referencing system which is part of a geographical grid system.

The OS National Grid System

8B4.19 It is important that all FRS personnel are able to understand a topographical map and use the information available on it. At a wildfire incident, they must also have the ability to pinpoint their location using a map, and understand the positioning of features of terrain both on a map and on the landscape. A useful way of communicating an accurate position is by using grid referencing.

8B4.20 The British National Grid is a geographical grid referencing system that is used to divide the country into about 50 100km x 100km squares. These are either referenced numerically or alphanumerically. Each of these 100km grid squares is uniquely numbered from the bottom left corner of the UK and also has a unique 2 alpha character code. The alpha characters are not always marked on Ordnance Survey Landranger or Explorer maps so can be difficult to reference. The numeric system is always referenced on all OS maps and is therefore more reliable. Electronic systems, such as those used in Mobile Data Terminals (MDTs), use this system and it is referred to as a 12-figure grid reference.

It is normal to reference printed maps with the alphanumeric system if known and the most common form of this is the six figure grid reference. Various ways of expressing alphanumeric references are described below.

8B4.21 Positioning within large areas is focused by dividing each of the 100km grid squares into 10km-wide grids. These are identified by adding a two-number grid reference to the alpha code, for example TL-63. This identifies a 10km x 10km square grid (100km^2) found 60km east and 30km north of the south-west corner of the TL grid square. (All grid squares of whatever size are identified by using the vertical and horizontal lines that intersect at the south-west corner of the square in question). As greater accuracy is required, each square is further sub-divided by 10 from 10km to 1km to 0.1km and so on.

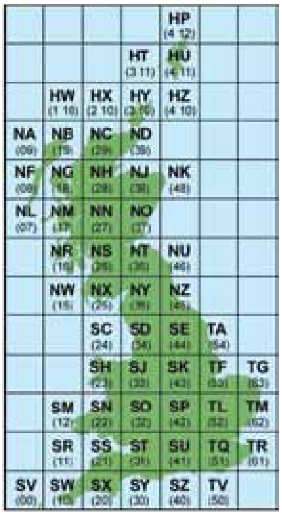


Fig. B4.1
The OS National Grid

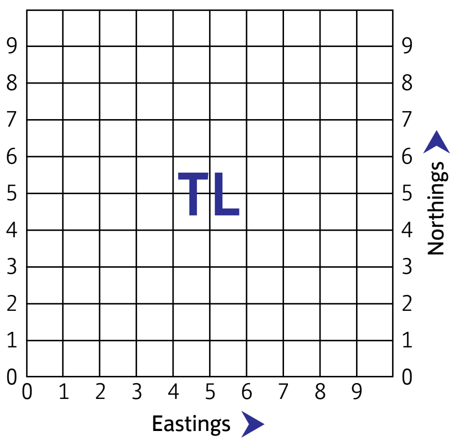


Fig. B4.2
Grid square

OS Map Grid Squares

8B4.22 OS maps are covered in a series of faint blue lines that make up a square kilometre ($1km^2$) grid. The lines have a number accompanying them that can be used to pinpoint positions on the map.

Photo B4.1
Showing grid squares and grid numbers

The grid numbers can be located along the edges of an OS map on the margin and also at 10km intervals on the map itself.

Photo B4.2
Grid numbers running across the map

Grid Referencing

8B4.23 The horizontal lines going across the face of the map, left to right or west to east are called Northings, i.e. line 45. All the lines going from the bottom to the top of the map, or from the south to the north are called Eastings, i.e. line 19. When giving a grid reference the Eastings number must always be given first followed by the Northings number.

8B4.24 During operations at a wildfire four- and six-figure grid references will be commonly used to identify positions on a map or on the landscape. Operationally, it is important that all FRS personnel are able to understand how to use grid referencing.

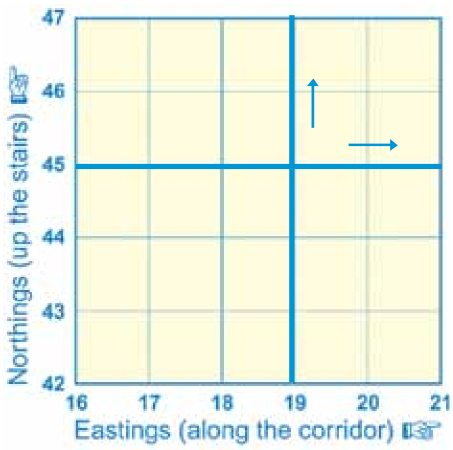


Fig. B4.3

Four-figure Map References

8B4.25 Using the numbers that identify each Eastings and Northings line, a four-figure reference number can be used to identify each individual km^2 contained within the blue grid lines shown on an OS map. The reference is always given from the bottom left corner of the grid square.

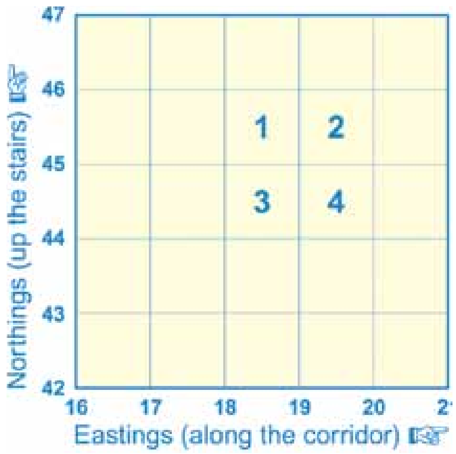


Fig. B4.4

For example, the number 2 in the diagram below is **19** across and **45** up and therefore the four-figure grid reference is **1945**.

The numbered squares on the diagram would have the following four-figure grid references:

1 = **1845**

2 = **1945**

3 = **1844**

4 = **1944**

Six-figure Grid Reference

8B4.26 A six-figure grid reference simply allows more accuracy by sub-dividing each square into tenths; this is physically not shown on a map but can easily be estimated. Using the example below, the grey box is positioned within the square **1844**. More accurately it is 7-tenths across and 8-tenths up within grid square **1844**. Therefore it has a six-figure grid reference of **187448**. It is important to note that a six-figure grid reference is not unique as it will be represented within each of the 100km grids. If there is a need to make it unique then it must be prefixed with the alpha characters previously described. Therefore the grid reference would become **TL 185443**.

The red shape is located at six-figure grid reference **185443** or **TL 185443**.

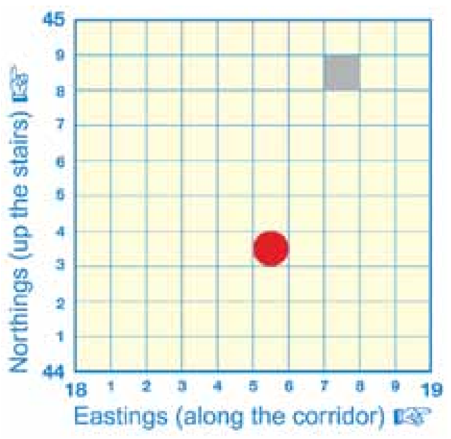


Fig. B4.5

Ordnance Survey Explorer and Landranger Maps

8B4.27 Both the Explorer and the Landranger paper maps provide extensive geographical information and present this in a similar, but not identical, format. It is important to understand that OS maps do not cover a 100km x 100km national grid square but are considerably smaller. They may cover areas that are within more than one national grid square and these are identified on the map.

The OS Explorer Map

8B4.28 Great Britain is covered by 403 separate explorer maps which use a 1:25000 scale, this equates to 4cm to a km or roughly 2½in to a mile. They show considerable detail which is useful in connection with navigation but can make the interpretation of relief, particularly contour detail difficult to read. Explorer maps do not cover as much area as those covered by the Landranger maps.

Photo B4.3

The OS Landranger Map

8B4.29 There are 204 Landranger maps each covering an area of 40km by 40km, they use a 1:50000 scale which equates to 2cm to a km, or roughly 1¼in to a mile. These are less detailed than the OS 1:25000 maps and do not show walls or fences which are useful indicators when navigating. Due to their increased scale they can be easier to read, particularly in relation to relief.

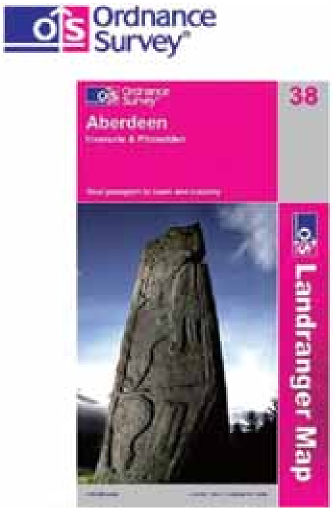


Photo B4.4

Information on a Map

8B4.30 There is a huge amount of useful information on a map, but a lot of it is in a form that needs to be interpreted. Therefore, all OS maps have some explanatory information which is available in the form of a legend. This provides details on how features are represented and on the different symbols used.

See Appendix 2 showing Legend of 1:50000

See Appendix 3 showing Legend of 1:25000

Topographical Information

8B4.31 Maps give an accurate interpretation of the relief found on a landscape. This information is presented in a unique format that proves to be exceedingly useful during wildfire incidents. There are various mapping systems available for use, but topographical maps prove to be the most useful.

8B4.32 Nevertheless, the gathering of relevant intelligence is essential if fire service managers are to formulate effective plans, therefore all relevant means should be used. Visual aids such as aerial photography is now easily obtained and, wherever possible, should be utilised at incidents alongside topographical maps.

Photo B4.5

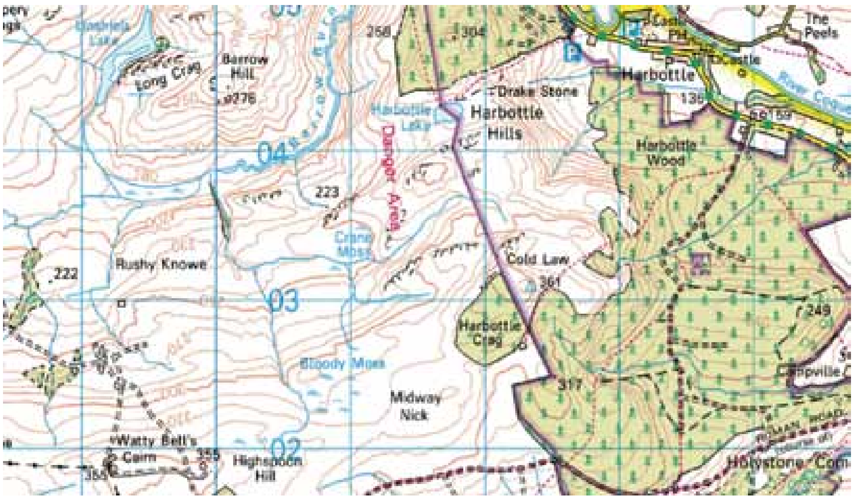


Photo B4.6

8B4.33 The illustrations above show the contrast between topographical maps and aerial photography, each show a representation of same area, but provide different information. Topographical maps are in a format that displays data that is strongly related to relief, accurately showing the shape of the landscape and the position of features on it. Distances can be easily measured using the relevant 1:25000 or 1:50000 scales. Aerial photography presents a visual representation that can give more detailed information on fuel and in particular its horizontal arrangement. It also identifies features that may not be included on a topographical map such as clearings, informal tracks or paths, or changes in land use across the landscape. When referring to either topographical maps of aerial photography, it is crucial to appreciate that older material may contain inaccurate information. An example of this is the changes that occur to woodland, where trees may have been planted or harvested.

Understanding Contours

8B4.34 Contour lines are used on topographical maps to define the shape and height of the surface of the ground. The lines are shown as faint orange or brown lines that join together points of equal height. These lines are separated by what are termed to be vertical intervals, or measured height differences between each line. On a 1:50000 scale map this is always 10-metre intervals.

8B4.35 On a 1:25000 scale map the contours are normally 10 metres, but the interval can be 5, 10 or 20 metres depending upon the prevailing terrain.

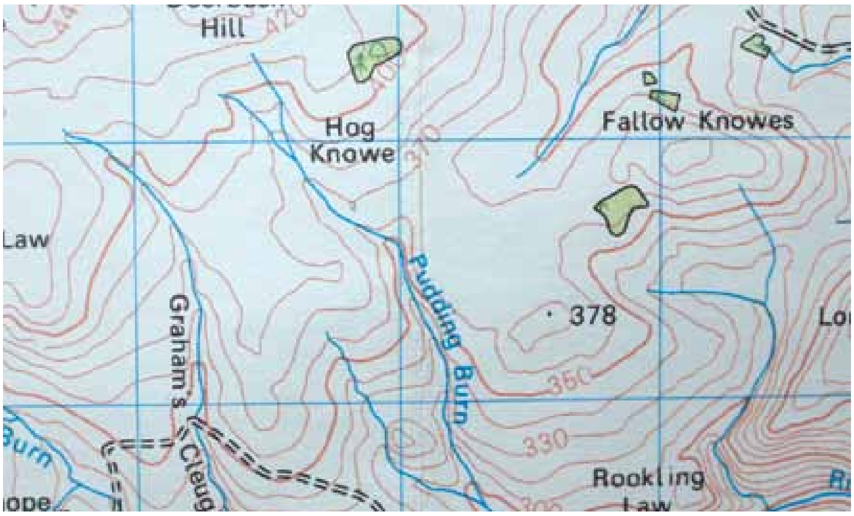


Photo B4.7
Showing contours on an Explorer map

8B4.36 In mountainous areas this interval may be greater; this is to prevent the insertion of too many contour lines into a small space.

Photo B4.8
Showing the contour interval

Upslope and Downslope

8B4.37 How contour lines display upslope and downslope is important, as it is this information that allows an interpretation of the shape of the ground. Contour lines show a number indicating height in metres, which is always displayed as an ascending value. If the numbers increase in value this denotes an uphill slope and as the value decreases they indicate a downhill slope. Usefully, the top of the number is always printed so that it points upslope, while the bottom of the number points downslope. To make maps easier to read, each fifth contour line is drawn thicker, and is known as an Index Contour Lines.

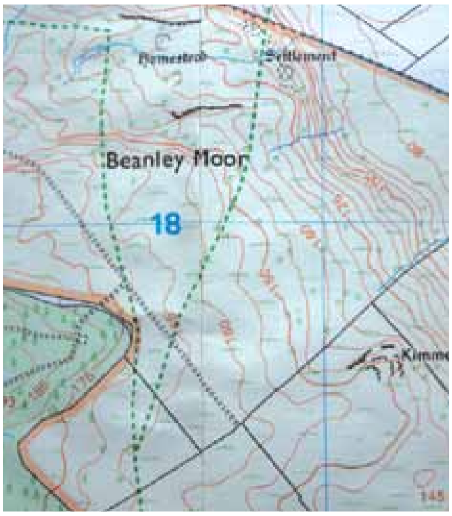


Photo B4.9
The direction of a slope is indicated by the contour interval numbers

8B4.38 Where contour lines are placed close together they represent a steep slope, where they are further apart the ground is more level. This gives a very accurate representation of the shape of the landscape.

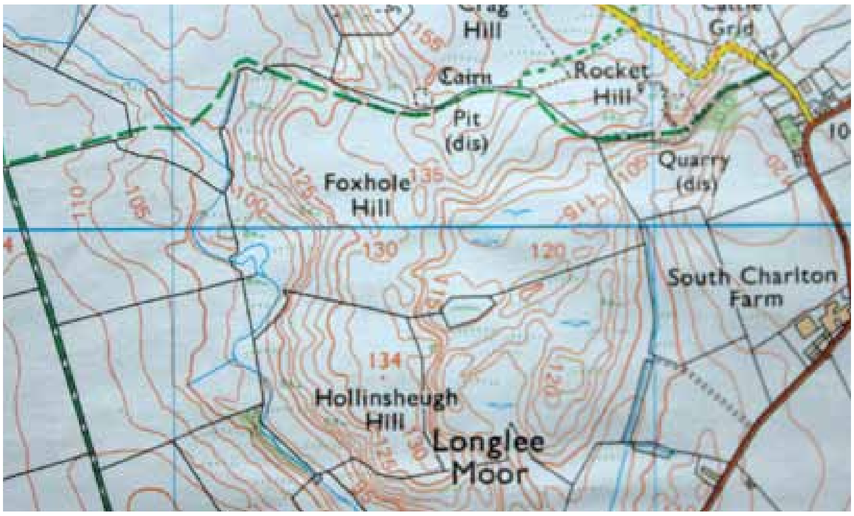


Photo B4.10
Contour line showing detailed terrain information

Interpreting Relief

8B4.39 Having an understanding of the shape of the ground is extremely useful during wildfire incidents. This information is important when formulating a plan or carrying out an operational task on the fire ground. Differentiating between upslope and downslope is particularly useful and by making reference to the shape of contour lines it is possible to understand topographical features. This can help determine the influence the terrain may have on fire development. The patterns formed by contour lines give a visual representation of the shape of the landscape. By making reference to these contour patterns, hills, valleys, re-entrants, ridges, spurs, and other ground features can be recognised.

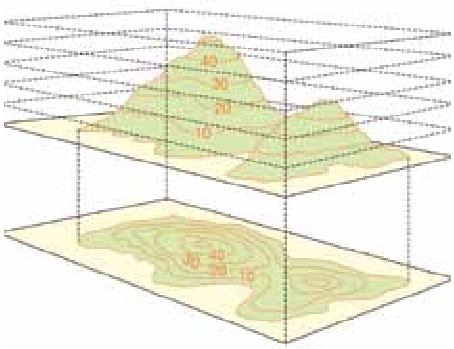


Fig. B4.6 The contours indicate the profile of the landscape

8B4.40 The relationship between higher and lower contours and the distance between them can give you valuable clues about the shape of the surface on the ground.

- **Decreasing ring contours denote a summit or basin, but inside a circle is normally higher ground**
- **Flat areas have very few contour lines**
- **Contours placed very close together indicate a very steep slope**
- **V or U contour shapes pointing uphill indicate a re-entrant**
- **V or U contour shapes pointing downhill indicate a spur**
- **Contours descending on either side of a line show a ridge**
- **Contours grouped together on either side of lower ground normally indicate a valley**

8B4.41 Contour lines show patterns that indicate the horizontal and vertical shape of the surface of the ground, at a wildfire this can help identify parts of the landscape where:

- **the rate of fire travel may increase or decrease**
- **there will be a change to fire intensity**
- **a fire is in or out of alignment with slope**
- **parts of the landscape are in or out of aspect**
- **wind direction may change**
- **wind strength may increase**
- **parts of the landscape that will have a critical effect on fire behaviour**
- **points on the landscape will trigger changes to fire behaviour which may result in a re-assessment of suppression tactics**
- **routes may be identified to get to and from the scene of operations**
- **safety zones can be located**
- **escape routes can be found**

Calculating Distance on a Map

8B4.42 Distances on a map can be calculated using a number of different methods; these provide a varying degree of accuracy.

Measuring Distance Using Grid Squares

8B4.43 Grid squares on a map offer a quick method to estimate distance. Each one of the grid squares represents a distance of 1km along its edge, or 1.4km when measured diagonally from corner to corner. By counting the number of grid squares between two points, and adding 100 metres for every tenth of a grid square, a rough calculation of distance can quickly be made.

Using Map Scales to Measure Distance

8B4.44 The scale used on a map is a ratio between map unit and ground unit, any measurement taken from a map can therefore be converted into actual distance. A ruler can be used to accurately measure the distance between two points, this measurement can then be converted by using a maps linear scale. On a 1:50000 OS map this equates to 1cm to 50000cm, or 1cm to 500 metres. On a 1:25000 OS map it is 1cm to 25000cm or 1cm to 250 metres. All OS maps have a linear scale which is located along the bottom margin.

8B4.45 In reality, it is unlikely that personnel will be able to proceed across terrain using a direct route. It should be acknowledged that there are methods for measuring indirect routes which may give a more accurate assessment of the distances to be travelled. For example, indirect distances can be measured using measuring wheels, digital mapping software or even a length of string.

Map Ratios

Ratio = 1:25000		25000cm on the ground
	1cm	250 metres on the ground
		0.25km on the ground
Ratio = 1:50000		50000cm on the ground
	1cm	500 metres on the ground
		0.50km on the ground

Measuring Distance on the Ground

8B4.46 Being able to calculate distance on the ground is very important, and there are two main ways ground distance can be measured; these are known as pacing or timing.

Single Pacing Method

8B4.47 Pacing is a practical method of estimating distance on the ground, it is based around having an understanding of how many paces an individual takes to walk a distance of 100 metres. To find out a pacing average an individual should walk 400 metres over a route that has been set on level ground, a count should be made of the total number of steps taken to complete the course. This total should be divided by 4, the resulting number is the average number of paces required to cover 100 metres. This average pacing can be used by an individual to measure distance covered on the ground. For example, if it is known that a person's average pacing is 126, every 126 paces taken will equate to 100 metres. Distance can then be estimated by counting multiples of 100-metre measurements.

Double Pacing Method

8B4.48 Double pacing is the preferred method for estimating distance on the ground and has been adopted by a number of UK FRSs as it reduces the amount of counting required. The process used to establish an average double pacing is similar to that used for establishing single pacing averages, the only difference being that only every other pace is counted. This is achieved by starting on the right foot and counting the number of times the left foot is placed on the ground. The double pacing average can then be used to measure ground distances in the same way as the single pacing method.

Measuring Distance by Estimating Travel Time

8B4.49 Distance can also be measured by calculating the time it takes to travel between two points. By estimating an average speed a person can be expected to travel across the existing terrain, and by making adjustments for ascents and descents, a travel time can be estimated. Average speed is affected by surface conditions, type of terrain, time of day, gradients, equipment being carried and the type of PPE worn.

See Plate B4.1 Chart with Travel Times

See Plate B4.2 Chart with approximate speeds for given terrain

Navigation

8B4.50 An understanding of maps, and the ability to relate the information on the map to what can actually be seen on the ground, can provide some capacity to navigate across the landscape. Unless personnel have advanced or specialist map reading skills, navigation should be restricted to recognised paths and tracks that are shown on a map.

Cardinal Directions

8B4.51 The cardinal directions are all based on north being the base of 0 or 360 degrees. There are eight cardinal directions which are shown in dark blue, each one of these can be found by measuring degrees clockwise from north.

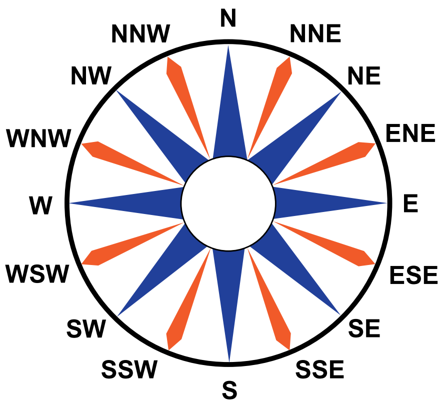


Fig. B4.7
The dark blue arrows show the cardinal directions

North at 0 or 360 degrees	**South** at 180 degrees
Northeast at 45 degrees	**Southwest** at 225 degrees
East at 90 degrees	**West** at 270 degrees
Southeast at 135 degrees	**Northwest** at 315 degrees

Fig. B4.8
Cardinal directions

Understanding the Use of a Compass

8B4.52 This guidance highlights the need for map reading and navigation skills, it is not intended to provide detailed information on either. The following section contains a basic description of a lightweight or Silva compass and its use.

8B4.53 A compass is an instrument that can be used to help find your way across the landscape. Before using a compass you need to have an understanding of its basic features.

The Main Features of a Compass

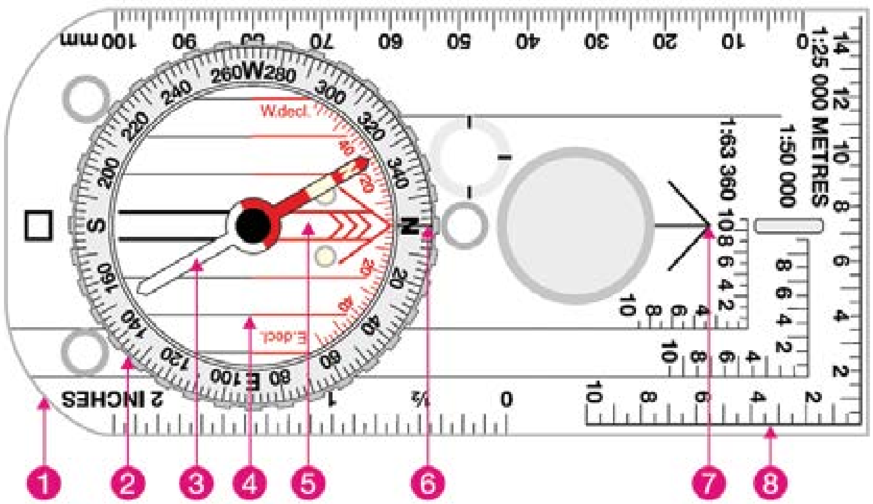


Fig. B4.9 The main features of a compass

1. **Base plate**
2. **Compass housing** – also known as the compass wheel, it has a mark every 2 degrees.
3. **Magnetic needle –** the red end will point to magnetic north.
4. **Orienting lines –** fixed within the compass housing and designed to be aligned to the Eastings on a map.
5. **Orienting arrow –** fixed and aligned to north within the compass housing.
6. **Index line –** extension of the direction of travel arrow where the compass user reads off a bearing.
7. **Direction of travel arrow –** the arrow at the end of the base plate.
8. **Map scales –** used to measure distances on 1:50000 and 1:25000 scale maps.

8B4.54 The main working part of the compass is the magnetic needle which rotates on a central pivot. The red end of the needle always points to the Earth's magnetic north. By rotating the compass housing to line up the red north end of the needle with the red arrow on the compass baseplate, a bearing can be taken from the index line. To get an accurate reading you then have to adjust the bearing to take account of the difference between grid north and magnetic north. The degree of magnetic variation can be found on all OS maps.

8B4.55 When taking a magnetic bearing the compass needle can be influenced by nearby metallic objects which may affect the accuracy of the reading.

The Main Uses of a Compass

8B4.56 A compass can be used in a number of ways including:

- **Taking a bearing from a map and following this to reach a specific position**
- **Orientating a map so that it matches what is seen on the ground**
- **Using a bearing to identify features found on the ground**
- **Identifying your own position on the landscape**

8B4.57 The first two uses are covered in detail within this guidance, whereas the last two uses are more practically-based skills which should ideally be taught in an outdoor environment and are therefore not addressed within this chapter.

Setting Direction of Travel from a Map

8B4.58 There are three simple stages to transferring the direction you want to travel shown on a map, to the direction you need to travel on the ground using a compass.

Stage One

8B4.59 The compass should be laid flat on the map with one of the long edges joining the two points of travel ensuring that the compass is facing in the correct direction.

Photo B4.11
Stage 1 – The direction of travel arrow should always point towards the intended destination

Stage Two

8B4.60 Keeping the base of the compass in position on the map, the compass housing is rotated until the compass orienting arrow points north/upwards and the orienting lines on the compass housing are parallel with the grid (Eastings) lines on the map.

Photo B4.12
Stage 2

Stage Three

8B4.61 The compass can then be taken from the map and any magnetic variation should be added by turning the wheel in an anti-clockwise direction. The compass is now set in a horizontal position; the compass should be turned until the red end of the magnetic needle is positioned inside the orienting arrow and the direction of travel arrow points towards the destination.

Photo B4.13
Stage 3

Aligning a Map

8B4.62 If you know your position on the landscape and can locate this on a map, you can use known features as reference points. Roads, rivers, power lines, stone walls, fences and other features can be used to align a map. By rotating the map so that it matches what is seen on the ground will clarify the relationship between the two.

Orientating a Map

8B4.63 The grid lines running from the bottom to the top of a map (Eastings) are drawn to the north. By using these and a compass the map can be accurately orientated to align with magnetic north.

There are two stages to this process:

Stage One

8B4.64 Set the north mark on the compass housing so that it aligns with the direction of travel arrow. Then place the compass on the map so that the direction of travel line is running along Eastings, or towards the top of the map. The edges of the compass base plate will run parallel with the grid lines on either side of the compass.

Photo B4.14
Stage 1

Stage Two

8B4.65 Holding the map and compass firmly in place, rotate the map until the north end of the compass needle points north along the grid line, sitting within the orienting arrow.

Photo B4.15
Stage 2

8B4.66 The map and the compass are now orientated against magnetic north and the map will align with what is seen on the ground.

Electronic Systems

8B4.67 Mobile Data Terminals (MDTs) use a 12-figure grid reference and it is important to understand the relationship between an alphanumeric and a 12-figure grid reference.

Photo B4.16

An example of an alphanumeric grid reference identifying the summit of Ben Macdui, in the Cairngorm Mountains (found on Landranger Map 36), would be NN989989. This is a unique, 100m accurate grid reference which is made up of three elements:

- NN indicates the 100km x 100km grid square;
- 989 are the eastings;
- 989 are the northings.

This would be represented by the 12 figure grid reference 298900.798900

As demonstrated earlier the initial numbers of the Easting and Northing are shown in the corners of all OS maps so it is relatively simple to create a 12-figure grid reference of all locations within the UK. This can then be used within MDTs to find a location on a map and vice versa.

The Global Positioning System (GPS)

By default, most GPS devices will use the projection WGS84. This is a spherical projection and is expressed in latitude and longitude. It is difficult to translate these in the field to paper-based OS maps, so it is recommended that all GPS devices are set to use the British national grid projection which will then display either as alphanumeric values or in the 12-figure grid format previously described.

8B4.68 GPS uses the known position of satellites that orbit the earth, and by using triangulation, or contact with three of these satellites, a receiver can accurately calculate its position on the Earth's surface.

GPS receivers have a number of capabilities including:

- **Give an exact location, time and elevation**
- **It can plot movement on the surface or in the air**
- **Identify speed of travel**

- Give time, distance and direction to other positions on the landscape
- Record information on time, distance and direction journeys made
- Store topographical mapping

8B4.69 The use of the Global Positioning System (GPS) has become common. With the development of small and highly-efficient GPS receivers, GPS is becoming relied upon more and more.

8B4.70 In connection with wildfire, it can provide invaluable information that can aid recognition of ones position on the landscape and assist in navigating across it. GPS can also plot your location and transmit this information to others, this intelligence can be used to improve safety, and assist in controlling operational resources that may be dispersed across wide areas. FRSs should exploit this technology to its full potential and incorporate its use into FRS systems whenever possible. GPS is a useful aid; it cannot provide the field skills and knowledge necessary to operate efficiently within a spatial operational environment.

Plate B4.1

Time given in hours, minutes and seconds at given speed						
Pacings based on 62 double pacings per 100 metres speed in kph						
Distance (m)	Paces	5 kph	4 kph	3 kph	2 kph	1 kph
50	31	0:00:36	0:00:45	0:01:00	0:01:30	0:03:00
100	62	0:01:12	0:01:30	0:02:00	0:03:00	0:06:00
200	124	0:02:24	0:03:00	0:04:00	0:06:00	0:12:00
300	186	0:03:36	0:04:30	0:06:00	0:09:00	0:18:00
400	248	0:04:48	0:06:00	0:08:00	0:12:00	0:24:00
500	310	0:06:00	0:07:30	0:10:00	0:15:00	0:30:00
600	372	0:07:12	0:09:00	0:12:00	0:18:00	0:36:00
700	438	0:08:24	0:10:30	0:14:00	0:21:00	0:42:00
800	496	0:09:36	0:12:00	0:16:00	0:24:00	0:48:00
900	558	0:10:48	0:13:30	0:18:00	0:27:00	0:54:00
1,000	620	0:12:00	0:15:00	0:20:00	0:30:00	1:00:00
2,000	1240	0:24:00	0:30:00	0:40:00	1:00:00	2:00:00
3,000	1860	0:36:00	0:45:00	1:00:00	1:30:00	3:00:00
4,000	2480	0:48:00	1:00:00	1:20:00	2:00:00	4:00:00
5,000	3100	1:00:00	1:15:00	1:40:00	2:30:00	5:00:00

Plate B4.2

Approximate speeds for given terrain	
5 kph	Hard, level surface
4 kph	Variable, rough surface
3 kph	Soft ground, strong headwind, wearing structural firefighting PPE
2 kph	Severe head wind
Time to add for given ascent/descent	
1 min per 10m ascent	
10 min per 100m ascent	
1 min per 20m descent	
Time to add for other conditions	
Night – ½ daytime speed	
Heavy load – 1kph less	
>20 kg – ½ normal speed	
Speed and distance conversions	
1 mile	= 1.6km, 1km = 0.6 mile
1 mph	= 0.4 m/s
	= 1.5 ft/s
1,000 ft	= 305m, 1,000m = 3,281 ft
Pacing is based around an average of 62 double paces; adjustments will have to be made to compensate for terrain and ground conditions. With experience, pacing can be extremely accurate.	

8B4
Key Considerations

- An understanding of maps provides useful information relating to the operational environment and the hazards found on the landscape (especially the parts that cannot be seen).
- Grid references should be given to identify positions on the landscape. When communicating these, they should be repeated by the recipient to confirm understanding.
- Maps can be used to identify different fuel types found on a landscape. These can change over time, therefore the latest versions of OS maps should be used.
- Topographical maps can provide invaluable information that can assist when formulating a safe suppression plan.
- Teams committed on to the fire ground should have, or be supervised by, personnel who have an appropriate understanding of navigation.
- Maps can be used to identify travel times, distances and the safe routes to be taken by operational personnel.
- Contour lines can be used to identify areas such as steep slopes, gullies and re-entrants, where fire behaviour may be more dangerous.
- Contour lines show the shape of the landscape and this information is essential when using the Wildfire Prediction System (WPS).
- Understanding how to utilise the information on a map is a key skill that improves safety, resource management and assists in the decision making process.

8B5

Fire Development

Introduction

8B5.01 The wildfire environment is one that is subject to almost constant change and although some of these variations will be subtle, others will result in a dramatic and rapid change to fire intensity and rate of spread. To ensure that firefighters remain safe and effective it is imperative that they and their managers have an understanding of the circumstances that will bring about these changes. The appreciation of when, and where, fire behaviour is likely to alter will assist firefighters to apply suppression tactics safely and at times and at locations where they are most likely to succeed in bringing the fire under their control.

8B5.02 Changes will result in a fire becoming more or less responsive to its environment and increasing or decreasing levels of risk. If managers have an understanding of when and where these changes are likely to occur, they can apply this knowledge to the decision making process and adopt appropriate control measures within a suppression plan.

8B5.03 Understanding the changes in fire behaviour at a wildfire will also assist fire commanders to take the correct tactical decisions. Timing is crucial and taking full advantage of windows of opportunity where the fire is within the threshold of control of available resources is hugely important. The application of appropriate tactics and successful fire management techniques will ensure that changes are controlled within the governance of an effective incident command system and safety regime.

The Influence of Time and Space on the Wildfire Environment

8B5.04 A wildfire will burn over a period of time, on a landscape that provides the space over which the fire can move. The behaviour demonstrated by any wildfire is dependent on a number of important variables. Its movement across the landscape brings instability within the fire environment caused by changes to the available fuel, its combustibility and arrangement, the shape of the topography and the effects of weather. The changes that time and space bring to the fire environment, if properly understood, mean that the fire can be fought in a safe and effective manner.

Time

8B5.05 One of the main influences of time is the change it brings to the condition of the fuel and its combustibility during the event. The accumulated affect of solar radiation throughout the day can have a significant impact on temperature, relative humidity, wind speed and the moisture content of the fuel. Another change that time may bring is to the general weather pattern bringing stable or unstable weather conditions. Time can have a positive or negative effect on fire development throughout the day and this will bring both advantage and disadvantage to firefighting operations.

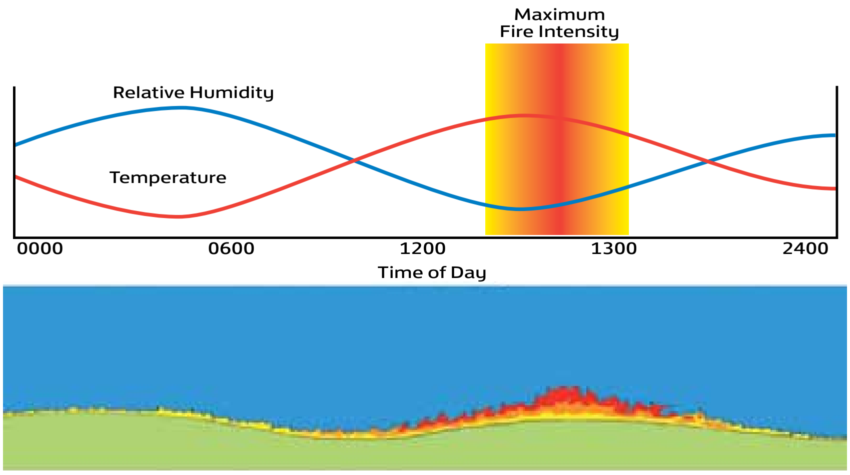


Fig. B5.1
Diagram showing the changes brought about by variations in temperature and relative humidity throughout the day. As temperature rises relative humidity falls resulting in increased fire intensities

Space

8B5.06 Likewise, the space in which the fire is burning brings changes to the shape of the landscape altering the fire's alignment with wind and slope and bringing a variation in fuel types, its loading and arrangement. The availability of fuel, its type and its horizontal and vertical arrangement obviously impacts on how readily fire will develop, however there are other variables that are important to consider. For instance, as a fire changes its location and moves across the landscape, topographical and climatic conditions will work for and against the fire altering its intensity and speed.

Explaining Fire Growth

8B5.07 A fire burning in uniform fuels will normally start at a single point of ignition and the resulting flames firstly consume the surrounding fine fuels. As the fire develops, convection currents draw the flames towards the centre and away from the surrounding fuel. Fire development at this stage is mainly caused by flame contact with any unburnt fine fuels.

Equilibrium

8B5.08 In the absence of any alignment with wind or slope the convection plume will continue to dominate early fire development, the fire will burn more or less equally in all directions and most of the heat will be drawn into the convection plume and lost to the atmosphere. This situation will continue until there is a variation in the fuel or its combustibility, or where the fire finds alignment with wind or slope.

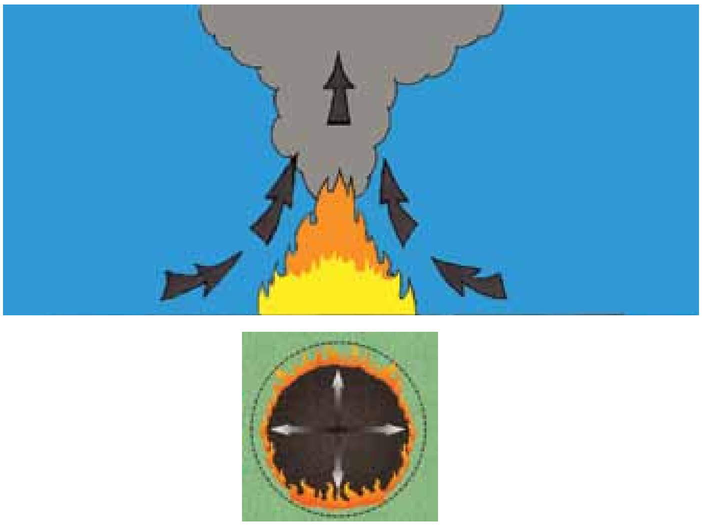


Fig. B5.2
Illustration of the effect of the convection plume in the early stages of fire development. A fire in a state of equilibrium burning with equal intensity in all directions

Photo B5.1
A fire in relative equilibrium

The Loss of Equilibrium

8B5.09 When the outer edge of a fire is supported by wind or slope and the strength of this alignment is stronger than the convection force created by the fire, this equilibrium is lost. The part of the fire that finds most alignment with wind or slope will overcome the influence of the plume and the flames at this part of the fire will angle towards the fuel, the flames at the rear part of the fire are bent away from the fuel.

8B5.10 As a result, the fuels at the front of the fire are subjected to more preheating and the fire is able to penetrate these with more ease, increasing fire intensity and rate of spread. The fire at the rear has less interaction with the fuel and activity is reduced. The shape of the fire footprint is likely to change and depending on the strength of alignment may become elongated as the front part of the fire develops what is termed to be a head.

8B5.11 Wind normally drives a fire in the direction it is blowing and has a strong influence on the fire's outer shape; it supports the head fire but restricts fire development on the flanks and tail. As wind speed increases this effect dominates fire spread providing more support to the head and less to the tail and flanks. The head fire will be the part of the fire that has maximum alignment; the flames can be significantly angled towards, and sometimes be brought into contact with, the fuel, thus increasing the rate of spread and intensity. The flames and heat generated at the tail part of the fire are pushed away from the fuel and intensity is reduced, sometimes to a point where the combustion process ceases.

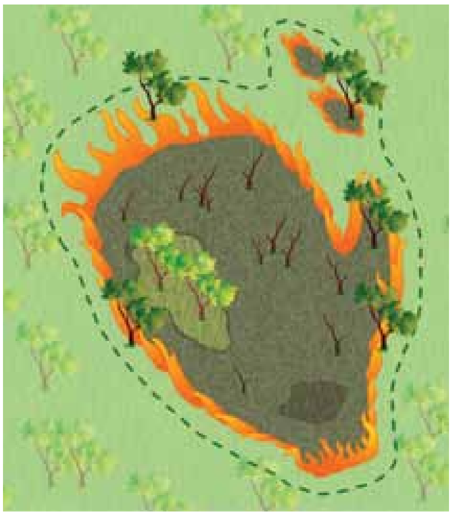


Fig. B5.3
Showing a typical fire pattern once equilibrium is lost

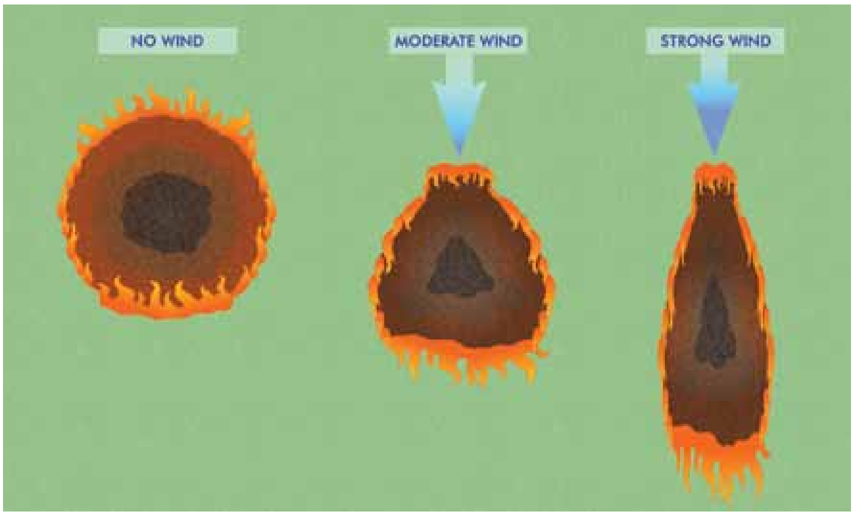


Fig. B5.4
The effect of wind on the shape of the fire

Fire Growth

8B5.12 A fire spreading with the support of wind will burn into the available fuel with different intensities around its perimeter. The following diagram shows an elliptical fire pattern.

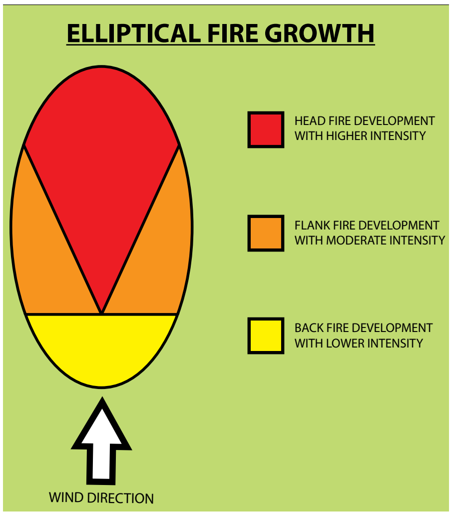


Fig. B5.5 Elliptical fire development where the fire burns with different intensities around its perimeter, depending on its alignment with wind

Photo B5.2 A fire being supported by wind

The Parts of a Wildfire

The Head Part of a Fire

8B5.13 The head of the fire has the most sustained alignment and as a result is the fastest moving and most intense part of the fire. Depending on the fuel and its arrangement, the head fire is the part of the fire that has the greatest flame length, flame depth and rate of spread. It is essential to understand that fire intensity can change around the fire perimeter, and any part of a fire that aligns with wind or slope can potentially develop head fire behaviour.

Photo B5.3
Showing a well-developed head fire. Note the flame angle/length etc

The Flanks of a Fire

8B5.14 The sides of the fire are termed to be the flanks and these burn outwards into the unburnt vegetation. This results in the flanks having less alignment than the head, normally reducing their intensity and rate of spread. Flank fire intensity nearest the head is normally more intense, particularly where the flanks meet the head which is known as the 'shoulder'.

8B5.15 The flanks of a fire can make up most of the fire perimeter, and therefore there may be variations in fire activity due to changes in fuels or topography. This can lead to a different fire behaviour being demonstrated by each flank. This can be explained by the fact that usually one side of the fire will have better alignment or be burning in more supportive fuel types. It is important that attending personnel understand which is the left flank, and which is the right flank of a fire. This is best explained by imagining that you have taken position behind the fire, with the head moving away from your position. The left part of the fire is to your left and the right part to your right.

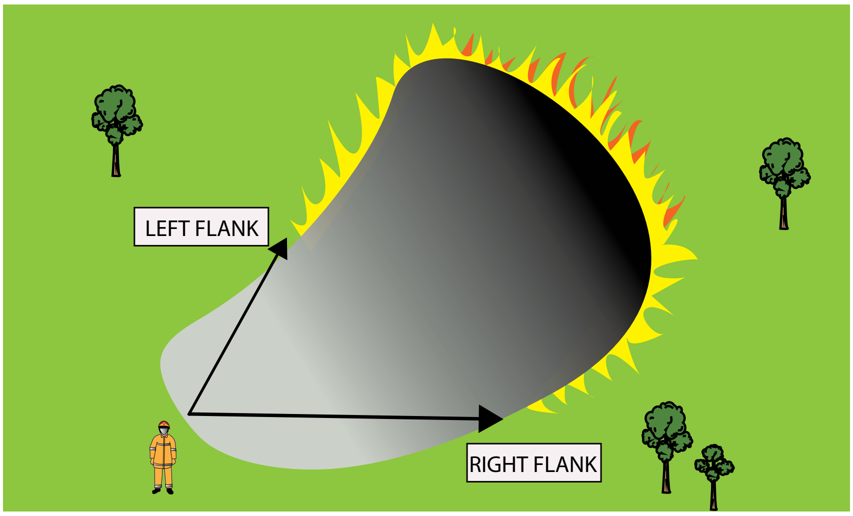


Fig. B5.6
Showing the left and right flanks of a fire

Photo B5.4
A flank part of a fire

The Tail Part of a Fire

8B5.16 The back part of the fire is called the tail and this part of the fire is where there is the least amount of fire spread. Usually the flames at the tail are being bent towards the already burnt fuel and the fire moves into the vegetation against the alignments that are working in the favour of the head fire. The tail fire is potentially the slowest moving part of the fire with the shortest flame length. When the tail is backing against a strong wind or steep slope it can self extinguish. Tail fires usually demonstrate low amounts of fire activity but it is important that they are recognised as a significant risk, if they burn into areas that are more supportive a significant and rapid change in fire behaviour can occur.

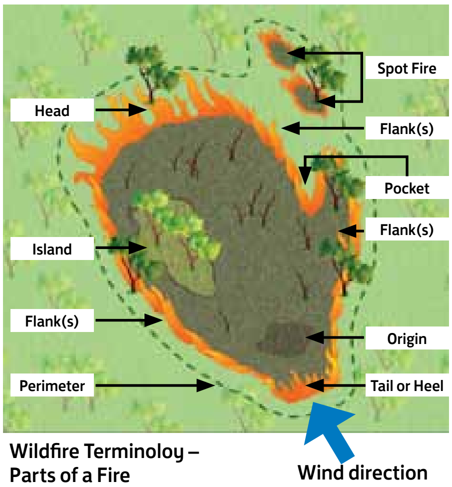


Fig. B5.7
An illustration showing the parts of a fire

Wind as an Alignment Force

8B5.17 Wind is a major alignment force and supports fire development, it does this in a number of ways including:

Providing the Fire with Added Oxygen

8B5.18 This assists in the combustion process and adds to the fires intensity, allowing the fire to become hotter resulting in more radiated heat being transferred to the unburnt fuel in its path and an increase in rate of spread.

Tilting the Flame and Pushing it Closer to the Fuel

8B5.19 Without the support of wind the heat generated by the flames and fire plume is mostly lost to the atmosphere. When a fire is burning in alignment with wind the flame is pushed forward towards the fuel, the flame angle then allows more radiated heat be transferred to unburnt fuel accelerating fire development. In extreme cases the wind can be bent over to a point where the flame is in direct contact with the fuel.

Driving the Smoke Plume into the Unburnt Fuel

8B5.20 With the support of wind the convection plume maintains more contact with the ground preheating and drying out the fuel in the fire's path.

Drives the Fire and Gives it Direction

8B5.21 The accumulative effect of wind is that, some areas of unburnt fuel surrounding the fire are preheated and become dryer, the fire is then able to burn into these with more speed creating more intensity.

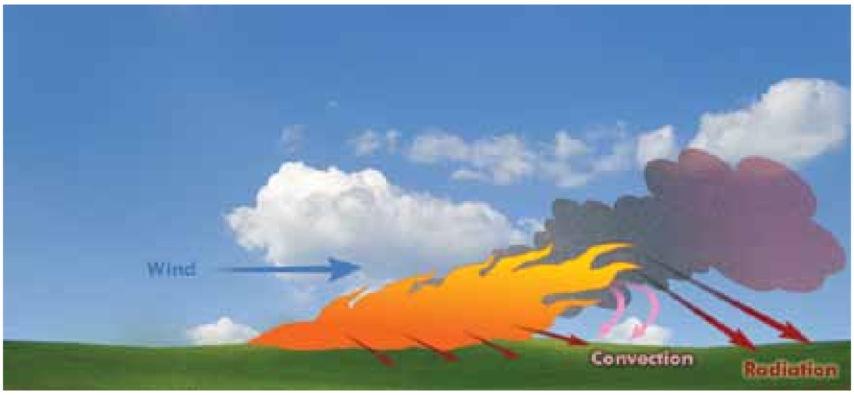


Fig. B5.8
Illustration of the effect of wind fire spread and intensities

Slope as an Alignment Force

8B5.22 Slope is also a major alignment force that supports fire development; it does this in a number of ways including:

Bringing the Fuel Closer to the Flame

8B5.23 The slope alters the angle at which the fuel is presented to the flame, the steeper the slope the closer the fuel moves towards the flame. This allows more radiated heat to be transferred to the unburnt fuel; increasing rate of spread and fire intensity.

Increasing the Impact of the Convection Plume on Unburnt Fuels

8B5.24 In the absence of slope substantial amounts of heat generated by the convection plume is lost to the atmosphere, when a fire moves upslope the convection plume is able to pass nearer to the surface and preheats and dries out the fuel in the fires path potentially increasing the rate of spread and fire intensity.

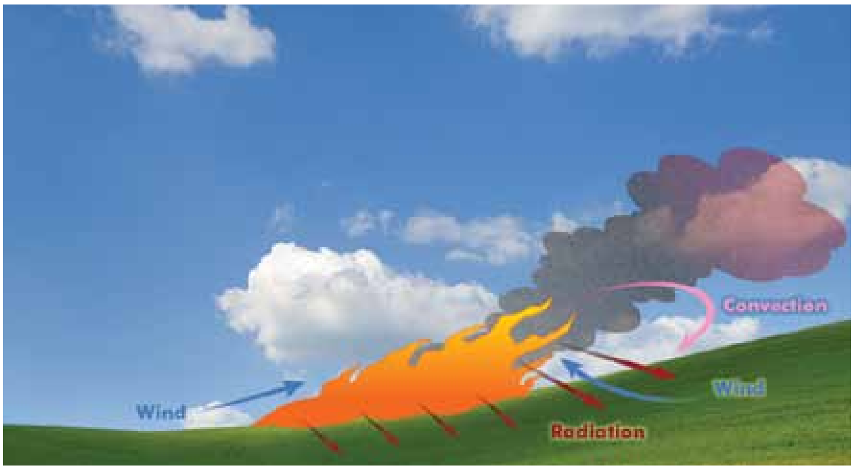


Fig. B5.9
Showing the effect of slope on fire behaviour

Aspect as an Alignment Force

8B5.25 One of the main reasons wind and slope are predominant factors within the wildfire environment is that it enhances the ability of the fire to interact with vegetation, preheating takes place altering the chemistry of the fuel and surrounding atmosphere.

8B5.26 A similar process takes place in fuels that are in aspect or where they are located on the landscape that is oriented towards the sun. In these areas the drying environment can be accelerated increasing the combustibility of the vegetation.

8B5.27 Solar radiation has a cumulative affect so areas of the landscape that receive sunlight on a daily cycle, over longer periods, are likely to be much dryer than areas that do not and fires in these areas will burn with more intensity.

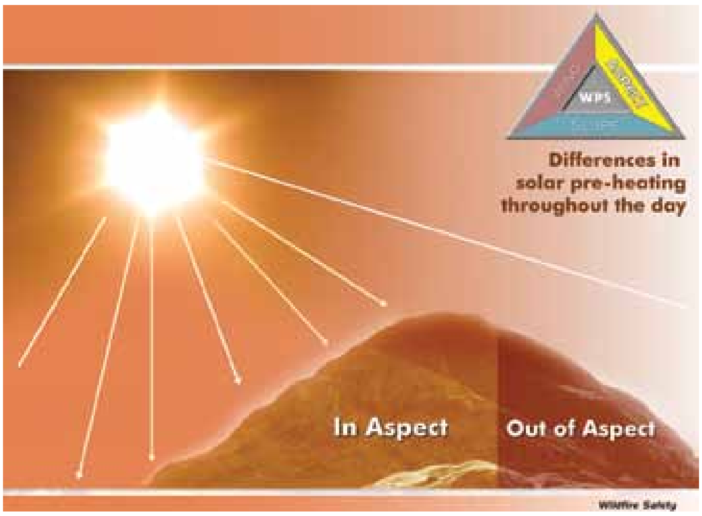


Fig. B5.10
Showing the effect of the shape of topography on surface preheating

Changes to Alignment

8B5.28 The parts of a fire that find alignment with wind, slope or aspect are those that will increase their intensity and rate of spread. Where these alignments are strong, then it is probable that a head fire will develop. In areas of the fire where there is little or no alignment fire behaviour is likely to be significantly less.

8B5.29 Consideration should be given to the fact that although the head fire normally displays the most fire activity, it is not necessarily the most dangerous part of the fire. The higher risk locations are generally those where there is a change in alignment or strength of alignment that allows a fire to rapidly and sometimes unexpectedly increase its intensity and rate of spread.

8B5.30 These changes can occur anywhere around the fire perimeter, an example being where the wind changes direction and aligns itself with a part of the fire that had previously had little or no alignment. It is important that fire officers do not concentrate their assessment of risk only at locations that currently have the highest fire intensities; they must understand that the fire's future potential development may occur elsewhere, even at parts of the fire where it appears to be quite inactive.

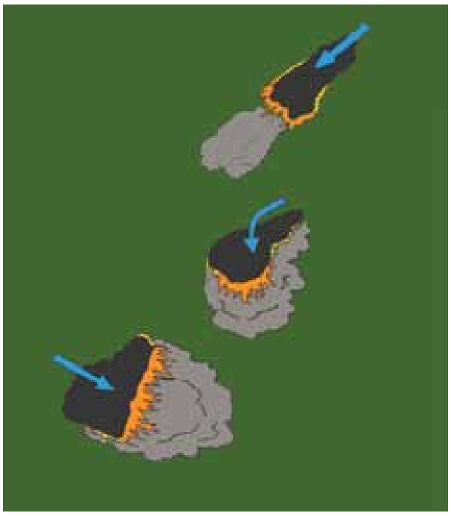


Fig. B5.11
Illustration of wind change on a flank fire

Flame Description

Flame Height

8B5.31 The height of the flame is measured vertically from ground level to the top of the flame.

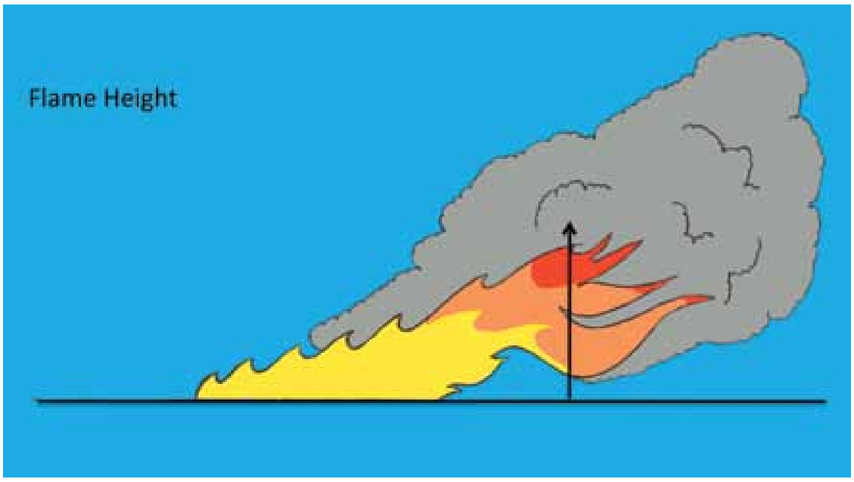


Fig. B5.12
Showing flame height

Flame Angle

8B5.32 The angle of the flame is measured from the horizontal, and gives the incline of the flame indicating the strength of the fire's alignment with wind and slope and the amount of preheating that the flame can bring to bare on unburnt fuels.

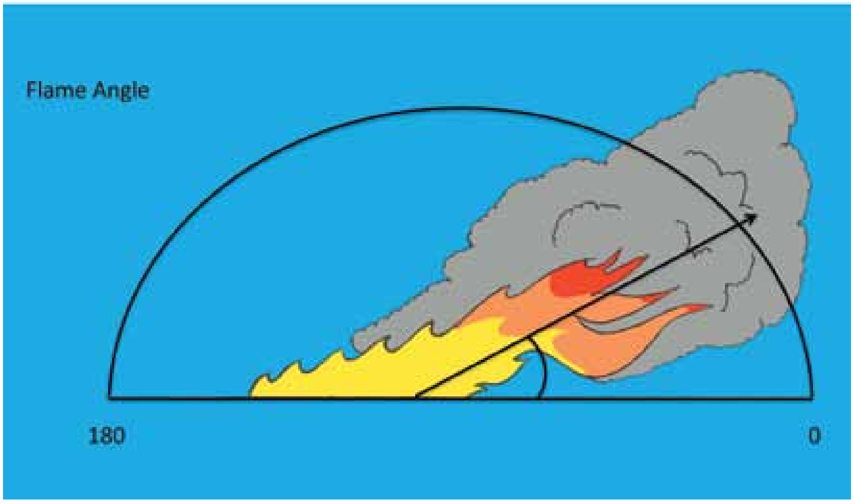


Fig. B5.13
Showing flame angle

Flame Length

8B5.33 The flame length is the measurement taken from the base to the tips of the flame, irrespective of the flame angle.

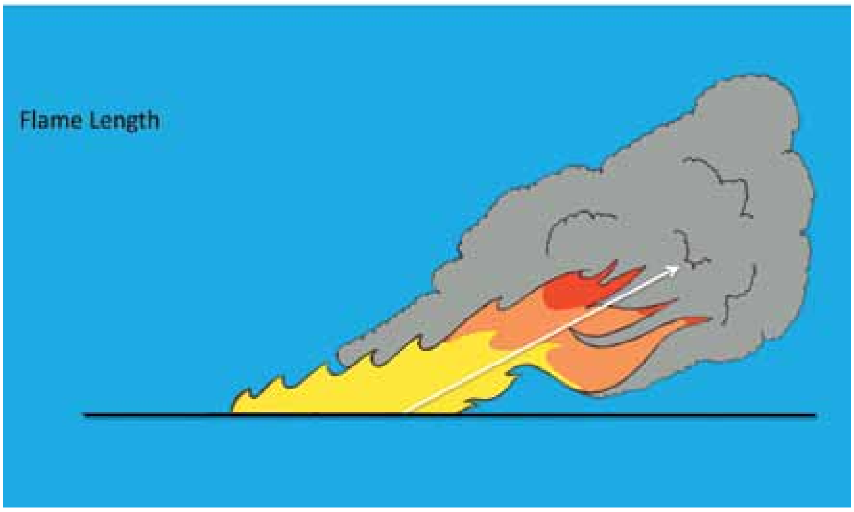


Fig. B5.14
Showing flame length

Flame Depth

8B5.34 The flame depth is a measurement of the total area of continuous burning fuels taken from the front part of the fire to the rear most part of the flaming zone. It should not be extended to individual and separate fires burning outside the flaming zone.

Fire Front

8B5.35 The fire front is the area of the fire that is at the foremost part of the flaming zone and is where the available fine fuels are consumed. This usually results in the fire demonstrating its most intense behaviour and the longest flame length.

Flaming Zone

8B5.36 The flaming zone is the total area of burning fuels measured from the front of the fire to the rear most part of the fire.

Rate of Spread

8B5.37 The rate of spread refers to the movement of the fire across the landscape and is normally measured in metres per hour. The rate of spread is not limited to the forward motion of the head fire but can be used to describe the outward movement of the flanks or tail. Rate of spread is not a constant and the alacrity of movement will vary over time and within the space the fire is burning. Wind, slope and aspect will influence rate of spread as will the type and arrangement of the fuels the fire has access to. The amount of fine fuels within the fuel loading is important as fire will move much faster through finer fuels compared to coarser ones.

8B5.38 Fire spread can also be measured vertically as the fire travels upwards between the ground, surface and aerial fuels within its arrangement.

Depth of Burn

8B5.39 The depth to which a fire penetrates into the fuel bed, this is normally into surface and ground fuels.

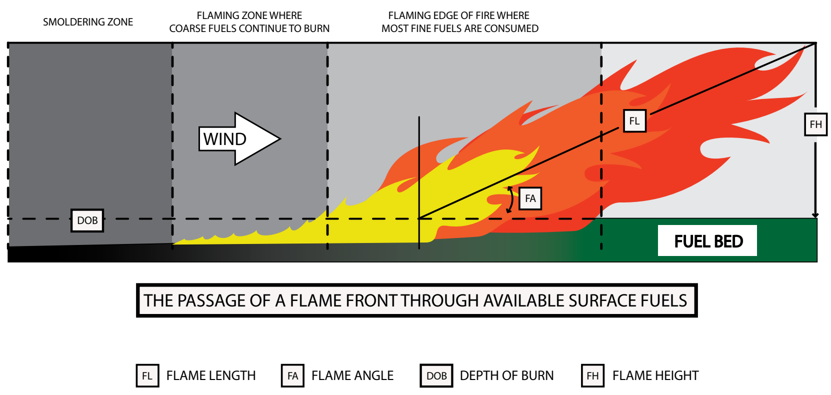


Fig. B5.15
Showing a representation of a head fire spreading through fuels on level terrain

Types of Fire

8B5.40 The fire type is normally described making reference to the fuel layer it is burning in, for example a fire burning in the surface fuels would be referred to as a 'surface fire', it is the same for fires burning in ground, elevated or aerial fires.

8B5.41 Fires that demonstrate more extreme fire behaviour have names that are more descriptive of their behaviour such as 'Torching', 'Spotting' or 'Crowning' these are covered in Section 11.13 'Extreme Fire Behaviour'.

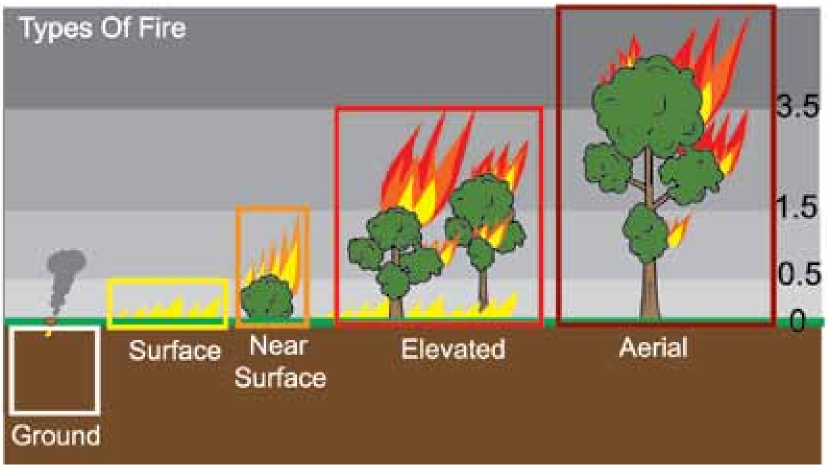


Fig. B5.16
Showing the different types of fire

Extreme Fire Behaviour

8B5.42 Extreme fire behaviour can result from a single, or a number of situations within the fire environment that are likely to cause fire activity to reach dangerous proportions.

These include:

- **High fuel loading, particularly in fine fuels**
- **The existence of strong ladder fuels**
- **Fire aligned with a strong wind**
- **Fire aligned with a steep slope**
- **High temperatures**
- **Low humidity**
- **Drought conditions**
- **High percentage of dead fuels within the fuel complex**

8B5.43 Extreme fire behaviour can be demonstrated sporadically or sustained over long periods of time. It is imperative that these events are predicted at a local and tactical level and managed within the suppression plan. The causes of probable extreme fire behaviour are listed above but the indicators that these events are actually taking place are:

- **A surge in fire severity**
- **Pulsating flames**
- **Very dark smoke**
- **Separate fires occurring outside the fire edge (spotting)**
- **Increased flame height or length**
- **Ignition of aerial fuels in the canopy**
- **An increase in surrounding air movement**

8B5.44 A good practical indication as to whether fire behaviour will become extreme is the **30-30-30** rule. The three figures are the measurement of **wind speed** in km/h, **temperature** in centigrade and **relative humidity** as a percentage of air moisture content. If the wind speed is ≥ 30km/h and the temperature is ≥ 30°C and the RH is ≤ 30%, then any wildfire (depending upon the fuel) will always demonstrate extreme fire behaviour and intensity.

High individual measurements in any of these areas can also stimulate conditions that will result in dangerous fire behaviour.

The Junction Zone Effect

8B5.45 The term junction zone is used to describe the increase in fire activity caused by two fires, or flaming parts of a fire, coming together. This is caused by the in-drafts generated by each fire drawing them towards each other, this increases the speed at which the fuel is consumed and the subsequent intensity and rate of spread. Sometimes this also results in a stronger fire plume that can generate increased spotting.

Photo B5.5
Two fires coming together

Spotting

8B5.46 Spotting is a term that is commonly used to describe a particular type of fire behaviour which can result in a very dangerous form of fire propagation. Burning embers of fuel are carried upwards by the convection plume or wind and then distributed amongst areas of unburnt fuel ahead of the main fire. The area immediately under the smoke plume is particularly vulnerable to localised spotting, although it must be recognised that burning material can be carried considerable distances and result in significant secondary fires which can become the primary means of the wildfire spreading across the landscape.

8B5.47 Spotting activity can also breach control lines or threaten escape routes of personnel working on the fire ground.

Photo B5.6
Showing hot sparks and embers that could lead to spot fires

Photo B5.7
Showing short-range spotting behaviour and the dangers that this may present to firefighters on the ground

Photo B5.8
Showing a fire in the background that has been caused by long-range spotting

Torching

8B5.48 Torching is likely to occur in areas where there is vertical fuel arrangements (ladder fuels) present within the fuel complex; this can support fire spread that will move from the surface into the upper aerial fuels.

8B5.49 Torching is an event that is dependent on there being continuity within the fine fuel structure. This allows a fire to develop a strong upward motion. Torching is normally a localised event restricted to single trees or small clumps of trees.

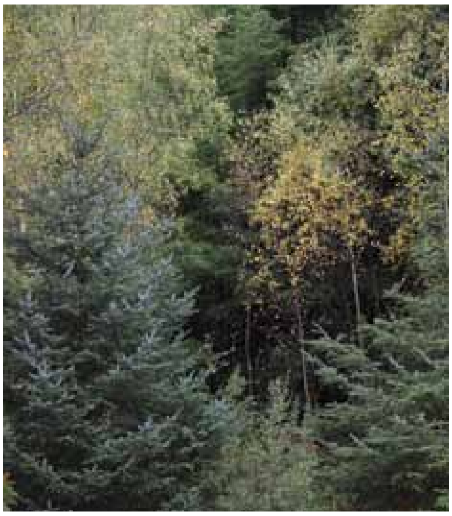


Photo B5.9
Showing ladder fuels within the vertical fuel arrangement

8B5.50 In areas where the upper canopy has sufficient horizontal fuel continuity this fire penetration into the upper canopy may be the precursor of crowning behaviour.

Crowning

8B5.51 The term crowning is used to describe a number of fire types that burn in the upper canopy of vegetation. For crowning to occur there is a reliance on there being sufficient and continuous fine fuel, these can be rapidly consumed resulting in a fast-moving and very intense fire. Crowning can occur in shrubs or trees, and intensities are usually dependent on the amount and condition of the fuel and the alignment that this is in. (Support from wind, slope and aspect)

Photo B5.10 Showing a fire moving through the vertical fuel arrangement and demonstrating torching behaviour

Active Crown Fire

8B5.52 This is a fire type that establishes itself within the whole fuel complex but is reliant on a strong surface fire to transfer heat and flames into the aerial fuels.

Photo B5.11 Showing active crown behaviour

Photo B5.12
Showing extensive active crowning

Independent Crown Fire

8B5.53 An independent crown fire is one that burns within the aerial fuels and upper canopy and does not depend on a surface fire to support its development, as it can sometimes burn without involving surface fuels.

Passive Crown Fire

8B5.54 A passive crown fire burns from the surface into the aerial and canopy fuels but is unable to maintain forward motion at the upper fuel levels.

Photo B5.13
Passive crowning

Convection- or Plume-driven Fire

8B5.55 A convection-driven fire is one that is spread mainly by the convection plume. Heat is carried in the form of hot air and this dries out vegetation, which is then susceptible to ignition by hot brands or burning embers that are carried within the fire plume.

Photo B5.14
A convection-driven fire

The Six Factors which Influence the Fire Environment

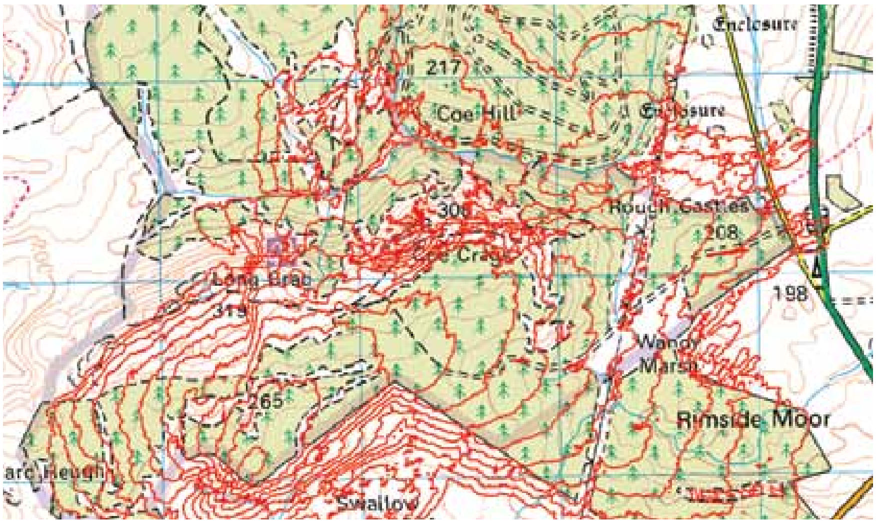
8B5.56 As a conclusion to this chapter, emphasis is made to the six principal influences which, when supportive to the fire, will indicate an increase in intensity and rate of spread. Although these factors have been referenced previously, an awareness of their importance is essential to understanding the potential development and behaviour of a wildfire.

- **The strength and type of wind**
- **Atmospheric stability**
- **Fuel and how it is arranged**
- **The temperature of the fuel**
- **Fuel moisture**
- **Topography**

8B5.57 These factors, and other common situations which can influence and bring about changes to wildfire behaviour, are explained within 8B10 Safety at a Wildfire Incident.

8B5 Key Considerations

- Fire behaviour is the result of the interaction between the available fuel and its arrangement, the weather and the shape of the topography.
- Wind strongly influences fire behaviour and plays a significant role in a fire's development and expansion across the landscape.
- A prolonged drying period will dramatically increase surface and ground fuel loading leading to increased fire intensities.
- An ample and continuous supply of fine fuel will allow a fire to spread quickly.
- A surface fire can dry and heat the fuels located in the upper levels of the fuel arrangement.
- Crowning is not limited to trees, this type of behaviour can occur in shrub species such as heather and gorse.
- Spotting behaviour can lead to rapid fire spread and an increase in fire intensity.
- A fire that moves into a location where it is supported by wind and slope can burn with great speed and intensity.
- Observe the fire and how it burns, this will provide some understanding of how it will behave in the future.
- Base suppression tactics on expected fire behaviour; take advantage of areas where intensities will be lower.
- Fire behaviour is likely to be much less early in the morning and later in the evening and will generally reduce significantly during the hours of darkness.
- Understand which fuels are in aspect and are likely to be hotter and dryer.
- Most fire accidents occur due to an unexpected change in fire intensity, normally accompanied with an increase in its rate of spread. These events are normally a result of a fire changing its alignment with wind and slope or to changes to the fuel or its arrangement, identify where these changes are likely to occur and take proactive action.



8B6

The Wildfire Prediction System (WPS)

Introduction

8B6.01 Without the ability to predict future fire spread and behavioural change, it is difficult to manage wildfire incidents safely or indeed select appropriate systems of work within an effective tactical plan.

8B6.02 The purpose of this section is to provide firefighters with a methodology that allows them to proactively anticipate and quantify probable changes that will occur to fire behaviour during an incident.

8B6.03 If this methodology is adopted it will assist in providing assurance that the primary responsibilities of incident commanders can be fulfilled, and that the health and safety of operational personnel active on the fire ground can be maintained.

Fire Prediction

8B6.04 The likely fire behaviour that will result from changes within the wildfire environment has been described within the previous sections, providing some awareness and knowledge of fire development. This information allows a limited interpretation of the fire behaviour that is likely to occur, and provides a useful baseline knowledge that can be applied to explain what may happen in the future. To further build on this understanding, this section will describe a system that can be used by all personnel to predict where and when changes are likely to occur as the fire moves across the landscape.

8B6.05 In simple terms the purpose of WPS is to provide a prediction tool that gives an understanding of where fire behaviour is likely to get better or worse, it can then be used to identify the 'Windows of Opportunity' or in other words, time slots that exist where fire behaviour is such that it will allow the use of successful suppression tactics. The fuel arranged across a landscape is positioned in different fire alignments; its location in relation to fire spread will determine how readily it will burn and WPS can be used to identify what fire alignment fuel is in and where this will change. Recognising that change will occur during the incident, then having the ability to identify when and where the changes will happen is the key to effective wildfire management. This is a methodology that has hitherto been lacking within the UK FRS.

Background

8B6.06 The prediction system used in this guidance is based on the Campbell Prediction System (CPS) which was developed by the veteran wildland firefighter Doug Campbell from the USA. The CPS has been modified to provide UK firefighters with a flexible and practical tool that can be applied to our own national wildfire environment.

The UK Wildfire Prediction System

8B6.07 The Wildfire Prediction System (WPS) described within this guidance is designed not only to provide fire service personnel with a tool to explain present fire behaviour, but more importantly, predict likely changes to fire behaviour in the future.

8B6.08 The primary purpose of any wildfire prediction system is to reduce levels of risk. The application of WPS by fire service personnel represents an effective risk management tool. Not only will WPS provide an interpretation of fire severity it can be used to formulate an understanding of how a fire will spread across the landscape and explain the wildfire's interaction with the terrain and the available fuel covering. The need for such a tool is obvious, as it allows the adoption of a proactive approach and assists in the risk assessment and decision making processes. WPS can be used to assist in the effective management of any wildfire incident.

8B6.09 WPS is designed to be a practical tool that can be applied to meet different operational situations; it can be used on the fire line to address safety issues, or it can be employed as a risk assessment tool and progressive planning aid allowing Incident Commanders to make informed decisions to develop appropriate tactics to resolve the incident.

8B6.10 In short, WPS can be adapted to suit the needs of the user depending on their role within the incident command structure or operational activity.

Advantages and Benefits

8B6.11 For personnel working near to the fire:

- **Explains current fire behaviour.**
- **Identifies likely changes to local fire intensity and fire spread.**
- **Allows an understanding of when it is necessary to adopt different tactics to address changing levels of risk.**
- **Delivers a risk assessment tool that can be applied by individuals to their local operational environment.**
- **Contributes to the maintenance of personal situational awareness.**
- **Provides an assurance and support mechanism for less experienced personnel.**

8B6.12 For personnel supervising or commanding operations:

- **It allows a proactive rather than reactive approach to risk management.**
- **Provides operational commanders with a planning aid that improves the decision making process**
- **Assists operational commanders to make professional judgements in order to use the available resources in such a way as to maintain safe systems of work during work activities**
- **Indicates which tactics are most appropriate, and when and where these are likely to succeed. (Windows of opportunity)**
- **Assists in the communication process.**
- **Allows efficient use of available resource.**

Managing Change in the Wildfire Environment

8B6.13 The safety of personnel operating near to the fire front is dependent on those individuals having the ability to identify change, and understand when these changes are likely to occur. This will allow fire service personnel to proactively take action and adopt suitable control measures.

8B6.14 Proactive identification of hazards ensures that commanders are able to adopt a balanced and informed approach between risk management and the achievement of the operational objectives set within the incident plan. Tactically, WPS is of great benefit to operational commanders as it provides them with information that will help to identify, where and when, the various parts of the fire will fall within the threshold of control of the available resources. This allows for an effective plan to be formulated that takes advantage of changes to fire behaviour.

Improving Safety and Effectiveness

8B6.15 Historically, a major problem encountered at wildfire incidents has been the misconception that the parts of the fire demonstrating the most fire activity are the locations at which resources must be deployed, and where control of the fire must be immediately established.

8B6.16 This potentially results in a concentration of effort and resource at these specific locations. FRS personnel should understand that sometimes, the parts of the fire that show little activity are those that have the most potential for significant future fire development.

8B6.17 Plans should be based not on what a fire is doing at a particular point in time, but on what it is likely to happen in the future. The initial and continuing priority must be to analyse the fire perimeter and establish what potential each part of the fire has for development and where changes to intensity will occur.

Changes to Fire Behaviour

8B6.18 By analysing a fire's outward motion and identifying where fire behaviour will alter, officers will be able to formulate a plan that is based around fighting the fire in areas where control can be more easily established, before it moves into areas where fire behaviour will be beyond the control of available resources or where firefighting operations will be more dangerous.

8B6.19 WPS identifies windows of opportunity where timed offensive strategies can be applied when a fire's alignment with wind, slope and aspect is weakest and the situation is advantageous for firefighting. WPS also identifies locations where suppression methods would be likely to fail or, more importantly be dangerous. This approach ensures that tactics are applied at the appropriate time ensuring that they are safe and effective.

8B6.20 All personnel that are operationally deployed at wildfire incidents should have an understanding of the Wildfire Prediction System.

The Wildfire Prediction System

8B6.21 If we include all of the many variables that can influence fire behaviour within the wildfire environment, prediction models can become hugely complicated and almost impossible to apply as a practical tool. Furthermore the level of understanding required to manage such a system would demand a huge amount of knowledge and experience. In the UK, where firefighters are required to operate within a wide portfolio of emergency response scenarios, a simpler system is required. To understand how WPS works it is important to realise that although fire behaviour appears to change unexpectedly, the fire is simply reacting to its environment. In essence, the shape of the landscape, the weather, and the available fuel complex are the factors that will influence and bring changes to the fire.

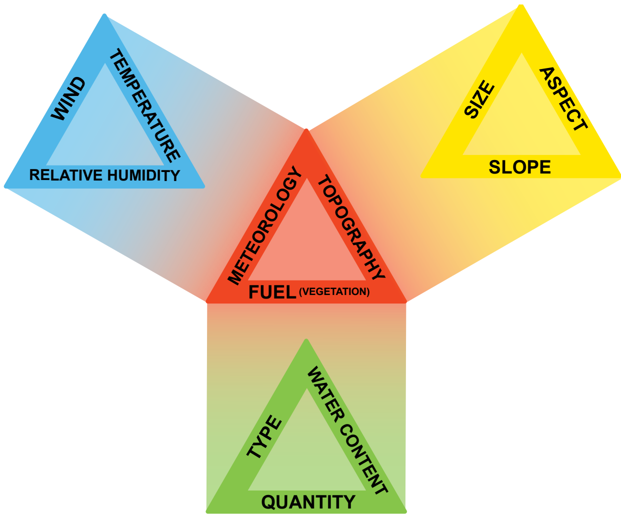


Fig. B6.1
The wildfire environment is dominated by fuel, weather and topography

8B6.22 The fundamental purpose of the UK Wildfire Prediction System is to provide a simple tool that will assist in proactively identifying likely fire intensities; this simplicity allows it to be applied practically and in real time. It can be used by personnel that have limited knowledge and experience and is therefore ideally suited for FRSs that have a sporadic wildfire risk and whose personnel may lack familiarity with the complexities involved in dealing with wildfire incidents.

Fire Alignments

8B6.23 WPS uses the principle that fire behaviour within a given fuel is influenced predominately by its alignment with three major forces, these are:

- **Wind**
- **Slope**
- **Aspect**

8B6.24 These are described within WPS as '***the forces of alignment***' because whenever a fire is supported by wind, slope or aspect its ability to interact with the available fuel is improved and it burns with more intensity. Whenever the fire loses support from one or more of these influencing factors, the fire activity and intensity will decrease.

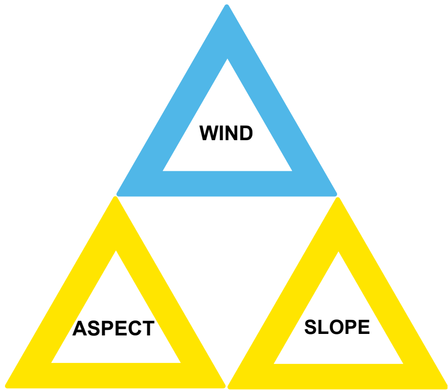


Fig. B6.2
Three principal fire alignments' forces

8B6.25 WPS is a process that analyses the landscape, identifying the fire's potential alignment as it moves through the fuel arrangement. The variable strengths of alignment can be used to forecast fire intensity and indicate direction of travel around the fire perimeter.

8B6.26 For example, if a fire is burning in a common fuel type, the parts that demonstrate the highest fire intensity are those that are being supported by one, or more, of the alignment forces. The parts that burn with less intensity are those that have less support or where they are burning against them.

8B6.27 Fire alignment can therefore be used to explain why a fire develops a head, tail and flanks – all usually showing different fire activity because of the differing strengths of alignment.

The Wildfire Triangle

8B6.28 The wildfire triangle visually demonstrates the concepts involved in wildfire prediction. Although it is important to understand that fuel is not an alignment force, it remains the central, and crucial, element of the triangle. As illustrated below, it is surrounded by the three alignment forces. The intensity of any fire will be dictated by the fuel complex in which a fire has the opportunity to burn, and the support given to it by the topographical and meteorological alignment forces used in the prediction system.

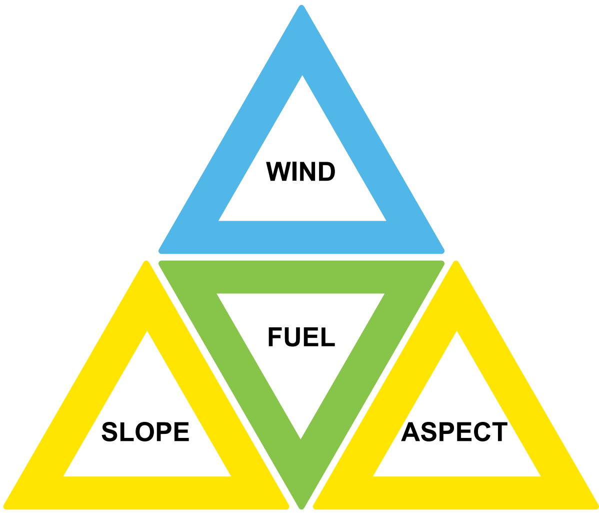


Fig. B6.3
This is the wildfire triangle which shows the alignment forces arranged around the fourth part of the triangle which is fuel. The alignment forces will affect the way a fire burns within a fuel source; the stronger the alignment the more intense the fire is likely to be in whatever fuel is available to burn

The Three Stages of Prediction

8B6.29 There are three ways or stages that WPS can be applied:

Stage one is by observation normally reliant upon intelligence collected by personnel on the fire ground. By using WPS during operational activity, responding personnel can keep themselves and others aware of probable changes to fire behaviour.

Stage two is utilised more by those involved in planning who wish to take a broader view of the incident and map the predicted changes that are going to take place across the landscape. This information can then be used to chart the extent of fire travel over a defined period of time and identify locations critical to fire development and suppression across the landscape.

Stage three is the final stage and should be applied by wildfire specialists. It involves making a judgement on what fire behaviour will be experienced in the various alignments. Specialists assess the alignment strengths and consider the fuel source before the risk is measured and expressed as a flame length.

First-stage Prediction

Using WPS to identify positions across the landscape where fire behaviour is likely to change.

8B6.30 If the three alignment forces can be used to explain current fire intensity they can also be applied to help predict future fire behaviour. This can be achieved by identifying the changes that will occur as the fire alters its position on landscape. In other words, predicting where the fire moves in and out of alignment with wind, slope or aspect. This can be achieved by examining the landscape and recognising where these effects will take place and whether they have a positive or negative effect on fire development.

Prediction Terminology

8B6.31 The language used to communicate or record this information is important and plays an integral part in the process. By classing each alignment force as a 'factor' that will change fire behaviour then a measurement of alignment support can be made.

Parts of a fire that are supported by any one force are described as a Factor One Fire

Parts of a fire that are supported by any two forces are described as a Factor Two Fire

Parts of a fire that are supported by all three forces are described as a Factor Three Fire

8B6.32 A fire that lacks support from any of the alignment forces should be termed to be a **Factor Zero Fire**. This terminology can be further abbreviated to **F0, F1, F2,** and **F3**.

Additional terminology to be used when describing fires alignment is:

An F0 part of a fire is one that is ***'Out of alignment'***

An F1 or F2 part of a fire is one that is in ***'Partial alignment'***

An F3 part of a fire is one that is in ***'Full alignment'***

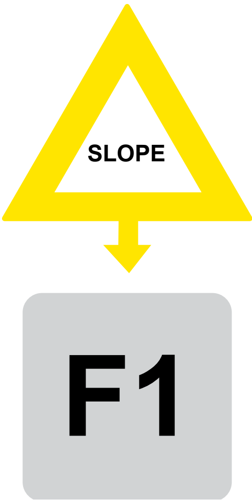


Fig. B6.4
An F1 fire is one that is supported by any alignment force – in this case Slope

Fig. B6.5
An F2 fire is one that is supported by any two alignment forces – in this case Slope and Wind

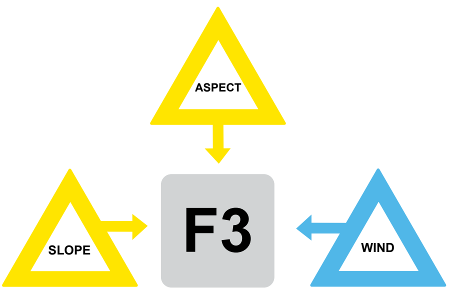


Fig. B6.6
An F3 fire is one that has the support of all three alignment forces; Wind, Slope and Aspect

Prediction Values

8B6.33 To reach a prediction value all factors acting in the fires support should be added together. No deduction is made for factors that are acting against the fire.

8B6.34 As an example, if a part of a fire has the support of wind and aspect +1 would be added for the wind and +1 for the aspect. Even if the fire was burning down slope there would be no reduction to the value (i.e. -1). Therefore it would remain an F2 fire rather than F1. Using this principle, a fire cannot have a value lower than F0.

8B6.35 The use of this terminology allows the communication of risk critical information in a simple and easily understood format and when used, will improve the flow of information during operational incidents.

The Practical Application of WPS

8B6.36 WPS can be used to identify all locations where there is an alteration in fire alignment and therefore a probable change to fire intensity. By using this method firefighters and fire officers can identify potential fire severity around a fire's whole perimeter. Using WPS to explain what alignment each part of a fire is in will help build up a picture of the fire's likely outward spread across the landscape.

8B6.37 Visual observation is the simplest and quickest method to use. By observing the fire and the topography, and then assessing its potential movement across the landscape, the locations where the fire will change its alignment can be determined.

8B6.38 The illustration below shows the head part of a fire that is burning upslope, with the support of the wind and in an area that is in aspect. The strength of alignment would in this case be described as a Factor Three Fire (F3).

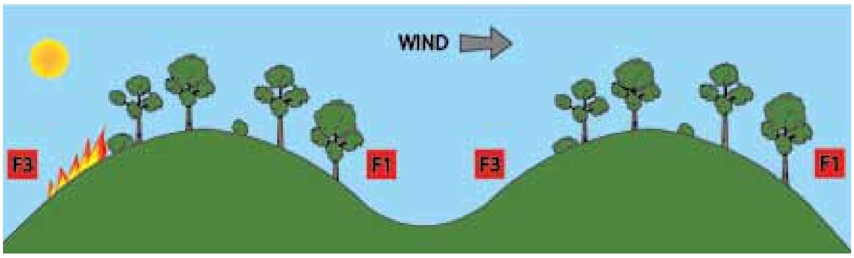


Fig. B6.7
Fire burning in full alignment

8B6.39 When the head fire reaches the top and starts to burn down the slope it loses alignment with slope and aspect, it still has the support of wind, so its alignment strength has changed from factor 3 (F3) and becomes a Factor One fire (F1).

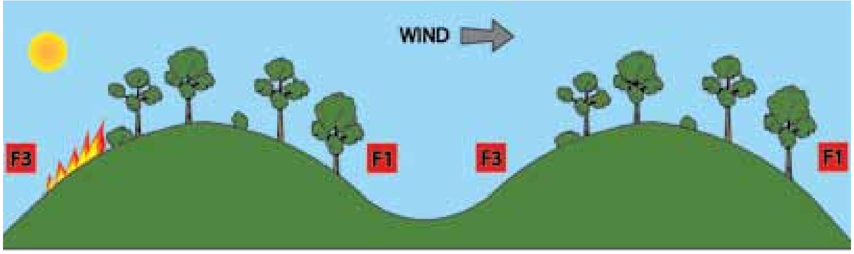


Fig. B6.8
The fire has lost the support of slope and aspect resulting in a reduction in alignment and fire behaviour

8B6.40 In this next illustration the fire has progressed down the slope and up the next one in full F3 alignment again and finally moving back down the final slope as an F1 fire.

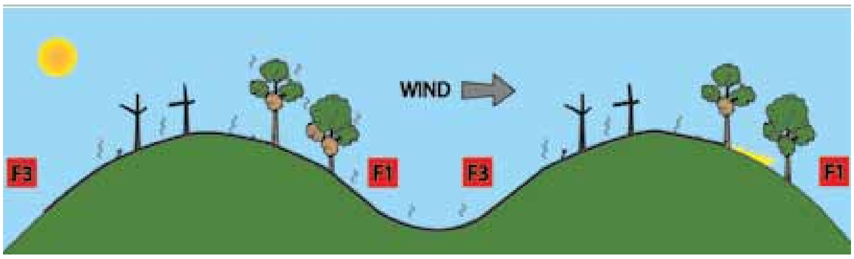


Fig. B6.9
The fire found full alignment on the reverse slope but then has reverted back to being supported only by wind

8B6.41 As is demonstrated in the illustration, when the head fire is in an F3 alignment it is likely to be much more intense than an F1 fire leading to an increase in flame length and rate of spread.

8B6.42 This simple exercise demonstrates how the changes to fire alignment, and therefore potential fire strength, can be identified. This information can then be used to identify locations where the fire may have more, or indeed, less intensity and consequently enable Incident Commanders to maximise fire suppression opportunities and maintain personnel safety.

Case Study

8B6.43 This section will examine how the prediction system can be used operationally to help understand fire behaviour.

The photograph below is taken of a wildfire burning under the following circumstances:

- **The fire is burning from the top and moving towards the bottom of the slope.**
- **The wind direction, as is shown by the direction of the smoke column, is directly opposite to the forward motion of the fire.**
- **The fuel which is scrubland, is exposed to sunlight and is in aspect.**

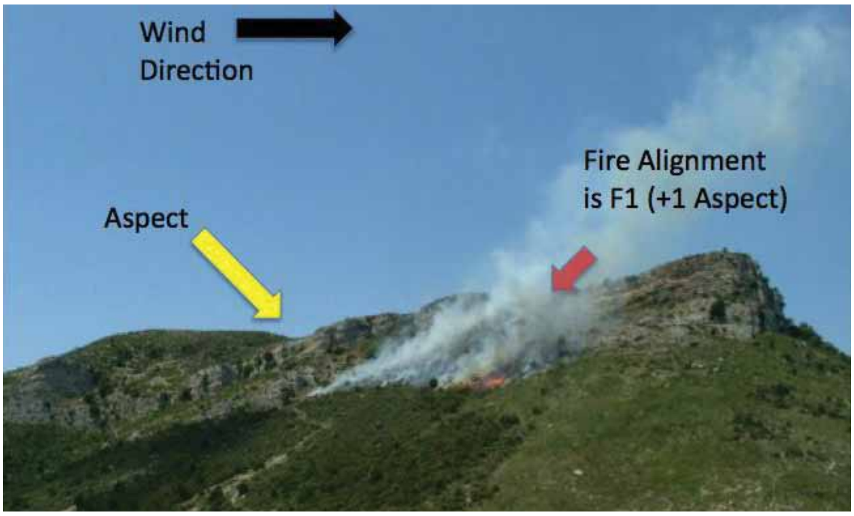


Photo B6.1
A fire that is burning against the wind and slope

8B6.44 To determine the fire's strength of alignment we must decide which of the forces are supporting the fire and which are not.

Slope – The fire is burning on a slope but is actually moving downwards against the alignment. In this situation the fire is not supported by the slope.

Wind – As can be seen by the direction of the smoke column, the fire is backing against the wind and therefore the fire is not being supported by the wind.

Aspect – The slope is in aspect and the fuel arranged on it has been preheated by the sun. The fire is aligned with aspect.

Taking these factors into account the fire only has aspect in its favour so it is a Factor One Fire (F1).

8B6.45 To bring the fire under control a team of wildfire specialists have decided to use fire as the suppression method. They have lit a fire along a control line which will burn out the fuel on the lower part of the slope.

The counter fire is burning under the following circumstances:

- **The fire is burning from the bottom and moving towards the top of the slope.**
- **The wind direction is the same and supports the fire's forward motion.**
- **The fuel type is the same type and is in aspect.**

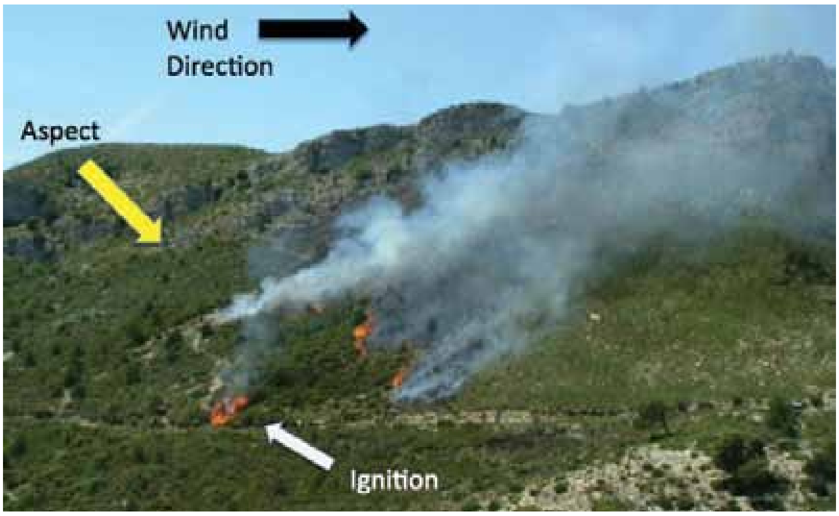


Photo B6.2
The operational offensive burn is in full alignment

8B6.46 Although the counter fire is burning on the same slope its position on it has altered the fire's potential strength. To determine the counter fire's alignment we must decide which of the forces are supporting the fire and which are not.

Slope – The counter fire is burning upslope and is therefore in alignment with it.

Wind – The counter fire is burning with the support of the wind and is therefore in alignment with it.

Aspect – The counter fire is burning in fuel that is in aspect.

8B6.47 Taking these factors into account the fire benefits from the support of all three alignment forces and is therefore termed to be a Factor Three Fire (F3).

8B6.48 Although both fires are burning on the same slope and in the same fuel, the photograph below illustrates the dramatic effect a change in alignment can have on fire behaviour. WPS can proactively identify where these changes in alignment will occur.

Photo B6.3
The operational burn has much more intensity than the wildfire and is used to remove all fuel in the fire's path

Fire Signature

8B6.49 A fire signature is the term used to describe how a fire behaves when it is burning in different fire alignments, within a uniform fuel. By observing the behaviour demonstrated in each alignment, an understanding can be reached regarding the potential flame lengths that can be expected in the future.

Example:

- **A head fire is burning upslope in an F3 alignment.**
- **The tail of the fire is burning down the same slope in an F1 alignment.**
- **The head fire reaches the top of the slope and starts to burn down the reverse side in an F1 alignment – the flame length should now be similar to the tail fire.**

8B6.50 An understanding of the potential differences in flame length, as the fire moves across the landscape, can be used to maximise the effectiveness and safety of resources deployed onto the fire ground.

Second-stage Prediction

Mapping Potential Fire Development

8B6.51 WPS can be used in conjunction with mapping systems to identify changes to alignment on a broader scale. The methods described within this section will assist officers to develop safe, efficient and effective plans.

8B6.52 Alignment mapping is a process where changes to alignments are identified and then recorded on a map. This process can be used to build up information on how the shape of the landscape is likely to influence future fire behaviour, pin pointing locations where alignments will change.

8B6.53 To carry out an assessment exercise of this type, it is essential to understand how the landscape is represented on a map. Of particular importance are the contour lines which show the shape of the terrain.

Fire Footprint Mapping

8B6.54 Having first recorded the fire alignments on a map, judgements can then be made on likely fire spread. The shape of the landscape and strength of alignments will dictate a fire's outward motion. This can be estimated and drawn within a time frame that is relevant to the event.

8B6.55 To construct a fire footprint the alignments around the fire must be identified and recorded. This may involve examining the map in detail and recording all of the alignment changes over an extensive area. This process builds up a picture of how the fire will potentially move across the landscape.

8B6.56 The initial fire footprint should not take into account any expected fire suppression activity but concentrate on the natural spread of the fire over the landscape. Consideration should also be given to the fuel types that are present. Where this is not uniform, rate of spread may vary depending on its type and arrangement.

Placing Alignments on a Map

8B6.57 The following example is used to show how to apply WPS to a map, identify likely fire spread and explain how this information assists in the development of a plan.

Case Studies

Scenario one:

- **The time of day is 09.00 hrs.**
- **The wind speed is 5 mph and its direction is northerly, this will change to an easterly with a speed of 11 mph at 13.00 hrs.**
- **The fuel type is moorland consisting of a mix of heather and grass.**
- **The point of ignition is shown as a red dot on the map.**

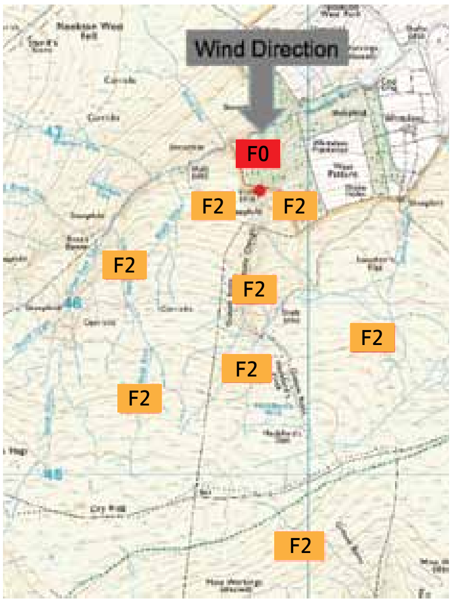
8B6.58 This information allows the use of contours on a topographical map to predict the fire's potential movement and strength over a period of time, in this case over the next 6 hours.

Fig. B6.10
Showing the point of ignition

8B6.59 As has already been explained, fire will spread outwards from the point of ignition, but its movement through the available fuel will be most rapid where it has alignment with wind, slope or aspect. To discover how the fire will develop we must identify the alignment the fire is in during its initial stages.

8B6.60 The northerly-facing slopes in this illustration are out of aspect at 09.00 hrs and are likely to remain so. Therefore the fire is burning in fuel that has not benefited from any solar preheating. The tail of the fire is backing against the wind and slope and is therefore completely out of alignment. The head is being supported by wind and slope. Although alignment remains consistent, the re-entrants in the fire's path will concentrate wind speed and exaggerate fire spread. This will allow the fire to develop a strong head with broadening flanks.

8B6.61 Based on the alignment the fire has, the illustration above is an estimation of fire spread from 09.00 hrs until 13.00 hrs after which the wind will change its direction.



In all illustrations showing fire alignments use the following key;
F0 Light Yellow
F1 Yellow
F2 Orange
F3 Red (This gives an indication of risk

Fig. B6.11
Showing the alignments that will be in as it moves across the landscape

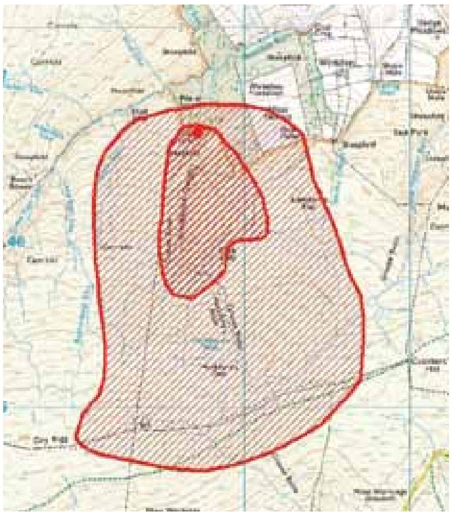


Fig. B6.12
The potential fire development over 4 hours

8B6.62 The change in wind direction at 13.00 hrs will shift alignment and alters the fire's potential development around its whole perimeter. With the change in alignment, some parts of the fire will become stronger while others have weakened. The right flank becomes the head, this will move towards the south-easterly-facing slopes that have been aligned with the sun during the morning and which are identified as F3 areas on the map.

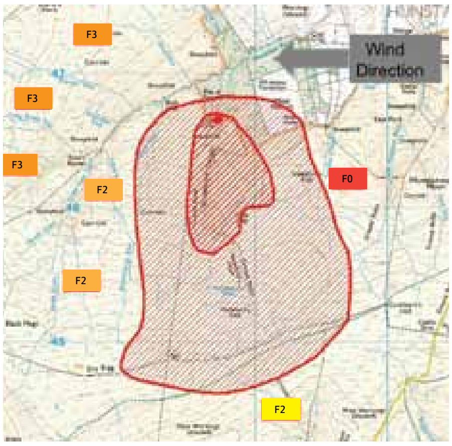


Fig. B6.13 The potential fire spread after 13.00 hrs, note how the wind has influenced significant changes to alignment values and direction of fire travel

8B6.63 The wind change will provide the fire with potential to develop into a fire of some magnitude. Once it moves into the F3 areas it will find full alignment and this will dramatically increase the fire's intensity and rate of spread. (Note the strong fire runs that are indicated along the steep re-entrants)

Fig. B6.14 Showing the potential fire spread over a 6-hour period

Using the Fire-mapping Information

8B6.64 Having proactively identified the fire's full potential development over the coming 6 hours, we are able to use this information to formulate a plan. This should be based on preventing the fire from achieving its potential by taking full advantage of any windows of opportunity.

8B6.65 The wind change at 13.00 hrs is a critical event that will change fire behaviour, spread and intensity. The fire will be driven towards the F3 areas and the fire will become a more prolonged and dangerous incident. Knowing what the consequences of this change will be helps us to understand what the operational objectives are.

8B6.66 The window of opportunity to gain control over the fire is from 09.00-13.00 hrs. The right flank of the fire is now recognised as the part that is critical to the fires future development. If control over the right flank is achieved before 13.00 hrs, the wind change is actually advantageous to firefighting operation as the rest of the fire will lose some alignment and as a result reduce in intensity.

The plan might therefore be:

- **Extinguish the tail immediately while it has no alignment.**
- **Attack both flanks but with an emphasis on maintaining complete control of the right flank. If the right flank is extinguished before 13.00 hrs then the fire will not be able to develop a head when the wind change occurs.**
- **Wait until the wind changes direction and then extinguish what had been the left flank (now the tail), taking advantage of its reduced intensity.**
- **Extinguish what had been the head fire (now the left flank), taking advantage of its reduced intensity.**

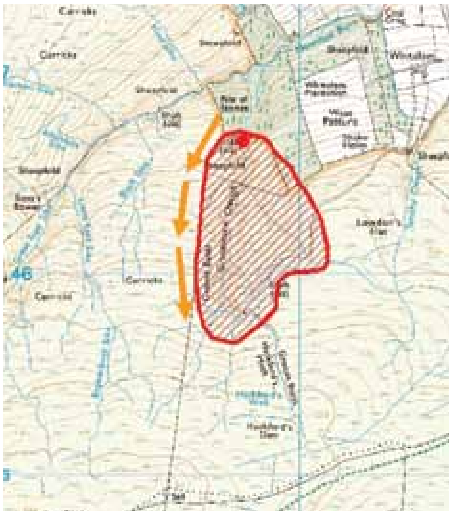


Fig. B6.15 The fires future potential intensities and size can be limited by applying appropriate tactics

8B6.67 The use of alignment mapping has allowed us to understand the fires potential over a 6-hour period. This has provided us with the information necessary to formulate a plan that anticipates and takes advantage of the changes that will occur.

8B6.68 This knowledge allows us to outmanoeuvre the fire, deploying appropriate resources and gaining control of parts of the fire that are critical to its future development.

Using WPS to Locate Critical Parts of the Landscape

8B6.69 The following example is used to show how to apply WPS to a map to help identify critical points on the landscape where fire behaviour may increase substantially. The identification of these will assist in establishing priorities within the suppression plan.

Scenario two:

- **The time of day is 13.00 hrs.**
- **The wind speed is 7 mph from the south west.**
- **The fuel type is moorland consisting of a mix of heather and grass.**
- **The point of ignition and the fire footprint for the first hour is shown on the map.**

8B6.70 This information allows the use of contours to predict the fire's potential movement and strength over a period of time; in this case over the next 4 hours.

8B6.71 The illustration above shows the fire perimeter after one hour. It also details the potential fire alignments across the landscape. These alignments, along with the contour information on the map, can be used to identify the likely pattern of fire spread during hours two, three and four.

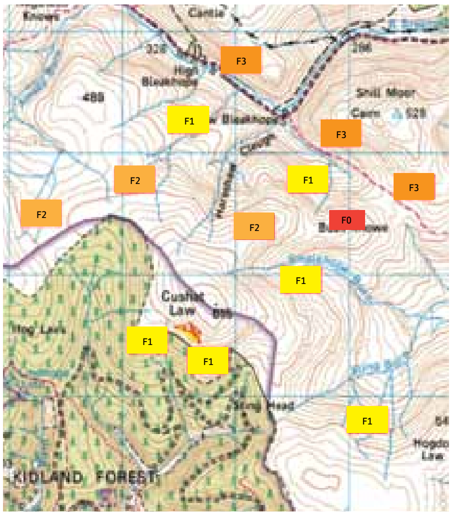


Fig. B6.16
Alignments show where there may be significant changes to fire alignments and fire behaviour

8B6.72 The alignment mapping shows that the fire is burning downslope at the tail, both of the flanks and the head. The major critical points are identified where the fire reaches a point where there is a slope reversal, this is identified by the factor-three alignments in the north-east corner of the map. This will result in a significant increase in rate of travel, flame length and intensity.

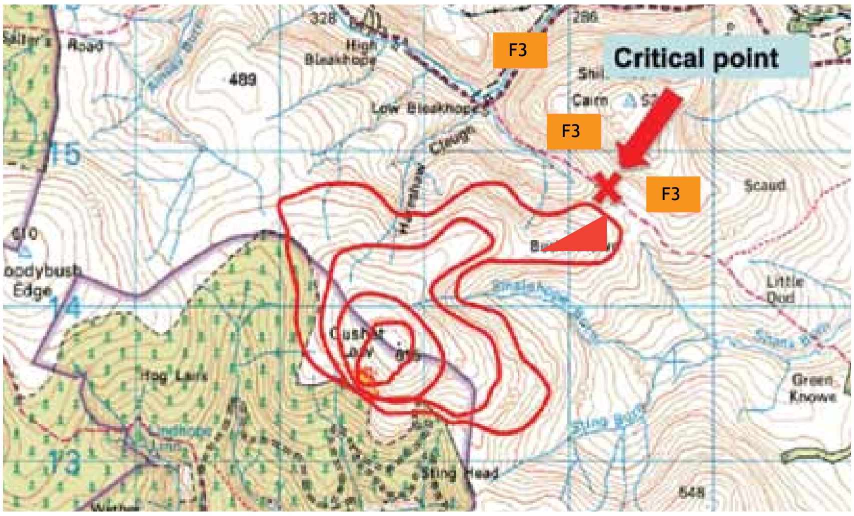


Fig. B6.17
The critical area is along the base of the slope where fire alignment changes from F1 to F3

8B6.73 The identification of these critical points shows the importance of extinguishing the fire before it reaches these locations or, taking measures to protect them such as the construction or strengthening of a control line.

Third-stage Prediction

8B6.74 Trained wildfire specialist officers can apply their more advanced knowledge and understanding to provide a more comprehensive assessment of risk. This third phase is based on analysing the fuel complex across the landscape and the alignments that they are in. Taking these variables into consideration it is possible to estimate the expected flame length; this can be used as a key indicator of potential risk within the wildfire environment.

Using Flame Length to Measure Risk

8B6.75 Flame length is a visual method of measuring risk at a wildfire. Its use allows the adoption of safe systems of work, or tactics that are appropriate to specific flame lengths.

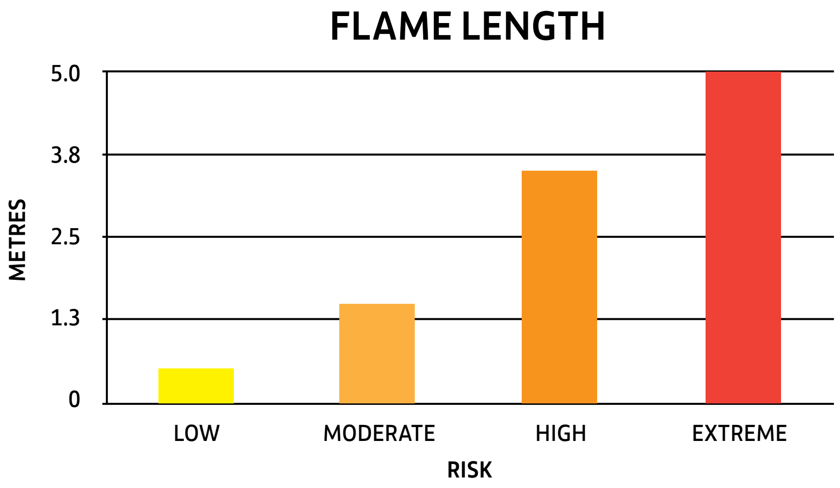


Fig. B6.18
Risk associated with each flame length

LOW RISK
Flames that are less than 0.5 metre in length are deemed to be of low risk.

MODERATE RISK
Flames that are between 0.5 and 1.5 metres in length are deemed to be of moderate risk.

HIGH RISK
Flames that are between 1.5 and 3.5 metres in length are deemed to be of high risk.

EXTREME RISK
Flames that are more than 3.5 metres in length are deemed to be of extreme risk.

Scenario Three:

- **The time of day is 10.00 hrs**
- **The wind speed is 6 mph from the south-west**
- **The fuel is mixed consisting of thicket stage conifer forest, heather and scrub**
- **The point of ignition is shown as is the fire footprint for the first hour**

8B6.76 This information, and the use of the contours on the map, allow personnel to predict the fire's potential alignments over a period of time, in this case over the next 3 hours.

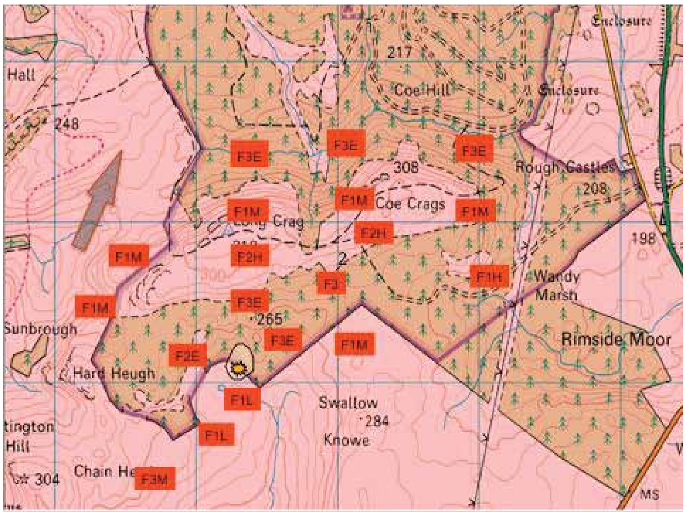


Fig. B6.19
Fire alignments are placed on a map

8B6.77 As can be seen in the illustration above the alignment information is useful but it gives no detail on the expected fire intensity or levels of risk.

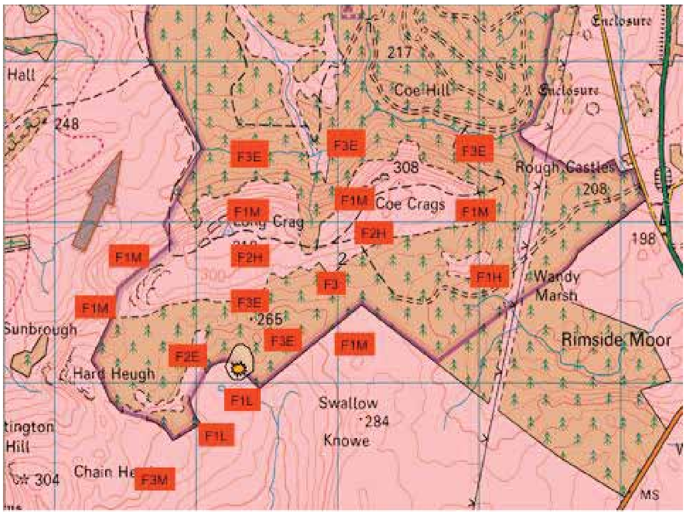


Fig. B6.20
A risk factor based on expected flame lengths is added to the alignment values

8B6.78 In the second illustration a risk factor based on expected flame length has been added. This takes into account the alignment and fuel type at each location.

8B6.79 This form of hazard mapping adds value to the process as it not only identifies risk, it also indicates which tactics might be successful or more importantly those that could be hazardous.

Fire-risk Mapping

8B6.80 This final map shows how the alignment information can be used to assist in the formulation of a safe suppression plan. The areas marked in red are those at which the fire behaviour is expected to be very intense and of high risk; in this case likely to demonstrate behaviour beyond the threshold of control of the available resources. The areas marked in green are where suppression tactics are forecast to be safe and where they are likely to succeed.

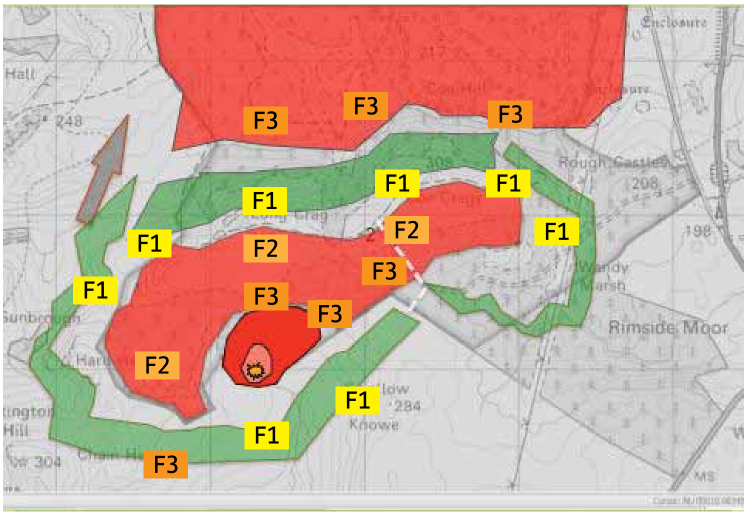


Fig. B6.21
This map shows areas of different alignment and risk which indicates which tactics may be appropriate. Direct attack would only be appropriate in the areas shaded in green

Summary

8B6.81 Historically, wildfire has been an incident type that has been very challenging and difficult to manage. It is dynamic, non-static and alters behaviour within time and space. If WPS is used as a forecasting tool it can greatly assist in understanding the times and places where intensity will change. It is a system that is flexible and simple to apply and instead of reacting to what a fire is doing WPS allows a proactive and assessed response. Planning can be based around timed initiatives and the use of appropriate tactics. If trained and experienced personnel develop an accurate prediction of future wildfire development and this subsequently is shown to be correct; then when married to appropriate response tactics, then there is a high likelihood that the tactical plan will succeed.

B86.82 Variations of slope, wind and aspect are important sources of fire behaviour information and are observable. The fourth part of the equation is the existing fuel complex. Understanding how a fire will react within this complex is crucial when making accurate fire predictions.

8B6 Key Considerations

- By applying WPS to a topographical map, alignment strengths can be used to identify likely fire spread, fire intensity and fire behaviour over periods of time.
- When used in conjunction with the LACES protocol, WPS can proactively assist in maintaining the safety of personnel at a wildfire incident.
- WPS can show areas where the fire has little alignment and where suppression tactics are likely to succeed.
- WPS allows FRS personnel to identify areas where a wildfire may become difficult to control or exhibit extreme fire behaviour.
- WPS can be adapted to suit the needs of the user depending upon their role within the incident command structure or tactical operational response.
- WPS highlights the importance of the three wildfire alignment forces of Wind, Slope and Aspect.
- WPS can be used as a three-stage iteritive process depending upon the users skill and experience.
- All personnel operating at a wildfire incident should have an understanding of the WPS system.

8B7

Wildfire Incident Management

Incident Command at Wildfire Incidents

8B7.1 Wildfire incidents can often be complex and dynamic; taking place within a spatial environment that can result in rapid, and frequent, alterations to fire behaviour. Effectively applying an Incident Command System (ICS)[1], resilient enough to cope with the demands and rigours imposed by a wildfire incident is often challenging.

8B7.2 The UK ICS is the doctrine used by Fire and Rescue Services (FRS) to manage all operational incidents. ICS is fundamentally based around establishing effective control of the incident and all personnel committed to it. A critical factor will be the Incident Commander's understanding of the operational context and environment within which incident command is to be exercised.

8B7.3 The effectiveness of the ICS used within the UK is heavily dependent upon effective communications, the ability to gather incident related intelligence and to use this information to formulate a plan that will bring the situation to a safe conclusion. This plan is reliant on the use of supporting systems that are capable of monitoring the effectiveness of the operational tactics and strategy, and instigating suitable responses to any changes to the wildfire operational environment.

8B7.4 The ICS achieves its objectives by establishing effective command in three functional areas which are:

- **Organisation on the Incident Ground**
- **Incident Risk Assessment**
- **Command Competence**

8B7.5 Effective Incident Command depends on whether personnel have the capacity and the inherent skills necessary to manage, and demonstrate all three. Any failure of wildfire Incident Command is not due to weaknesses in the system itself, but rather by the failure to provide officers with the necessary competencies to gain effective control.

8B7.6 The UK ICS relies on the provision of trained, experienced and confident officers. These must be able to apply systems that support the ICS by addressing issues that are specific to wildfire.

Decision Making

8B7.7 There is a necessary reliance within the UK ICS, on the decision making process. To have confidence and assurance in the ability of their personnel to make relevant command decisions in a wildfire environment, FRSs must ensure an appropriate level of wildfire understanding and expertise. Personnel that have only limited understanding of the operational environment may not have the ability to make the precise judgments necessary to fulfil their operational responsibilities.

8B7.8 Effective decision making is dependent on officers having had appropriate training, obtained relevant experience and by having the means to gather sufficient and accurate incident-related intelligence. Informed and competent officers are then able to formulate a plan, set objectives and assess and control risk.

1 Fire and Rescue Manual Volume 2 – Fire Service Operations – Incident Command.

8B7.9 The decision making process is addressed in greater detail within Section 8 Part C – Generic Standard Operating Procedure.

Wildfire Training

8B7.10 Without an appropriate understanding of wildfire behaviour or the complexities of the broader wildfire environment which can result in extreme changes to fire intensity, there is the potential for individuals to fail to evaluate wildfire risk effectively. A lack of wildfire command and control or operational competence results in a reactive, rather than a proactive approach to safety, and can potentially result in the adoption of unsafe systems of work.

8B7.11 Only by providing appropriate wildfire training, can FRSs expect their operational activity to succeed. Every UK FRS, to a greater or lesser extent, has a wildfire risk and it is essential that each service adopts a training response based upon local circumstances.

8B7.12 It is interesting to note, that the UK ICS is based on a system that was developed by the US Forest Service to specifically manage wildfire incidents. This is an example of the many good practices that have been developed by land management agencies.

Partnership Approach

8B7.13 FRSs should consider the significant benefits of incorporating partners from land management agencies within the incident command structure when developing their operational response.

8B7.14 Whilst it should be routine practice to make use of the expertise and knowledge of land managers who are present at the scene of a wildfire incident, the proactive and planned inclusion of rural sector environmental specialists such as SEPA (or the EA in England and Wales) within the incident command structure may not be commonplace.

8B7.15 All these partners can bring a wide range of specialist skills and expertise to the effective management of a wildfire incident, and they may possess knowledge and expertise that cannot be replicated by FRS personnel. Wherever possible, consideration should also be given to the inclusion of rural sector and land management personnel within specialist teams to provide additional support to FRS personnel.

8B7.16 As FRSs have a statutory responsibility to prevent damage to the environment resulting from their activities, the utilisation of representatives from SEPA and SNH (EA or NE in England and Wales) to advise the Incident Commander should be considered at an early stage of operations.

These expert partners can play an important role in assisting in the development of environmental considerations within the analytical risk assessment which the command team should use to deal with the potential impact of:

- **Contamination of water courses or catchment areas from water run off or airborne particles.**
- **Potential impact of wildfire/firefighting operations upon highly vulnerable sites, i.e. SSSI/SPA/SAC.**

- **The use of chemical gels, retardants, foams and wetting agents.**
- **Potential impact of soil erosion (i.e. increased flood risk) arising from the wildfire or firefighting operations.**
- **Potential impact of the wildfire smoke plume and products of combustion on human health.**
- **The potential release of ground pollutants and heavy metals into the atmosphere due to wildfire activity.**
- **The impact of fire suppression techniques on the recovery and regeneration of habitat networks.**

8B7.17 The use of partners within the FRS response to a wildfire incident can be enhanced following detailed and robust awareness training between both sectors. It is of particular benefit to ensure that rural and land management partners have a thorough understanding of fire service ICS and they understand the roles they may be expected to perform and the range and limits of their responsibilities.

8B7.18 FRSs should consider including partner agencies within their local wildfire training arrangements and partners should be encouraged to develop appropriate skills and awareness building within their own agencies.

Crew Management

8B7.19 *"The ICS and supporting processes constitute a template against which incident command policies and procedures can be written in FRSs, and the training and assessment of **individuals and teams** to operate those safely and effectively can be conducted."*

This is text taken from Chapter 1, Fire Service Manual, Volume 2, Incident Command (3rd edition). This statement makes clear the responsibility on all FRSs to formulate their own plans in order to meet the requirements of personnel expected to work within the ICS.

8B7.20 It is particularly relevant to the deployment of personnel to wildfire events where the generally accepted 'team' or 'crew' refers to an appliance staffing level. At wildfire incidents, a team of this limited size may not be ideal and can actually prove to be counterproductive due to the complexities of managing large numbers of disparate personnel within a spatial environment.

8B7.21 Wildfire incidents can sometime require the attendance of significant resources, drawn from a number of FRSs and partner agencies. Often, hundreds of personnel can become involved and the command structure can be placed under extreme stress. Establishing a command structure that can ensure the safety of personnel operating within a very dynamic situation, and who may be dispersed in small groups across a very wide area, can be exceedingly challenging.

Crew Size

8B7.22 At an incident that has large numbers of personnel in attendance, it may be appropriate, and more efficient and effective to place some of these personnel in larger groupings, typically of 10-12 persons. There can be significant benefits to this approach, not only to the ICS but also to the individuals making up the teams.

- Fewer crews – raising the number of people in each team can significantly reduce the total number of disparate crews committed onto the fire ground.
- A crew supervisor is more able to concentrate on the Lookout role within the LACES protocol. They are then able to monitor fire behaviour and issues related to team safety.
- Due to the lower numbers of crews the communication process is simplified and commanders are better able establish and maintain contact with all crews throughout the incident.
- Tactical lookouts will be responsible for fewer teams and will have to communicate with fewer crew lookouts.
- Less radio traffic and a less complex communication system facilitating a more efficient transfer of information within the ICS.
- Fewer briefings required allowing for a better information exchange.
- Crews have the capacity to be more resilient.
- Crews are more effective, a larger team can employ a more effective system of work utilising a number of tactics at once that benefits all team members.
- Crews can remain active for longer and address many of their own welfare issues.

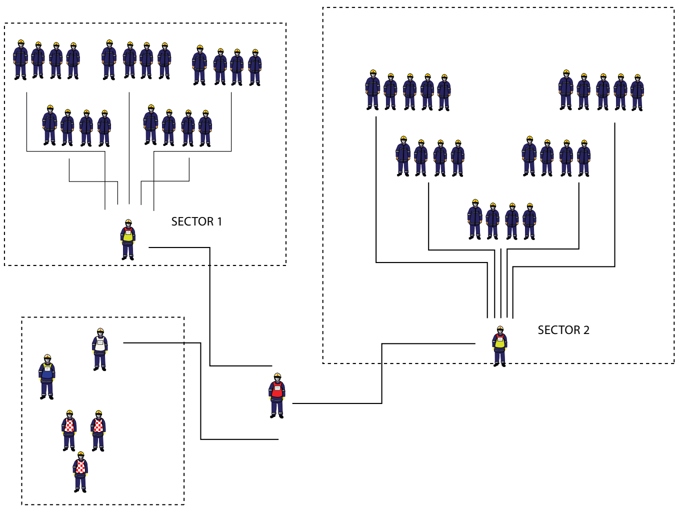


Fig. B7.1
Showing a wildfire at which the personnel have been deployed in standard appliance sized groupings

8B7.23 The illustration above shows an example of personnel within an ICS utilising crew sized groupings. If we examine the resilience of a small crew, it is more difficult for a team of 4/5 personnel to establish an effective or safe system of work. A small team is unlikely to have the capacity to meet the minimum requirements of LACES. If each team requires a supervisory officer then up to 25% of the total work force may be required to perform this management role. It will be difficult to maintain control over so many teams, or even establish effective communications.

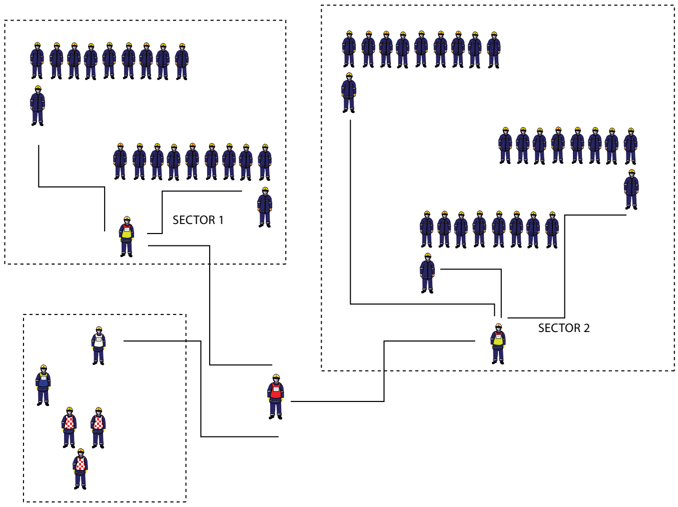


Fig. B7.2
This illustration uses a similar number of personnel as in fig 13.1 but the personnel have been deployed in larger crews

8B7.24 This illustration shows a similar number of personnel that have been deployed in crews of 10. This can significantly ease communication problems and improve control over operational issues. Larger teams, made up of between 8-12 personnel are operationally more resilient and able to operate more efficiently by rotating tasks. This allows individuals to be rested, and more importantly for team supervisors, to concentrate their efforts on maintaining safe systems of work.

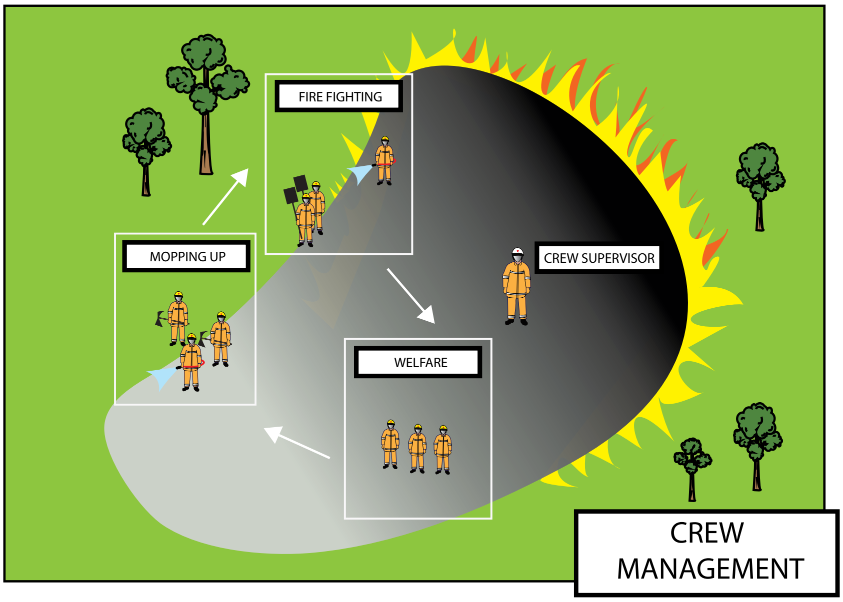


Fig. B7.3
A larger sized crew can be more resilient and adopt a more flexible system of work

The LACES Safety Protocol

8B7.25 This guidance emphasises the hazardous nature of wildfire, and the various risks that firefighters can be exposed to whilst taking part in operational activities. Globally, wildfire tragedies occur with regrettable frequency. At many of these tragic events there are multiple casualties, and at some, whole groups of firefighters have perished. These misfortunes are not restricted to countries such as the USA and Australia but frequently occur on the continent of Europe, and in recent years many European firefighters have tragically been killed at wildfire incidents.

8B7.26 The wildfire behaviour within the UK wildfire environment can be equally dangerous. All wildfire incidents are potentially hazardous, many are life threatening, and it is imperative that FRSs appreciate that without proper training, appropriate understanding and effective systems of work, FRS personnel and those that work with them remain at significant risk.

The acronym LACES stands for:

L – LOOKOUTS

A – AWARENESS

C – COMMUNICATION

E – ESCAPE ROUTES

S – SAFETY ZONE

8B7.27 The LACES protocol is developed from a US wildfire safety system that was created to address the major risks to firefighter safety. The LACES protocol simplified more complex safety advice used in the USA and elsewhere such as the 10 Standard *'Fire Orders'* and the 18 *'Watch Out'* situations.

8B7.28 LACES is an uncomplicated and easily applied safety system that is ideally suited for UK FRS use. It is internationally recognised as good practise, and has been adopted in many countries to improve the safety of operational personnel at wildfire incidents. The UK version of LACES is similar to the US system but has been adapted to ensure its compatibility with UK FRS systems.

8B7.29 The principal advantage of LACES is that it can be applied to all wildfire situations and acts as a controlling process, which, if followed, ensures critical risks are considered and monitored and that others are significantly diminished.

8B7.30 It is used to establish effective control of safety issues during a wildfire incident. It does this by ensuring that the activities of personnel, operating within a dynamic environment are closely supervised, and that changes to fire behaviour are identified and appropriately monitored.

8B7.31 The five elements of LACES are the primary safety factors that require supervision and management at any wildfire incident. If these issues are properly addressed, personnel should be kept safe. The various elements contained within the LACES protocol, ensure that:

- **Personnel are supervised and remain informed of the status and development of the wildfire.**

- **The situation is monitored and the risks that personnel are exposed to are continually assessed.**
- **It proactively identifies a response to any unexpected events, ensuring that an escape route exists to take personnel from a place of danger to one of complete safety.**

8B7.32 All large wildfires began as small fires; therefore LACES should always be adopted as a safety system at all vegetation fires. The risk to firefighter safety should not be measured by the apparent size of an incident and it is extremely hazardous to assume that smaller incidents are less dangerous than larger ones. Globally this perception has resulted in many firefighter casualties in the past. LACES should be instigated at the earliest opportunity.

An overview of the Five Elements of the LACES Protocol

Lookouts

8B7.33 A Lookout is a person that has the responsibility to monitor fire behaviour and how this may impact on the activities of operational personnel under their supervision. Lookouts at a wildfire incident can be appointed at crew, sector or incident level, depending on their training, expertise and experience.

Crew Lookouts

8B7.34 A Crew Lookout must always be appointed and is normally the team leader who is supervising the activities of an operational crew. This will usually be the crew or watch manager who already has the responsibility of managing the safety of the personnel under their command. In a wildfire situation they should take on the additional role of lookout. If resources allow, another officer can be appointed to act as the Crew Lookout. Crew Lookouts must be trained to understand and recognise dangerous wildfire situations and be able to instigate appropriate response actions.

A Crew Lookout has the following responsibilities:

- **Ensure that all personnel are fully briefed on the situation.**
- **Ensure that everyone knows what escape routes and safety zones are to be used.**
- **Take up a position from where they can observe the activities of all team members.**
- **Observe and monitor fire behaviour and identify locations where it is likely to change.**
- **Establish and remain in communication with team members, updating them with any relevant information.**
- **Establish and remain in communication with tactical lookouts (If these have been appointed).**
- **Establish and remain in communication with relevant officers within the ICS including Tactical Lookouts.**
- **Withdraw personnel from areas that pose an unacceptable level of risk.**

Tactical Lookouts

8B7.35 Crew lookouts usually operate in close proximity to the fire front and it is difficult for them to gain a full appreciation of what is happening beyond their immediate vicinity. In areas of higher risk, Tactical Lookouts perform a pivotal role within the LACES protocol and is a term used to describe a person who has been appointed by the Incident or Sector Commander to undertake the delegated responsibilities listed below:

- **Take up a position from where the area and the team(s) they have responsibility for can be observed.**
- **Ensure that all personnel operating within the area they have responsibility for are operating within the LACES protocol.**
- **Evaluate the escape routes and safety zones that have been selected.**
- **Observe and monitor fire behaviour and proactively identifying areas where this might change.**
- **Establish and remain in communication with Crew Lookouts, updating them with any relevant information.**
- **Establish and remain in communication with other Tactical Lookouts (If these have been appointed).**
- **Establish and remain in communication with relevant officers within the ICS.**
- **Monitor current weather conditions and obtain forecasts.**
- **Exchange information with relevant personnel.**
- **Cause personnel to be withdrawn from areas that pose unacceptable levels of risk.**

8B7.36 Tactical Lookouts must be trained to have an understanding of risks within the wildfire environment and an awareness of the potential changes to wildfire behaviour. At larger incidents or, where deemed appropriate, more than one Tactical Lookout may be appointed.

Awareness

8B7.37 Awareness is covered in more detail in the section covering 'Situational Awareness'. Within the LACES protocol, awareness concentrates on maintaining alertness to the changes that may impair safety and ensuring that personnel remain fully informed. The deployment of Tactical Lookouts, and the existence of Crew Lookouts, ensures that the dynamics of the situation can be constantly monitored.

8B7.38 Nevertheless, individuals within the team should ensure that they also remain vigilant and continually evaluate both their working, and the wider fire situation. By observing fire behaviour team members can also raise awareness of any potential hazard to colleagues which can then subsequently be relayed to the incident command team.

8B7.39 When working near the fire front it is important that team members remain conscious of the broader situation taking place around them and do not become too focused on their immediate surroundings. It is important that personnel are given detailed briefings and receive regular updates from their lookouts and supervising officers.

Communication

8B7.40 At a wildfire incident, where changes to fire behaviour can occur suddenly it is necessary to establish an effective communication system. As close supervision, and effective communication with personnel is often difficult at a wildfire incident, full advantage should be made of hand held and portable radio systems on the fire ground.

8B7.41 As part of the preplanning processes, FRSs should be aware of areas where radio communications may be ineffective and should make suitable alternative arrangements to ensure that contact can be maintained with personnel and teams working on the fire ground. An inefficient communication system will seriously impair the effectiveness of any command structure.

It is also important to ensure that any rural and land management partners are included within the established communication system.

8B7.42 Communication within the LACES protocol is not limited to direct radio contact but also includes verbal communication. For instance, it is imperative that meaningful briefings are given to personnel prior to deployment onto the fire ground and that subsequent, and on-going; briefings should be provided at the fire front to maintain situational awareness.

8B7.43 The LACES protocol encourages communication and the exchange of information between fire ground operational Commanders, Tactical and Crew Lookouts, and personnel that make up any operational teams.

Escape Routes

8B7.44 It is essential that personnel are aware of what action to take should an emergency situation arise. As a priority, the Crew Lookout must establish a safety zone and escape routes that will allow all team members to withdraw to a location that offers a place of complete safety. Whenever possible, it is good practice to have a primary and secondary escape route; in the event of the primary route being compromised the secondary one can then be used.

8B7.45 All personnel must understand the route to be taken as well as what signal will be given to trigger a move to the safety zone. During the identification and briefing of escape routes, positive affirmation should be sought from all personnel that they fully understand the information they have been given.

8B7.46 Escape routes should be kept as simple as possible moving through areas that pose little risk. Consideration should be given to topography, fuel types and weather factors such as wind direction when planning a route.

Safety Zone

8B7.47 A Safety Zone is a predetermined area where personnel can find refuge and safety from the effects of fire. It should be large enough to be used by all members of the crew(s) and should allow personnel to remain a minimum of four times the flame length away from the fire. Its size and location will depend on a number of factors but will generally be dictated by the size of the crews, the fuel types, terrain, expected fire behaviour and prevailing weather conditions.

8B7.48 Information on the area to be used as a Safety Zone should be communicated to Sector or Operational Commanders, and Tactical Lookouts if they have been deployed. The location of all identified Safety Zones should be relayed and recorded at the incident command post.

8B7.49 Safety Zones should be situated as close as possible, to the scene of operations. This will keep escape routes shorter and easier to follow. Establishing an escape route to a Safety Zone can be relatively easy to achieve and might be as simple as withdrawing back along the fire perimeter and into an area already burnt to mineral earth.

8B7.50 As the fire progresses across the landscape it may be necessary to change the location of the safety zone. If this is done, all personnel and supervising officers should be immediately informed and the changes recorded at the incident command post. By establishing a plan of escape everyone knows what action to take should an emergency situation occur. This will help team members make a composed and speedy response to any unforeseen event.

Situational Awareness (SA) in an Operational Environment

8B7.51 The actions or behaviour of individuals at an incident is often dictated by their interpretation of their environment and of the situation that they find themselves in. An individual's perception of any given situation, including a wildfire event, plays a significant part in their decision making processes and on their ability to perform within an operational role.

8B7.52 The attainment and maintenance of SA relies on a number of facets, some are human and others are environmental. In a dynamic situation such as a wildfire, what is clear is that SA is reliant on two major factors:

- **The practical knowledge and ability of individuals; this is normally acquired through a combination of training and experience.**
- **The amount of information made available during an incident.**

Situational awareness has been defined as:

"...the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future."

Endsley M. R. (1988)

8B7.53 This interpretation of SA makes it clear that perception is dependent on an individual's ability to correctly comprehend what factors are influencing their surroundings, and what affect these will have on their current and future situation.

8B7.54 SA can also be described as having a true understanding of an operational environment. This should include an appreciation of any variations that are likely to occur within the time and space that the event is taking place. Having a true perception of the dynamics involved within an operational environment, allows an accurate interpretation of events. Individuals are then able to apply their training, skills and experience to the situation ensuring that safety and tactics are effective.

8B7.55 If personnel are inadequately trained and informed it is unlikely that they will be able to perceive their true world situation. In an environment as dynamic as a wildfire this can lead to inappropriate levels of risk.

The Three Hierarchical Phases of Situational Awareness

8B7.56 To expand upon the definition provided above SA is described as being achieved through three hierarchical phases, perception, comprehension and projection.

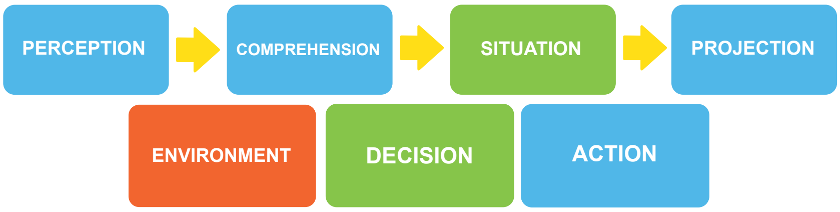


Fig. B7.4
Diagram showing the three hierarchical phases of situational awareness

Level 1 SA – *Perception of the elements in the environment*
The first step of achieving SA involves perceiving the status, attributes, and dynamics of relevant elements in the environment. In a wildfire situation this might include the fuel and its arrangement, the shape of the topography and the weather.

Level 2 SA – *Comprehension of the current situation*
This goes beyond having an understanding of the elements that are present. It includes an understanding of how these will affect the environment and being aware of the significance of available information and events.

Level 3 SA – *Projection of future status*
This is having the ability to project the future actions of the elements of the environment, at least in the near term. This is the highest level of SA. This is achieved through knowledge of the status and dynamics of the elements and a comprehension of the situation.

Understanding the Environment

8B7.57 In a high risk low time environment such as wildfire, there is a need to understand what elements are influencing the situation and comprehend what will happen as a result. The ability to extract relevant environmental information during a crisis situation will largely depend on the provision of appropriate training and is the reason why all personnel that are deployed at wildfire incidents should have an understanding of the factors that influence fire behaviour.

Intelligence Gathering

8B7.58 SA is also dependent on an individual having the knowledge necessary to assess the factors and variables that may influence their situation. Effective situational awareness is dependent on the availability and collation of relevant information. Relevant intelligence that is gathered in relation to the wildfire event must be disseminated to personnel as part of the ICS communication process.

8B7.59 In a dynamic situation at the fire front, it is also critical that real time and contemporary information is given to personnel during briefings, both before and during the incident. All relevant personnel should be provided with information regarding any potential change either to the environment or the operational situation.

8B7.60 The dynamic and analytical risk assessment processes provide important information that is essential in attaining and maintaining SA. Specific wildfire intelligence to support the risk assessment process can be gathered through the use of the Wildfire Prediction System (WPS), this will provide information that explains which elements are relevant to the current situation and what changes are likely to occur in the future.

8B7.61 The LACES Protocol can also play an important part in supporting the acquisition and maintenance of SA. Whilst its primary purpose is one of maintaining overall safety, awareness is an element within its structure and therefore supports the concept and importance of SA.

8B7.62 The adoption of LACES at a wildfire incident requires that safety officers, in the form of crew and tactical lookouts, are appointed. These provide a network of officers on the fire ground that have a responsibility to collect and exchange information.

8B7.63 A prerequisite of LACES is that information is cascaded to relevant personnel. This process can guarantee that individuals are made aware of any changes to their situation or working/ operational environment.

Constraints to Situational Awareness

8B7.64 There are two main factors that influence the degree to which individuals can acquire and maintain SA.

1. Human Factors

These are concerned with whether an individual possesses the personal attributes to enable them to extract information from the environment, and formulate an accurate assessment of the situation. This factor is related to individual ability, and the training and experience they have acquired.

2. Environmental Factors

These are concerned with the environment itself. If the situation is very dynamic, complex and high risk it may be difficult to extract the information necessary to form an accurate perception of the situation.

Incident Commanders must be aware of the challenges to maintaining effective SA and put in place processes that ensure that all appropriate information is shared with relevant personnel in good time.

The Importance of Situational Awareness to Incident Command

8B7.65 One of the primary functions of Incident Commanders must be the acquisition and maintenance of SA. It plays an integral part in the risk and decision making processes which are fundamental to achieving effective command.

8B7.66 At its lower levels, SA is applied by personnel who use it to perceive what is relevant to their local situation and apply this within their role and to their task. At a higher level it can be applied to predict future developments so that tactical adjustments can be made. This guidance has provided a number of important systems that can be utilised by officers to raise their awareness of their environment.

8B7.67 At a wildfire incident it is imperative that personnel have the competence to develop an accurate perception of their situation. Without appropriate wildfire training that enables the development of SA, personnel may not only be at increased risk, but they may not have the ability to fulfil their responsibilities within an incident command system.

Briefings at Wildfire Incidents

8B7.68 The primary responsibility of any Incident Commander is the safety of personnel working under their control. A briefing must be provided so that any hazards can be identified and that control over them can be established. Due to the dynamic and spatial nature of wildfire incidents the need for comprehensive briefings is particularly relevant. Briefings are an integral part of the ICS communication process and, as advised in Fire Service Manual, on Incident Command.

8B7.69 *"A thorough briefing of crews must take place prior to deployment so that safety critical information can be shared."*

Information has to be relayed accurately from the Incident Commander, or delegated officer, to the crews/teams prior to operational deployment. Crews must be aware of not only the risks involved but must also understand the overall plan and their role within it. The extent of any briefing will depend on the complexities of the operational environment.

8B7.70 This guidance recommends the adoption of **SMEAC** as an organisational aid to assist officers who are required to provide briefings at wildfire incidents. **SMEAC** can be used as a method of structuring a briefing that will ensure that all critical information is included.

8B7.71 As with all risk critical briefings, it is **essential to ensure that opportunity is provided to ask questions and confirm understanding**. FRS personnel may be aware of a number of variations of the SMEAC acronym, however due to the dynamic nature of a wildfire incident additional emphasis has been placed upon the Administration and Command and Control of the incident. Therefore, with regard to this wildfire guidance, SMEAC stands for:

S – Situation
M – Mission
E – Execution
A – Administration
C – Command and Control

Situation

This should include a full description of:

- **The fire including, its behaviour, location, size, and direction and rate of spread.**
- **The topography over which the fire is burning and the effects that this will have on the fire.**
- **The fuel and its arrangement.**
- **The weather – including a detailed forecast.**

Mission

- **This should provide details of the overall incident plan and the role of the team and their tasks within it.**

Execution

- **This includes more specific information on how the team will operate and carry out the task that has been allocated.**
- **It should include information on how LACES will be managed throughout the incident.**

Administration

The team should be briefed on relevant logistical issues these might include:

- **Length of deployment**
- **Reliefs**
- **Welfare issues**
- **A record of team members should be kept by Incident Command**

Command and Control

Information on the command structure should be provided, this should include:

- **Lines of command**
- **Communication processes and systems**
- **Team Management within the ICS**

Additional Information on ICS

8B7.72 This guidance does not deviate from the command doctrine outlined within the FRS Manual on Incident Command and recognises that the key principles of the UK ICS can be applied to wildfire incidents to ensure that they are effectively managed. It does however provide additional supporting systems and information that can be used at wildfire incidents.

Terminology

8B7.73 It is recommended that FRSs adopt the terminology introduced in this guidance as it provides the framework for effective and consistent wildfire related communication on, and off, the fire ground.

Wildfire Policy

8B7.74 It is recommended that FRSs should develop effective policies governing their approach to wildfire incident command.

Procedures should be structured in accordance with the information contained within this guidance and Fire and Rescue Manual – Volume 2 Fire Service Operations – Incident Command, and be underpinned by an effective training strategy.

Fire and Rescue Jurisdiction

8B7.75 Although this guidance seeks to encourage an increased involvement with rural and land management partners, in particular their participation in operational activities, it is essential that all operational command roles at a wildfire incident remain under the jurisdiction and control of FRS officers.

FRS Incident Command Roles

The Incident Commander (IC)

8B7.76 The IC remains at all times responsible for the overall management of a wildfire incident including the tactics and resource management. The IC should have an appropriate understanding of wildfire and the command competence to safely manage the associated risks.

8B7.77 ICs must ensure that all personnel are operating within the LACES protocol and that this is instigated at the earliest opportunity. If appropriate, the IC should deploy tactical lookout(s) to oversee crews that are at risk and provide intelligence regarding fire behaviour and updates on the operational situation.

The IC must put in place a command structure that is able to safely support the management / control of the resources committed during the incident.

Operations Commander (OC)

8B7.78 An OC is an officer tasked with co-ordinating and directing the operations of several sectors. Due to the potential size and complexity of some wildfire incidents it may be necessary to appoint more than one OC. When an OC is appointed, Sector Commanders will report to the OC rather than the Incident Commander.

Sector Commander (SC)

8B7.79 Sector Commanders are tasked with responsibility for tactical and safety management of a clearly identified part of the incident. Subject to objectives set by the IC the SC has control over all operations within the sector and must remain within it.

8B7.80 Sector Commanders must remain in communication with all relevant officers within the command structure, and all personnel in their sector. Due to the nature of wildfire incidents it is often difficult for Sector Commanders to observe all operational activities of the crews under their command.

8B7.81 The LACES Protocol and the deployment of Tactical Lookouts can mitigate some supervision issues. LACES, ensures that the SC can have confidence that a situation is being continually monitored, and an immediate response can be made to any previously unforeseen hazards or developments.

Crew Commanders

8B7.82 A Crew Commander's primary responsibility is the supervision of specific tasks or meeting specific objectives utilising one or more firefighters and managing the safety of the personnel under their direct supervision.

Within the LACES Protocol Crew Commanders should also act as the Crew Lookout, and apply the guidance outlined within the LACES Protocol.

8B7.83 Crew Commanders must react immediately to deteriorating operational conditions and if necessary withdraw the crew following pre-arranged escape routes.

Crew Commanders should ensure that their team has the resilience to carry out its operational task, remain safe, and address welfare issues that may arise during a prolonged deployment.

Safety Officer

8B7.84 A safety officer can be designated at any time during a wildfire incident and will have specific responsibility for monitoring operations and ensuring the safety of personnel working on the incident ground or a designated section of it.

To enable them to be fully effective safety officers should have an awareness of wildfire behaviour.

Tactical Lookouts

8B7.85 Tactical Lookouts can be appointed by the Incident Commander or Sector Commanders to monitor the activities of crews operating in higher risk areas, their primary duty is to ensure the safety of the personnel that they have been given responsibility for.

8B7.86 A Tactical Lookout may be deployed to supervise the safety of a crew, a number of crews, a sector or depending on its size a whole incident.

HMEPO – Hazardous Materials and Environmental Protection Officer

8B7.87 FRSs should give consideration to the inclusion of an HMEPO within the wildfire incident command team to act as an environmental advisor to the Incident Commander and also provide sector competent liaison with partners from SEPA or the EA. Whenever possible, the deployment of an HMEPO should be based upon the potential environmental risks identified during the pre-planning process.

The Role of Specialist Wildfire Officers

8B7.88 Officers with specialist knowledge of wildfire can carry out a number of functions to ensure that their FRS is better prepared to meet the wildfire risk in their local area. At an incident, they can act as subject matter advisers or take on more complex risk critical operational roles, and their expertise can prove to be invaluable to the Incident Commander.

8B7.89 Prior to any incident occurring, specialist officers can assist in the preplanning required to determine a service's local operational response to the wildfire risk within their area. They can also play an important part in ensuring that there is effective liaison with partner agencies, to underpin the preplanning and prevention strategies developed by their services.

8B7.90 Operationally, specialist officers or personnel performing an advisory role will operate at a tactical level, providing support to the incident command structure and assisting in the control and co-ordination of resources. Personnel performing a wildfire advisory role should have the knowledge and understanding to provide information on issues including:

- **Fire behaviour and its future development.**
- **The associated risks and the control measures to be instigated during the incident.**
- **The appropriate tactics to be employed.**
- **The suppression methods to be used.**
- **The deployment of resources on the fire ground.**
- **Provide advice or practical guidance in relation to map reading or navigational issues.**
- **To gather and analyse operational intelligence.**

(All wildfire specialist officers should have a thorough understanding of map reading, navigation and orienteering)

Specialist Teams

8B7.91 Some services may find it beneficial to develop teams of specialist officers or personnel that can perform more complex operational roles. The roles undertaken will depend on the needs identified by individual FRSs but can include the following:

- **Operating as Team, Sector or Incident lookouts.**
- **Giving tactical support to operational commanders.**
- **Form teams able to construct control lines.**
- **Provide specialist skills such as operating mechanical tools such as chain saws or brush cutters.**
- **Provide teams that are able to operate safely in areas on the fire ground that are more complex and require more wildfire expertise.**
- **Provide teams that can operate safely during the hours of darkness.**
- **Provide teams that can carry out specialist operational activities involving the use of fire.**
- **Act as Aerial Sector Commanders.**
- **Provide teams that have the operational capacity to provide ground support to aerial units.**

The Role of Rural Wildfire Specialists/Fire Teams

8B7.92 Rural partners can play an invaluable role in supporting the incident command team in the effective resolution of a wildfire incident. Whereas it is always beneficial to make use of the local knowledge and experience that may be available at a wildfire incident, personnel performing the role of Rural Wildfire Specialists differ in so much as they should not only have sector competence within their own area of expertise, but should have received equivalent training and exercising as a FRS Specialist Wildfire Officer. This will ensure that they have knowledge and understanding of the FRS incident command system and the operational wildfire environment in which they will be required to operate.

8B7.93 Although it will be a matter for each FRS to determine, it is suggested that Rural Wildfire Specialists, subject to appropriate command and supervision, can undertake the following roles:

- **Act as an advisor to the incident command team**
- **Act as a Tactical Lookout**
- **Rural sector logistics support/management**
- **Supervising vegetation clearance**
- **Act as part of the incident command planning team/cell**
- **Perform appropriate specialist operational roles under the command of the FRS Sector/Ops Commander**
- **Assist in the compilation of accurate and timely media briefings**

8B7.94 Rural Fire Teams can act independently in support of the tactical fire plan or they can be combined into larger fire teams which may also include FRS personnel. They consist of rural sector personnel trained to undertake fire suppression activities and can be led by a rural sector manager or Rural Wildfire Specialists, but must always remain under the control and direction of the FRS. Fire and Rescue service should satisfy themselves that any rural partners utilised to perform fire suppression activities have suitable PPE and equipment to perform the role.

Command Support

8B7.95 Command Support is a role undertaken by one or more staff at a wildfire incident to provide assistance to incident command team. The Command Support role typically provides recording, liaison, resource management, and information gathering for the Incident Commander. Land managers, or rural sector representatives included within the command support team, may assist in gathering valuable information and provide additional support throughout the incident.

8B7.96 With reference to a wildfire incident, it will be necessary to provide updates by gathering specific intelligence related to topography, weather, fuel types and potential fire behaviour. It may be useful to include personnel with specialist wildfire knowledge within the command support team. These may be FRS personnel or members of the rural sector.

Summary and Examples of Wildfire Incident Command

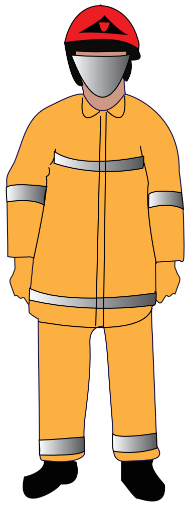
8B7.97 This guidance has provided information on a number of subjects that will enhance ICS at wildfire incidents, these include:

- **The deployment of personnel in appropriately sized groupings reduces the number of crews deployed onto the fire ground, simplifying the lines of communication. In addition, larger groups can be more resilient allowing them to address many of their own safety and welfare issues. There is more tactical flexibility within a larger crew allowing crew leaders to adopt appropriate systems of work.**
- **The LACES Protocol can be used to improve safety and can be utilised to address risk during firefighting operations.**
- **The Wildfire Prediction System has many uses within Incident Command. It can be utilised at crew, sector or incident level by firefighters or fire officers. It can be used to improve safety or to assist in deciding what tactics will be effective.**
- **Personnel who have the expertise to effectively use mapping, and who are supported by others who have the ability to navigate will prove to be invaluable at any spatial incident.**
- **Situational awareness is a concept that can only be made a reality through effective communication. At wildfire incidents it is of critical importance that accurate and real-time information is relayed to all personnel. This should include effective information exchange spanning all levels within the ICS. Briefings play a critical part in this process and the information contained will depend on the complexity of the situation. Maintaining Situational awareness should be seen as a key outcome of an effective ICS.**

Identification of Command Roles

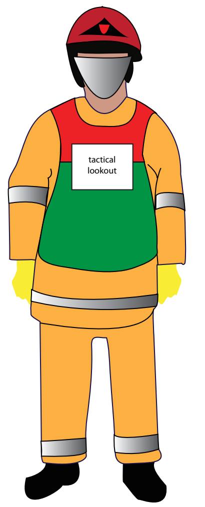
8B7.98 At a large wildfire, attending personnel may deploy from a number of FRSs and partner agencies, and those personnel will be expected to work together seamlessly within the incident command structure. It is important that there is a common understanding of how the roles within the ICS are identified. This guidance uses the system depicted in the FRS ICS manual, but also suggests the introduction of some additional roles and how these may be identified on the incident ground.

8B7.99 **Specialist Wildfire Officers** – It is suggested that Specialist Wildfire Officers wear a red helmet, which allows them to be distinguished from other personnel on the fire ground without the use of a surcoat. These officers can be specialist FRS personnel or be individuals from partner agencies who have had equivalent training.



8B7.100 **Tactical Lookouts** – It is suggested that Tactical Lookouts wear a green surcoat with red shoulders.

In addition, there are a number of examples of patterns of uniform and surcoats which may assist in the management and command of a wildfire incident event. The diagrams are for illustration purposes only.



8B7.101 **Rural Wildfire Specialist** – It is suggested that personnel from the rural/land management sector are identified in a PPE or a Surcoat which clearly differentiates them from FRS personnel.
In this example they are wearing red PPE. It should be noted that the Rural Wildfire Specialist also wears a red helmet to signify a more advanced level of knowledge and/or training that their peers and the ability to act as an advisor within the command team.

Identification of Incident and Sector Command Points

8B7.102 Due to the size and remoteness of some incidents it may be difficult to visually locate command points on the incident ground. Therefore it is important that the locations are marked on the incident map and this is cascaded to personnel in the form of a grid reference. In addition it is beneficial to use some form of visual indicator so that personnel can clearly identify their location.

8B7.103 To assist with the effective management of individual sectors, personnel should consider the establishment of 'zones' where relief crews, equipment and other logistical supplies can be conveniently located. Ideally these should be positioned close to but not at the same locations as the command points.

Where a large amount of equipment is provided by partner agencies, the logistical management of this should be given to the partners involved.For example, if the Forestry Commission (FC) is supporting FRS operational activity by providing heavy equipment and vegetation removal machinery, this should remain under the management of the FC. Nevertheless the operational activity of this equipment must remain under the supervision of the FRS.

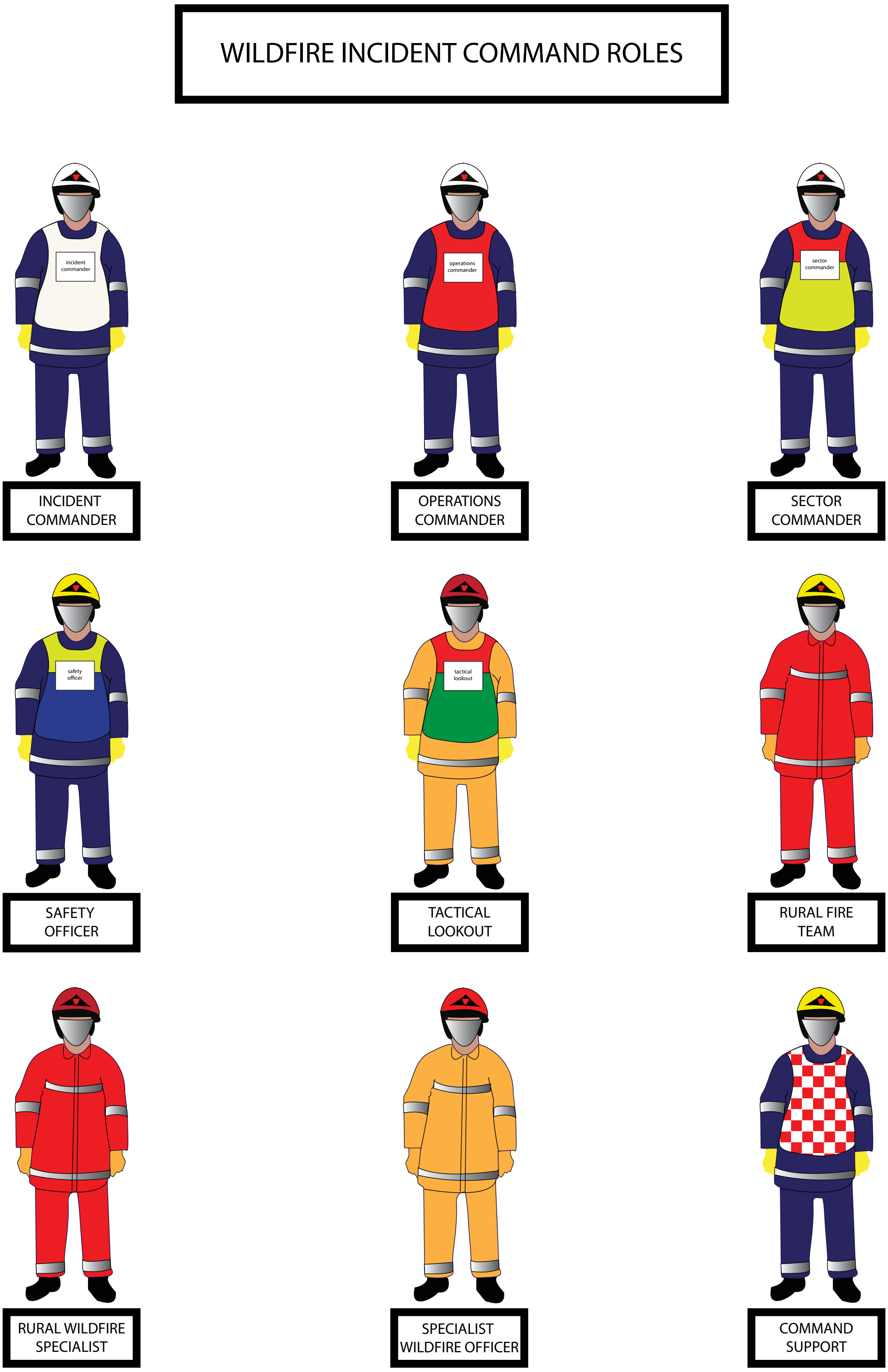

WILDFIRE INCIDENT COMMAND ROLES
INCIDENT COMMANDER
OPERATIONS COMMANDER
SECTOR COMMANDER
SAFETY OFFICER
TACTICAL LOOKOUT
RURAL FIRE TEAM
RURAL WILDFIRE SPECIALIST
SPECIALIST WILDFIRE OFFICER
COMMAND SUPPORT

Fig. B7.5

Examples of appropriate ICS structures

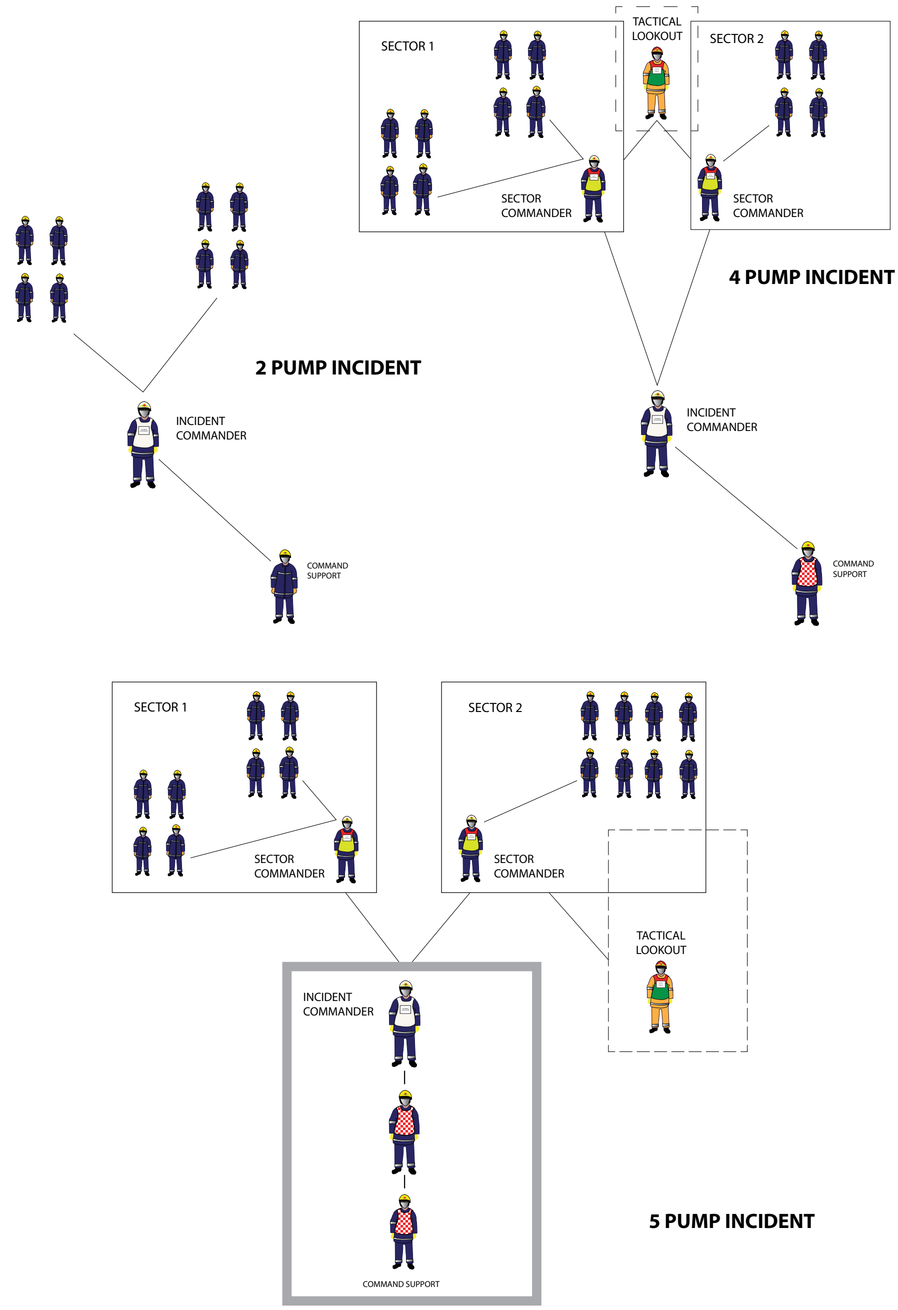


Fig. B7.6 Illustration showing 2, 4 and 5 pump incident

Fig. B7.6 shows three separate ICS structures that have been scaled to manage incidents of different levels of risk. The first is a 2 pump grass fire. As in all subsequent illustrations LACES has been instigated and Crew Commanders have taken on the role of Crew Lookouts.

In the second command structure where the incident is of higher risk it has been divided into two sectors. The Incident Commander has appointed a Tactical Lookout who is monitoring the situation in both sectors.

The third command structure shows a more complicated incident that has been divided into two sectors. Sector 1 has been given the responsibility for the tail part of the fire and sector 2 is responsible for the head part of the fire.

The flame lengths in sector 1 are of low risk, while the flame lengths within sector 2 are of moderate risk.

As a control measure the IC has appointed a Tactical Lookout to monitor the higher risk operational situation in sector 2.

The size of the team in sector 2 has also been increased to eight personnel simplifying lines of communication and improving its own resilience to manage safety and welfare issues.

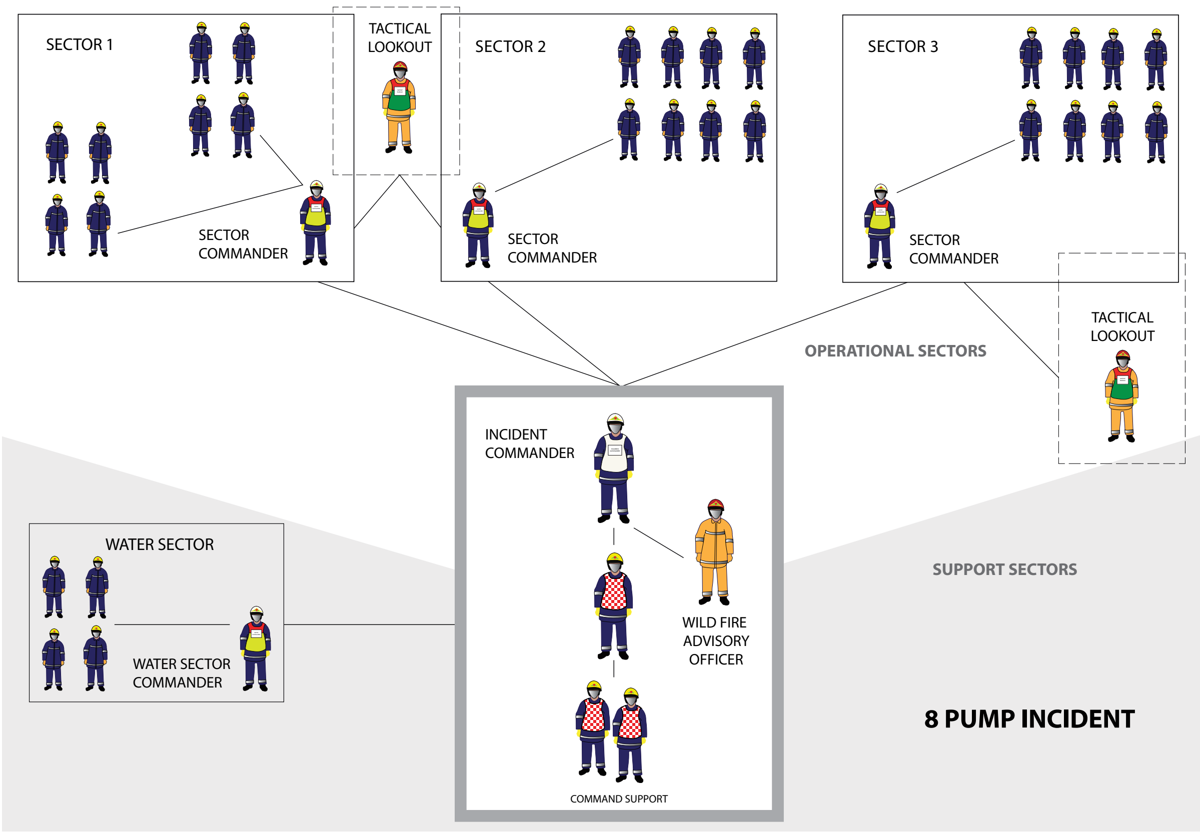


Fig. B7.7 8 pump incident

In Fig B7.7 the command structure has been expanded to address a high level of risk on the fire ground.

A fire is burning in mixed fuel types resulting in frequent changes to fire behaviour in all sectors.

Due to the geographical size of the incident it has been necessary to appoint two Tactical Lookouts.

As an additional safety measure a Specialist Wildfire Officer has been appointed to the support the IC as a wildfire advisor.

In this illustration an Operations Commander has been appointed, two Tactical Lookouts have been put in place to monitor sectors 1, 2, and 4. Sector 3 is involved in mopping up operations at the tail part of the fire and is deemed to be low risk.

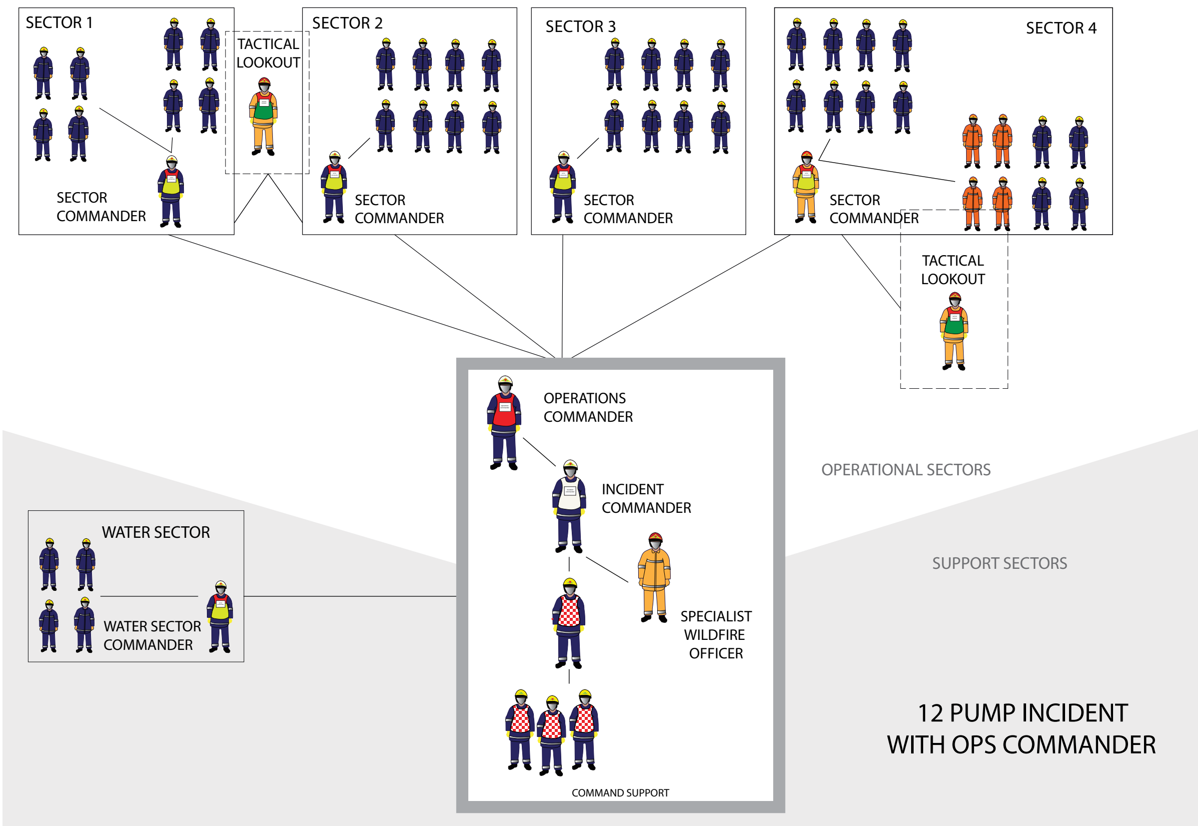


Fig. B7.8 12 pump incident with OPs commander

Additionally, due to a higher level of risk in sector 4, a Wildfire Specialist has been appointed as Sector Commander. The enlargement in the size of crews also reduces complexities within the lines of communication and command.

A small group of partners have been included in sector 4.

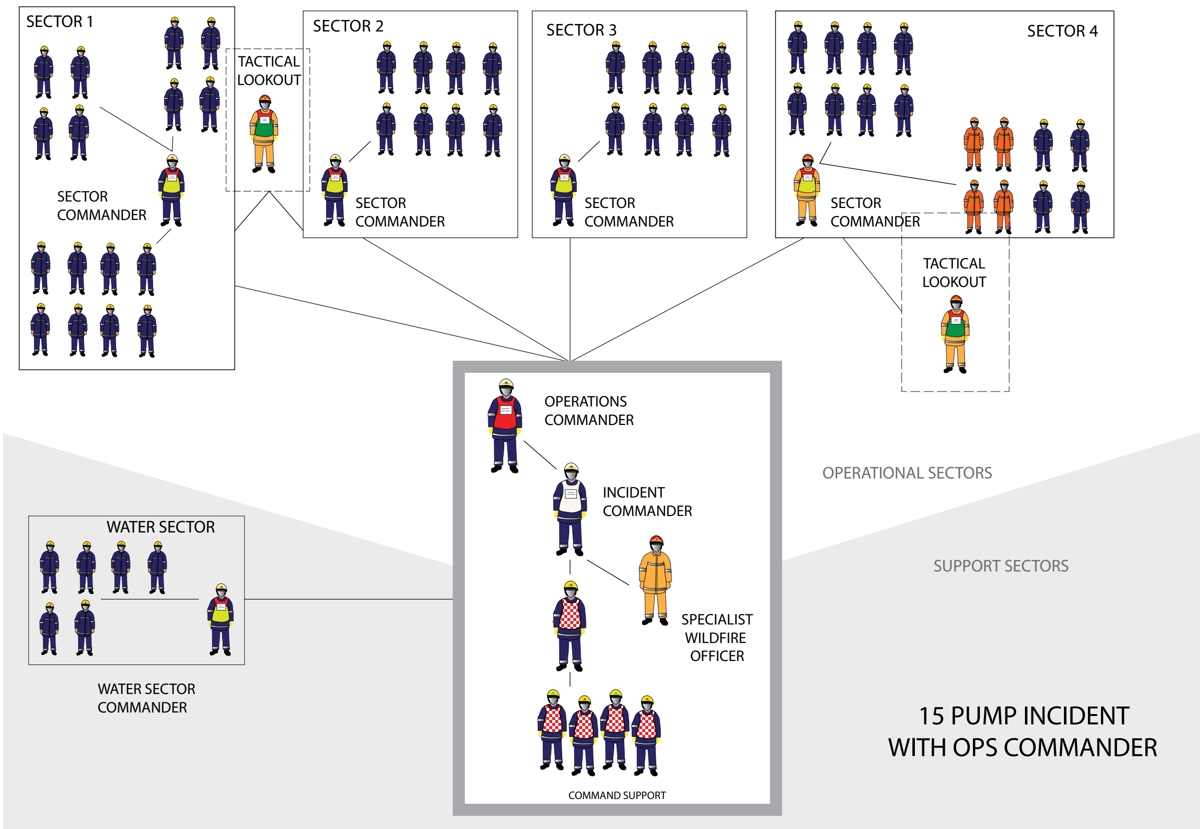


Fig. B7.9 15 pump incident with limited partnership support

Fig B7.9 shows a representation of a larger incident where a FRS is unable to call upon any large scale assistance from the rural sector.

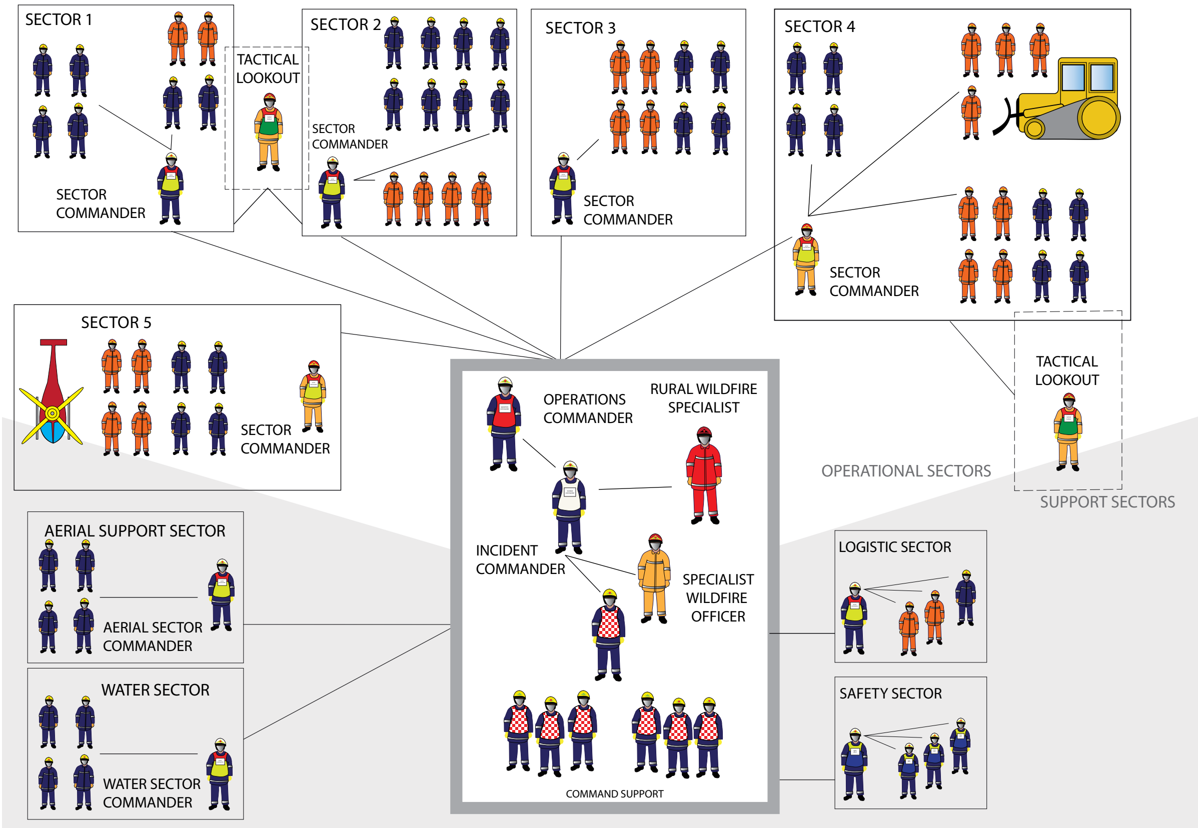


Fig. B7.10 15 pump incident with partnership support

Fig. B7.10 demonstrates the value of partnership assistance at incidents that require large amounts of resource. The FRS commitment is 15 fire appliance crews, but additional provision from partners results in an attendance equivalent to 20 FRS crews.

An aircraft is being used in sector 2 and as a result an aerial support sector has been established to manage its operational activities.

In sector 4 vegetation clearance is being carried out by partners from the rural sector utilising heavy plant machinery.

The logistics sector support comprises FRS and rural sector personnel. The rural partners have specific responsibility for the mangement of non-FRS resources.

Sectorisation of Wildfire Incidents

8B7.104 Establishing effective command at a wildfire incident can often be difficult, the situation may be extremely complex for a number of reasons including:

- **The fire may cover a large geographical area stretching lines of communication and restricting the flow of risk critical information.**
- **A wildfire may demonstrate diverse fire behaviour around its perimeter.**
- **Changes in fuel, weather or topography may alter fire intensity or rate of spread.**
- **Changes to fire behaviour can be rapid and significant which can place personnel at risk.**
- **There may be substantial numbers of FRS and partner agency personnel active on the fire ground.**
- **The incident is often still spreading and expanding outwards.**

8B7.105 Due to the nature of wildfire, it is often advantageous to sectorise wildfire incidents. Lines of command and communication are thereby shortened, and Sector Commanders are more able to remain in contact with personnel that they have responsibility for.

8B7.106 They also have the advantage of managing a part of an incident rather than the whole; therefore they can address the dynamics of a 'local' operational situation and remain responsive to the need for tactical flexibility.

8B7.107 As with all incidents, sectorisation should only take place at a wildfire if it is necessary to do so. Nevertheless due to the complexities faced at this type of incident sectorisation on many occasions will be inevitable.

8B7.108 Although it is normal practise that sector 1 would be placed at the main scene of operations, this is often difficult to do at a wildfire incident due to changes in fire intensities around the fire perimeter. Nevertheless, sector 1 should be located in the area where most operational activities are anticipated to take place.

8B7.109 Sectorisation of a wildfire is complicated by the dynamics of the incident type. Spatially the incident is likely to expand, sometimes spreading over large areas so that it concludes a great distance from where the original subdivision took place.

8B7.110 The fact that a fire's perimeter or fire front may be expanding causes problems as to who takes on the responsibility of managing the additional parts.

8B7.111 In some countries sectors are defined by the parts of the wildfire, i.e. the head, flanks and tail. This system has a number of potential weaknesses as it is sometimes difficult to understand where one part of the fire begins and finishes, and where sector responsibility is set. Sectors based on fire behaviour can also become confusing if this behaviour changes, for example if the wind direction alters and a flank fire becomes the head fire.

8B7.112 Another method used is by reference to direction around the fire's perimeter, i.e. North, East, West and South sectors. Although a relatively simple concept, in practicality it can be difficult to determine and communicate where a sector's boundary is on the ground.

8B7.113 Setting fixed sector boundaries, at an incident where the outer perimeter of a fire is expanding, and at which a fire may change direction, rate of spread or intensity, is difficult. It is however essential that the method used gives a clear indication of the extent of the sector area, as only then can Sector Commanders be expected to understand the parts of the fire they have responsibility and control over.

8B7.114 At larger and more complex incidents, a solution can be found by not focusing attention on the fire, but on the surrounding landscape. By sectorising the land over which the fire must travel rather than the fire itself, sectors are based on a fixed space. This allows secure and unambiguous sector boundaries to be drawn that can remain in place for the duration of the incident.

8B7.115 Using an OS map a circle is drawn around the incident, this should be far enough away to take into account any future fire development; this can be used as the outer perimeter of the sectors. The circle can then be divided into sector areas, these should be based on expected fire behaviour and spread. For example if the fire has little potential on its tail and left flank then these can be combined into one sector. If the head fire is expected to expand and increase in intensity this can be divided into two sectors.

8B7.116 When setting boundary lines between sectors, it may be useful to use features of terrain that can be identified on the ground. Walls, fence lines, roads, streams, features of terrain can all be used as visual indicators showing sector boundaries to personnel on the fire ground. If these are not present then lines drawn between two points can simply be drawn on the map.

8B7.117 Signs can also be placed at key areas indicating which sector they are in, for example bridges and gates, on main routes could show a sector marker, especially where these are at a boundary between two sectors.

8B7.118 When using this system it is of the utmost importance that the sector boundaries are fully understood and that maps containing this information are issued to relevant personnel including crew supervisors on the fire ground.

8B7.119 The advantage of this system is that sector commanders have a clear indication as to their command area and that this will remain fixed. They can then take the appropriate measures necessary to contain the fire within their sector, ensuring that these plans are co-ordinated with those of adjoining sectors.

8B7.120 Although the fire situation may remain volatile, the fire dynamics do not have to impinge on the sector areas. If necessary as fire behaviour alters sectors can be added or closed down. ICs also have clarity with regards to who is responsible for each part of the landscape and the fire on it.

8B7.121 The following example shows how a wildfire may be sectored closely following the principles outlined within the Fire and Rescue Manual Volume 2 – Fire Service Operations – Incident Command.

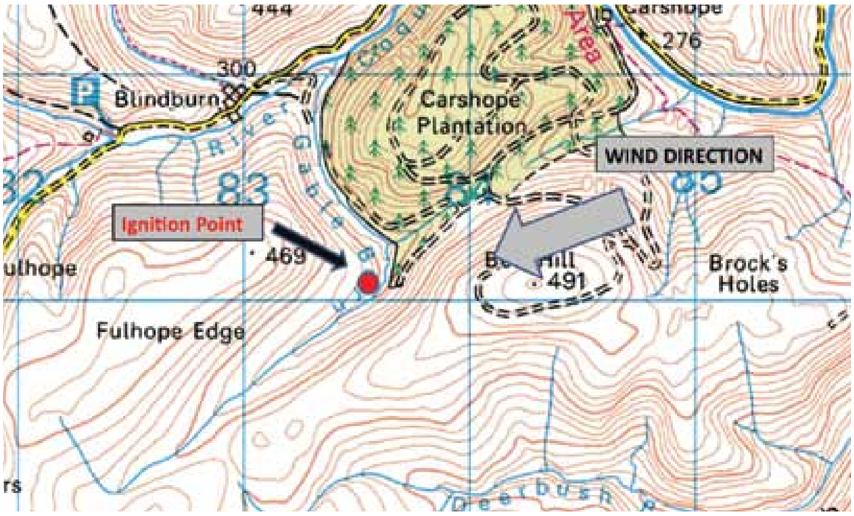


Fig. B7.11
This illustration shows the point of ignition and the wind direction. The fire will align itself with the wind and the upslopes of the surrounding topography.

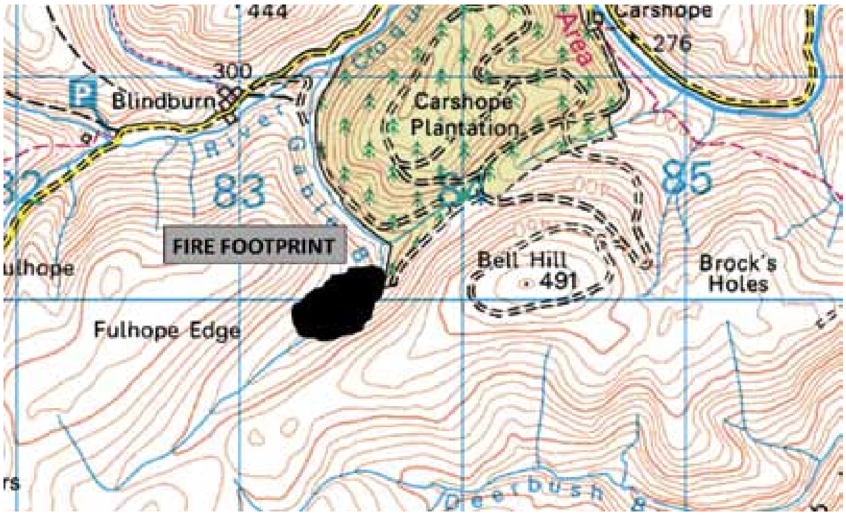


Fig. B7.12
The fire has developed a strong head and its forward motion is upwards along the valley. The steep slopes either side provide alignment for lateral movement by both flanks.

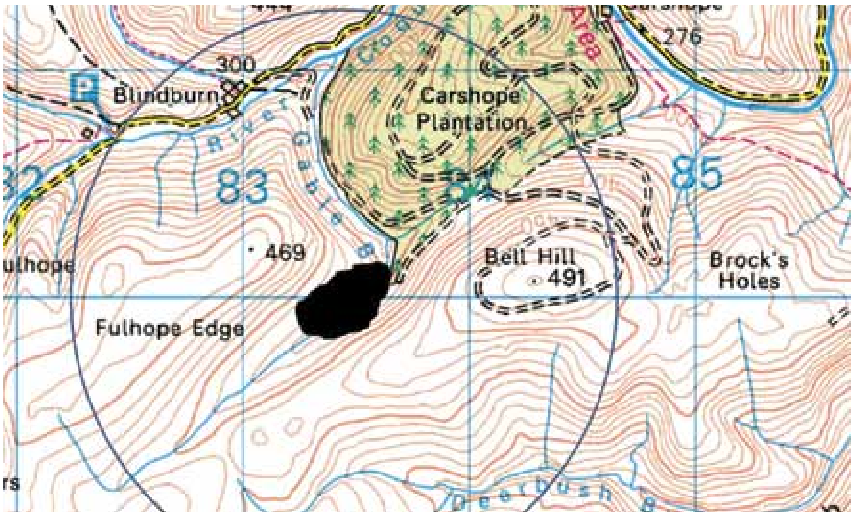


Fig. B7.13
Taking into account the likely development of the fire in the future, a circle is drawn around the incident. In this particular example the diameter of the circle is about 2km. This circle represents a flexible outer control boundary in which sectorisation of the landscape can take place.

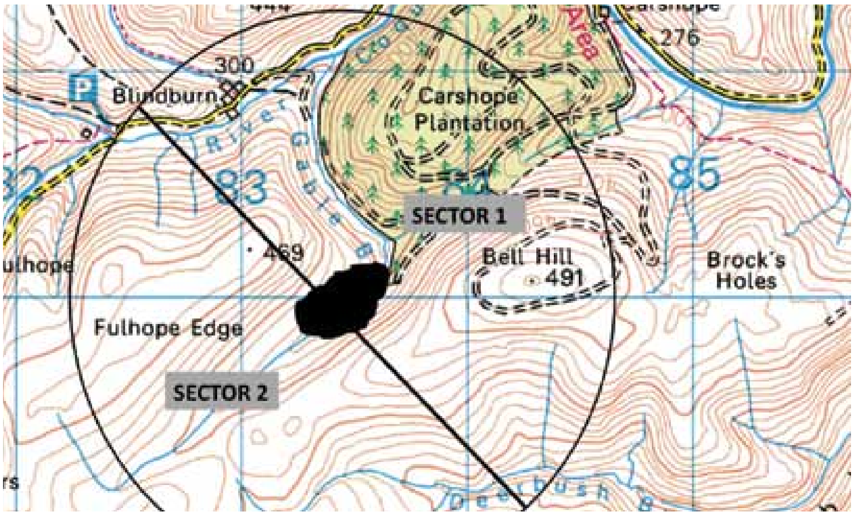


Fig. B7.14
The landscape can now be sectored in a number of ways. This example shows that the fire has been divided into two sectors. Sector 1 covers the area in which the head part of the fire may expand into. Sector 2 covers the area in which the flanks and tail may develop.

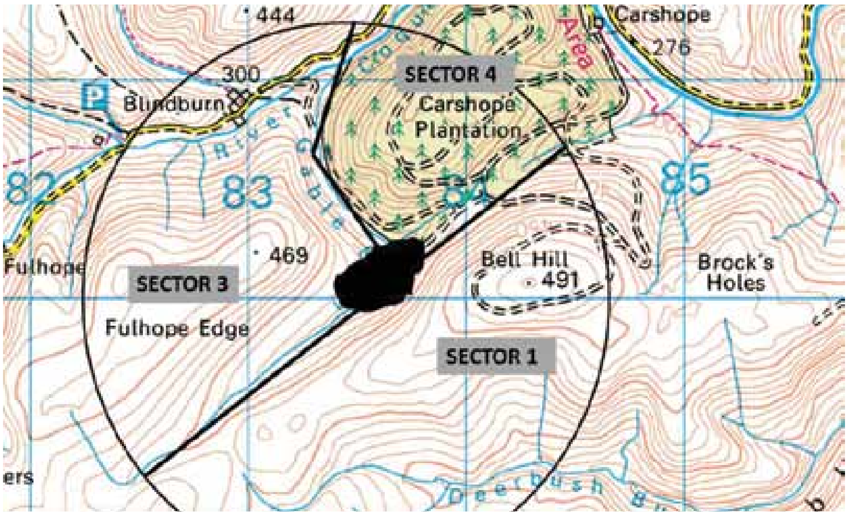


Fig. B7.15
A second method is to use features on the landscape to identify sector boundaries. In this example the stream and the edge of the wood have been used as a visual method to divide the incident into three sectors.

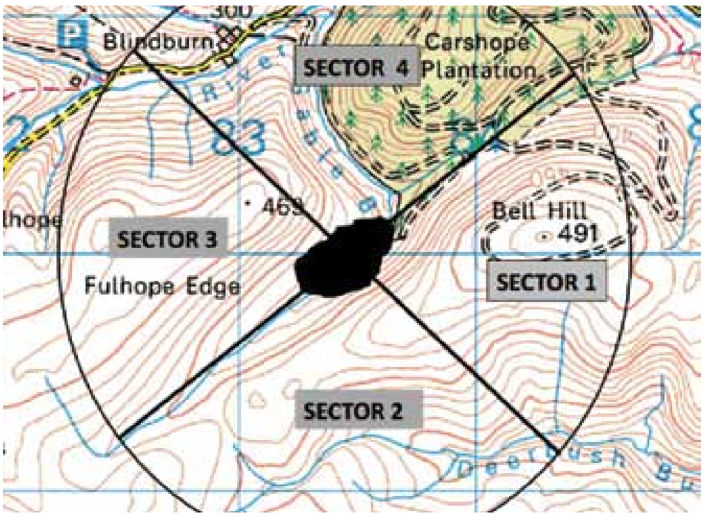


Fig. B7.16
In this example the fire has been divided into four sectors so that each sector covers a smaller area of the landscape

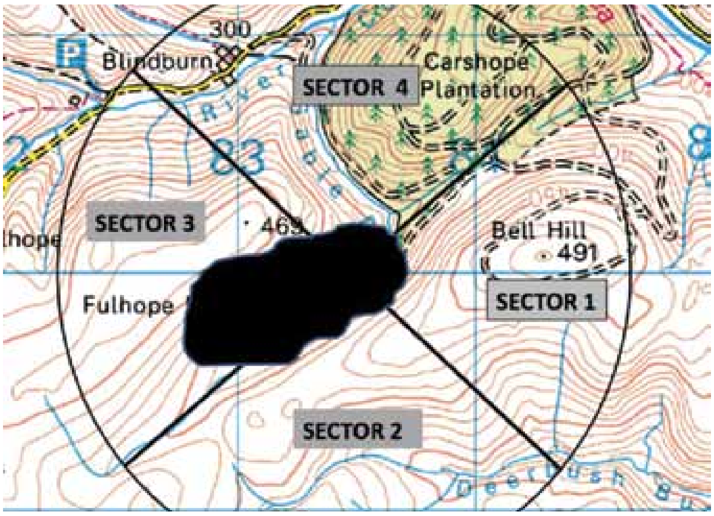


Fig. 7.17
This illustration shows that although the fire is expanding, the sector arrangement accounts for this spatial enlargement and remains the same.

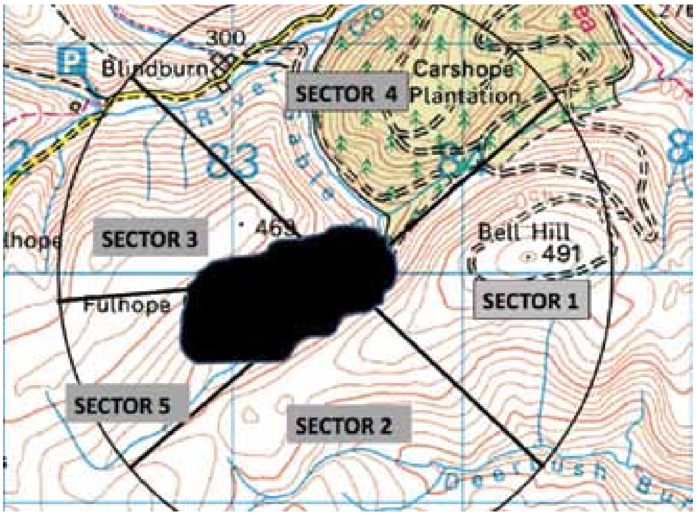


Fig. 7.18
Further sectorisation can take place if the situation demands it. In this instance, the head part of the fire in sector 3 is expanding rapidly. With the introduction of sector 5 this part of the fire has been sub-divided so that it can be more effectively managed.

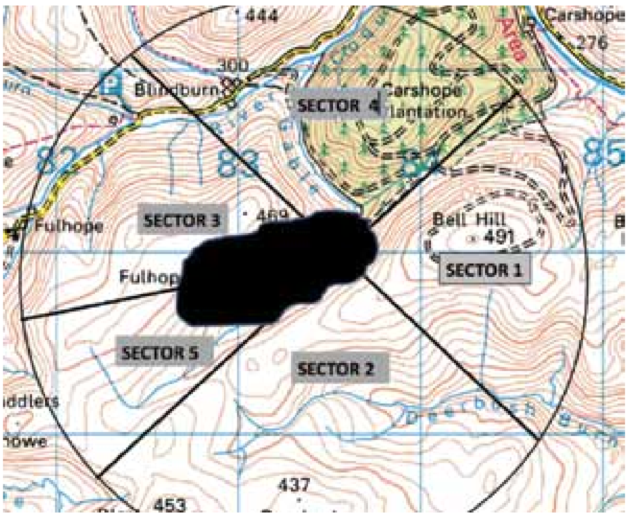


Fig. 7.19
As the fire expands the outer perimeter of the control area can be enlarged to cover a greater part of the landscape.

8B7 Key Considerations

- The adoption of the LACES safety protocol will assist in the mitigation of many wildfire hazards.
- All personnel at a wildfire incident should have an understanding of the LACES safety protocol.
- Tactical Lookouts can play an important role in maintaining situational awareness by providing real time information to commanders and operational personnel.
- All personnel must know their escape route(s) and the location of their safety zone.
- The safety zone should allow personnel to be able to remain a minimum of 4x the flame length away from the fire.
- Escape routes should be as short and straightforward as possible.
- The Wildfire Prediction System can be used as an effective risk management tool.
- At large incidents it may be useful if the size of crews is enlarged, this will reduce the total number of teams committed onto the fire ground and simplify management and communication issues.
- Comprehensive briefings using the SMEAC methodology should be given to everyone before deployment and updates should be given at appropriate times throughout an incident.
- Individuals must maintain an accurate understanding of their operational environment at all times.
- FRSs should consider the significant benefits of incorporating partners from land management agencies as advisors within the incident command structure.
- Land management partners can provide valuable practical support to firefighting operations whilst under the supervision and command of FRS personnel.

8B8

Fire Suppression Tactics

Overview of FRS Wildfire Suppression Tactics

8B8.01 There are two main methods used to suppress wildfire, these are:

Direct Attack – where personnel and resources work at, or very close to, the burning edge of the fire. Firefighting crews aggressively attack the fire either by applying water or extinguishing the fire using *'hand tools'* and *'beaters'*.

Indirect Attack – this method involves applying suppression tactics that take place away from the burning edge of the fire. Either by using control lines to contain fire spread, or the proactive use of fire as a suppression tool.

8B8.02 Although some FRSs have a limited knowledge of indirect attack methods, few have incorporated these fully into their systems of work. Fire is a very effective suppression tool and is used extensively in Europe, the USA and Australasia. Unfortunately it is not widely used in the UK and only a few FRSs have developed the skills necessary to apply it operationally.

8B8.03 Helicopters and fixed-wing aircraft can also use direct and indirect attack methods. Water drops, directly applied onto the fire, are an example of direct aerial attack; while drops made to strengthen or create fire breaks some distance away from the fire's edge are an indirect attack technique.

8B8.04 Aerial attack and suppression tactics are dealt with in more detail in Part B9.

Fire and Rescue Tactics

8B8.05 Direct attack is an effective method of suppression, and one that can be used with great success, but it is a technique that has limitations and is more successful when used on fires with an intensity producing a flame length of below 1.5m.

8B8.06 If a FRS's tactical fire fighting methodology is limited to direct attack, it becomes increasingly difficult to gain control of a fire as the intensity increases. This can lead to a situation where more and more resources are being committed with little effect. Fire behaviour at such fires may increase the levels of risk to a point where they become dangerous.

8B8.07 The use of alternative 'indirect attack methods', can prove to be more effective than direct attack methods and can often be applied with a greater emphasis on personnel safety. The indirect attack methods described in this guidance were developed by agencies from outside the UK, (most from a land management and non FRS background) and they are specific to wildfire. Once understood, they can be introduced and used by FRSs with confidence.

The successful application of these tactics will depend on FRSs acquiring new skills and adapting their firefighting approach.

Direct Attack

8B8.08 The emphasis in a direct attack focuses on a fire being fought aggressively by personnel at close quarters at the fire edge. This attack can be launched by crews using hand tools, or crews equipped with a water delivery system or a combination of both.

8B8.09 It is always advisable that water, or some other form of extinguishing media, is available when undertaking a direct attack. FRSs in the UK are already familiar with, and competent in the use of, open and closed circuit water relays, water ferrying and the deployment of High Volume Pumps (HVPs) when dealing with large spatial vegetation fires.

8B8.10 Direct attack methods can be extremely successful when deployed against fires of low (flame length up to 0.5m) and low/medium intensity (flame length up to a maximum of 1.5m). Fires that demonstrate flame lengths above 1.5m become progressively more difficult and dangerous to control. Although the application of water via pressurised systems may still have some success on fires above this threshold, personnel working with hand tools such as beaters should be withdrawn until flame length is reduced.

Hand Tool Crews

8B8.11 These are made up of personnel who are equipped to fight a fire using techniques, which utilise hand tools and portable firefighting equipment. Hand tool crews should be equipped with fire fighting equipment such as beaters and knapsack sprayers. They can also use mattocks, spades, saws and other equipment specific to control line construction.

8B8.12 Hand tool crews should consist of an appropriate number of personnel specific to the task. They can include trained personnel drawn from the land management sector operating under FRS supervision and control.

8B8.13 Depending upon the size of the wildfire event and the tactics deployed by the Incident Commander, it is often more effective to utilise larger crews consisting of between six and 12 personnel.

Water Attack Crews

8B8.14 These are crews that have the capability to launch a pressurised water attack on a fire. This could include the use of fire appliances, portable pumps and other assets, such as high pressure water fogging units.

Attacking the Fire

8B8.15 A wildfire, under normal circumstances, should always be attacked from the rear and where possible from an area that has already been burnt. This prevents personnel from being placed in front of a fire in unburnt fuel, which can be particularly dangerous.

8B8.16 The timing of an attack is also important, changes to alignment and fuels will result in different fire intensities. Attacks should be made at times and places where the fires are burning with lower intensities. For example, if a fire is burning upslope it might be prudent to delay any attack on the head part of a fire until it reaches the top of the slope, where its intensity will fall.

Working from an Anchor Point

8B8.17 It is crucially important that suppression tactics are begun from secure locations on the landscape, strong enough to act as barriers to fire spread. The commencement of operations from these 'Anchor Points' ensures that the fire cannot escape from the containment area threatening the success of the operation or the safety of personnel. If necessary, Anchor Points should be strengthened, or even created, by the use of hand tools or machinery.

8B8.18 Crews should normally work from an Anchor Point along the flank or flanks of the fire towards the head.

Working from the Black

8B8.19 Whenever possible, it is good practise to work from within the burnt area or what is termed to be 'the black'. Working from 'the black' can provide crews with some security as they are working from behind the fire, in an area that has already been burnt. When doing so, it is still important to understand that the fuel in the black area may not be completely burnt, and should the fire change its direction; the remaining fuel may support a second burn.

8B8.20 Nevertheless, the black area is usually the safest place to work from and offers some protection to FRS personnel from the effects of heat and smoke.

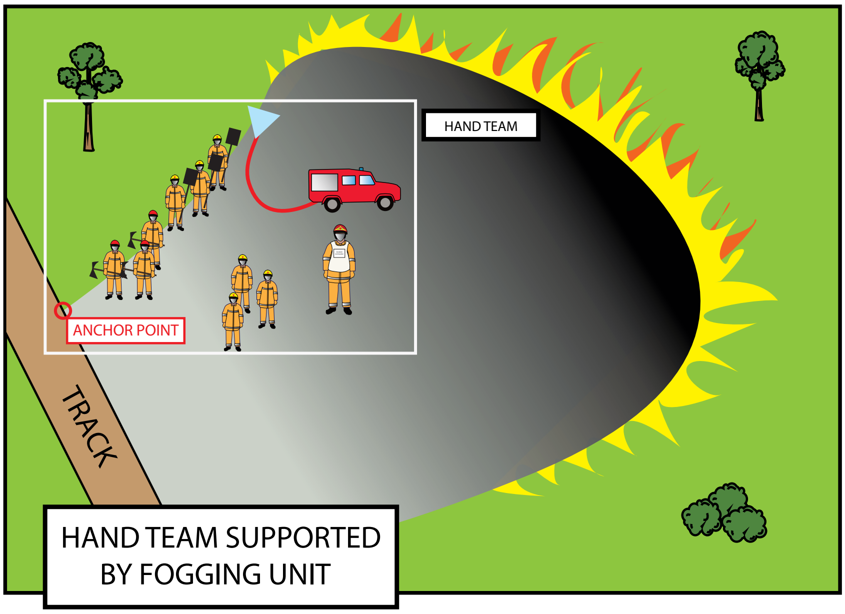


Fig. B8.1
Wildfire hand tool crew supported by a pressurised water system using the track as an Anchor Point and attacking the flank from within the black

Responding to Changes in Fire Behaviour

8B8.21 As wildfire behaviour is changeable, it is important that crews using a direct attack maintain a flexible approach to the tactics being used. As a wildfire progresses across a landscape there will invariably be changes in fire behaviour. Advantage should be taken of situations where a fire is burning in different fuel types at lower intensities, but in areas of higher intensity tactics may have to be modified, sometimes this may mean that indirect tactics are adopted.

The Use of Water at a Wildfire

8B8.22 Water remains the most effective method of extinguishing wildfire, especially when supplies are plentiful and it can be applied via a pressurised system such as a fire service pump. Most FRS firefighting pumps are mounted on vehicles that have limited capability to operate off-road or away from level, and hard, surfaces. These limitations often result in assets and resources being unable to be deployed at, or even near to, the scene of operations.

8B8.23 Where there is a lack of suitable and sufficient water supplies in rural areas. FRSs should make arrangements to identify open water supplies as part of their local pre-planning arrangements.

8B8.24 There may be problems in moving and supplying water to the scene of operations. Where water supplies are limited then it should be used sparingly. Under certain circumstances High Volume Pumps (HVPs) can be utilised to move large volumes of water to and around a fire ground. FRSs should assess the suitability of HVP deployment within their local pre-planning arrangements.

Whenever HVPs are deployed, early consideration should be given to the potential requirement for an HVP Instructor or Subject Matter Advisor to attend.

8B8.25 Water has its limitations, and at very intense fires its application may not substantially reduce the intensity and rate of spread of a fire, to a point where it allows the fire to be contained or extinguished.

The Application of Water

8B8.26 The purpose of applying water as the main suppression method is to completely extinguish the fire, as with structural firefighting techniques, which is best achieved by applying the water to the base of the flame. This is particularly relevant in wildfire situations where maximum efficiency is required from the use of water.

8B8.27 Operatives should take up a safe position, as close to the fire as possible. As they work along the fire front extinguishing the flames, they should constantly check that all hot spots are extinguished. If any are left burning the fire may reignite and the resulting fire may place the water attack crew in danger.

Water should normally be applied using a spray or fog. Jets should only be used:

- **To cool a hot fire to enable personnel to get closer to the fire front**
- **If more penetration is required**
- **Where water has to be applied from a greater distance**

It is good practise for a hand tool crew to work in tandem with the water attack crew; they should extinguish or dig out hot spots as the water attack progresses along the fire front.

Different Methods of Direct Attack

8B8.28 Attacks should be based on expected fire behaviour and full advantage should be taken of when a fire is demonstrating low intensities. It is advantageous to extinguish the tail part of a fire as soon as possible, this can secure an anchor point to work from and eliminates the possibility of it changing its alignment and increasing in intensity.

Flank Attack

8B8.29 Fire behaviour is normally less intense on the flanks; it is normally good practice to attack the fire from behind, progressing along the flank towards the head.

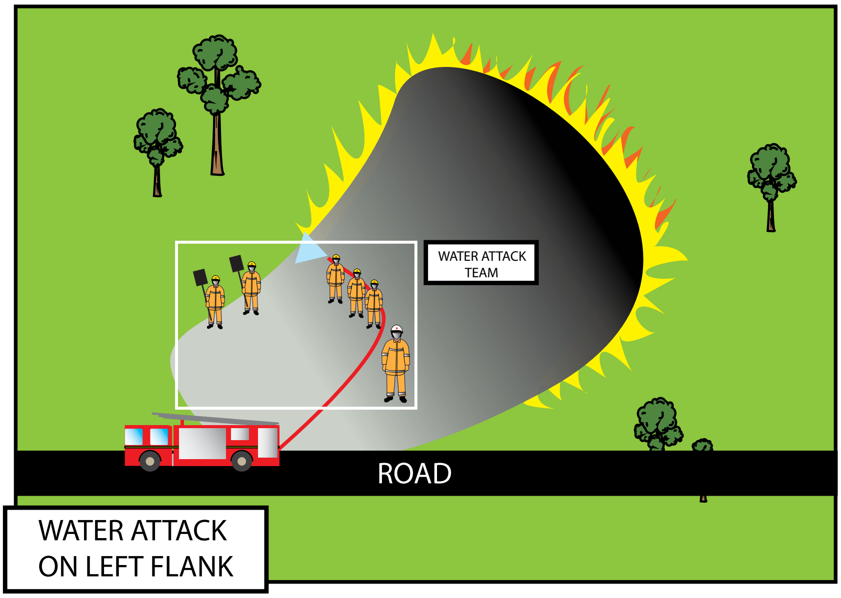


Fig. B8.2
In this illustration the crew is attacking the left flank and working in the pre-burnt area

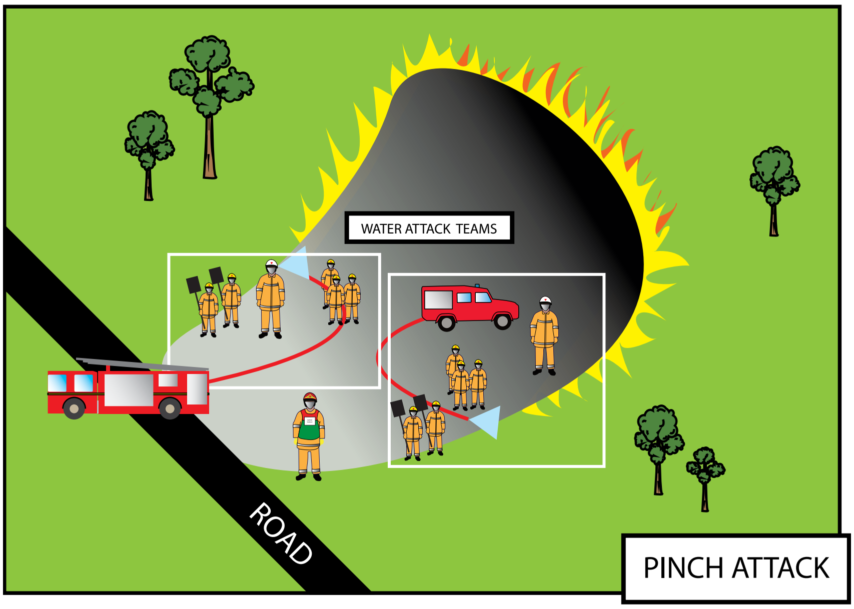


Fig. B8.3
In the illustration above two crews are attacking both flanks of the fire; this is referred to as a 'pinching attack'. Working from the tail of the fire the crews take advantage of the black area where the fuel has already been burnt

Head Attack

8B8.30 Unless a fire is of low intensity, the head part of a fire should normally only be attacked once the flanks have been extinguished. This is partly because the head fire gains some support from the flank fires and, once these have been extinguished, fire intensity at the head will normally reduce. Direct attack against a head fire is normally only successful on lower intensity fires. It may be dangerous to attack a head fire from the front, particularly when personnel are placed in unburnt vegetation.

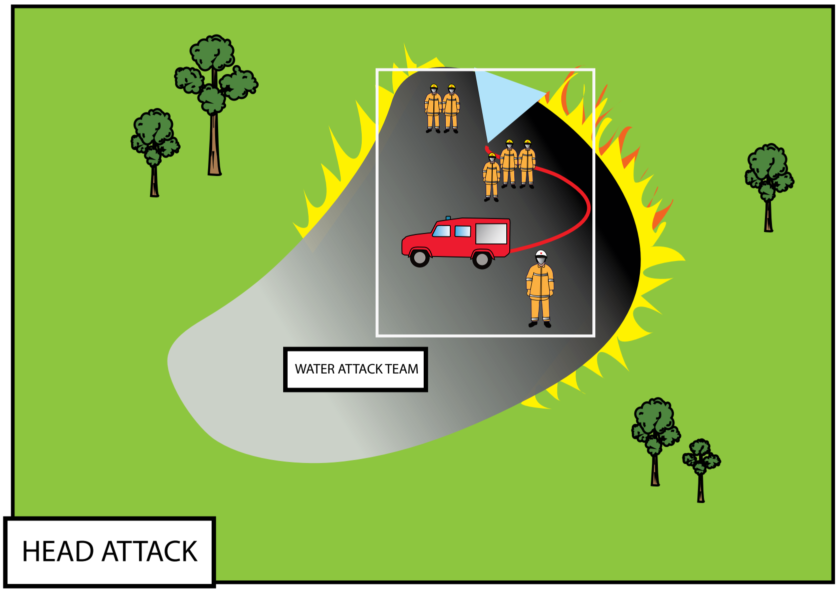


Fig. B8.4
Crew working from the back using water to attack a head fire

This illustration shows a water attack crew extinguishing the head of the fire from the rear. Due to the head fire having the greatest fire intensity and rate of spread, head attack is normally only possible at low intensity fires and extreme care should be taken when employing this tactic.

The Use of Water as a Secondary Method of Suppression

8B8.31 Where water supplies are scarce or when FRS vehicles are unable to gain access to the scene of operations, hand crews may have to carry out an attack using hand tools and knapsack sprayers. Wherever possible crews should be supported by 'All Terrain Vehicles' (ATVs) that carry portable firefighting systems or are equipped to carry water supplies that can be used to refill knapsack sprayers.

Photo B8.1
A photograph of a wildfire vehicle equipped with a fogging unit which can provide water support to hand crews

8B8.32 A hand crew should consist of sufficient numbers to meet the requirements of the task. Where water supplies are limited the water should be used to lower the fire intensity rather than extinguish the fire. The application of very small amounts of water will reduce flame length and the heat generated by the fire. The application of water in this way will significantly increase the duration of the water supply. Personnel using fire beaters or other hand tools positioned close to the fire front are then able to work more effectively, and are protected from the worst effects of the heat and smoke generated by the fire. Whenever appropriate, and subject to the operating procedures within the FRS, the use of water additives should be considered to increase the effectiveness of the water application.

The Use of Water with Water Additives

8B8.33 There are a number of chemical substances that can increase the effectiveness of water used at a wildfire. Where water supplies are limited, the use of additives will significantly increase its effectiveness. FRSs who are considering using water additives, should ensure that they undertake appropriate research to determine the most suitable product for their local wildfire risk and that any impact to the environment is acceptable and complies with current FRS guidance.

Water additives fall into three main categories:

Wetting Agents – are substances that increase the ability of water to penetrate and spread over a surface. Wetting agents are very effective when applied directly onto the flame or during the mop-up phase.

Photo B8.2
A retardant drop

Retardants – can be applied onto vegetation to create a fire break or can be applied directly onto the fire. Many of these types of substances have chemicals that limit combustion and fire spread even when the application has dried out.

Gels – can be applied as a firefighting medium or used as a fire break; these types of substances thicken the water allowing the application to stick to the surface and remain in situ for much longer.

8B8.34 The use of wetting agents, or 'Class A' foams, in wildfire situations is by no means new, although there has not been a long tradition of doing so in the UK. Wetting agents are generally mixtures of synthetic hydrocarbon detergents designed to lower the surface tension of the applied water. This has two main effects. First, the projected water is better able to split into smaller droplets which vastly increases the surface area per unit of water, making the application more efficient and effective. Secondly, a weak detergent solution will soak into the wildfire fuel much better than plain water which, because of its higher surface tension, can have a tendency to 'bounce off' and run unsatisfactorily to ground.

8B8.35 Wetting agent concentrates are highly polluting in the aquatic environment. Detergents are both acutely toxic to aquatic organisms and oxygen depleting owing to their very high Biochemical Oxygen Demands (BOD).[1] It is important to ensure that if foam or wetting agents are to be applied to a wildfire, that it is definitely a Class A product. Film forming Class B products, whether protein (as in FP or FFFP) or synthetic AFFF should not be used. Class B foams are designed to flow over a flat liquid surface and seal it so removing the oxygen; they do not adhere well to the vertical surfaces or convoluted shapes that would be present in the wildfire environment. In spite of containing detergents, the presence of the film forming ingredients virtually prevents the foam solution from soaking into the wildfire fuel.

1 For an explanation of these effects in the Fire Service context seethe Fire and Rescue Manual Vol 2 Fire Service Operation: Environmental Protection, 2008

Indirect Attack Methods

8B8.36 These tactics should be applied at higher intensity fires, where firefighting close to the fire's edge may be more dangerous. As the name suggests, Indirect attack is where firefighting techniques are applied 'indirectly' or away from the fire's edge. The purpose is normally to contain a fire within a chosen boundary. Due to the fact that these techniques are applied some distance from the fire front, they can often be a much safer way of fighting a fire.

There are three principal methods of indirect attack and these are:

- **The use of control lines**
- **Parallel Attack**
- **The use of fire as a tool**

The Use of Control Lines

8B8.37 The principal indirect attack method employed at most wildfires is likely to be the use of fire breaks and what are termed to be '*control lines*'. Control lines can be constructed manually, mechanically or by the application of water or retardants which are termed to be 'wet lines'. Existing features of terrain can also be used; roads, tracks, rivers or streams, even outcrops of rocks or areas of vegetation that will not support combustion can all be used to prevent fire spread.

8B8.38 Control lines are constructed to form a barrier that will prevent fire spread. This can be to specifically impede the spread of the wildfire, or to create a safe strip from which to start firefighting operations.

8B8.39 Manual or mechanically created control lines ***must*** be dug down into mineral earth and all fuel must be removed, and they ***must*** be wide enough to prevent the fire from jumping over into fuel on the far side. Normally this should be two and a half times the length of the fire's flame length.

8B8.40 The edge of the control line facing the fire should be termed to be the ***'Inner edge'*** and the edge facing away from the fire should be referred to as the ***'Outer edge'***.

8B8.41 A fire that is 'spotting' (creating additional fires due to flying brands and embers) can create secondary ignitions that can ignite fuel in front of the main fire; these can easily jump over into the fuel beyond the outer edge of the control line. Therefore, before constructing a control line, consideration should be given to the fuel types that the control line is being constructed through, and whether these are likely to support spotting behaviour.

Planning the Construction of a Control Line

8B8.42 Before commencing the construction of a control line, a plan should be made, and it is important to consider the following points:

- **Always ensure that the control line is started from a strong anchor point. A control line that does not completely close in a fire may allow fire to spread around it.**
- **Plan to take the shortest route and keep the line as straight as possible. Sharp bends will create weak points where the fire may be able to penetrate the line. When a change of direction is made, ensure that bends are gradual. If bends have to be more severe consider broadening the width of the control line at these points.**
- **Take full advantage of existing features of terrain and natural or man-made features that will prevent fire spread.**
- **Where possible control lines should be constructed in fuels that produce low fire intensities.**
- **Plan the route to pass through fuel and vegetation that is easier to work in. For example, a longer route through grass may be significantly quicker to build than a shorter route through scrubland.**
- **Build the line as close to the fire as possible, but take into consideration the rate of fire spread. Ensure that there is enough time to complete the control line before the fire reaches it. By keeping close to the fire, crews may be able to use the black area as a safety zone.**
- **Constructing a control line on a slope above a fire is extremely hazardous and, because of the likely increase in fire intensity, is potentially ineffective. Consider routing lines along the base of slopes or on the reverse side.**
- **Constructing a control line in front of the head fire is extremely hazardous. Ensure that crews are positioned a safe distance from the fire front and that their escape routes and safety zones cannot be compromised if the fire changes its behaviour.**
- **When constructing a control line on a slope below a fire, it should be constructed in such a way that it prevents any rolling materials passing over it and into unburnt fuel on the outer side.**
- **Plan what threat there is to the line being penetrated. Flame length, wind strength, radiant heat, fuel type, ground fuels such as roots or buried branches, rolling fire debris etc. must all be considered.**
- **Control lines can be strengthened by wetting the surrounding fuel, covering it with some form of fire retardant, or using fire to remove the fuel completely.**
- **Due to the arduous nature of control line construction consideration should always be given to the welfare of personnel, particularly with regard to maintaining hydration and providing regular rest intervals/reliefs.**

Manually-constructed Control Lines

8B8.43 The manual construction of control lines requires a great deal of effort and can be labour intensive. Nevertheless with tools appropriate to the vegetation and soil types they can be established relatively quickly. The ease at which a control line can be constructed will depend on a number of factors including:

- **The vegetation type**
- **The terrain**
- **The tools available**
- **The soil type**
- **Training and crew work**
- **The time available**
- **The availability of sufficient numbers of personnel**

Photo B8.3
A Catch Trench on a slope and constructed to prevent burning material from rolling down slope

8B8.44 Control lines can be used on fires of lower intensity as well as those of higher intensity. It may be more beneficial to construct a control line than commit crews to the edge of a fire where they may have to work in heat and smoke.

Hand Tools

8B8.45 All personnel will require training in the safe and effective use of tools that are used in the construction of control line. The tools required will vary depending mainly on vegetation and soil types, the following are only examples of the many types available:

Rakes

Polaski or mattocks

Spades and Shovels

Powered Hand Tools

Common mechanical tools include:

Chain saws

Brush cutters and strimmers

Progressive Control Line Construction

8B8.46 This guidance recommends that the 'progressive method' of control line construction is used. This is a systematic technique that involves each member of a crew performing a particular task. It is a system of work that maintains a safe space for personnel to work in and ensures that personnel are not over worked.

8B8.47 Under normal circumstances, a hand crew building a control line should consist of about ten members with the crew leader taking on the role of crew lookout. If the crew is not able to observe the fire continuously a tactical lookout should also be appointed and take a position from where they can observe both the crew and the fire.

Roles of Crew Members

(a) Pathfinder(s)

8B8.48 The first member of the crew should identify the best route for the line to take through the vegetation. When necessary personnel operating as pathfinders should be equipped with a mechanical tool such as a chain saw or brush cutter so this can be used to remove larger pieces of vegetation. If appropriate additional crew members can assist by removing any cuttings, branches or logs. All fuel removed should be placed on the outer side of the control line; this will prevent a fire increasing its intensity on the inner side as it approaches the control line.

The rate, at which the crew makes progress, depends on the speed that the lead members can clear a path through the vegetation.

(b) Edge cutters

8B8.49 Following the line chosen by the pathfinder(s), two members of the crew cut the edges of the control line into the soil. The first forming one edge and the other, following at least 3 metres behind, cuts the second edge. The width between the two edges of the control line will vary, but must be the minimum required to prevent fire spread.

(c) Diggers

8B8.50 Next in line are the diggers; these operate at least 3 metres apart and progress along the line digging/raking out the fuel between the edges that have already been cut. Care should be taken to place all debris on the outer-side of the control line.

8B8.51 Fuel is removed in blocks. The size of block depends on the number of personnel available. Each of the diggers clear only a section of the block before progressing along the line where they dig out another section from the next block. Fuel from each block is progressively cleared until the last digger cuts the final section which must remove the last of the fuel. For maximum efficiency and safety, only one digger should be working in a block at any one time.

Photo B8.4
Showing each digger working a separate block

(d) Tail Crew

8B8.52 The last members of the crew clean the line by removing any remaining or missed fuel, making sure that all of the debris is placed on the outer side of the control line.

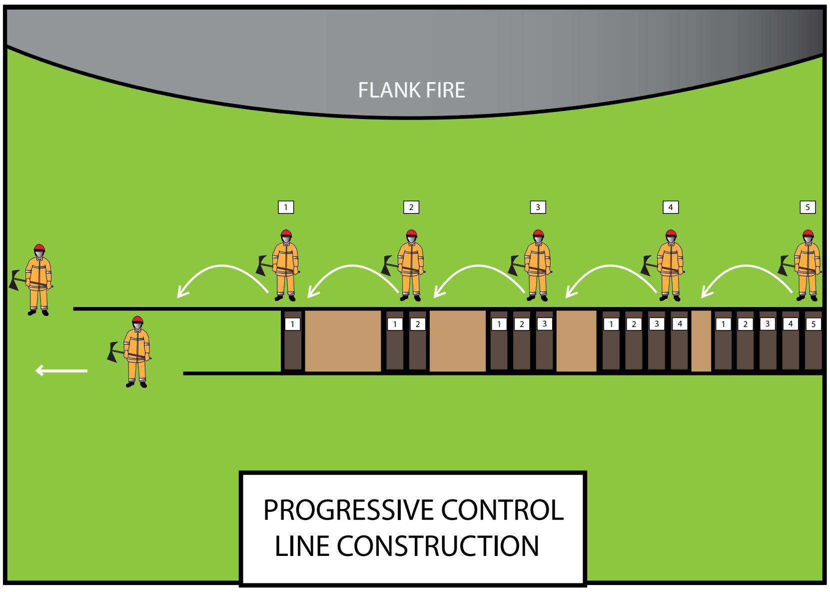


Fig. B8.5
Progressive control line construction

8B8.53 This illustration shows a crew using the progressive method. Two crew members cut the line to the required width while the rest of the crew follow on behind. Each removes a single strip from a block before moving on to the next. Working in sequence each member clears their designated strip until the last of the fuel is removed.

Photo B8.5
Showing diggers maintaining a safe distance apart whilst clearing a single strip from each block

8B8.54 Using this system of work, each person does an equal amount of work and has a short rest while moving between blocks. Personnel are only allowed to move forward once the person preceding them has completed their cut. This ensures that a safe distance is maintained between personnel and that the crew works to the physical capacity of its members.

Mechanically-constructed Control Lines

8B8.55 The construction of control lines using machinery depends on the availability of suitable equipment and operators. Therefore it is crucially important that FRSs engage with partners and make the necessary arrangements to ensure that this type of equipment is available. The engagement with both the public and private sector may provide access to machinery that is specific to a particular vegetation type or industry; examples include moorland management, forestry or farming.

Photos B8.6 and B8.7
Showing a control line being cut into heather and subsequently how successful this was in containing fire spread

Advantages

8B8.56 The use of machinery to construct control lines can bring a number of important advantages over manual construction which include:

- **Control lines are constructed much more quickly.**
- **As they take less time, they can be built closer to the fires edge thus reducing the size of the fire footprint.**
- **Depending on the type of machine, a greater channel of fuel can be removed creating control lines of a greater width.**
- **Machines can be used to dig control lines to a greater depth.**
- **Fewer personnel are involved in the operation.**
- **Control lines can be constructed through denser and courser fuels.**
- **Less physical effort is required.**
- **Equipment can often be provided by land agencies who also have skilled operators.**
- **Equipment is often specifically designed to remove fuel of a particular type.**

Disadvantages

8B8.57 There are a number of disadvantages which personnel need to be mindful of when using mechanically constructing a control line. These include:

- **Variations in the types of vegetation or soil types encountered across the landscape may require the use of different machines.**
- **Difficulty in operating over all types of terrain, steep slopes or soft ground may restrict the use of machines.**
- **Access or egress, to and from, the scene of operations may be restrictive.**
- **The machine may break down placing the operator at risk or resulting in the loss of the machine.**

8B8.58 Machines can either be used independently or work with the support of a hand crew. While a machine is at work, it must be continually supervised and arrangements must be made for the operator to be included within the LACES protocol. Machine operators must not work in isolation; no one should be allowed to work alone when at a wildfire.

Photo B8.8
Forestry Commission equipment clearing woodland

Photo B8.9
Heavy machinery being used to clear scrubland

Parallel Attack

8B8.59 Parallel attack is a tactic that may involve a number of different techniques. It is effective against fires of various levels of intensity, but is normally employed as an indirect attack method against fires of higher intensities.

8B8.60 The main objective of parallel attack is to secure the area around a fire through the construction of control lines. The construction of these should begin from a strong anchor point to the rear of the fire and move around the flanks. These should be built far enough from the fire to ensure that they are completed in good time. If the control lines are considered to be too weak to secure the area, then the vegetation between the control lines and the fire can be burnt out. Burn out operations can also take place as the lines are being constructed.

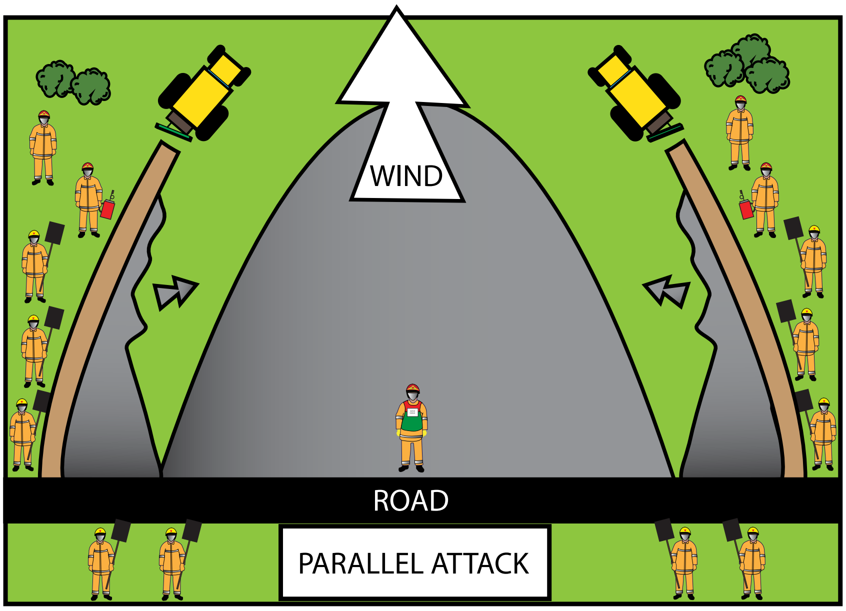


Fig. B8.6
A Parallel Attack with control lines and burn out operations occuring simulataneously

Fig B8.6 shows two ploughs constructing a control line around each flank of the fire. The vegetation between the lines and the fire are being burnt out depriving the fire of fuel and preventing the wildfire from burning up to the control line.

Mop-up

8B8.61 Mop-up is the action involved in ensuring that a fire does not reignite or escape once it has been brought under control. The burnt area has to be secured by extinguishing any hot spots or burning material. Mop-up operations should be started as soon as suppression methods are applied and should continue throughout the incident. As an attack is launched efforts should be made to dampen down or dig out any hot spots as progression is made along the fire's edge.

8B8.62 Once a fire has been contained it is important to extinguish any burning material, especially near to the outer edge of the fire perimeter where burning material may be lying within unburnt fuel. Once the outer perimeter has been secured crews should work inwards exposing and extinguishing hot spots or burning fuel as they go.

8B8.63 To secure the area, existing control lines may be strengthened or new ones constructed. Pockets of remaining fuel can also be burnt out using controlled burns.

8B8.64 Mop-up operations may take a considerable length of time and, depending on the size of the incident and the vegetation involved, continue for a number of days. To maintain efficiencies it is important that FRSs make arrangements to obtain assistance from rural agencies or partners during this closing phase of the operation. At the conclusion of the emergency and mop-up phase of the incident it is recommended that a formal handover of the incident back to the appropriate land owner or land management agency is conducted. FRSs should consider the utilisation of handover agreement forms for this task.

Photo B8.10
A Ranger assisting with damping down hot spots at a fire in the Peak District

Photo B8.11
Partner agency workers assisting with mopping-up at a wildfire incident

The Use of Fire

8B8.65 Although the use of fire can be perceived to be a higher risk strategy, in reality if its application is carried out by well trained personnel and the operation is managed correctly, it can be used with confidence.

8B8.66 Only those personnel who have obtained appropriate training and have the relevant experience should be allowed to apply this suppression method operationally. A skilled specialist can apply fire safely to achieve a number of objectives including:

- **The widening of existing control lines**
- **Creating control lines**
- **Burning out fuel**
- **Changing fire behaviour**

This section provides a simple overview of the methods involved, and the information given is not sufficient to allow FRSs to apply any of the techniques described.

Controlling the Use of Fire

8B8.67 Without effective control mechanisms, fire may be used inappropriately and the indiscriminate use of fire can lead to dangerous escalations of the situation. It is therefore essential that FRSs that choose to use these methods, do so following a thorough risk assessment and are satisfied that they have robust procedures in place governing the proactive use of fire as a suppression tool. Operationally this should include the Incident Commander's authorisation to use fire on the incident ground.

Fire as a Suppression Method

8B8.68 This guidance encourages FRSs to develop the skills necessary to apply these techniques operationally. Fire provides a means to combat the spread of fire when other tactics are likely to be ineffective or dangerous. If used properly it is a safe, effective and a very efficient suppression method.

Terminology

8B8.69 Internationally, very similar terms are used to describe parts of a wildfire and the fires that are deliberately ignited to suppress it. Examples include back fire, backing fire, back firing, flank fire, flank firing, head fire, ring fire etc. To avoid confusion, in this guidance the term '**fire**' refers to terminology related to flaming parts of the wildfire, the term '**burn**' describes a fire that has been lit as part of an operational plan.

The Tactical Use of Fire

Defensive Burning

8B8.70 This type of burn involves the removal of fuel by a fire that is extinguished before the arrival of the wildfire. It is normally applied some distance from the fire front and therefore can be planned in good time.

This tactic can be used for a number of purposes including:

- **To remove fuel from along a control line so that the wildfire cannot burn up to its edge.**
- **As a method to create control lines in finer fuels.** ***This is a highly skilled and technical procedure that must only be carried out by specialist officers.*** **A line of fire is lit with the head of the fire being extinguished immediately and before it has time to fully develop. The tail fire is then allowed to burn back into the fuel. When the fire has created a break of sufficient width, it is then fully extinguished.**
- **To burn out fuel in a controlled way thus reducing fire intensity or altering the fire behaviour.**
- **To burn out fuel from areas that have been identified as critical to fire development.**

Photo B8.12
A burn out operation in progress to remove surface fuels from a wooded area

Offensive Burning

8B8.71 An offensive burn occurs when a fire is lit and allowed to burn into an approaching fire front. This type of burn should be carried out by specialists who have advanced knowledge and experience of applying fire as a suppression method.

The offensive use of fire can be used for a number of purposes including:

- **To reduce fire intensity or behaviour, i.e. when a wildfire is approaching a control line and is generating spot fires. An offensive burn can be used to straighten the flame angle and/or the fire plume. This may reduce the amount of spotting caused by the fire.**

- An offensive burn can be carried out to defend a control line. By lighting a fire along its inner edge, the fire will burn towards the main fire. As the burn moves away from the control line it burns out fuel, broadening its width. Eventually the two fires are drawn together and burn out some distance away from the control line further reducing the possibility of the fire escaping out of the containment area.

Photo B8.13
An offensive burn being carried out to strengthen a dirt track which has been utilised as a control line

- Fire is a useful way to remove fuel that exists between a control line and a fire front. A good example being when parallel attack is being used as a suppression method. As the control lines are constructed along the fires flanks, the remaining vegetation between the control lines and the wildfire, can be burnt out by offensive burning, this prevents the wildfire making a run through the fuel towards the control line.

Photo B8.14
A joint FRS and land management parallel attack being carried out to remove fuel from the flanks of the fire

Managing an Operational Burn

8B8.72 FRSs that wish to use fire as a suppression method must ensure that they adopt appropriate systems of work, and that personnel have the necessary training and expertise required to safely carry out this method of suppression. Burns should not be carried out by individuals but by crews of trained and competent personnel. These must be supervised by a skilled specialist who has the support of specialist burners and a holding crew. Together, these must operate to a pre-determined scheme or programme of activities which ensures the safety of personnel and effectively manages the activities of the team.

An Operational Burn Crew

8B8.73 Operational crews should consist of the following:

A Burn Supervisor

The burn supervisor carries out a specialist role. They have the responsibility to risk assess, plan and manage the operation. They must ensure that the burn is only carried out if it can be achieved safely.

Burners

Operational burn crews would normally include 1-3 burners. These are specialists with the knowledge and skills to be able to burn out the fuel in accordance with the burn supervisor's instructions.

Holding Crew

A burn crew should include a number of personnel that have the responsibility to maintain on going control over the fire. In particular, they must ensure that the fire does not break out into fuel that is outside the intended burn area. The number of personnel and equipment required to carry out this support role is dependent on the complexities of the operation and should be part of the burn supervisor's risk assessment and plan. A holding crew may be required to carry out extensive work before a burn to ensure that the site is secure.

Types of Operational Burns

A Back Burn

8B8.74 This is a low intensity fire that burns against the wind or slope (or both). The fire should normally be lit along the inner edge of a control line which acts as a barrier; as a result the fire is forced to burn back, against the forces which in other circumstances would have driven it in a forward direction. This is an excellent method to use to strengthen a weak control line as it broadens its width, removing fuel from along its edge. This type of burn can be used either defensively or offensively.

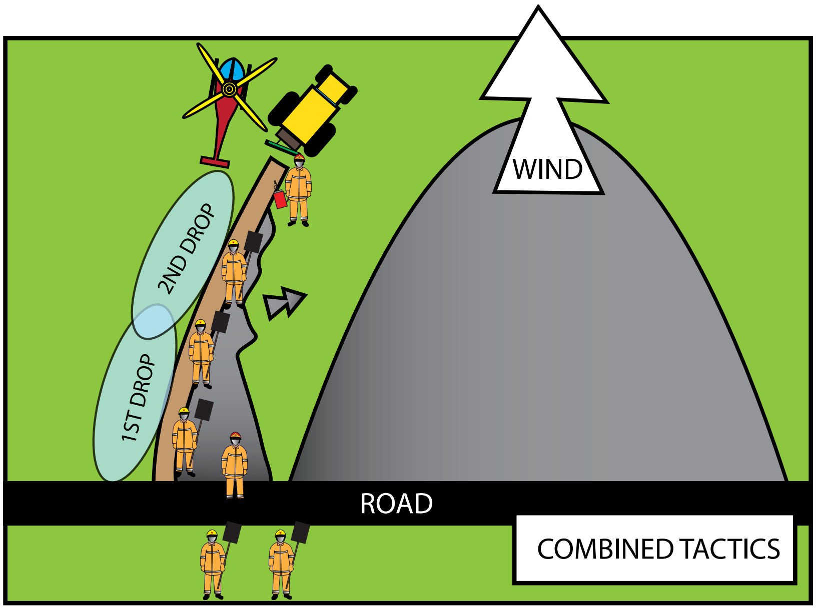


Fig. B8.7
In this illustration a burn has been lit along the closed side of a track and allowed to burn towards the approaching wildfire

A Counter Burn

8B8.75 In this guidance the term counter burn is used to describe a fire that is lit with the intention of allowing it to burn into the fire front. Counter burning is an offensive technique that requires an advanced understanding of fire behaviour as it often takes advantage of the in-drafts created by the wildfire. These allow the counter burn to build up momentum and intensity as it approaches the advancing fire front. Counter burns can also take advantage of alignments that allow the fire to be driven towards the wildfire.

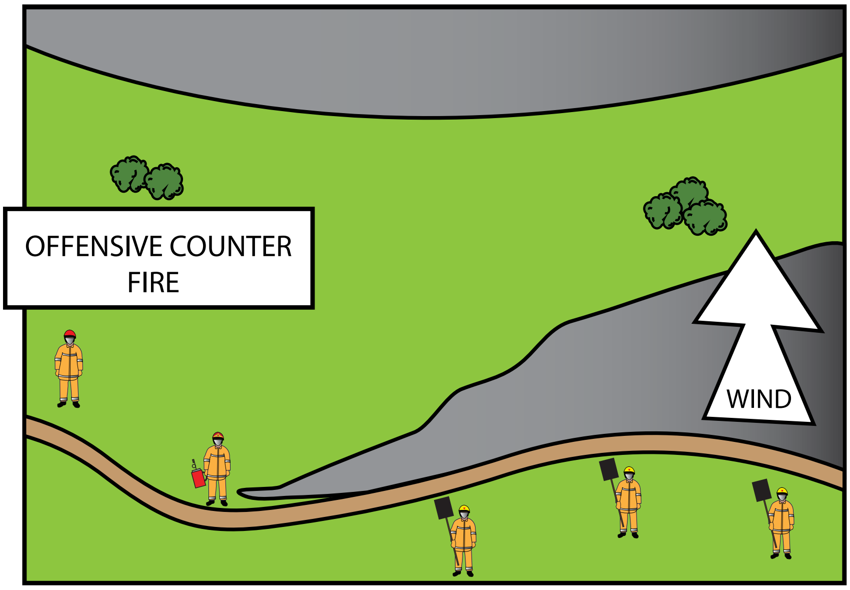


Fig. B8.8
Example of a burn using the in-drafts to draw the two fires together

A Flank Burn

8B8.76 A flank burn is a fire that is lit parallel to the flanks of a wildfire, normally along control lines. This type of operation is often carried out as part of a parallel attack. This type of fire can develop behaviour of high intensity as parts of the burn may find alignments similar to the main fire.

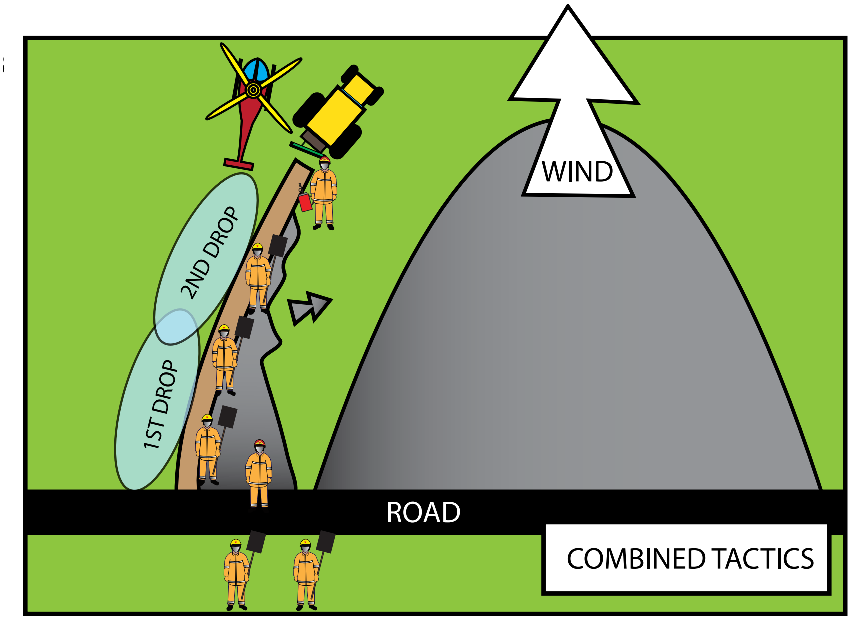


Fig. B8.9
A flank burn being carried out from a strong control line. The helicopter is strengthening the control line by placing a wet line along the outer edge of the control line.

Centre Burning

8B8.77 Centre burning is a complex defensive method used to burn out parcels of vegetation that are enclosed within surrounding control lines.

8B8.78 This technique should only be undertaken by burners with advanced knowledge and experience. The use of centre burns can prevent a burn from developing a strong head fire that may escape out of a containment area. The process involves lighting a fire(s) near to the centre of a plot, followed by secondary ignition(s) along the inner edge of the control lines around the sites perimeter.

The inner and outer fires then interact, drawing each towards the other; as the fire is forced to burn inwards the major fire intensities take place towards the centre of the plot away from the control lines.

Centre burning involves two distinct phases:

Phase One

8B8.79 A fire or a number of fires are lit near to the centre of the area to be burnt, these are allowed to build up some strength.

Phase Two

8B8.80 When the inner fire has developed sufficiently, the closed edge of the control line is lit, this results in the inner fire being surrounded by an outer fire. The two fires then interact causing both to be drawn together.

8B8.81 As this type of burn relies on the interaction between the inner and outer fires, the important issue is the timing of the ignitions. The inner fire must be allowed to develop so that it is of sufficient strength to draw the outer fire inwards.

8B8.82 The outer fire must be lit in good time and must include lighting a fire around the whole perimeter. This usually requires the employment of a number of burners who each take responsibility to ignite a section.

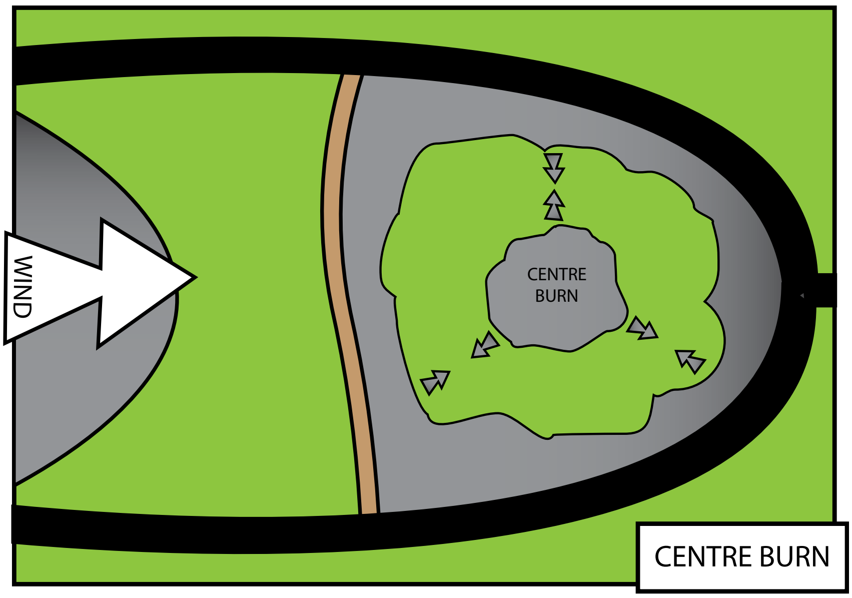


Fig. B8.10
Showing the in-drafts of both fires interacting and drawing the fire away from the control lines

Photo B8.15
A plot being burnt out using the centre burn technique

Ignition Patterns

8B8.83 There are a number of different ignition patterns that can be used to carry out an operational burn. These pattern techniques can be used to create fires of different intensities, and varying rates of spread. The technique chosen should be appropriate to the situation and be safe.

8B8.84 By selecting the correct ignition technique, control over a burn can be established and maintained. A burn should be planned to generate only the desired amount of fire intensity; this is normally measured in flame length. Skilled personnel can manipulate this by using different ignition patterns within appropriate fire alignments. The Wildfire Prediction System should be used to determine the fire alignment necessary to generate differing amounts of fire intensity within the same fuel types and load. When carrying out a low intensity burn; fuel alignment should obviously be kept to a minimum.

8B8.85 Burn out operations are normally only carried out against strong control lines or other barriers to fire spread. It may be appropriate to alter the ignition pattern to meet changing circumstances such as weather conditions, fuel types or fuel arrangements.

The Three Ignition Patterns

8B8.86 The three ignitions that should be used are:

Lines of fire

Points of fire

Fingers of fire

8B8.87 Each of these will create ignitions of different intensities, but it is important to understand that the alignment of any ignition is of paramount importance. A fire that has the support of wind or slope will result in a burn being more intense than one that is burning against them. It is therefore crucial that the Wildfire Prediction System is used to identify the locations where ignitions can be placed to create burns of the desired intensities.

Lines of Fire

8B8.88 This technique can be used to achieve a number of objectives. It involves lighting a strip or a number of strips of fire through the fuel that is to be burnt. It can be used to strengthen control lines or burn out areas of fuel either as a defensive or offensive tactic.

8B8.89 When using this method to strengthen a control line, the lines of fire should run parallel to the fire break and burn towards it. The first line lit is called the base line and it is intended to remove the fuel along the very edge of the control line and to form a 'base' for subsequent lines to burn into.

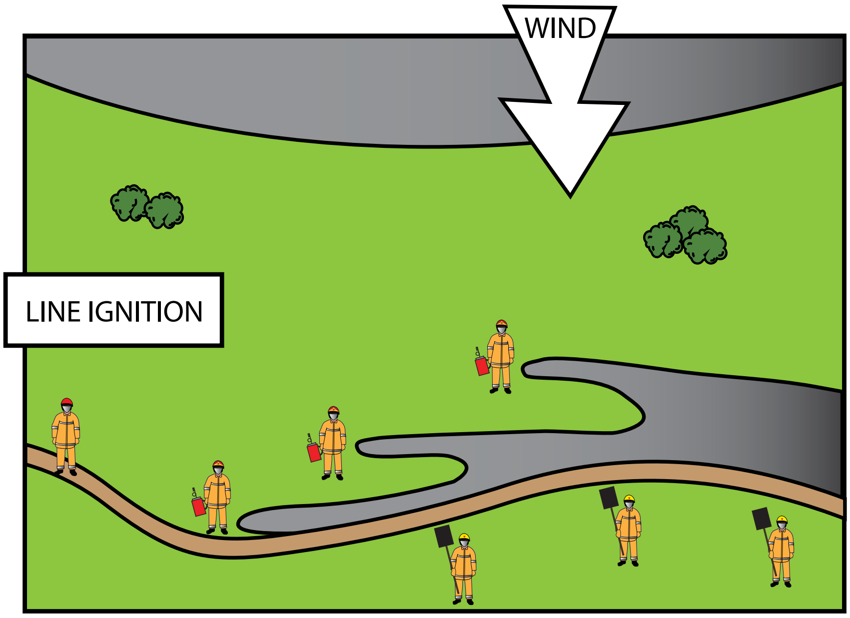


Fig. B8.11
Three lines of fire burning out fuel along a control line

8B8.90 Fire intensity can be influenced by altering the distance a fire is allowed to burn through the fuel. A wider spacing between lines will allow a fire to build up momentum and intensity; narrower spacing prevents the fire from reaching its full potential. Depending upon the strength of the control line and the fuel involved, the spacing between lines can be varied to achieve manageable and appropriate fire intensities.

8B8.91 By increasing the number of burners, multiple lines can be ignited simultaneously. Whilst the ignition pattern is ultimately under the control of the burn supervisor, the burners must adopt the appropriate burn techniques and co-ordinate their actions. By doing so they are able to burn out a broader area of fuel much more quickly.

8B8.92 The baseline is burnt very close to and along the control line creating a narrow strip which removes the fuel along its edge. Further lines can then be lit further into the fuel and as the burnt out area increases in width and the control line is strengthened, burns can be placed further and further into the fuel. B8.11 shows three burners working together quickly reinforcing a control line. Lines must be started (opened) and finished (closed) at a strong anchor point. Open lines of fire can result in a fire building up its intensity and possibly penetrating the control line.

Points of Fire

8B8.93 The success of this technique depends on there being little alignment with wind or slope. It is a method that can be used to create an operational burn of lower intensity than those started using the line technique.

8B8.94 Instead of lighting a line of fire, individual points of fire are ignited within the fuel. The intensity of the burn is controlled by the spacing between the ignition points. A lower intensity is created by lighting a greater number of separate fires which burn into each other. Each burn out small areas of vegetation, before reaching areas already burnt out by neighbouring fires. The separate fires are therefore starved of fuel, preventing them from reaching their full potential.

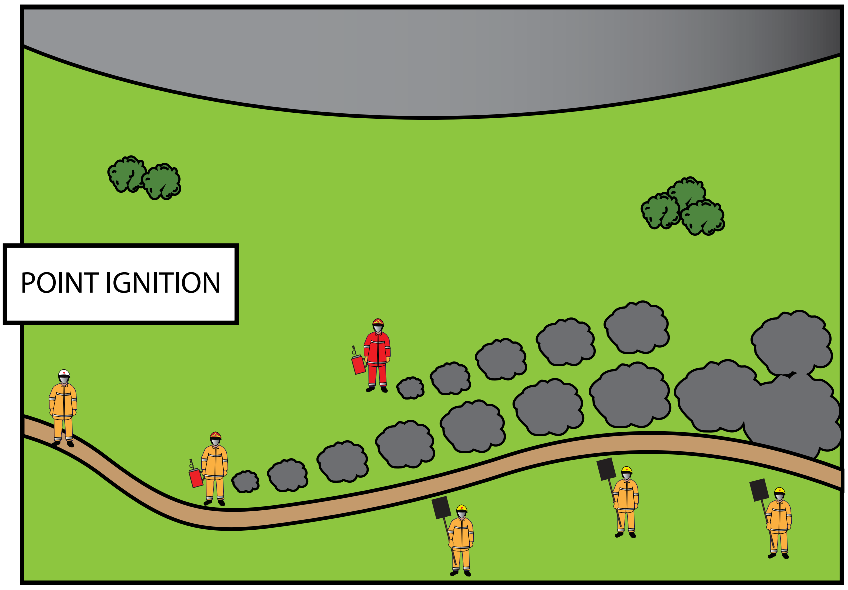


Fig. B8.12
A burn using points that will produce a fire of lower intensity

Fingers of Fire

8B8.95 This is a method used to create an operational burn of low intensity. It must be lit along a strong anchor point or control line. This technique involves lighting short strips of fire, lit from the edge of the control line into the wind. As the fire is anchored, it cannot burn forwards as a head fire, instead it is forced to burn outwards as a flank fire. The intensity of a fire lit using this ignition pattern is reduced because it cannot be supported by the wind, therefore its alignment is limited to factor one or factor two.

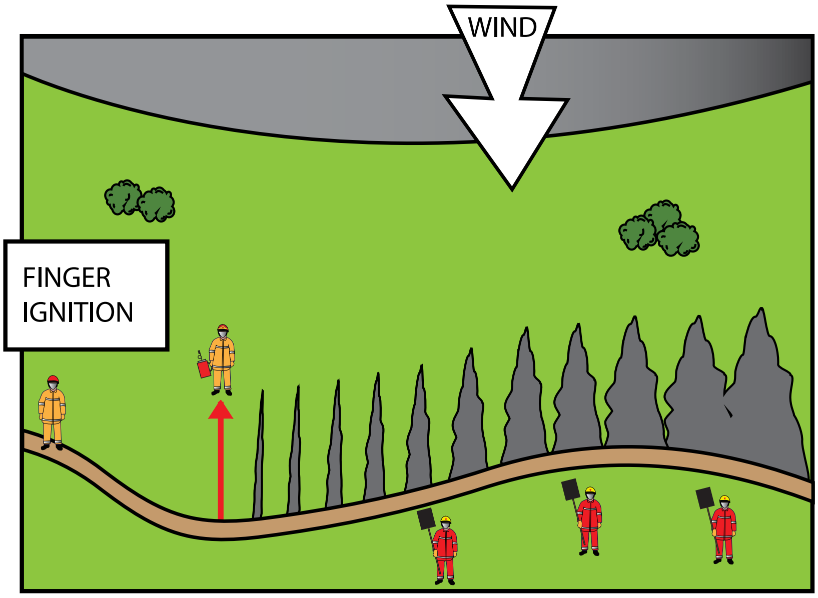


Fig. B8.13
Fingers of fire that cannot develop a head as the control line acts as a barrier, the fires are only able to develop along their flanks

Safe Use of Fire

8B8.96 When using fire as a suppression method it is important to consider the following points:

- **The burn should be part of the incident plan and the burn supervisor must fully understand the objectives of the operation.**
- **Permissions must be obtained before the operation has begun.**
- **The burn should be carried out by qualified specialist burners who are supported by appropriate and sufficient resource.**
- **These resources should include a water capability suitable to the task.**
- **A risk assessment must be carried out by the burn supervisor to establish whether it is safe to carry out the burn.**
- **The burn supervisor must formulate a safe burn plan which meets the requirements of the local conditions.**
- **WPS should be used to help identify how to achieve a fire of the desired intensity.**
- **A test burn should always be carried out to confirm fire behaviour.**
- **An ignition pattern which creates manageable fire intensities must be used.**
- **An operational burn must be started against a strong anchor point.**
- **Burners must be cautious and should continually assess fire behaviour, where necessary adjusting the ignition pattern to meet the requirements of the plan.**
- **The fire must be restricted to within its intended boundaries; too much fire can overstretch the holding crew, therefore fire activity should be monitored closely to keep it at a manageable level.**
- **Whenever fire is being used as a suppression tool, a tactical lookout should observe the operation.**
- **If the situation becomes dangerous the operation must be terminated.**
- **The holding team should be used to control fire intensities and spread.**

The Application of Appropriate Wildfire Tactics

8B8.97 Appropriate tactics are those that, when applied, are safe, effective and efficient. In the UK the predominant tactic will remain direct attack, but it is important that FRSs are able to employ alternative methods.

8B8.98 There are two main fire factors fire officers must consider before deciding on what attack method to use. The first is the potential rate at which the fire will move across the landscape and the second is the fire intensities that will be generated. Obviously it would be inappropriate to use direct attack against a fast-moving intense fire, therefore it is important to obtain an understanding of not only present fire behaviour but also its potential behaviour. Flame length is useful as it is a visual indicator and one that can be measured. Importantly, more experienced officers will be able to predict what flame lengths will be throughout the duration of the incident.

Direct Attack Suppression Methods

8B8.99 Crews using direct attack methods must be of sufficient size, be properly equipped and have the appropriate skills and understanding necessary to apply this tactic successfully. Direct attack is a suppression method that should be used against low to moderate intensity fires having a flame length of about 1.5 metres. Above this height this suppression method becomes increasingly less effective and progressively more dangerous for the firefighting personnel.

8B8.100 Whenever possible, crews working at the fire front should be supported by resources that have the capacity to apply water onto the fire.

8B8.101 If water supplies are limited, instead of being used to extinguish the fire, it should be applied sparingly and used only to lower its intensity. Small amounts of water can significantly reduce flame length resulting in increased effectiveness. The most efficient method of applying water onto a fire is via pressurised systems such as FRS pumps or wildfire firefighting systems such as fogging units. Where these are not available, hand teams should include personnel that are equipped with knapsack sprayers, these can also be used to great effect.

8B8.102 The chart below is not intended to be restrictive but outlines which tactics are more effective when fighting fires of different flame lengths. Indirect attack methods can be used to fight low intensity fires as well as those of higher intensity.

Tactic	Flame length	Primary methods of extinction
Direct Attack	Low intensity fires 0-0.5m	Use of hand tools Application of water using knapsack sprayers Application of water using pressurised water systems
Direct Attack	Moderate intensity fires 0.5-1.5m	Use of hand tools supported by knapsack sprayers to lower fire intensity Application of water using pressurised water systems

8B8.103 Where sufficient water can be applied and a risk assessment has identified that it is safe to do so, it is possible to use water attack to control fires demonstrating longer flame lengths and higher intensities but this becomes progressively more difficult as the flame length increases.

8B8.104 Where a fire has flame lengths that occasionally go beyond 1.5 metres, direct attack methods do not have to be abandoned. Personnel using this method can apply it to areas of the fire demonstrating shorter flame lengths and wait for the more extreme parts of the fire to reduce in intensity. An example of this would be when a fire makes a run up a steep slope; direct attack may still be successfully applied to the flanks and tail, but not to the head. When the head fire reaches the top of the slope, fire intensity and flame length may reduce to a level where direct attack can be re-applied. So long as the loss of control over parts of a fire is not prolonged or sustained, direct attack can be used with success to extinguish the whole fire. When adopting this approach it is of the utmost importance that direct attack is only applied to parts of the fire that is within the threshold of control and it is safe to do so.

Indirect Attack Suppression Methods

8B8.105 Indirect attack methods can be used against fires of all fire intensities; they do not need to be only applied against fires of higher intensities and flame lengths above 1.5m.

8B8.106 For example, in some situations, it may be more appropriate to construct a control line using mechanical equipment, rather than commit large numbers of personnel with beaters and knapsack sprayers along a fast moving fire front.

Tactic	Flame length	Primary method
Indirect Attack	High intensity fires 1.5-3.5m	Use of control lines Parallel attack Application of water additives along control lines Defensive and offensive use of fire Aerial operations
Indirect Attack	Extreme intensity fires > 3.5m	Use of control lines Defensive and offensive use of fire Aerial operations

8B8.107 The main tactical advantage gained through the use of indirect attack methods is that they can be applied with success at fires that have gone beyond the control of direct attack methods. As intensity increases direct attack methods become less effective to a point where they can become inappropriate or dangerous. Indirect attack can be used against fires of higher intensity ensuring that personnel are not placed in areas of high risk. The particular techniques used will depend on the circumstances and the skills and equipment available.

8B8.108 As fires become more intense, there is often an increasing benefit in using fire as a suppression tool, this can be used to strengthen control lines, alter fire behaviour or attack the fire aggressively through the use of offensive burns.

8B8.109 A FRS that has a full understanding of wildfire is able to apply tactics that are appropriate to the fire intensity. This may involve using a number of different techniques at the same fire in response to changing circumstances.

8B8
Key Considerations

- Base all suppression tactics on expected fire behaviour rather than current activity.
- Consideration should be given to the level of training, expertise and experience of personnel when allocating tasks.
- If operational burns are to be used then all relevant personnel should be informed.
- Firefighting operations should always begin from a strong anchor point.
- Unless a fire is of low intensity, the head part of a fire should normally only be attacked once the flanks have been extinguished.
- Do not ignore the opportunity to extinguish low intensity parts of the fire such as the tail, before they spread into locations that provide more support to fire development.
- When fire intensity is high, indirect attack methods should be used.
- Direct attack (other than aerial suppression) should only be used on the parts of the fire demonstrating lower intensities.
- Where water supplies are scarce the application of small amounts of water will significantly reduce fire intensity making it easier for hand teams to extinguish the fire.
- Whenever possible, water or some other form of extinguishing media should be made available when undertaking a direct attack.
- Indirect attack methods can be used against low or high intensity fires.
- All burn out operations must be planned and managed by a burn supervisor.
- Plans should be based on timed intervention when the fire is within the threshold of control of the available resources.

8B9

Aerial Suppression Tactics

Introduction

8B9.01 One example of the distinct difference between the UK approach to wildfire suppression and those adopted by many overseas agencies is in the use, and availability, of tactical aerial support and using this as a primary response, control and suppression method.

8B9.02 Many international wildfire agencies and FRSs are provided with substantial aerial support. These aircraft are specifically designed for wildfire firefighting and, almost without exception, are flown by trained and very experienced pilots familiar with the aerial techniques involved in wildfire suppression. The aerial units available include helicopters, fixed-wing aircraft, and unmanned drones.

Photo B9.1
Air operations in Catalonia, Spain

8B9.03 These aerial assets operate within strict guidelines and procedures that ensure that the aircraft and ground units are able to fully combine and complement each other's efforts and work effectively in unison.

Photo B9.2
Air and ground operations

UK Aerial Provision

8B9.04 In contrast to the international capability, with very few exceptions, UK FRSs are unable to rely on any aerial support. Those capabilities which do exist are available through local arrangements which are in the main provided by companies whose primary commercial interests are not related to firefighting.

8B9.05 This can present a number of challenges at a wildfire incident as these aircraft are not specifically designed for wildfire suppression operations and may have limited firefighting capability; they are often unavailable due to other commercial commitments and in some cases they may be flown by pilots that have little understanding of wildfire suppression methods.

The Use of Aircraft

8B9.06 The lack of aerial provision is further compounded by the fact that many FRSs also have a limited awareness of aerial firefighting tactics, and a lack of understanding and experience of how to best utilise aircraft at a wildfire. At many wildfire incidents aircraft can provide essential tactical support to ground teams, improving their effectiveness and safety. If used effectively they can shorten the duration of an incident and reduce its size; therefore, the deployment of aircraft at a wildfire can bring significant efficiencies.

8B9.07 These benefits can only be realised if aircraft are deployed at the appropriate time and in such a way that they are able to have the maximum impact on a fire. FRS officers who request aerial support should ensure that the request, and deployment, is made as part of a plan and not in reaction to a loss of control.

8B9.08 Normally, the attendance of aircraft is only requested as a result of one or more of the following situations:

- **Fire spread has become extensive.**
- **Parts of a fire are demonstrating fire behaviour that is beyond the control of ground operations.**
- **The amount of resource committed to an incident is having an impact on the resilience of a service.**
- **The ground resources are unable to gain, or have lost control of, the fire or parts of it.**

Timely Deployment

8B9.09 The attendance of aircraft, weighed against the cost and the potential benefit, is a consideration that should be made at the onset of an incident. At many wildfires the early deployment of aerial resources will prevent a small fire from developing into a more major and costly incident. Aircraft can perform an important part in a safe, effective and efficient operational plan that can significantly reduce FRS resource commitment.

8B9.10 The early deployment of an aircraft, especially during the initial stages of an operation, may prevent a fire from reaching its full potential.

Preparedness

8B9.11 As there is lack of aerial resource, it is of the utmost importance that those available are utilised to their full potential. It is recommended that FRSs establish what aerial assets, if any, are available within their local areas and also develop an understanding of how to best utilise the resources available.

8B9.12 Through their local pre-planning FRSs should also be fully aware of the capabilities of the aircraft available, i.e. whether they can effectively perform firefighting operations or will be restricted to transportation of water, equipment and personnel or use as an aerial observation platform.

8B9.13 Through liaison with aircraft providers, FRSs should determine the relevant competency of the pilots to undertake wildfire firefighting operations. These should have an awareness of FRS tactics and ICS. Interoperability can be improved through co-operative training and joint multi-agency exercises.

Aircraft Supervision

8B9.14 Operationally, the request for aerial support at a wildfire will be made by the Incident Commander. To ensure that appropriate control and management of deploying aircraft can be provided, it is recommended that procedures have already been established to oversee the activities of any aircraft responding to the incident.

8B9.15 Aerial asset co-ordination and management must remain within the FRS ICS. This helps to ensure that the tactical support provided by aircraft meets the requirements of the operational plan. FRSs must ensure that when these resources are deployed at a wildfire that appropriate personnel are appointed to supervise all aerial activities. If military air assets are used, then dedicated personnel from the relevant service should be requested to provide air asset co-ordination and liaison with FRS personnel.

Support from Ground Crews

8B9.16 When it is safe to do so, aircraft missions must be co-ordinated with, and supported by, ground units; if aircraft work independently they may prove to be ineffective.

Aircraft Providers

8B9.17 Companies that have a commercial interest in providing aerial support to FRSs, should ensure that the aircraft and the equipment provided are fit for purpose, can contribute to the successful response and suppression of a wildfire incident and that their pilots understand wildfire phenomenon and are trained to appropriate standards.

8B9.18 This will assist to ensure that FRSs utilising commercial aircraft are provided with confidence that the use of air assets will be compatible with their H&S procedures, the aircraft will provide value and there is an increase in the potential use of aircraft at wildfire incidents.

It is suggested that training for pilots should include:

- **A comprehensive understanding of wildfire behaviour**
- **Wildfire ground suppression tactics**
- **Wildfire aerial suppression tactics**
- **Ground and air co-ordination**
- **Wildfire terminology**
- **FRS incident command system**

Tactical Roles

8B9.19 Aircraft can perform a number of tactical support roles at a wildfire incident which include:

- **Direct Aerial Attack – which involves dropping water or fire retardants onto burning areas of the fire.**
- **Indirect Aerial Attack – which involves the dropping of water or fire retardants to form control lines or to strengthen existing control lines.**
- **Airlifting water to, and around, the incident ground.**
- **Airlifting personnel and equipment to, and around, the incident ground.**
- **Aerial reconnaissance and intelligence gathering.**

8B9.20 It is crucial that FRS officers request the attendance of aircraft that have the capability to perform the purpose for which they are intended.

Limitations to Aerial Operations

8B9.21 There are a number of factors that will limit the effectiveness of aircraft at wildfire incidents, or present significant flight hazards. These can include:

- **The terrain, particularly steep slopes or mountainous areas where low-flying operations become more complex and hazardous.**
- **Man-made structures such as power lines or communication masts.**
- **Prevailing weather conditions such as high winds making aerial water drops inaccurate and flying conditions dangerous.**
- **The inability of most aircraft to fly at night resulting in aerial operations being suspended during the hours of darkness.**
- **Inability of water drops to penetrate through vegetation and onto a fire; for instance if a fire is burning in surface fuels beneath a dense tree canopy, water drops may have little effect.**

- The turnaround time between water drops and refills may take too long.
- Dense smoke or extreme fire behaviour.
- Lack of ground support.
- Aircraft being tasked with inappropriate missions.

Photo B9.3
Overhead powerlines are a significant risk to aircraft

Aircraft and their Roles

8B9.22 There are a number of different aircraft that can be used at a wildfire and these include both fixed and rotary-wing aircraft. The number of fixed-wing aircraft able to deliver water or retardants directly onto a fire is extremely limited within the UK and it is unlikely that the position will alter for the foreseeable future.

Therefore, the aerial guidance within this chapter concentrates on rotary-wing aircraft.

Photo B9.4
There are limited fixed-wing aircraft with water drop capability

8B9.23 The most common aerial platform used in the UK is the helicopter. These can carry an under-slung water container commonly known as a 'bambi-bucket'. These specialised containers have a release valve on the bottom which is controlled by the helicopter crew to allow accurate delivery of the water onto the target area. The bambi buckets can be filled from water hydrants, fire appliances or open water supplies.

Photo B9.5
A water drop using a bambi bucket

8B9.24 Another, but less common system used to carry water, is by helitanks. These are attached to the fuselage, or form an integral part of the aircraft. These can be refilled from pressurised or open water supplies.

Photo B9.6
A helicopter fitted with water helitanks

8B9.25 Helicopters can perform a number of useful roles on the fire ground and are much more versatile than fixed-wing aircraft.

8B9.26 As well as being able to make water or retardant drops, they can be used to transport personnel and equipment to, and around, the fire ground; be used as an observation platform; or simply supply water to ground units. Therefore, even if aircraft are not required to attack the fire, they can provide invaluable support at the incident.

The use of Aircraft as an Observation Platform

8B9.27 At a large spatial incident, it is very often difficult to gather intelligence in sufficient detail to permit a complete and accurate assessment of the situation. One of the most useful ways aircraft can be used at a wildfire incident is to provide a means to quickly obtain an understanding of what is happening on the fire ground.

8B9.28 By observing the fire and the landscape from above, invaluable intelligence can be obtained which will assist in formulating an effective incident plan. This can include evidence regarding, extent and rate of fire spread, fire behaviour, fuel arrangement, features of terrain, critical points, fuel breaks, existing features that will prevent fire spread, open water supplies, access and egress points, roads and tracks, infrastructure including power lines and communication masts, habitation sites. To obtain most benefit, aerial reconnaissance should be carried out by a wildfire officer or specialist.

Photo B9.7
Police helicopter in use as an observation platform

Aerial Supervision

8B9.29 Aerial supervision is best achieved by forming an Aerial Support Sector within the command structure. An Aerial Sector Commander (ASC) should be appointed to co-ordinate the aerial operations, and make the necessary arrangements for ground support to be provided to the aircraft.

8B9.30 Essential to the success of the Aerial Support Sector is the provision of robust and effective communications between the aircraft and the Aerial Sector Commander and other relevant personnel, including military liaison personnel who may be in attendance.

The Aerial Sector Command Responsibilities

8B9.31 These may include:

- **Establish Aerial Support Sector.**
- **Establishing ground-to-air communication with aircraft.**
- **Providing appropriate logistical ground support including, landing area, fuel, water supplies etc.**
- **Evaluating hazards posed to the aircraft safety including ground features, power lines, communication masts etc.**
- **Prioritise actions and assign aircraft tasks to meet the requirement of the incident plan.**
- **Provide tactical and operational ground support.**
- **Monitor the effectiveness of aerial operations.**

These arrangements will ensure that aircraft are used effectively and will maintain interoperability between ground and air units.

Establishing a Landing Area

8B9.32 If aircraft are to be deployed it is useful to establish a landing area before their arrival; its location should be one that provides the aircraft with a safe and convenient base from which aerial support activities can easily be provided.

8B9.33 If military aircraft are being used, the responsibility for establishing an appropriate landing zone will be the responsibility of the military liaison officer.

Photo B9.8
Aircraft Landing area close to FRS resources

Considerations when setting up a landing area may include:

- **The site must be large enough to accommodate all the aircraft that may have to use it.**
- **Cones and tape should not be used to cordon off the area.**
- **It should be on level ground that is dry and firm.**
- **The surface should be compact, sandy and gritty soil types should be avoided.**
- **Whenever possible, the approach to the landing site should be free of flight hazards such as high vegetation or man-made structures.**
- **Helicopters prefer to land into the wind.**
- **The landing area should be approximately 50 metres in diameter, if more than one aircraft is in use the landing area may have to be enlarged.**
- **All debris should be cleared from the surrounding area.**
- **Vehicles should be parked outside the landing site.**
- **Where possible, the site should be located near to a road or track, this will ensure that supplies of fuel and other essentials can be provided.**
- **Firefighting equipment should be made ready but should be kept outside of the landing area.**
- **Where possible, the landing area should be close to a water supply that can be used to re-supply the aircraft's firefighting systems.**
- **The location of the landing site should be given to pilots in the form of a grid reference.**

Tactical Ground Support

8B9.34 The success of aerial firefighting operations depends largely on support being provided on the ground. It is of the utmost importance that aerial and ground tactics remain co-ordinated and a constant update of information should be provided between the aircraft, the ASC and the Incident Commander. An effective communication system between ground and aerial units must be established allowing ground units to be pre-warned about the intended locations of any aerial drops.

Aerial Water or Retardant Attacks

8B9.35 When an aircraft drops water onto a fire it will normally significantly reduce the amount of burning material and inhibit fire intensity; rarely though will a water drop completely extinguish a fire. On some occasions the impact of the water will spread burning embers over a wider area, creating the possibility of secondary fire ignitions. To ensure the success of the aerial operations it is necessary for ground and aerial units to work in unison.

8B9.36 Following an aerial attack, and when safe to do so, ground teams positioned near to the drop location should quickly secure the area, extinguishing any pockets of fire, hot spots or secondary ignitions.

Monitoring Aerial Water Attacks

8B9.37 The effectiveness of any water drop may not be apparent from the air, therefore intelligence provided by personnel positioned on the ground may be crucial to the success of any water drops. Aerial attacks should be monitored by an observer and the success of these operations should be communicated to the pilot and the Aerial Sector Commander. This will allow the pilot to make adjustments to the positioning of the aircraft during subsequent runs. At some incidents, and where resources allow, it may be beneficial to observe the aerial operations from the air, in such situations both ground-to-air, and air-to-air communications must be established.

Photo B9.9
Effective communication between aerial to aerial and aerial to ground units are essential

Effective Water or Retardant Drops

8B9.38 The accuracy of drops made on a fire depends on a number of factors; wind speed, convection, altitude, air speed, and smoke can all lead to inaccuracies. Adjustments can be made quickly if the aerial observer communicates the necessary information. A successful drop should hit the target area and interlink with the previous drop.

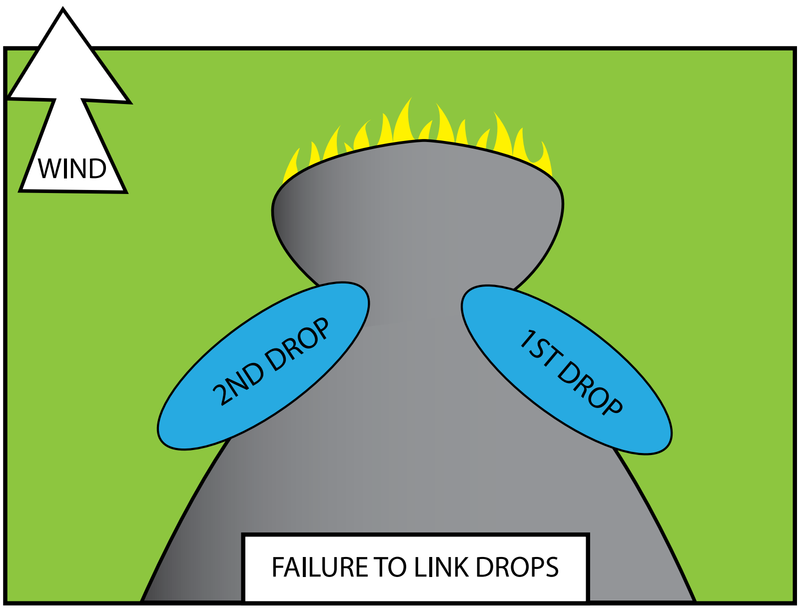


Fig. B9.1
The illustration showing the serious consequences of failing to link water or retardant drops

8B9.39 Ideally, a drop should be made so that a third of it falls onto the fire and into the black area, and the remainder is dispersed onto the unburnt vegetation outside the fire perimeter.

8B9.40 The density of a drop can be manipulated by adjusting the height or speed at which the water is dropped; this requires considerable piloting skills. In addition, the type of aircraft and the firefighting equipment carried may also affect the density or shape of a water drop. For example, a helicopter that is fitted with integral water tanks may be able to disperse water over a much wider area than water dropped from a bambi-bucket.

8B9.41 Photo B9.11 shows a water drop released from a bambi bucket onto coarse fuels. This drop is more concentrated and although it will cover less surface area it will penetrate further into the vegetation.

8B9.42 Photos B9.12 and B9.13 show a drop from helicopters with fixed water tanks. The height and speed at which the water has been released results in it being dispersed over a fairly wide area. This type of drop lacks penetration and is therefore more suitable when applied onto finer surface fuels such as grass or heather.

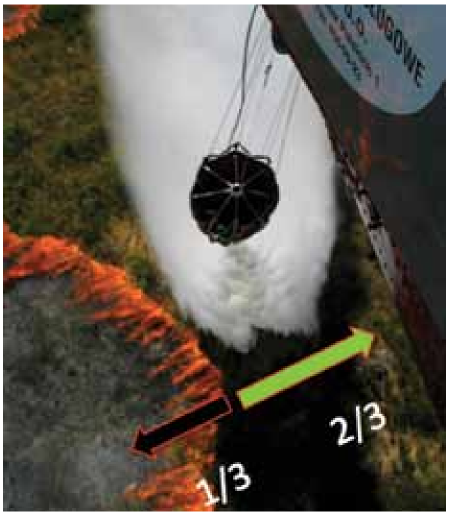


Photo B9.10
An ideal water drop

Photo B9.11
A drop from a bambi-bucket

Photo B9.12
A wide drop made from fixed water tanks

8B9.43 Some aircraft can partially drop their water supply, while others have to discharge all of the water in one application. It is therefore important that any ground teams or supervising officers communicating with the aircraft have an understanding of the drop capabilities of aircraft being used at an incident.

Photo B9.13
A dense drop made from a bambi-bucket

Communicating with Aircraft

8B9.44 Effective communication with airborne units from the ground is not difficult if aircrew have an understanding of wildfire and its terminology. FRSs should ensure that the appropriate Airwave or Radio channels to be used in ground-to-air communications are identified through local pre-planning and are established and maintained during all aerial operations.

8B9.45 Locations on the ground can be identified through the use of normal wildfire terms such as 'head', 'right or left flank' or 'tail'. Further clarification can be provided by using grid references and by using the 'o'clock' method.

Fig. B9.2
Safe approach to a helicopter under the direction of the aircrew

8B9.46 This method enables the ground and aircrew to exchange information using the aircraft's facing position referred to as '12 o'clock', as a point of reference.

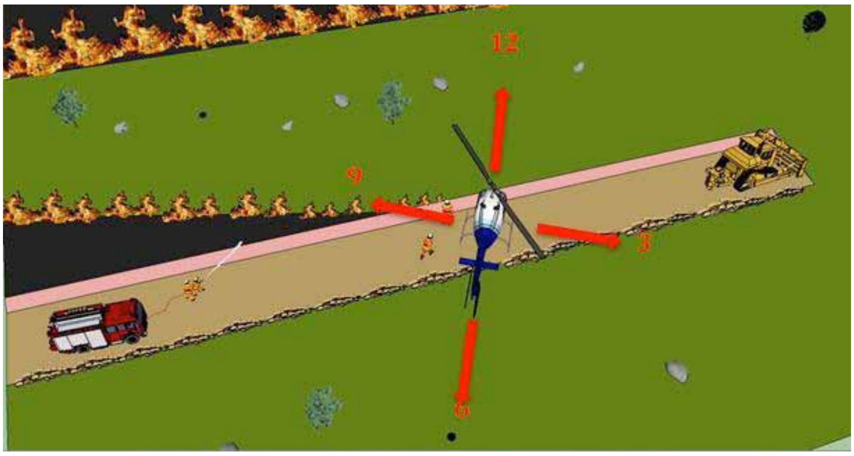


Fig. B9.3
Showing the position of resources in relation to the clock face

8B9.47 Using this method the appliance in the illustration is positioned at 8 o'clock and the bulldozer is at 2 o'clock.

Aerial Tactics

8B9.48 Similar to ground units, aircraft can attack a fire using a number of techniques:

Direct Attack – Using this method the aircraft discharges water onto the fires edge, or on other burning parts of the fire. This includes any attack made on spot fires or other secondary ignitions.

Indirect Attack – This involves drops being made into vegetation to create control lines, or to strengthen existing control lines by discharging water along their edge.

Aerial Suppression Tactics

8B9.49 The tactics used by aircraft are in many ways similar to those employed by ground teams.

8B9.50 Aerial attacks should be started from a strong anchor point, with hand tool crews or mechanised units on the ground preparing these where necessary. The aircraft should usually start their attack from behind and work along the flanks towards the head of the fire. It is important that, whenever achievable, ground support is provided so that following each drop, any remaining burning material or hot spots can be extinguished.

8B9.51 It is important that all of the water drops that are delivered interlink; in this way a complete barrier is formed along the fire's edge. Advantage should always be taken of changes to fire alignments, topography and fuel so that the attack is made in areas where it is more likely to prove to be successful.

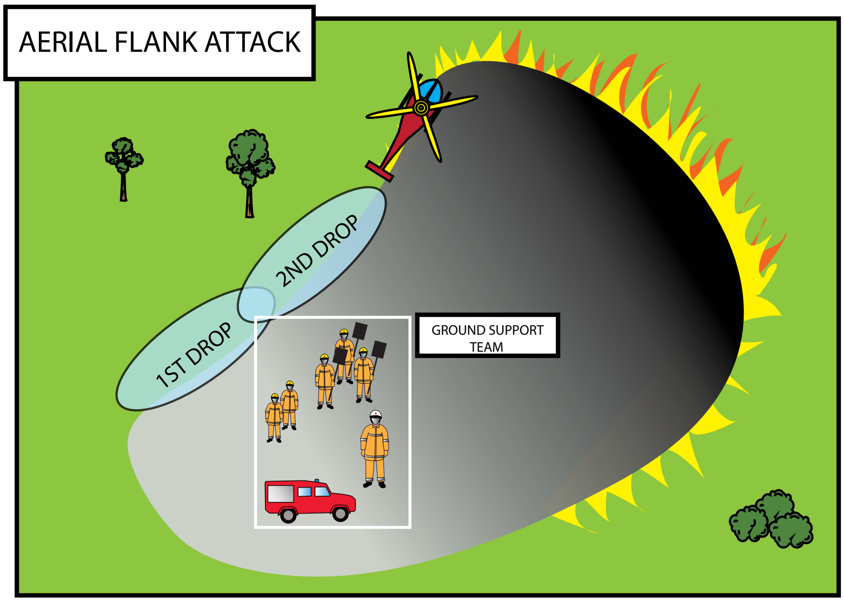


Fig. B9.4
An aerial attack on the left flank of a fire being supported by a ground team equipped with hand tools and which has water attack capability

Direct Aerial Head Attack

8B9.52 An attack on a head fire is normally made when fire intensity is too high for ground units to gain control of it, or to slow the progress of a fast-moving fire.

8B9.53 The attack should usually only be made when the flanks of the fire have been extinguished, as attacking the head fire before the flanks have been brought under control is not normally good practice as the water drops will not be securely anchored. Fig. B9.5 shows a 'V' head attack, this is where a drop is made along one section of the fire and then a subsequent attack is made on the remaining part.

8B9.54 This method is best achieved by two aircraft making drops in quick succession. If there is a delay in making the second drop the fire may re-establish its momentum and regain its previous intensity.

8B9.55 Once the attack has been made, supporting ground units should extinguish any remaining fire as quickly as possible and secure the line.

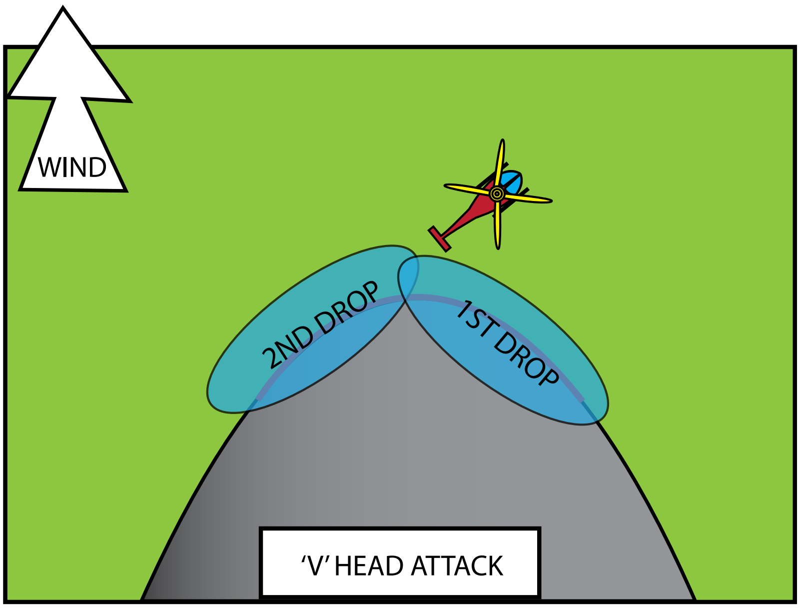


Fig. B9.5
'V' attack against the head

Combined Aerial and Ground Operations

8B9.56 At most wildfires where aircraft are used, both aerial and ground operations will be taking place simultaneously. It is vitally important that the ground and aerial operations are co-ordinated.

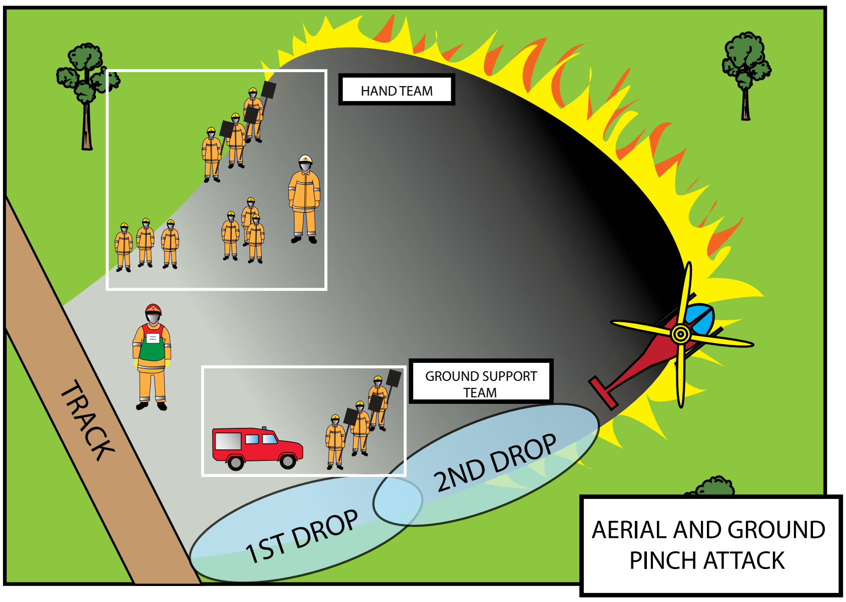


Fig. B9.6
Combined operations

8B9.57 Fig. B9.6 shows a pinch attack on a fire, the left flank is being extinguished by a hand team, while the right flank is being suppressed by an aerial attack which is being supported by a ground team.

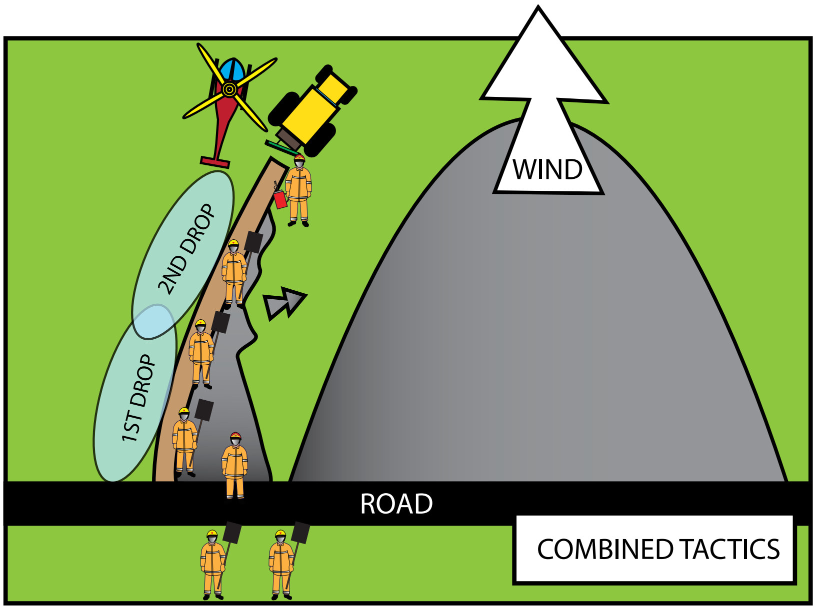


Fig. B9.7
Aerial support to ground operations

8B9.58 Fig. B9.7 shows a more complex operation, combining the activities of ground and aerial resources in order to achieve a common objective. A parallel attack against the left flank of a wildfire is in progress. A mechanically constructed control line is being built and, to allow burn-out operations to be carried out safely, it is being strengthened by water drops along its edge. A burn team is then able to burn out the vegetation between the control line and the wildfire.

Indirect Aerial Attack

8B9.59 Water, or retardant drops, can also be used to create control lines that can be used to prevent fire spread. The example used in Fig B9.8 shows a hook attack, this should be started from a strong anchor point; drops are then made along the flank and around the head of the fire. It is important to start these far enough from the fire's edge to allow the wet line to be completed before the fire reaches it. To ensure that the fire is secured all the drops must be interlinked.

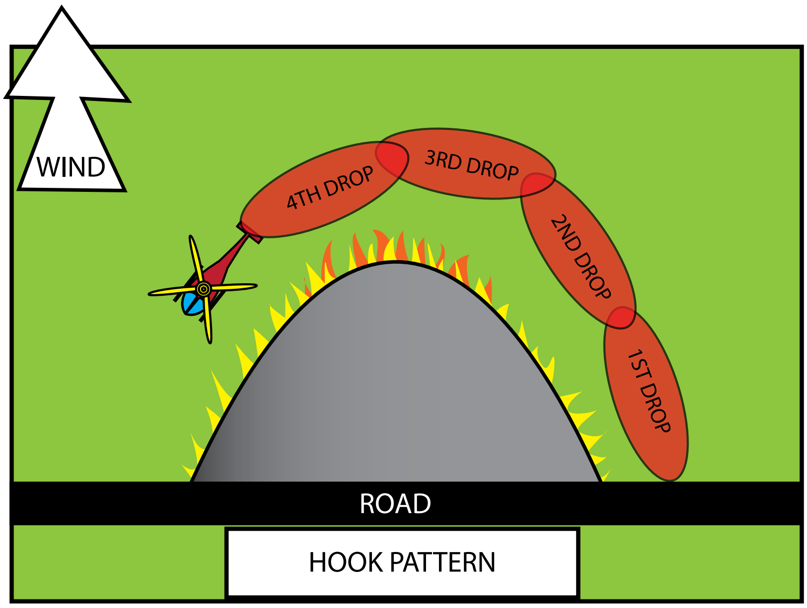


Fig. B9.8
Water drops using a hook pattern

Indirect Aerial Attack Against the Head

8B9.60 Fig. B9.9 shows a retardant line being constructed by a sequence of water drops, this tactic might be used to prevent or slow fire spread into heavier fuels. The success of this type of operation will normally depend on how quickly the line can be anchored by ground teams.

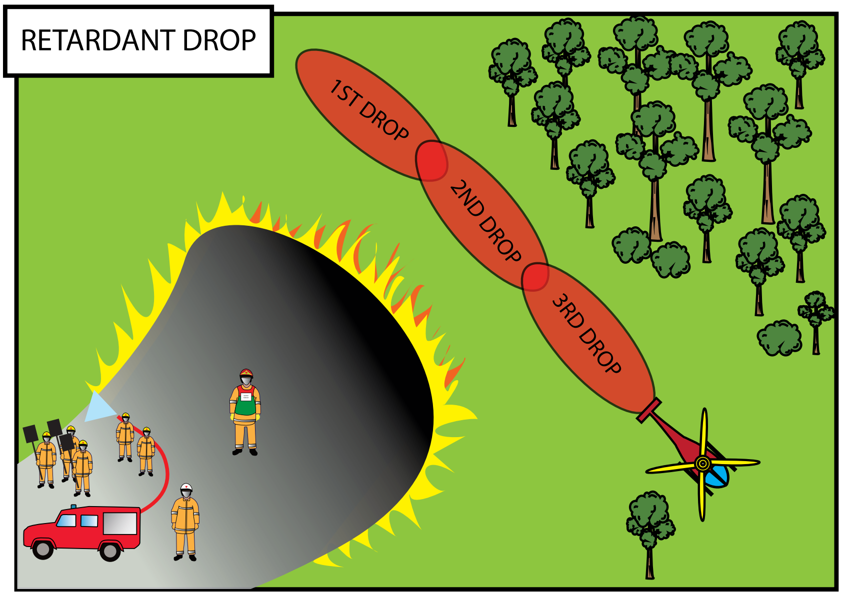


Fig. B9.9
Indirect attack preventing the head from moving into different fuel types

8B9.61 A fire that is demonstrating spotting behaviour, can pose a significant challenge to firefighters. Spots can 'jump' control lines or can accelerate fire spread. One method that can be used to control this type of behaviour is shown in Fig. B9.10. It shows two separate fire retardant lines, one is formed in front of the head fire while the second is placed behind and parallel to the first. The spacing between the two lines will depend on the distance the fire is spotting. The first line is intended to hold the main fire; the second will prevent fire spread caused by the spot fires that jump the first line. Again the success of such an operation will depend on rapid intervention by supporting ground teams.

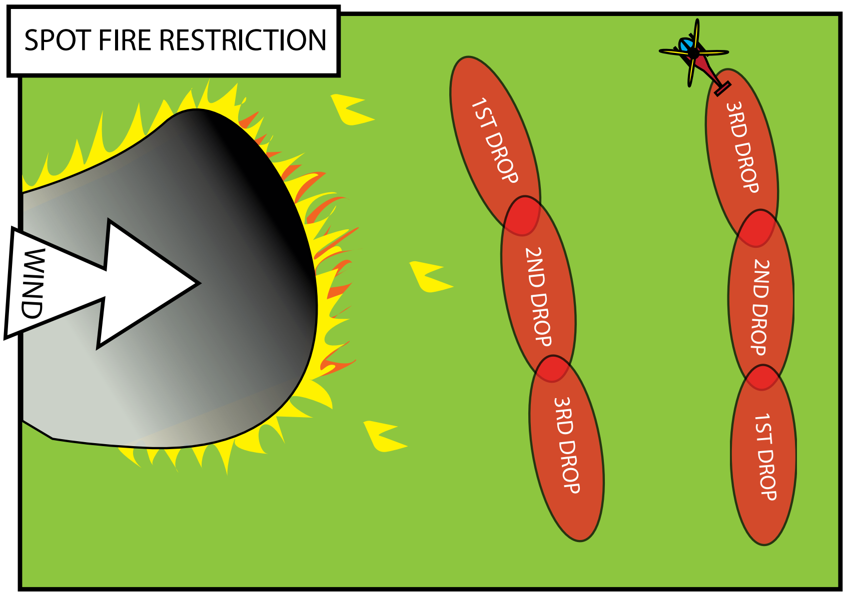


Fig. B9.10
Double wet line to prevent fire spread through spotting

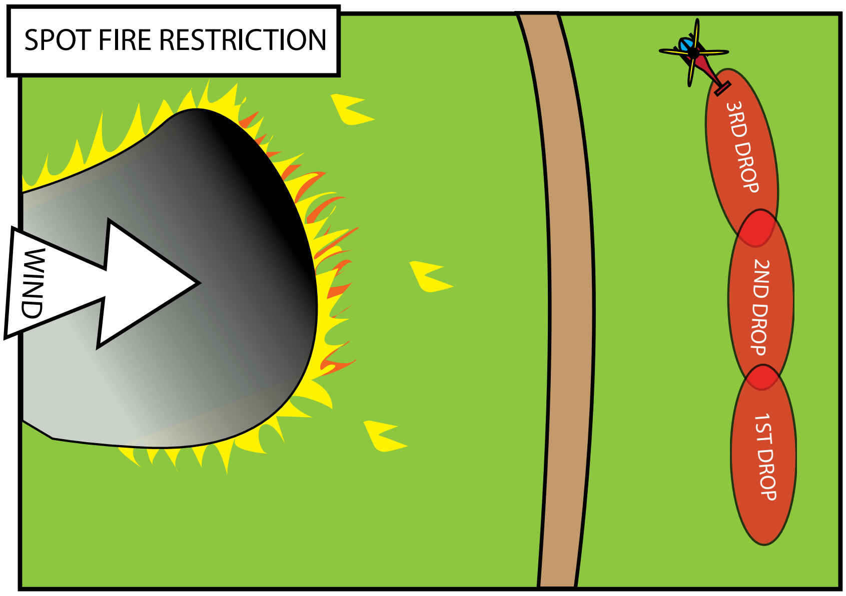


Fig. B9.11
Illustration showing the same tactic used to defend a control line

8B9.62 The successful use of aircraft at wildfire incidents depends on how well it is incorporated into FRS management and incident control systems. It is imperative that aircraft are allocated tasks that are within its operational capacity and that it is provided with tactical, logistical and ground support.

8B9 Key Considerations

- The use of aircraft at wildfire incidents should be pre-planned, exercised and governed by local FRS SOPs.
- An aerial sector within the ICS should be used to manage aerial involvement.
- Base all aerial suppression tactics on expected rather than current fire behaviour.
- Consideration should be given to the early use of aerial tactical support.
- Ground teams should be used to support aerial attacks.
- Aerial firefighting operations should always begin from a strong anchor point.
- It is important to establish the tactical limitations of the aircraft and/or pilot.
- Communication with the pilot must be established and maintained throughout the incident. Radio communication channels and air management procedures to be adopted should form part of the pre-planning for wildfire incidents.
- Personnel responsible for the supervision and monitoring of aerial activity must ensure regular liaison with the incident command team.
- Aircraft can be used for both direct and indirect firefighting tactics.
- A suitable landing area should be established from where the aircraft can be re-supplied with fuel, firefighting media and other essentials.

8B10

Safety at a Wildfire Incident

Introduction

8B10.01 Wildfires, as with any other type of fire, are potentially hazardous regardless of their size and intensity, and the risks to personnel are not limited to those posed exclusively by the fire.

8B10.02 This chapter is not intended to be seen, or used, as a definitive reference to all of the potential risk permutations associated with a wildfire incident. Rather, it should be utilised as a generic guide to the main risks which will be encountered at a wildfire event, and should form the basis of a more detailed risk assessment process based on the local circumstances within individual FRSs.

8B10.03 By following the guidance detailed in Sections 6.6 and 6.7, *The Risk Assessment Process*, FRSs should be well placed to identify the wide range of service-related and community risks and hazards associated with wildfire events in their areas, and enable the development of appropriate control measures and mitigation actions.

Fire Behaviour

8B10.04 Changes to wildfire fire behaviour can result in the following:

- **An increase in intensity, normally resulting in a surge in flame growth.**
- **A rapid increase in the rate of travel through the horizontal fuel arrangement.**
- **A rapid change in direction and fire spread.**

8B10.05 It is important to recognise that under certain situations all three changes can occur at the same time, or one change can be the precursor which triggers one, or both, of the others to take place.

8B10.06 As described in Part B6, the Wildfire Prediction System (WPS), the LACES Protocol and the maintenance of personal Situational Awareness during a wildfire incident, can all be used to alleviate risk. The main threat to firefighter safety at a wildfire incident is likely to be when a fire **unexpectedly** changes its behaviour. Personnel must remain constantly vigilant, and the operational situation must be subject to continual dynamic risk assessment by personnel who are trained in the understanding and awareness of wildfire behaviour. If potential fire change is identified then this should trigger a re-assessment and adjustment of the fire plan and to the tactics being used.

8B10.07 Monitoring changes to the main wildfire influences of fuel, weather and topography will not only allow FRS personnel to develop an appreciation of where, and potentially when, fire behaviour will change, it will also identify areas of highest risk where the placement of personnel and equipment should be avoided.

Common Situations that bring about Changes to Fire Behaviour

8B10.08 While much of the following section has been addressed in more detail in preceding sections, it is considered beneficial to briefly summarise the factors most likely to influence a change in the behaviour of the wildfire.

(a) Changes to Fuel

8B10.09 The size of the available fuel and the way in which it is arranged play a fundamental part in fire development. Dry fine fuels that are supportive to fire and arranged in continuity will readily support fire spread. When fire has access to an abundance of finer fuels, fire spread and intensities can become extremely intense. This is particularly relevant when fine fuels exist in both the horizontal and vertical arrangements, as this can allow the fire to penetrate into, and consume, the aerial fuels which can exist in huge quantities, resulting in a dangerous and rapid growth in fire intensity. This in itself can generate a further increase in the combustion process and accelerate the rate of fire growth. Another consideration should be the quantity of dead fuels that are available, not only at surface level but also in the elevated and aerial fuels.

(b) Changes to Fuel Moisture

8B10.10 Moisture found on, or contained within, fuel will determine how supportive it will be to the combustion process. Fine fuels dry out much more quickly than coarse fuels and this can lead to a rapid increase in fire intensity. Relative humidity readings can be used to indicate how dry fuels are and, when this is low, fine fuels will generally burn with considerable intensity. Dead fine fuels are particularly responsive to changes in the atmosphere and, when present, can be extremely supportive to the combustion process.

Photo B10.1

Photo B10.2

Photos B10.1 and B10.2 show the reduction of the moisture content within the atmosphere over a relatively short period of time. Rapid reductions in relative humidity allow the fuel to dry quickly, become more susceptible to combustion, and escalates the intensity of the fire. Depending upon the weather conditions, the drop in relative humidity can occur over an even shorter period of time.

8B10.11 A prolonged drying environment can have a significant impact on fire behaviour. A period of drought can dry out the ground, meaning that there is no resistance to fire development as the fire expends no energy overcoming the moisture content contained within the ground or surface fuels.

(c) The Temperature of Fuels

8B10.12 Fuels arranged across the landscape will be heated to different temperatures, those that are exposed to solar heating will generally be warmer (and dryer) than those that are not. Those fuels that are subject to prolonged exposure will normally be the warmest. The temperature of fuel affects the amount of heat it will take to ignite it, therefore fuels that are already warm will ignite and support flame propagation more readily than cooler ones.

8B10.13 Surface fuels that exist below aerial fuels can often be shaded and therefore cooler. Should the arrangement support vertical fire development there may be a rapid change in fire behaviour as the fire spreads into the hotter fuels above.

(d) Aerial Fuels

8B10.14 This effect can also influence vertical and horizontal fire spread above an existing fire. For example if a surface fire is burning under a dense canopy it is likely that the aerial fuels are subject to more sunlight than the shaded surface fuels. This may result in the aerial fuels being significantly warmer and dryer. If the fire penetrates into these fuels these may more readily support the combustion process resulting in the possibility of rapid and significant change to fire intensity, rate of spread and sometimes direction.

(e) Spotting

8B10.15 Both short and long-range spotting can be extremely dangerous. Shorter-range spotting can cause a fire to increase in intensity and accelerate fire development. Longer-range spotting can ignite fuels considerable distances away from the main fire, and depending on the fuels and fire alignments these occur in, may result in fires that demonstrate very different fire behaviour to the original wildfire. Spotting can also compromise escape routes and can penetrate into fuels beyond control lines.

(f) Upslope

8B10.16 An increase in the angle of a slope will result in an increase in rate of spread and fire intensity. Upslopes are particularly dangerous, and it is important that firefighters are not positioned above a fire on a slope.

(g) Downslope Hazards

8B10.17 If a fire is backing down a slope and firefighters are positioned below the fire on the slope and in unburnt fuel, there is the possibility that rolling materials or spotting could ignite secondary fires behind and below the firefighter's position. This is a particularly dangerous situation as the secondary fires may be much more intense, burning upslope with the support of the wind.

(h) Slope Reversal

8B10.18 When a fire is burning downslope, and then moves into a position where it has the opportunity to burn upslope, there is a possibility of a rapid if not immediate increase in fire intensity and rate of spread.

(i) Aspect

8B10.19 The direction a slope faces in relation to the sun affects the type, temperature and dryness of fuel. This can have a dramatic effect on fire intensity and rate of fire spread.

(j) Shape of the Landscape

8B10.20 The shape of the landscape can influence wind direction and strength. Certain features such steep-sided valleys or gullies can funnel and concentrate wind significantly which may result in a corresponding change to fire behaviour and a rapid acceleration in fire spread.

(k) Wind

8B10.21 Wind is a primary factor to consider as changes to its strength or direction can result in a fire quickly increasing in intensity and/or rate of spread. Changes to wind direction do not necessarily have to be extreme, a subtle change can enlarge the width of a head fire which can result in a seemingly disproportionate change in fire behaviour.

(l) Atmospheric Stability

8B10.22 A stable atmosphere normally restricts fire development limiting fire intensities and rate of spread. An atmosphere that is unstable can create a fire environment that can become progressively more erratic and less predictable. A rapid change from a stable to an unstable atmosphere can have a sudden and dangerous impact on a fire.

(m) Changes to More than One Factor

8B10.23 Particularly hazardous situations may arise if more than one factor combines causing a cumulative effect. This can result in an almost immediate and dramatic increase in fire development.

The Importance of the Key Factors

8B10.24 The key factors can be used to assess whether extreme fire activity is likely to occur. The presence of a single indicator may lead to a dangerous increase in fire intensity or spread, but when the fire environment is influenced by a combination of these factors the situation can become increasingly serious.

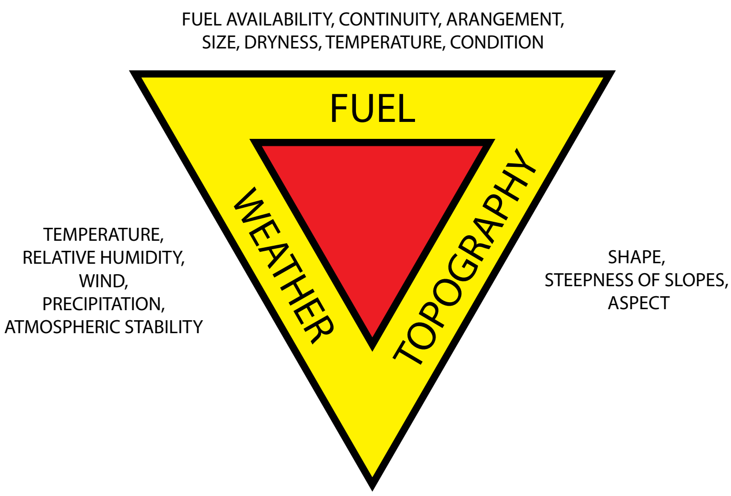


Fig. B10.1 Showing how, fuel, topography and weather interact and influence fire behaviour

Working in the Outdoor Environment

Heat-related Illnesses

8B10.25 During a wildfire event it is important to be aware of the added physical demands that are placed on the body and to be able to recognise the signs and symptoms of a heat-related illness. There are different types of heat-related illnesses, ranging from those that cause temporary discomfort, to the much more dangerous, and potentially fatal, condition of heat stroke. In a wildfire environment the symptoms of a heat-related illness may appear due to the combined effects of exposure to extreme temperatures (whether environmental or from the wildfire itself), arduous working conditions, unsuitable PPE and lack of regular fluid intake.

The following checklist can help you recognise the symptoms of heat-related illnesses:

Heat Rash

8B10.26 Personnel may suffer from skin irritation caused by excessive sweating brought about by firefighting conditions and prolonged exposure to high temperatures.

Heat Cramps

8B10.27 Fire Service personnel who have been participating in strenuous activity in the heat may develop muscle spasms in the arms, legs, or abdomen. These can be painful and debilitating. The individual's body temperature is usually normal, and the skin will feel moist and cool, but sweaty.

Heat Syncope

8B10.28 Personnel may experience the sudden onset of dizziness or fainting after exposure to high temperatures. Personnel undertaking firefighting operations in high ambient temperatures or at the fire front will be at greatest risk. As with heat cramps, the physical indicators of the onset of heat syncope may be pale, sweaty skin which remains cool, a weakened pulse and a heart rate that is usually rapid.

Heat Exhaustion

8B10.29 Should alert personnel to a deteriorating situation and is a warning that the body is beginning to overheat. A person with heat exhaustion may be thirsty, sweating profusely, lightheaded, weak, unco-ordinated. In more advanced cases personnel may become nauseous. Other symptoms may resemble those of heat syncope and heat cramps.

Heatstroke

8B10.30 Heatstroke is a very serious, and potentially fatal, condition that occurs when the body loses its ability to control its temperature. Once an individual is suffering from heatstroke critical medical intervention is absolutely essential. Immediate first aid cooling of the body should begin at once. Personnel suffering from heatstroke will normally develop a fever that rapidly rises to dangerous levels within minutes. Body temperature may rise above 104° F (40°C). Other symptoms and signs of heatstroke may include confusion, agitation, hallucinations, feeling faint, loss of balance, strong rapid pulse, dry flushed skin, and a lack of sweating. Coma can also result from heatstroke.

Travelling on Foot

8B10.31 FRSs must assess the risks of deploying personnel and resources into forested, muirland (moorland), heath and remote rural landscapes. If personnel have to leave recognised roads and paths they should be provided with appropriate training to enable safe navigation.

Photo B10.3
An area of slash following block harvesting showing the difficult terrain that personnel may need to traverse

When travelling on foot the following should be considered:

- **The essential elements of LACES should be put in place before deployment.**
- **The team should be led by a supervisor who has wildfire and map reading/navigation competencies.**
- **Teams should be equipped with a radio, a map of the area and a compass.**
- **Follow a planned route that avoids steep inclines or declines wherever possible.**
- **Consider the types and arrangement of fuels that are on the landscape.**
- **Consider the direction and rate of fire spread and any change that might occur.**
- **All team members should carry sufficient water and food to provide sustenance for at least 4 hours.**
- **Travel at a speed that is appropriate to the distance to be covered and the fitness levels within the team.**
- **The team must remain in communication with each other.**
- **To avoid injury from vegetation (springing branches) or hand tools being carried by other team members, personnel should remain at least 2 metres apart.**
- **If working at night or in low light conditions, each team member must carry appropriate lighting equipment.**
- **Appropriate footwear for the conditions should be worn. It is recommended that boots which provide good ankle support are worn.**

Photo B10.4
A stump hole which presents an obvious injury risk to firefighters – both as a trip hazard and due to the potential for the hole to be full of hot embers. Stump holes can be very difficult to see when full of ash and debris.

The Use of Topographical Maps

8B10.32 At large spatial incidents, the ability to read and understand topographical maps is critical to control and manage safety. Personnel within the command team and on the fire ground must have an appropriate understanding of topographical maps and the navigation skills appropriate to their role. Measures must be taken to ensure that personnel on the fire ground have, or have access to, topographical maps that are relevant to their location and task.

Photo B10.5
A trained firefighter using an OS map to identify features on the landscape

Night-time Firefighting

8B10.33 As night-time hours provide cooler temperatures, higher fuel moisture and higher relative humidity levels, there is an opportunity to firefight in conditions which have the potential to offer a substantial reduction in fire intensity.

8B10.34 Despite the potential benefits that may arise from conducting properly risk-assessed operations during darkness, there are a number of risks that will increase – the most obvious being slips and trips.

Increased risks to personnel during night-time operations will arise from:

- **Reduced visibility.**
- **Concealment of other fireground hazards, e.g. potholes, tree-stumps, power lines.**
- **Greater potential for the isolation of personnel.**
- **Colder, and generally more difficult, working conditions.**

8B10.35 There are a number of ways which FRSs may wish to consider mitigating the potential for increased risks to personnel if night-time working is considered appropriate or necessary:

- **No lone working.**
- **Using substantially fewer people.**
- **Limiting night-time operations to the completion of specific tasks identified within the tactical incident plan that will have a significant impact on the fire or its future development.**
- **Wherever possible, crews being led by personnel that have had advanced or specialist training.**
- **Ensuring crews deployed at night time are suitably equipped in accordance with local procedures.**
- **Operations being carried out close to recognised roads or tracks whenever possible.**

The Use of Tools

Hand Tools

8B10.36 This guidance has described a number of suppression methods that require the use of hand tools. Generally, hand tools are used to clear vegetation for ease of access/movement and for the construction of control lines. Some of the equipment that is commonly used within the wildfire arena will be unfamiliar to many firefighters.

8B10.37 As with any hand tool, incorrect or careless handling can result in injury, so it is recommended that FRSs raise awareness among their personnel as to the safe operation of these tools.

Basic Rules

- Tools should be well maintained, tested and ready for use.
- Hand tools should comply with the appropriate and relevant standards of manufacture.
- Many of the tools have sharp edges and, when not in use, a guard should be fitted.
- When being carried, tools should be carried at the side positioned at their balance point and with the working part pointing forward so that the dangerous part of the tool is in full view.
- Tools should never be carried on the shoulder.
- Never use a damaged or defective hand tool.
- Hand tools are particularly dangerous when they are being used, a safe working distance between operatives must be maintained and should normally be at least 3 metres.

Photo B10.6
Showing a firefighter correctly carrying a polaski

Photo B10.7
Firefighter using a long handled metal scraper.

Powered Hand Tools

8B10.38 Portable powered hand tools can be used to reduce the time and effort required to complete a task such as control line construction.

8B10.39 It is imperative that appropriate training is provided to all FRS personnel who may be required to operate powered hand tools, such as chain saws, brush cutters and strimmers, within a wildfire environment.

8B10.40 FRSs will be able to provide appropriate initial and maintenance training, but may find operational opportunities limited for personnel to gain and develop additional experience to further develop their expertise. Due to the specialist skills involved in the operation of powered hand tools and the maintenance of user accreditation, this guidance encourages an interagency approach whereby FRSs, whenever possible, also establish partnerships with agencies that already have available and qualified operatives.

8B10.41 Aside from reducing the risk to FRS personnel, the additional benefit of this approach is that tool operators from a land management background can also provide invaluable, experience, local knowledge and expertise to the Incident Commander.

8B10.42 When a mechanical tool is being operated, other personnel must keep a safe distance from the working area. The distance will depend upon the particular powered hand tool in use and FRS personnel should follow any instructions given by the tool operative.

Drip Torches

8B10.43 Drip torches are an item of equipment which many FRSs will be unfamiliar with. Due to the potential dangers involved in using drip torches, there are a number of safety feature built into their design. Torches are fitted with a check valve to control the flow of fuel through the igniter, as well as valves and safety features which prevent flame from traveling backwards up the nozzle and igniting the tank.

Photo B10.8
Correct handling of a large drip torch

- **Only trained specialists should use drip torches.**
- **Appropriate PPE should be worn at all times when operating and refilling drip torches.**
- **Drip torches should be well maintained and be subject to an appropriate testing system.**
- **Ensure that the correct fuel mix is used.**
- **Keep the drip torch away from your body, clothing, and boots.**
- **Always carry the drip torch upright with spout forward until ready for use.**
- **Only carry the drip torch by the handle.**

- There should be clear guidance providing information on the methods of fuelling and refuelling.
- Drip torches should only be lit when in use and extinguished as soon as this work is completed.
- On the fire ground they should be stored in a safe place.

Photo B10.9
Correct re-filling of a drip torch – full PPE, away from ignition sources and preventing spillages

Photo B10.10
Showing a firefighter carefully using a drip torch to ignite vegetation

The Safe Use of Vehicles

8B10.44 It is imperative that personnel fully appreciate the limitations of FRS vehicles deployed to wildfire incidents and do not use them inappropriately. An understanding of the vehicles' limitations and off-road capability must be established, even those with a 4x4 or 'all terrain' capability. When operating 'off road', vehicles should only be driven by personnel who have received specific training.

8B10.45 It is recommended that a risk assessment is carried out to establish appropriate safe systems of work for all vehicles in operation within individual services if they have to be deployed off roadways or hard standing.

8B10.46 During the development of wildfire fire plans all relevant vehicle access and egress routes, pathways, tracks and hard standing which may be suitable for use by fire service vehicles should be identified and recorded.

8B10.47 When vehicles are deployed onto a wildfire fire ground, the LACES protocol still applies. The vehicle OiC should establish all of the elements contained within the protocol.

General Vehicle Safety

- **Never get on or off vehicles when they are moving.**
- **Ensure that vehicles are checked before operation to ensure that they are fully fuelled, tyre pressures and water levels are satisfactory, and mirrors are properly adjusted and that all vehicles lights are in working order.**
- **When vehicles are parked on slopes ensure the handbrake is always applied; the vehicle is left in gear (or Park if automatic) and, where necessary, the wheels are chocked.**
- **Avoid traversing slopes if possible.**
- **Consider using headlights at all times to improve visibility to other vehicles and personnel.**
- **Depending upon the type of vehicle being used, whenever there is a need to drive off road it may be necessary to ensure that personnel are utilised to assess ground conditions ahead of the vehicle.**
- **Avoid parking under power lines.**
- **On undulating ground be aware of the risk of 'bottoming out'.**

Vehicle Entrapment

8B10.48 Fire Service vehicles can be vulnerable to entrapment at wildfire incidents, and personnel should always be mindful to prevent situations developing where personnel are placed in danger of being unable to escape in the vehicle or they need to use the vehicle as a refuge.

8B10.49 To avoid entrapment, the following should be considered:

- **Avoid parking vehicles in areas of vegetation or under tree canopies.**
- **If there is sufficient time, and trained personnel available, vegetation can be cleared or burned out to reduce fuel loading around vehicles.**

- **Maintain vigilance when vehicle pumps are being used to ensure that vehicles do not become bogged down in soft ground.**
- **Park vehicles behind natural barriers or structure for protection.**
- **Avoid taking vehicles into saddles and re-entrants.**
- **Always park vehicles in the direction of escape and ensure that the escape route has been recced to ensure it is suitable and obstruction free.**
- **Ensure any bridges can support the weight of the vehicle.**
- **Do not leave a vehicle parked unattended on a road or track as this as may block an escape route.**

8B10.50 FRSs should work with partners to establish guidance controlling the use of vehicles and emergency action in the event of vehicle entrapment on the fire ground.

The Use of Machines

8B10.51 Machines should only be used once a thorough risk assessment has been carried out and specific control measures have been put in place. Operators should never be allowed to work alone and, where necessary, fire service support should be provided. If deployed onto the fire ground, vehicle drivers and machine operators must be incorporated into the LACES safety protocol.

8B10.52 Specific vehicles or machines such as tractors, excavators, harvesters, mulchers, etc. will almost always be provided by contractors or land management partners, Fire Service personnel must take cognisance of the safety information and guidance provided by the operators of the machinery involved.

8B10.53 Where appropriate, and as part of preparedness activities, FRS personnel should be made aware of the vehicles and equipment which may be deployed by partners at wildfire incidents. This should include any risks involved in their use and the safe systems of work to be adopted by both the operators and FRS personnel.

Personnel Safety

- FRSs must ensure that personnel are provided with Personal Protective Equipment (PPE) which is suitable and appropriate for attendance at a wildfire incident.
- When involved in firefighting activities PPE must be worn at all times. Dressing down should only be permitted during rest periods away from the fire, and only when completely safe to do so.
- Personnel operating on the fire ground should be fully briefed before deployment and fully understand their role.
- When deployed onto the fire ground, it is essential that personnel undertake a complete equipment inventory check before deployment.
- Essential personal equipment will depend on the wildfire circumstances and local procedures, but it is recommended that it should include, PPE, firefighting equipment, a map of the area, a hand-held radio and fluids.
- All personnel should be aware of, and operate under, the LACES protocol.
- Effective communications between individuals, crews and command support personnel should be maintained at all times.
- Due to the arduous working conditions associated with wildfire incidents, personnel should be aware of the signs and symptoms of heat-related illnesses such as heat cramps, heat stress, heat exhaustion and heat stroke.
- Arrangements should be made to ensure that personnel have access to water/fluids to prevent dehydration.
- Due to the arduous working conditions, regular reliefs should be considered.
- Personnel should, whenever possible, work upwind and behind the fire, thus avoiding heavy concentrations of heat and smoke.
- Smoke can impair vision preventing observation of the fire and its behaviour and obscure visual contact with other personnel.
- Always maintain good escape routes to a designated safety zone.
- When working in or around tree cover, personnel should always be aware of the stability of surrounding trees.

Photo B10.11
Showing unstable conifers being supported by neighbouring trees. In the event of a fire affecting the stability and integrity of the supporting trees, a collapse may occur without warning – hence the nickname 'widow makers'

- Remain vigilant and maintain your situational awareness at all times.
- Do not become too focused on a task, observe what is happening around you; 'look up, down and around'.
- Whenever personnel are operating within the vicinity of aircraft (fixed-wing or rotary), then guidance and instruction must be taken from the aircraft crew, or the safety officer responsible for the landing and refuelling zone.
- Personnel should never operate any item of equipment that they are unfamiliar with.

8B10 Key Considerations

- LACES, WPS and the application of situational awareness can all be used to mitigate risk at a wildfire event.
- Personnel should understand the common situations which lead to changes in fire behaviour.
- Heat-related illness is a major risk when working in the outdoor environment – personnel should be aware of the signs and symptoms of heat cramps, syncope, exhaustion and stroke.
- FRSs should ensure they have undertaken a thorough risk assessment of their response and deployment to a wildfire incident.
- The ability to read, use and understand topographical maps is a key skill which relevant personnel should possess.
- There are advantages to fighting a wildfire during night-time periods. This should be balanced against the additional hazards and risks that may be encountered when considering whether to undertake night-time operations.
- Personnel operating on the fire ground should be aware of dangerous parts of the landscape.
- Remain in contact with other team members and your supervisor – Do Not Work Alone!!
- Be in a position where you can see the fire – this is particularly important if there is unburned fuel between you and the fire.
- When working below a fire on a slope look out for any rolling material that could start secondary fires below your position.
- Always maintain good escape routes to a safety zone. These may have to be changed as the fire moves across the landscape.
- Personnel must ensure that they carry all safety equipment relevant to the operational situation.
- Do not become too focused on a task, observe what is happening around you; 'look up, down and around'.

8C

Generic Standard Operating Procedure

Introduction

It is useful to see the emergency incident response phases in the context of the typical stages of an incident as referred to in Volume 2 Fire Service Operations Incident Command Operation Guidance and the Guide – Dynamic Management of Risk at operational Incidents. This is shown below.

Stages of an Incident (Dynamic Management of Risk)	ICS Decision Making Model Links	GSOP Response Phases
		1. Mobilising and En-route
Initial Stage	• Incident information • Resource information • Hazard and safety and information	2. Arriving and Gathering Information
Development Stage	• Think • Prioritise objectives • Plan	3. Planning the Tactical Plan
	• Communicate • Control	4. Implementing the Tactical Plan
	• Evaluate the outcome	5. Evaluating the Tactical Plan
Closing Stage		6. Closing the Incident

The generic standard operating procedure (GSOP) has been derived by breaking down an incident into six clearly identified phases which has been taken directly from the decision making model.

The purpose of this section is to cover possible actions that may need to be undertaken at each of the six stages of the incident and then offer up some possible considerations that the Incident Commander and other Fire and Rescue personnel may find useful in tackling the challenges and tasks that may be faced at a wildfire incident.

The GSOP is not intended to cover every eventuality however it is a comprehensive document that can be used by planning teams, who need to write standard operating procedures and responding personnel alike.

Further detailed and tactical information on specific wildfire related hazards are covered throughout this document.

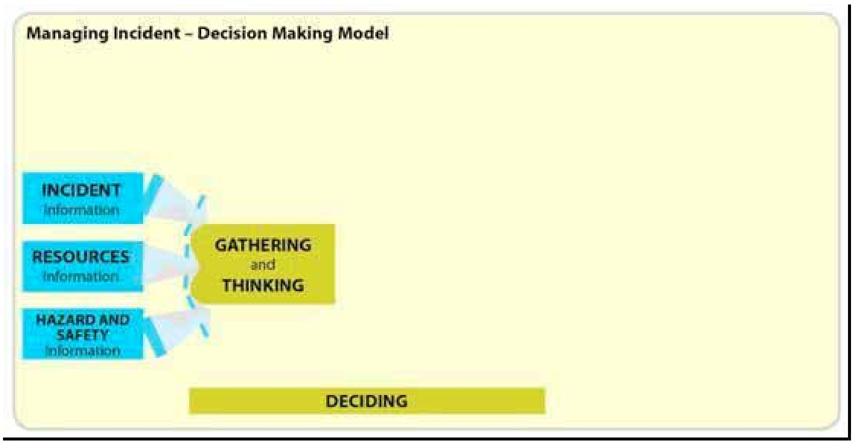
The decision making model comprises of two major components; these are the deciding and acting stages.

In seeking to resolve a wildfire incident the Incident Commander will use their knowledge and experience to identify the objectives to be achieved and formulate an appropriate tactical plan of action.

Emergency Incident Response Phase

1	Mobilising and En-route
2	Arriving and Gathering Information
3	Formulating the Tactical Plan
4	Implementing the Tactical Plan
5	Evaluating the Tactical Plan
6	Closing the Incident

Phase 1: Mobilising and En-route



All relevant information should be gathered during the pre-attendance phase of an incident.

Phase 1 – Actions Mobilising and En-route

1.1	Initial call handling
1.2	Assess the level and scale of the incident
1.3	Mobilise appropriate resources
1.4	Access incident specific information en-route
1.5	Notify relevant agencies

Considerations

1.1 Initial call handling

As with any incident the handling of the initial call is of critical importance to ensure that the correct predetermined attendance is mobilised. In handling the call the mobilising centre operator will need to gather as much information from the caller(s) as possible. If there is any doubt about the size or potential scale of the incident the predetermined attendance should be scaled up rather than down.

In determining the correct predetermined attendance the following may be considered.

- **Informed call coming from a reliable source, such as a land manager, land owner, member of a fire group or the Police.**
- **Uninformed call, vague call from a member of the public, or suspected hoax call.**
- **A number of calls in relation to the same location or incident.**

1.2 Assess the level and potential scale of the incident

Fire and Rescue Service's mobilising controls should try to obtain information regarding the size, potential scale and location of the incident prior to and during the mobilisation of Fire Service resources. This will provide quality information for the Fire and Rescue Service personnel and response partners who may be first on the scene.

Gathering information about incidents that often occur in very remote areas is difficult and Fire Services will benefit from assessing how this can be best achieved in their area.

Information may be obtained from.

- **Persons in attendance at the scene**
- **Pre-arranged lists of contacts that have detailed knowledge of the local geography and conditions, these may include private land owners/managers, foresters, farmers, National Parks rangers, military personnel etc.**
- **Fire group members that work or are located near to the incident**
- **The caller or subsequent callers**
- **Local knowledge of Fire Service Personnel or their partners**
- **Observations at the scene**

1.3 Climatic conditions

Importantly information should be gathered on the current, and forecasted, weather conditions.

This should include specific information on the following:

- **Wind speed and direction**
- **Temperature**
- **Relative humidity**
- **Precipitation**
- **Atmospheric stability**

1.4 Mobilise appropriate resources

During a protracted wildfire period, it is likely that some Fire and Rescue mobilising controls will face a significant increase in the number and scale of incidents requiring the attendance of Fire and Rescue Service resources. During such demanding periods arrangements should be made to co-ordinate the Fire and Rescue Service response and manage any Fire Group or partner involvement.

Fire and Rescue control centres should utilise any site specific plans to enhance mobilising information given to personnel, this is particularly important when the exact location or scale of the incident is not known and where it may be decided to mobilise to a geographical area or a pre-determined rendezvous point.

Fire and Rescue control centres may be required to activate pre-arranged mobilisation solutions including a collaborative response, sometimes involving other agencies or partners.

Determining the level of response to a wildfire can depend on a number of situations including:

- **Size or potential scale of the incident**
- **Fuel types**
- **Potential Fire Spread**
- **Reported fire behaviour**
- **The possible involvement of infrastructure**
- **Urban Interface fires**
- **The prevailing weather conditions**
- **The remoteness of the incident location**
- **Possible environmental impact**

Consideration should be given for the need to mobilise, at an early stage:

- **Specialist wildfire vehicles and equipment**
- **Trained and experienced Fire and Rescue Service personnel**
- **Specialist wildfire officers including subject matter advisers**
- **Specialist wildfire teams**

Local arrangements may exist whereby specialist vehicles, equipment or personnel are available via partnerships with land management agencies and landowners.

1.5 Access incident specific information en-route

Mobilised personnel should access site/incident specific information from mobile data systems, or hardcopy fire plans to clarify:

- **Appropriate routes to be taken to the scene**
- **Rendezvous points**
- **Site specific pre-determined plans**
- **Pre-determined collaborative arrangements**
- **Appropriate approach roads and tracks**

Mobilised personnel should request information on, and think about, the hazards they will face and the control measures that will need to be put in place.

1.6 Notify Relevant Agencies

Fire and Rescue Services should maintain contact details for all wildfire risk sites within their service area, and should establish robust working arrangements with relevant local and National organisations.

On most occasions land managers/owners will be aware of any incident that is taking place on their property; however it is good practise for Fire and Rescue control centres to inform/confirm with the relevant land manager/owner that a response has been made by their service.

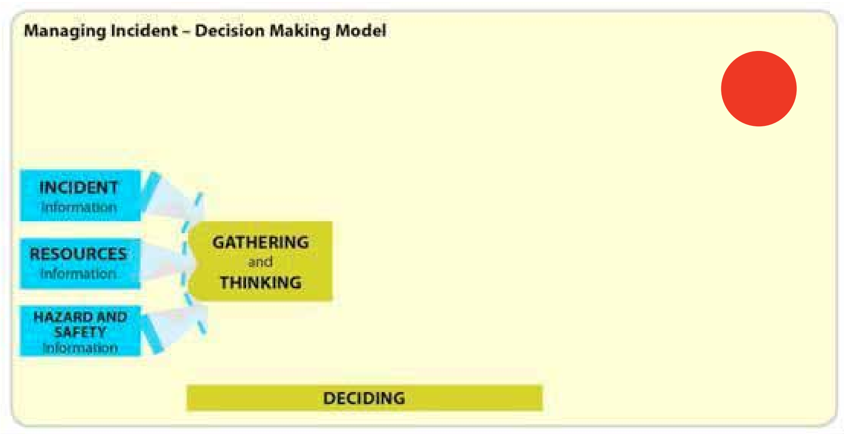
Resolving some wildfires will involve a multi-agency effort: where appropriate, Fire and Rescue Service control centres should share information with other relevant agencies.

Fire and Rescue control centres should have early dialogue with any agency that may be involved, be of assistance or may be affected by a wildfire incident. The scope of this requirement will depend on the location and size of the incident and the impact it may have on local communities, infrastructure and the environment.

Consideration should be given to the following:

- **The nature of the incident**
- **The hazards involved**
- **On-going actions**
- **Potential scale of the incident**
- **The level of support required**

Phase 2: Arriving and Gathering Information



The initial FRS attendance should gather sufficient information to allow an effective evaluation of the situation.

Phase 2 - Actions Arriving and Gathering Information	▪ Incident information ▪ Resource information ▪ Hazard and safety information
2.1	Confirm location of incident and incident type
2.2	Approach the incident safely
2.3	Assess hazards and risks and the implementation of an inner cordon (this will be continuously reviewed subject to risk assessment)
2.4	Cordon considerations
2.5	Liaison with other co-responders
2.6	Consider involvement of dwellings or other property
2.7	Estimate the resource requirements
2.8	Implement the Incident Command System (ICS)
2.9	Investigation and recording

Considerations

2.1 Confirm location of incident and incident type

The first Fire and Rescue Service personnel in attendance will need to confirm an accurate location and provide information on the following:

- **The exact location of the incident given using a six figure map reference**
- **The extent of the incident**
- **Potential fire spread**
- **Rendezvous points**
- **Safe access and egress routes**
- **Best approach routes to be taken and nature of the ground conditions**

This information will be broadcast to on-coming Fire and Rescue Service appliances and mobilising control centres, other agencies and partners should be informed via fire control centres.

2.2 Approach the incident safely

Wildfires can often occur at remote locations on terrain that is both difficult and hazardous to operate on. Whilst mobilising to an incident it is important that any relevant information is accessed, this should include site specific plans and topographical mapping systems. Any additional information required should be requested, this will allow an assessment of the difficulties and hazards that may be confronted.

The following points may have to be taken into consideration during the approach to a wildfire incident and may assist in assessing the suitability of response routes and rendezvous points (RVPs) to be used.

- **The position of access routes and RVPs in relation to potential fire spread**
- **The surrounding fuel types**
- **The topography**
- **Time of day**
- **Weather conditions**
- **Which roads or tracks are suitable for Fire and Rescue Service vehicles**
- **Whether there are suitable escape routes and passing points**
- **The presence of turning areas**
- **The presence of locked gates or other obstacles that may block access or egress**
- **Parked vehicles or machines**

Driver considerations:

- **Any route taken should be pre-planned and understood**
- **When approaching an incident drivers must use a safe speed**
- **Consideration should be given to the nature and condition of the surface**
- **Extreme care should be taken to avoid surfaces that will result in the vehicle becoming immobile, this includes ATVs**

Approaching the incident on foot:

At many wildfire incidents it is impossible to get to the scene of operations by vehicle and it is necessary to travel some distance by foot.

The following should be considered:

- **Where possible recognised paths or tracks should be used**
- **FRSs should assess the level of training and awareness required to ensure personnel can traverse open landscape safely**
- **Appropriate navigation equipment must be utilised**
- **The route should be pre-planned and safe**
- **The LACES safety protocol should be adopted**

2.3 Assessing the hazards and risks and the implementation of control measures

At a large wildfire, FRS incident commanders may have difficulty in obtaining sufficient quality information to enable them to formulate an effective initial plan. Incident commanders must ensure that whenever possible they take up a position from where they can observe the whole incident and the surrounding area. At larger incidents this may involve the use of an aircraft to allow assessment of the hazards from above.

As well as establishing an understanding of the current situation they must consider the potential changes that may occur in the future.

In assessing the demands of an incident and reaching a decision regarding the application of control measures, the incident commander should pay particular attention to the following:

- **The initial extent and size of the incident**
- **The fuels available to burn**
- **The shape of the topography**
- **The influence of weather conditions on the wildfire environment**
- **Pre-incident weather conditions**
- **The expected fire behaviour**
- **The potential the fire has to spread across the landscape and the changes to fire behaviour that this will bring**

- **The restrictions to fire spread that can be used to contain a fire (control lines)**
- **Resources available at the scene or en-route, these may include those provided by partners or other stakeholders**
- **The level of training, experience, knowledge of the personnel attending**
- **Persons or property at risk**
- **Risks to the environment**
- **Any specific hazards present on the landscape such as power lines, gas lines, electrical substations, military ordnance, topographical hazards, etc**
- **Assessment of risk and the declaration of an appropriate tactical mode**

2.4 Cordon considerations

Due to wildfires being highly dynamic with the potential to expand for considerable distances it may be difficult to set a fixed area that can be identified as an inner cordon.

Due to the size of many wildfires it may be impractical to establish a cordon around the whole incident area. Nevertheless, entry to within the restricted area by the general public and non-essential personnel, can be restricted by establishing control over specific access points such as gates, roads and tracks.

2.5 Liaison with other wildfire responders

Fire and Rescue Services should make pre-planning arrangements with other wildfire responders. These should include the formulation of agreed local operating procedures that outline how any collaboration will be managed during an operational incident.

At incidents where firefighting operations have begun before the arrival of the local Fire and Rescue Service, it is important that liaison with these responders occurs as soon as FRS resources begin to arrive on scene.

The first Fire and Rescue Service officer in attendance should assume command of the incident and instigate any actions necessary to ensure the safety of all personnel on the fire ground.

Information should be gathered on what actions have already been taken, what resources and equipment are available for use and where these are located.

The expertise and equipment provided by wildfire partners and non-FRS responders should be utilised appropriately by the FRS incident command team.

2.6 Consider the involvement of dwellings or other property

The Incident Commander must assess, at an early stage, whether there is any risk of the wildfire spreading to properties or the urban interface. A similar assessment of the impact on road, rail or air transport infrastructure should also be conducted.

Where any threat is identified, relevant agencies and partners, such as the police and local authorities, should be informed so that early action can be taken to minimise the risk to the public.

2.7 Estimate the resource requirement

The Fire and Service Incident Commander will need to consider requesting additional Fire and Rescue resources based on the information gathered during their scene assessment.

This might include:

- **The size and geographical location of the incident**
- **The need to make a strong and speedy initial attack**
- **Assessment of fire intensity and rate of fire spread**
- **The involvement of property, buildings or structures**
- **The availability of water supplies**
- **The ease of access to the scene of operations**
- **The suppression tactics to be used**
- **The involvement of wildfire specialist officers or teams**
- **The need for additional specialist equipment or vehicles**
- **Environmental protection issues**

The Fire and Rescue Service Incident Commander will also need to consider requesting additional non-Fire and Rescue resources which may include:

- **Rural sector equipment or machinery**
- **Specialist rural assistance or advice (Forestry or rural sector experts)**
- **Trained rural sector firefighting teams**
- **Pre-arranged fire group assistance**
- **Air Support from commercial providers, police or the military**
- **Mountain Rescue Teams**
- **Local authority emergency planners**
- **Environmental agency**
- **Voluntary organisations**
- **Commercial vehicle, equipment or machinery providers**

It is therefore important that Fire and Rescue Services have made appropriate arrangements with potential providers as part of their preparedness activities.

2.8 Implement the Incident Command System

The Incident Commander must instigate the Incident Command System as detailed in the *Operational Guidance Manual, Fire Services Operations Incident Command.*

Where appropriate, and if trained to do so, non-Fire and Rescue Service personnel can be included in advisory and non-command roles at the incident ground. The scope of these roles should be fully understood within locally agreed standard operating procedures.

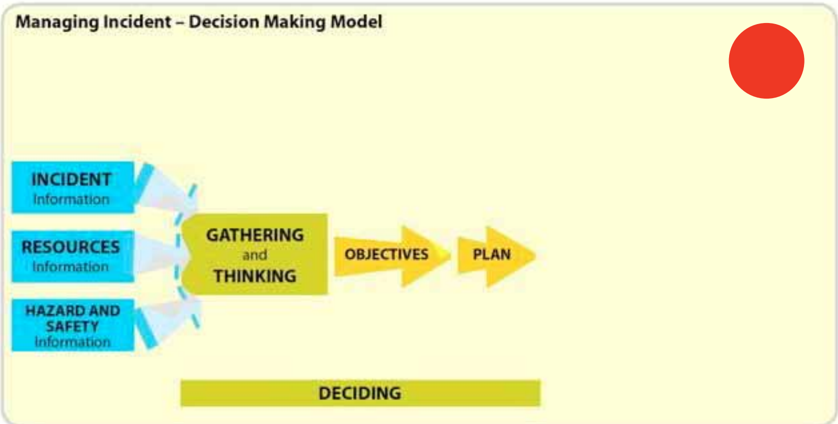
Depending upon the criteria contained in local wildfire, major incident or civil contingency plans, multi-agency command structures may need to be implemented due to the scale, severity and likely impact of the wildfire event.

2.9 Investigation and recording

Many wildfires are caused as a result of careless or deliberate actions that could require post incident investigation by the police or other authorities. It is therefore important that Incident Managers take reasonable steps to preserve evidence at the scene.

For analytical purposes it is also important that accurate data is collected on the extent of the fire on the arrival of Fire and Rescue Service resources and where possible a record should be made of the estimated point of ignition.

Phase 3: Formulating the Tactical Plan



Identify and prioritise clear objectives that can be achieved within a safe and effective plan.

Phase 3 - Actions Formulating the Tactical Plan	▪ Think ▪ Prioritise objectives ▪ Plan
3.1	Identify and prioritise objectives
3.2	Develop tactical plan

Considerations

Due to the large variation in incident scenarios and the many possible changes that will occur during a wildfire incident, it is difficult to outline a detailed tactical plan capable of meeting all potential wildfire scenarios. Nevertheless, wildfires will fall within four generic incident types which are:

- **Those that have limited potential for fire spread across the landscape and can be quickly contained and extinguished**
- **Those that have limited potential for fire spread across the landscape and can be quickly contained but will take longer to extinguish**
- **Those that have the potential to spread over large areas of the landscape but can be contained through planned intervention**
- **Those that have the potential to spread over large areas of the landscape and are difficult to contain because at times they are beyond the control of available resources**

Each of the generic wildfire types will require variations in the intervention response and resources allocated to ensure that they are effectively and safely managed.

3.1 Identifying and prioritise objectives

In order to identify objectives the Fire and Rescue Service Incident Commanders first action is to establish an understanding of what potential the fire has and the fire intensities that are likely to occur. In order to decide what objectives are to be achieved the following may have to be considered:

- **Safety of all personnel**
- **Life risk**
- **Protection of property**
- **Prevent escalation of the incident**
- **Containment of the fire**
- **Mitigation of hazards**
- **Environmental considerations**
- **Implement an appropriate incident command system**
- **Resources required to achieve objectives from both the Fire and Rescue Service and other responders**
- **Prioritising tasks**

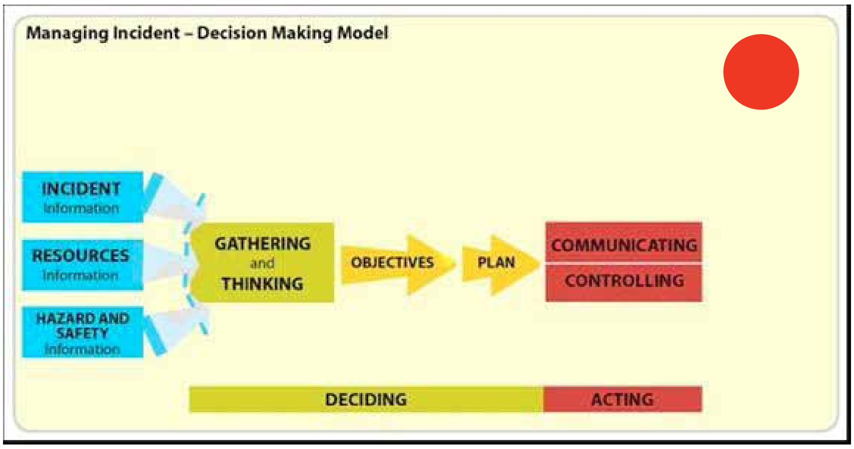
3.2 Develop tactical plan

Having identified the objectives and priorities the tactical plan will need to be created, communicated and implemented.

The following should be considered:

- **Declaration of a tactical mode**
- **Appropriate control measures and safe systems of work**
- **Allocation of tasks**
- **Comprehensive briefing of all personnel**
- **Available and required resources are sufficient to achieve the objectives**
- **Timely arrival of specialist tactical support (Aircraft, specialist teams, expert advice etc)**
- **The level of training and experience of personnel**
- **Inter-agency working and interoperability**

Phase 4: Implementing the Tactical Plan



All relevant information must be communicated to FRS personnel and other responders, with their activities being controlled within a safe and effective tactical plan.

Phase 4 – Actions Implementing the Tactical Plan	▪ Communicate ▪ Control
4.1	Implement effective firefighting operations
4.2	Communicate the tactical plan
4.3	Implement deliberate reconnaissance to gather further incident information
4.4	Communicating with other agencies
4.5	Controlling the tactical plan

Considerations

4.1 Implement effective firefighting operations

The operational environment at a wildfire incident will be challenging and dynamic and can be outside normal Fire and Rescue Service operations familiar to many personnel. Therefore particular care and consideration by the Incident Commander will be required when implementing the tactical plan.

Considerations should be given to:

- **The likely duration of the incident**
- **The adoption of the LACES safety protocol**
- **The Wildfire Prediction System should be utilised**
- **Comprehensive and concise briefing to all personnel to maintain their situational awareness**
- **Consider the skills, knowledge, competency, of personnel allocated roles within the tactical plan**
- **Assessing the available resources and their capabilities**
- **The allocation of tasks should be based on the level experience, training and expertise**
- **Tactical plan needs to be realistic and achievable, balancing risk against benefit**
- **The plan should be based on expected fire behaviour**
- **Predicted fire intensities should be used to decide whether it is appropriate to use direct or indirect suppression tactics**
- **Plan may include the involvement of non-Fire and Rescue Service resources**
- **The plan needs to comply with Fire and Rescue Service standard operating procedures and Fire and Rescue Service policies based on the *Generic Risk Assessment 3.4 Fighting fires in open rural areas***

4.2 Communicate the tactical plan

The plan will need to be communicated to all Fire and Rescue Service personnel and other responders at the scene in line with Incident Command protocols and local standard operating procedures:

- **Confirm understanding of the tactical plan with Fire and Rescue Service personnel and broadcast tactical mode to all Service personnel**
- **Disseminate information to other personnel and confirm understanding with reference to the tactical plan and identified hazards of the incident**
- **Implement pre-arranged liaison protocols with other agencies**

4.3 Implement deliberate reconnaissance to gather further incident information

Changes within the wildfire environment causes variations to fire behaviour and fire intensities, it is therefore important that sufficient information is gathered to allow control measures to remain effective throughout the incident.

In particular information should be gathered regarding:

- **Wind speed and direction, air temperature, relative humidity and atmospheric stability**
- **The shape of the landscape**
- **The availability of fuel and its arrangement across the landscape**
- **Fire behaviour and intensities**

Information can be obtained from:

- **Observation from the ground**
- **Observation from the air**
- **Topographical maps**
- **Weather forecasts and modelling systems**
- **On-site weather monitoring**
- **Digital imagery systems**
- **Site plans**

Additional information may be available from individuals including:

- **Land managers/owners**
- **Fire group members**
- **Foresters**
- **Game keepers**
- **Farmers**

4.4 Communicating with other agencies

To achieve a satisfactory conclusion many large wildfire incidents will require a multi-agency response. Historically both internal and external communications have been shown to be areas of weakness, therefore Fire and Rescue Service Incident Commanders should consider their methodology of communication with other agencies and co-responders.

The following are areas for consideration:

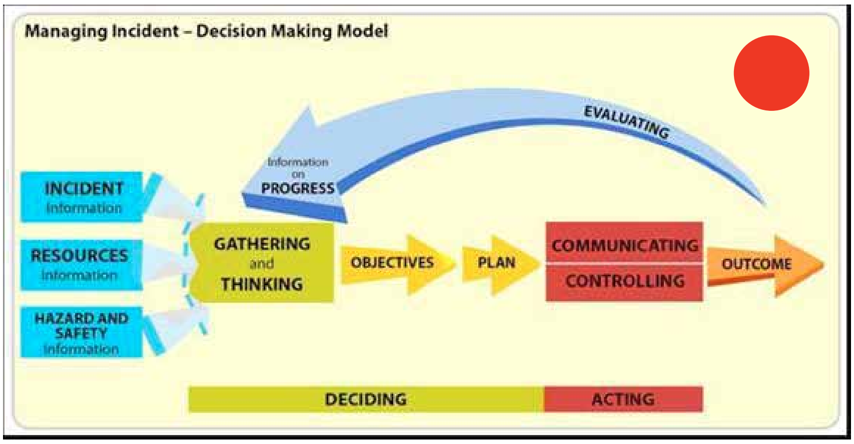
- **Airwave radio system**
- **Correct allocation of radio channels**
- **Dedicated inter-agency radio channels**
- **Danger of reliance on mobile telephone networks**
- **The use of field telephones between emergency service control centres**
- **The use of runners**
- **The appointment of inter-agency liaison officers**
- **Pre-planned and agreed arrangements**

4.5 Controlling the tactical plan

Once the tactical plan is in place, the Incident Commander will need to control its implementation to ensure that the objectives are met in accordance with the plan. Control is achieved by the use of the command structure that has been put in place.

Without effective communications control of the activities to meet the objectives will be compromised.

Phase 5: Evaluating the Tactical Plan



Fire behaviour at a wildfire can be extremely dynamic; it is essential that any potential situational changes which may affect the tactical plan are identified, and where necessary the plan revised.

Phase 5 – Actions Evaluating the Tactical Plan	▪ Evaluate the outcome
5.1	Evaluate the effectiveness of the tactical plan
5.2	Obtain and utilise specialist advice
5.3	Assessment of systems of work
5.4	Tactical plan not meeting objectives

Considerations

5.1 Evaluate the effectiveness of the tactical plan

With all tactical plans there will need to be a continual review of priorities and objectives of the plan balanced against the risks being taken by Fire and Rescue Service Personnel and co-responders.

The following questions may be considered:

- **Are personnel safe and are their welfare needs being maintained?**
- **Are the risks that are being taken by Fire and Rescue personnel and others proportional to the benefit?**
- **Have comprehensive analytical risk assessments been completed and appropriate control measures implemented?**
- **Are the resources appropriate and adequate to achieve the tactical plan?**
- **Do personnel in key roles have the skills, knowledge, competencies, and expertise to deliver the tactical plan?**
- **Is the selected Incident Command System effective?**
- **Has there been a change in the level of risks pertaining to the incident?**
- **Has the fire been contained or extinguished?**
- **Are the operational tactics effective and appropriate?**
- **Have the operational tasks achieved their objective in line with the tactical plan, if not why not and what needs to be altered to achieve the tactical plan?**
- **What are the environmental impacts of the tactical plan?**

5.2 Obtain and utilise specialist advice

The range of expertise that is available to the incident Commander from rural sector experts should not be underestimated. These individuals can provide advice on matters that will assist in the formulation of a safe and effective tactical plan.

Any new information or unforeseen change in circumstances will require the Incident Commander to evaluate its impact on identified objectives and whether the tactical plan needs to be amended.

5.3 Assessment of safe systems of work

In the assessment of safe systems of work that are being undertaken by Fire and Rescue Service personnel and other responders, the following may need to be considered:

- **Operational activities are being correctly monitored**
- **Actual fire behaviour is that which was expected or predicted**
- **The correct operational tactics are being used and that these are changed to meet expected variations in fire behaviour**
- **The measures defined within the LACES safety protocol have been implemented**

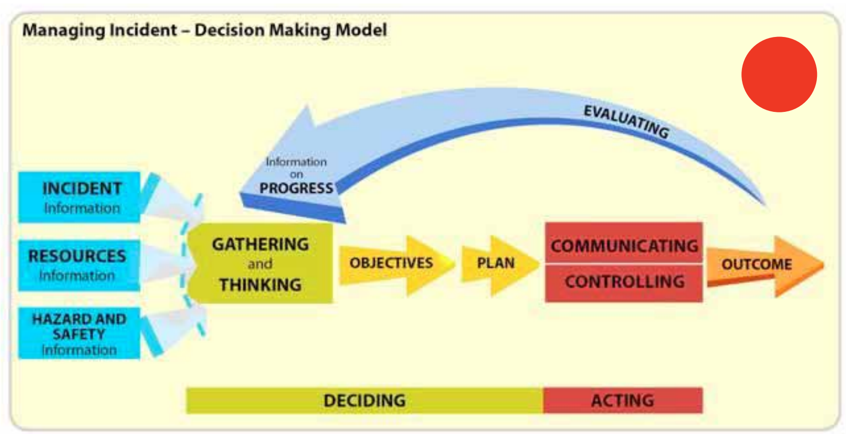
- **Personnel are able to maintain their understanding of the operational environment in which they are operating**
- **Personnel have the skills, competencies, training and experience necessary to remain safe**
- **If a safe system of work is not possible that personnel should be evacuated to a place of safety**

5.4 Tactical plan is not meeting objectives

Evaluating the progress of the tactical plan against the considerations outlined in 5.1 will lead the Incident Commander to decide on the effectiveness of the tactical plan. If progress is not being achieved this will provide information for the Incident Commander to consider. A plan not meeting its objectives will need to be amended which may lead to:

- **A decision to reallocate/re-task resources**
- **Request additional resources**
- **Change the prioritisation of the objectives**
- **Communicate changes to relevant personnel**
- **Is there a need to instigate an emergency evacuation of any/all personnel to a place of safety**

Phase 6: Closing the Incident



The objectives of the plan should recognise the importance of effectively closing down the incident and the proper management of post incident considerations.

Phase 6 – Actions Closing the Incident	
6.1	Scaling down FRS operations
6.2	Hand over control of the inner cordon
6.3	Post incident issues
6.4	Facilitate debriefs
6.5	Post incident considerations
6.6	Prepare and organise reports and documents

Considerations

6.1 Scaling down Fire and Rescue Services operations

This is an important phase of the incident and one during which accidents and injuries are likely to occur, therefore there is a need to maintain the highest attention to command and control throughout this phase of operations.

The closing phase of a wildfire incident may take an extended period to complete, it is important that only an appropriate amount of Fire and Rescue Service resource is committed to this task.

Possible considerations include:

- **Continued dynamic management of risk and a record of the Incident Commanders decisions**
- **Post incident security must be maintained**
- **Recovery of equipment and recording of those items that are missing or damaged**
- **Patrolling containment area and outer perimeter to prevent re-ignition or fire spread**
- **Mopping up of hot spots or deep seated fires**
- **Appropriate replacement of Fire and Rescue Service personnel and resources with those from partners and land management agencies**
- **Liaison with relevant agencies and authorities**
- **Personnel welfare**
- **Collection of appropriate data that may be required post incident**
- **Public access**

6.2 Hand over control of the incident

Following the scaling down of Fire and Rescue Service operations the responsibility for the incident will need to be handed over to a responsible authority/person.

This may include:

- **Land owner/manager**
- **Co-responder**
- **Police**
- **Local authority**
- **National Parks**
- **Military**
- **Relevant agency or authority**

The Incident Commander will need to consider the following points upon hand over:

- **Relevant risk assessments and identified hazards and controls**
- **Fire and Rescue Service post incident actions**
- **Arrangements for continued liaison and communication with those that remain at the scene**

6.3 Post incident issues

Following a wildfire Fire and Rescue Service may have to provide information to:

- **Local authority**
- **Insurance investigators**
- **Land managers/owners**
- **Utility companies**
- **Police**
- **Environmental agency**

It is therefore important that the Incident Commander keeps a record of Fire and Rescue Service actions.

It is also essential that all necessary information has been collected to ensure accurate completion of fire reports and statistical data.

6.4 Facilitate debriefs

Debriefs play an important part in promoting improvements in personal and organisational performance and should take place whenever there is an opportunity to improve standards of service delivery. Such post-incident reviews may be informal or formal. They can range from something as simple as an on scene 'hot debrief', to a large multi-agency debrief or a Public Enquiry following a major incident.

The format chosen for the debrief should be appropriate to the nature of the wildfire incident attended, and the level of involvement of partner agencies and other responders. In order to both embed and improve wildfire procedures, it is essential that wildfire debriefs be conducted in a manner that promotes open, supportive and constructive discussion of all aspects of the incident.

As with any other incident debrief, risk-critical issues highlighted during post-incident wildfire reviews should be addressed immediately through review of personal performance, equipment, working practices or systems.

Following a wildfire incident, significant information gained, or lessons learned, may relate to a number of areas including:

- **pre-planning**
- **partnership working**
- **appropriateness of fire plans**
- **multi-agency response arrangements**
- **existing operational intelligence information**
- **personal protective equipment**
- **the provision and use of equipment**
- **safe systems of work**
- **FRS and partnership training**
- **levels of safety supervision**

All noteworthy action points or learning outcomes must be fed back into the policy and procedures of the brigade highlighting equipment, systems or procedures which did NOT work satisfactorily, or which made the working environment unsafe. It is equally important to highlight any unconventional system or procedure used which was successful or made the working environment safe.

Where a formal post-incident review is required it should be held at a venue that is suitable and convenient for those to be invited to attend. Copies of relevant documentation should be available and provision made for recording proceedings, outcomes and learning points. Notes of the outcomes and details of action taken, or planned, to address the learning points raised should be made available to the relevant people as soon as practicable.

6.5 Post-incident considerations

The majority of fire service focus and activities centre around the pre-planning and emergency phase of a wildfire incident. However, there are issues which may involve the fire service far beyond the closure of the emergency phase.

Examples include the following:

- **Post-mortem enquiries and coroner's hearings**
- **Fire investigation**
- **Accident investigation**
- **Public or judicial enquiries**
- **Litigation**
- **Financial costs to the brigade, i.e. damaged equipment**
- **Criminal investigation**
- **Incident debriefing and evaluation**
- **Media**
- **Potential national implications**

The Incident Commander (or nominated personnel) must, at the earliest convenient time, attempt to assess what the post-incident wildfire considerations might be. On the basis of this assessment, the following tasks might need to be undertaken:

(i) Scene preservation
(ii) Recording and logging
(iii) Impounding equipment
(iv) Identification of key personnel
(v) Managing the closure of the incident
(vi) Liaison with partner agencies

6.6 Prepare post-incident reports and documents

Depending on the size and scale of an incident investigations may require a range of reports and documents to be prepared by the Fire and Rescue Service. These may include:

- **Internal and multi-agency debriefs**
- **Statements from the Fire and Rescue Service**
- **Records, recordings and transcripts of incident activities**
- **Fire investigation**
- **Reports for police/coroner/public enquiry**
- **Photographs/Video**
- **Records related to the decision-making process**

FRSs should ensure that appropriate emphasis is given to wildfire fire investigation. In order to ensure that a resilient and robust record of wildfire events can be developed locally, regionally and nationally, it is important to secure, as far as reasonably possible, information relating to:

- **The point of origin of the wildfire**
- **The cause of the wildfire**
- **The extent and area of the fire 'footprint'**
- **Environmental impact**
- **The extent of damage to habitat, wildlife and property.**
- **Records of any fatality or injury**
- **Criminal activities**
- **Estimated costs of the incident**
- **Any extreme or unusual fire behaviour**

Appendices

Appendix 1

An Example of a Fire Plan

Northumberland Fire Group

FIRE PLAN

Estate/Farm:

Reference number:

DATE:

1. CONTACTS

Estate Fire Officer (Primary Contact):

Estate Fire Officer (Secondary Contact):

Code	Position/Role	Name	Contact Number	Qualifications
1	*Land agent*			
2	*Keeper*			
3	*Keeper*			
4	*Keeper*			
5	*Estate Worker*			

2. NEIGHBOURING LANDOWNERS/CONTACTS

A. Estate/Farm

Key contact::

Location:

Code	Position/Role	Name	Contact Number

B. Estate/Farm:

Key contact:

Location:

Code	Position/Role	Name	Contact Number

C. Estate/Farm:

Key contact:

Location:

Code	Position/Role	Name	Contact Number

3. OTHER RELEVANT CONTACTS

Code	Name	Contact Number	Notes

4. RENDEZOUS POINTS

Map Code	Grid Reference	Site Name/Description	Notes

5. ACCESS POINTS

Map Code	Grid Reference	Name of Site/ Description	Notes	Type

6. AVAILABLE EQUIPMENT

Equipment	Usual location/Grid ref	Contact	Notes

7. COMMUNICATIONS

Please enter details of any communications systems in place:

8. WATER SUPPLIES

Code	Name	Grid Reference	Notes

9. IMPORTANT HAZARDS

Code	What?	Grid Reference	Notes	Contact

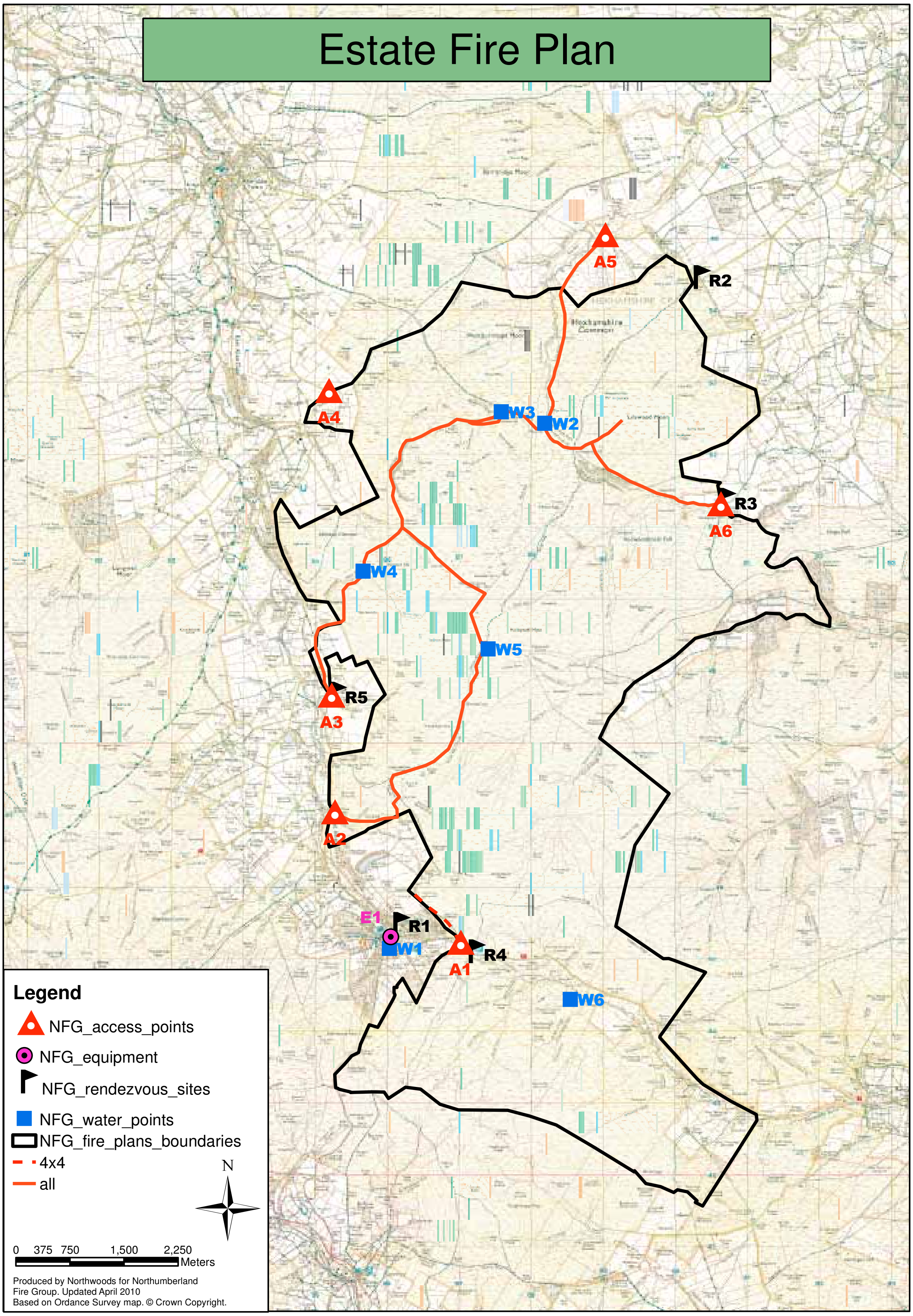
10. PRIORITY AREAS (i.e. SPA / SPC / SSSI)

Code	What?	Grid Reference	Notes	Contact

11. HELICOPTER AUTHORISATION AGREEMENT

Insurance:

Authorisation:


Estate Fire Plan
A5
R2
A4
W3
W2
R3
A6
W4
W5
R5
A3
A2
E1
R1
W1
A1
R4
W6
Legend
NFG_access_points
NFG_equipment
NFG_rendezvous_sites
NFG_water_points
NFG_fire_plans_boundaries
4x4
all
N
0 375 750 1,500 2,250
Meters
Produced by Northwoods for Northumberland
Fire Group. Updated April 2010
Based on Ordance Survey map. © Crown Copyright.

Appendix 2

OS 1:25000 Legend

Ordnance Survey®

OS Explorer Map / 1:25 000 Scale Colour Raster

Customer Information

Whilst we have endeavoured to ensure that the information in this product is accurate, we cannot guarantee that it is free from errors and omissions, in particular in relation to information sourced from third parties

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Communications

ROADS AND PATHS

Not necessarily rights of way

Service area

Junction number

M 1 or A 6(M) Motorway

A 35 Dual carriageway

A 30 Main road

B 3074 Secondary road

Narrow road with passing places

Road under construction

Road generally more than 4 m wide

Road generally less than 4 m wide

Other road, drive or track, fenced and unfenced

Gradient: steeper than 20% (1 in 5); 14% (1 in 7) to 20% (1 in 5)

Ferry; Ferry P - passenger only

Path

RAILWAYS

Multiple track / Single track — standard gauge

Narrow gauge or Light rapid transit system (LRTS) and station

Road over; road under; level crossing

Cutting; tunnel; embankment

Station, open to passengers; siding

PUBLIC RIGHTS OF WAY

(Rights of way are not shown on maps of Scotland)

Footpath

Bridleway

Byway open to all traffic

Restricted byway (not for use by mechanically propelled vehicles)

Public rights of way shown on this map have been taken from local authority definitive maps and later amendments.
Rights of way are liable to change and may not be clearly defined on the ground.
Please check with the relevant local authority for the latest information

The representation on this map of any other road, track or path is no evidence of the existence of a right of way

OTHER PUBLIC ACCESS

Other routes with public access (not normally shown in urban areas)

The exact nature of the rights on these routes and the existence of any restrictions may be checked with the local highway authority. Alignments are based on the best information available

National Trail / Long Distance Route — Recreational Route

Permissive footpath / Permissive bridleway — Footpaths and bridleways along which landowners have permitted public use but which are not rights of way. The agreement may be withdrawn

Traffic-free cycle route

National cycle network route number - traffic free

National cycle network route number - on road

Scotland

In Scotland, everyone has access rights in law* over most land and inland water, provided access is exercised responsibly. **This includes walking, cycling, horse-riding and water access, for recreational and educational purposes, and for crossing land or water.** Access rights do not apply to motorised activities, hunting, shooting or fishing, nor if your dog is not under proper control. The **Scottish Outdoor Access Code** is the reference point for responsible behaviour, and can be obtained at **www.outdooraccess-scotland.com** or by phoning your local Scottish Natural Heritage office. *Land Reform (Scotland) Act 2003

National Trust for Scotland, always open / limited opening - observe local signs

Forestry Commission Land / Woodland Trust Land

England & Scotland

DANGER AREA — Firing and test ranges in the area. Danger! Observe warning notices
Champs de tir et d'essai. Danger! Se conformer aux avertissements
Schiess und Erprobungsgelände. Gefahr! Warnschilder beachten
Visit **www.access.mod.uk** for information

ACCESS LAND

England

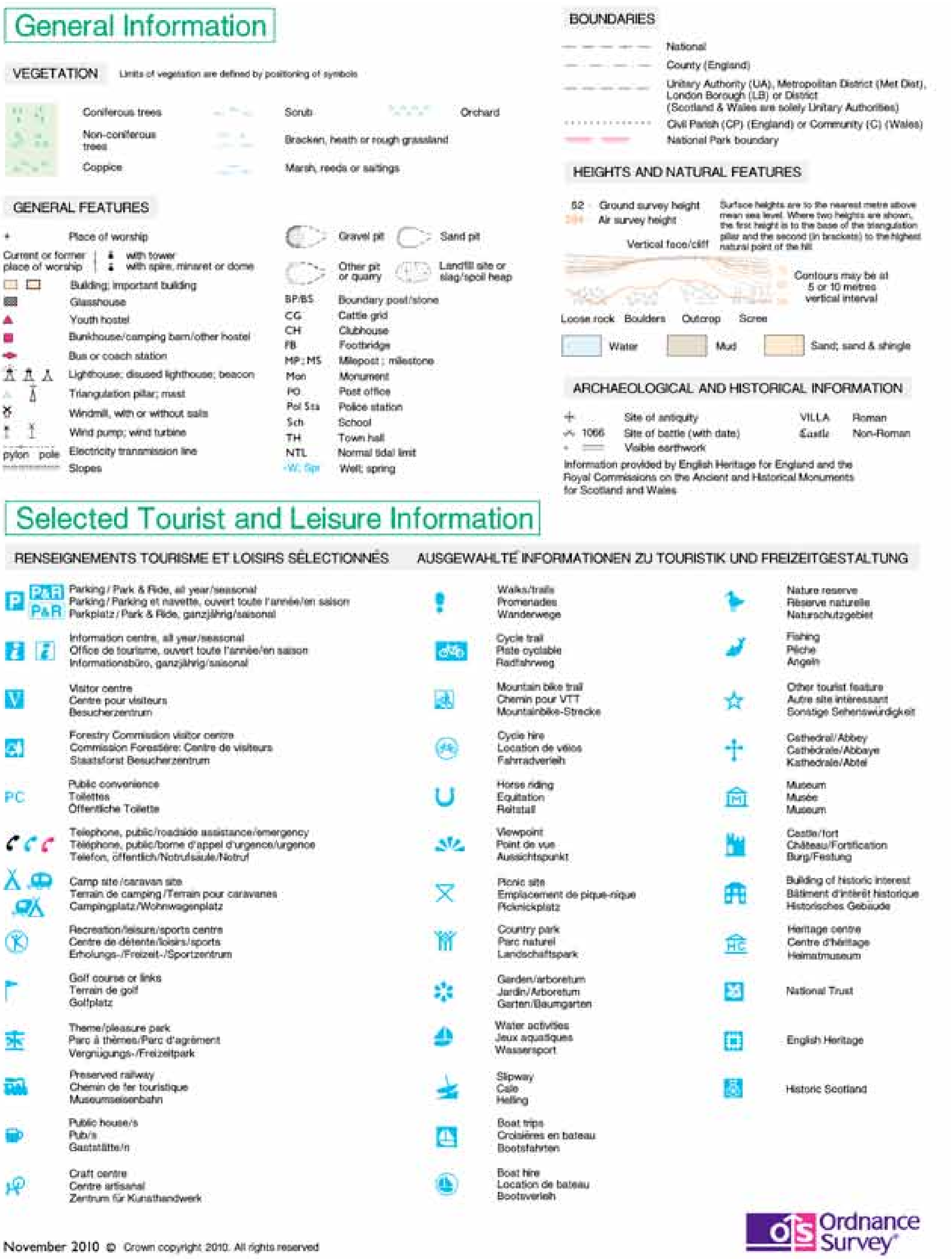
Portrayal of access land on this map is intended as a guide to land which is normally available for access on foot, for example access land created under the Countryside and Rights of Way Act 2000, and land managed by the National Trust, Forestry Commission and Woodland Trust. Access for other activities may also exist. Some restrictions will apply; some land will be excluded from open access rights. The depiction of rights of access does not imply or express any warranty as to its accuracy or completeness. Observe local signs and follow the Countryside Code.
Visit **www.countrysideaccess.gov.uk** for up-to-date information

Access land boundary and tint

Access land in woodland area

Access information point

MANAGED ACCESS — Access permitted within managed controls for example, local byelaws
Visit **www.access.mod.uk** for information


General Information
VEGETATION
Limits of vegetation are defined by positioning of symbols
Coniferous trees
Non-coniferous trees
Coppice
Scrub
Orchard
Bracken, heath or rough grassland
Marsh, reeds or saltings
GENERAL FEATURES
Place of worship
Current or former place of worship
with tower
with spire, minaret or dome
Building; important building
Glasshouse
Youth hostel
Bunkhouse/camping barn/other hostel
Bus or coach station
Lighthouse; disused lighthouse; beacon
Triangulation pillar; mast
Windmill, with or without sails
Wind pump; wind turbine
pylon pole
Electricity transmission line
Slopes
Gravel pit
Sand pit
Other pit or quarry
Landfill site or slag/spoil heap
BP/BS Boundary post/stone
CG Cattle grid
CH Clubhouse
FB Footbridge
MP; MS Milepost; milestone
Mon Monument
PO Post office
Pol Sta Police station
Sch School
TH Town hall
NTL Normal tidal limit
W; Spr Well; spring
BOUNDARIES
National
County (England)
Unitary Authority (UA), Metropolitan District (Met Dist), London Borough (LB) or District
(Scotland & Wales are solely Unitary Authorities)
Civil Parish (CP) (England) or Community (C) (Wales)
National Park boundary
HEIGHTS AND NATURAL FEATURES
52 Ground survey height
284 Air survey height
Vertical face/cliff
Surface heights are to the nearest metre above mean sea level. Where two heights are shown, the first height is to the base of the triangulation pillar and the second (in brackets) to the highest natural point of the hill
Contours may be at 5 or 10 metres vertical interval
Loose rock
Boulders
Outcrop
Scree
Water
Mud
Sand; sand & shingle
ARCHAEOLOGICAL AND HISTORICAL INFORMATION
Site of antiquity
1066 Site of battle (with date)
Visible earthwork
VILLA Roman
Castle Non-Roman
Information provided by English Heritage for England and the Royal Commissions on the Ancient and Historical Monuments for Scotland and Wales
Selected Tourist and Leisure Information
RENSEIGNEMENTS TOURISME ET LOISIRS SÉLECTIONNÉS
AUSGEWAHLTE INFORMATIONEN ZU TOURISTIK UND FREIZEITGESTALTUNG
P&R
Parking / Park & Ride, all year/seasonal
Parking / Parking et navette, ouvert toute l'année/en saison
Parkplatz / Park & Ride, ganzjährig/saisonal
Information centre, all year/seasonal
Office de tourisme, ouvert toute l'année/en saison
Informationsbüro, ganzjährig/saisonal
V
Visitor centre
Centre pour visiteurs
Besucherzentrum
Forestry Commission visitor centre
Commission Forestière: Centre de visiteurs
Staatsforst Besucherzentrum
PC
Public convenience
Toilettes
Öffentliche Toilette
Telephone, public/roadside assistance/emergency
Téléphone, public/borne d'appel d'urgence/urgence
Telefon, öffentlich/Notrufsäule/Notruf
Camp site /caravan site
Terrain de camping /Terrain pour caravanes
Campingplatz/Wohnwagenplatz
Recreation/leisure/sports centre
Centre de détente/loisirs/sports
Erholungs-/Freizeit-/Sportzentrum
Golf course or links
Terrain de golf
Golfplatz
Theme/pleasure park
Parc à thèmes/Parc d'agrément
Vergnügungs-/Freizeitpark
Preserved railway
Chemin de fer touristique
Museumseisenbahn
Public house/s
Pub/s
Gaststätte/n
Craft centre
Centre artisanal
Zentrum für Kunsthandwerk
Walks/trails
Promenades
Wanderwege
Cycle trail
Piste cyclable
Radfahrweg
Mountain bike trail
Chemin pour VTT
Mountainbike-Strecke
Cycle hire
Location de vélos
Fahrradverleih
Horse riding
Equitation
Reitstall
Viewpoint
Point de vue
Aussichtspunkt
Picnic site
Emplacement de pique-nique
Picknickplatz
Country park
Parc naturel
Landschaftspark
Garden/arboretum
Jardin/Arboretum
Garten/Baumgarten
Water activities
Jeux aquatiques
Wassersport
Slipway
Cale
Helling
Boat trips
Croisières en bateau
Bootsfahrten
Boat hire
Location de bateau
Bootsverleih
Nature reserve
Réserve naturelle
Naturschutzgebiet
Fishing
Pêche
Angeln
Other tourist feature
Autre site intéressant
Sonstige Sehenswürdigkeit
Cathedral/Abbey
Cathédrale/Abbaye
Kathedrale/Abtei
Museum
Musée
Museum
Castle/fort
Château/Fortification
Burg/Festung
Building of historic interest
Bâtiment d'intérêt historique
Historisches Gebäude
Heritage centre
Centre d'héritage
Heimatmuseum
National Trust
English Heritage
Historic Scotland
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Ordnance Survey

Appendix 3

OS 1:50000 Legend

Ordnance Survey®

General Information

LAND FEATURES

Electricity transmission line (pylons shown at standard spacing)

Pipe line (arrow indicates direction of flow)

ruin

Buildings

Important building (selected)

Bus or coach station

Glass structure

Heliport

Current or former place of worship with tower

Current or former place of worship with spire, minaret or dome

Place of worship

Triangulation pillar

Mast

Wind pump, wind turbine

Windmill with or without sails

Graticule intersection at 5' intervals

Cutting, embankment

Landfill site or slag/spoil heap

Coniferous wood

Non-coniferous wood

Mixed wood

Orchard

Park or ornamental ground

Forestry Commission land

National Trust-always open

National Trust-limited access, observe local signs

National Trust for Scotland-always open

National Trust for Scotland-limited access, observe local signs

Manx National Heritage

Isle of Man Forestry Division Plantation

BOUNDARIES

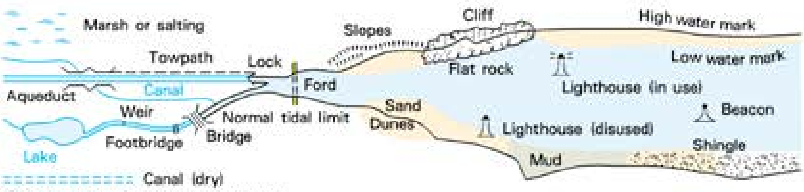
National

District

County, Unitary Authority, Metropolitan District or London Borough

National Park

WATER FEATURES



Contour values in lakes are in metres

HEIGHTS

50 Contours are at 10 metres vertical interval

·144 Heights are to the nearest metre above mean sea level

Where two heights are shown, the first height is to the base of the triangulation pillar and the second (in brackets) to the highest natural point of the hill

ABBREVIATIONS

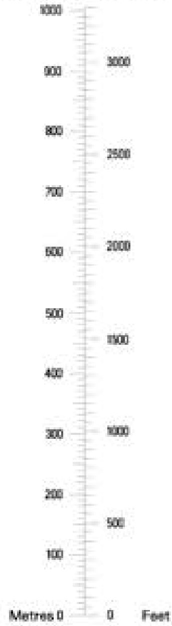
More information on abbreviations and symbols can be found on our website

CH	Clubhouse	CG	Cattle grid
PH	Public house	P	Post office
PC	Public convenience (in rural area)	MP	Milepost
TH	Town hall, Guildhall or equivalent	MS	Milestone

CONVERSION

METRES - FEET

1 metre = 3.2808 feet



15.24 metres = 50 feet

ARCHAEOLOGICAL AND HISTORICAL INFORMATION

+ Site of antiquity — VILLA Roman — Battlefield (with date)

Visible earthwork — Castle Non-Roman

Information provided by English Heritage for England and the Royal Commissions on the Ancient and Historical Monuments for Scotland and Wales

ROCK FEATURES

Tourist Information

TOURIST INFORMATION RENSEIGNEMENTS TOURISTIQUES TOURISTENINFORMATION

Camp site/caravan site
Terrain de camping/Terrain pour caravanes
Campingplatz/Wohnwagenplatz

Garden
Jardin
Garten

Golf course or links
Terrain de golf
Golfplatz

Information centre, all year / seasonal
Office de tourisme, ouvert toute l'année / en saison
Informationsbüro, ganzjährig / saisonal

Nature reserve
Réserve naturelle
Naturschutzgebiet

Parking / Park & Ride, all year / seasonal
Parking / Parking et navette, ouvert toute l'année / en saison
Parkplatz / Park & Ride, ganzjährig / saisonal

Picnic site
Emplacement de pique-nique
Picknickplatz

Selected places of tourist interest
Endroits d'un intérêt touristique particulier
Ausgewählter Platz von touristischem Interesse

Telephone, public / roadside assistance
Téléphone, public / borne d'appel d'urgence
Telefon, öffentlich / Notrufsäule

Viewpoint
Point de vue
Aussichtspunkt

Visitor centre
Centre pour visiteurs
Besucherzentrum

Walks / Trails
Promenades
Wanderwege

Youth hostel
Auberge de jeunesse
Jugendherberge

World Heritage site/area
Site du Patrimoine Mondial
Welterbestätte

Recreation / leisure / sports centre
Centre de détente / loisirs / sports
Erholungs- / Freizeit- / Sportzentrum

Ordnance Survey

OS Landranger Map / 1:50 000 Scale Colour Raster

Customer Information

Communications

PUBLIC RIGHTS OF WAY / DROIT DE PASSAGE PUBLIC / ÖFFENTLICHE WEGERECHTE

- Footpath
- Bridleway
- Restricted byway (not for use by mechanically propelled vehicles)
- Byway open to all traffic

Public rights of way shown on this map have been taken from local authority definitive maps and later amendments

The symbols show the defined route so far as the scale of mapping will allow.
Rights of way are not shown on maps of Scotland

Rights of way are liable to change and may not be clearly defined on the ground. Please check with the relevant local authority for the latest information

The representation on this map of any other road, track or path is no evidence of the existence of a right of way

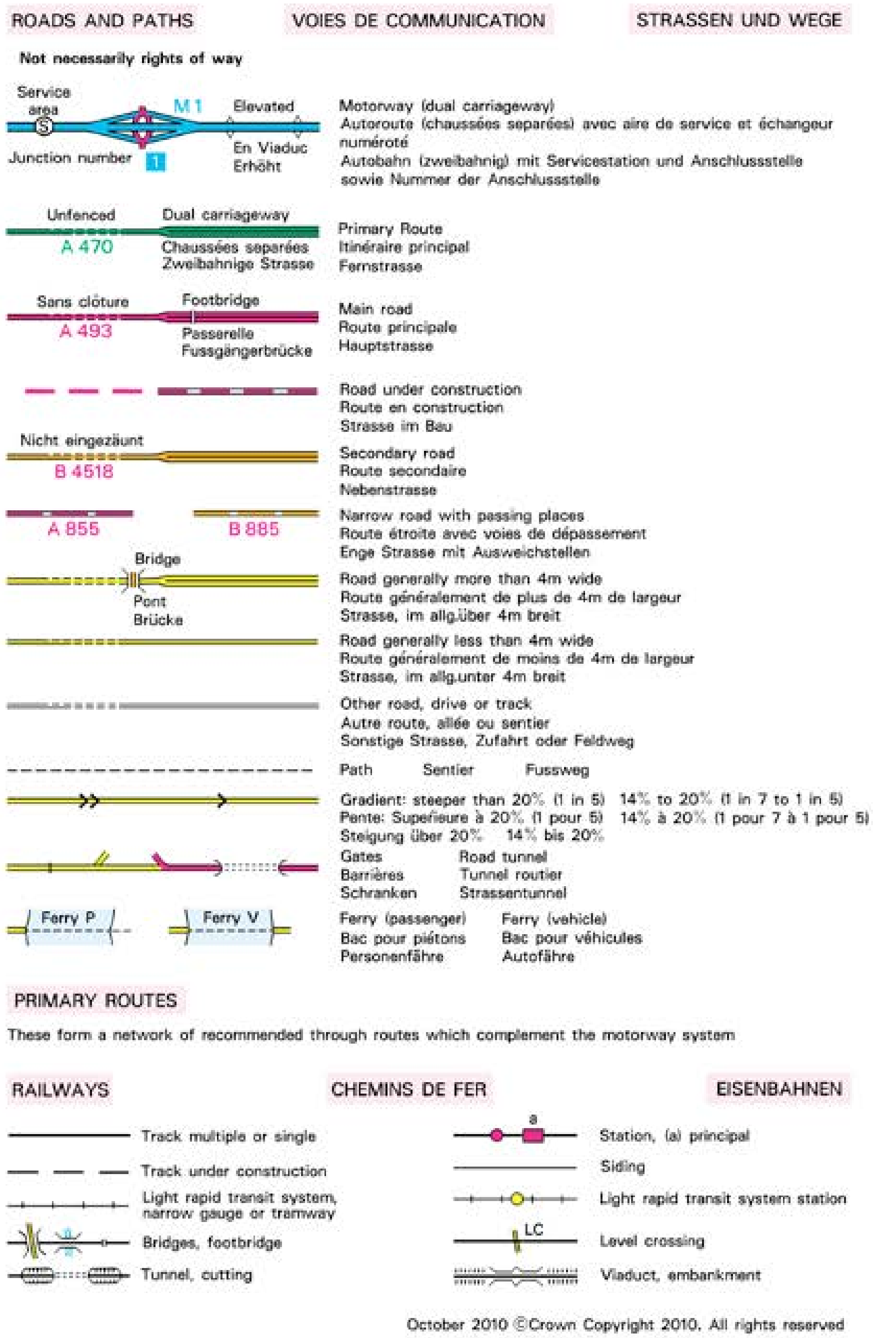
OTHER PUBLIC ACCESS / AUTRES ACCES PUBLICS / ANDERE ÖFFENTLICHE WEGE

- Other route with public access (not normally shown in urban areas)
- National Trail, European Long Distance Path, Long Distance Route, selected Recreational Routes

The exact nature of the rights on these routes and the existence of any restrictions may be checked with the local highway authority. Alignments are based on the best information available. These routes are not shown on maps of Scotland

- On-road cycle route
- Traffic-free cycle route
- 4 National Cycle Network number
- 8 Regional Cycle Network number

Danger Area — Firing and Test Ranges in area. Danger! Observe warning notices.
Champs de tir et d'essai. Danger! Se conformer aux avertissements.
Schiess-und Erprobungsgelände. Gefahr! Warnschilder beachten.


ROADS AND PATHS
VOIES DE COMMUNICATION
STRASSEN UND WEGE
Not necessarily rights of way
Service area
M 1
Elevated
Junction number
En Viaduc
Erhöht
Motorway (dual carriageway)
Autoroute (chaussées separées) avec aire de service et échangeur numéroté
Autobahn (zweibahnig) mit Servicestation und Anschlussstelle sowie Nummer der Anschlussstelle
Unfenced
Dual carriageway
A 470
Chaussées separées
Zweibahnige Strasse
Primary Route
Itinéraire principal
Fernstrasse
Sans clôture
Footbridge
A 493
Passerelle
Fussgängerbrücke
Main road
Route principale
Hauptstrasse
Road under construction
Route en construction
Strasse im Bau
Nicht eingezäunt
B 4518
Secondary road
Route secondaire
Nebenstrasse
A 855
B 885
Narrow road with passing places
Route étroite avec voies de dépassement
Enge Strasse mit Ausweichstellen
Bridge
Pont
Brücke
Road generally more than 4m wide
Route généralement de plus de 4m de largeur
Strasse, im allg.über 4m breit
Road generally less than 4m wide
Route généralement de moins de 4m de largeur
Strasse, im allg.unter 4m breit
Other road, drive or track
Autre route, allée ou sentier
Sonstige Strasse, Zufahrt oder Feldweg
Path
Sentier
Fussweg
Gradient: steeper than 20% (1 in 5) 14% to 20% (1 in 7 to 1 in 5)
Pente: Superieure à 20% (1 pour 5) 14% à 20% (1 pour 7 à 1 pour 5)
Steigung über 20% 14% bis 20%
Gates
Barrières
Schranken
Road tunnel
Tunnel routier
Strassentunnel
Ferry P
Ferry V
Ferry (passenger)
Bac pour piétons
Personenfähre
Ferry (vehicle)
Bac pour véhicules
Autofähre
PRIMARY ROUTES
These form a network of recommended through routes which complement the motorway system
RAILWAYS
CHEMINS DE FER
EISENBAHNEN
Track multiple or single
Track under construction
Light rapid transit system, narrow gauge or tramway
Bridges, footbridge
Tunnel, cutting
a
Station, (a) principal
Siding
Light rapid transit system station
LC
Level crossing
Viaduct, embankment
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Appendix 4

Example of SMEAC Form

SMEAC Wildfire Briefing Template

Date:		Time:	
Location:			

Situation

Fire	Location	
	Size	
	Direction of Spread	
Topography	Slope	
	Position on Slope	
	Aspect	
	Topographical Hazards	
Fuel	Types	
	Condition	
	Arrangement	
	Change	

		Current	Predicted
Weather	Temp:		
	RH		
	Wind Speed		
	Wind Direction		
Fire Behaviour	Alignment Factors		
	Fire Danger Classification		

Mission

Objective	

Execution

Specific Information		
Contingency Plans		
Hazards and Controls	Hazards	Controls

LACES	**Team Lookouts**	
	Tactical (Sector) Lookouts	
	Awareness	
	Communication	
	Escape Routes	
	Safety Zones	

Administration

Logistics	
Reliefs	
Welfare	

Command and Control

Incident Command Structure	
Line of Communication	
Radio Channels In Use	

Glossary of Wildfire Terminology

Glossary of Wildfire Terminology	
Access	A point of entry and exit and/or route to an incident location.
Accelerant	Material used to initiate or increase the spread of a fire. This will often be a flammable liquid.
Aerial attack	A fire suppression operation involving the use of aircraft to release water or retardant on or near a wildfire. An aerial attack can be: ***Direct attack (aerial)*** - **Head attack (aerial)** - **Tail attack (aerial)** ***Indirect attack (aerial)*** - **Flank attack (aerial)** - **Parallel attack (aerial**
Aerial operations	Any manoeuvre completed by an aircraft in support of wildfire suppression activities, inclusive of: - direct attack through drops of water or retardant - indirect attack through retardant drops - cargo drops of supplies - aerial observation and reconnaissance
Aerial reconnaissance	Use of aircraft for conducting preliminary surveys of a wildfire to gather information on: - fire behaviour - topography and fuel types - potential hazards and high risk areas - potential windows of opportunity - safety of ground personnel The information gathered from aerial reconnaissance will be communicated to the Incident Commander to assist in the decision-making process.
All Terrain Vehicle (ATV)	Any motorised vehicle designed to travel on four low pressure tires on unpaved surfaces, having a seat designed to be straddled by the operator and handlebars for steering control.[1] ATVs can be classified into two categories: - Type I – designed for transporting one operator. Type II – designed for transporting one operator and one passenger.
Anabatic wind	Upslope winds. Anabatic winds occur when daytime solar radiation heats air at lower elevations causing it to flow upslope.

1 Definition from the "All Terrain Vehicle Industry European Association" (ATVEA) at: http://www.atvea.org/9431E/What_is_an_ATV_.aspx

Glossary of Wildfire Terminology	
Anchor Point	A location on the landscape which is strong enough to act as barrier to fire spread. The commencement of suppression operations from an anchor point ensures that a wildfire cannot escape from an area of containment which could threaten the success of the operation and/or the safety of suppression personnel. It may be necessary for anchor points to be strengthened before use or even created by hand or machine. The creation of an anchor point is sometimes a key element included within the LACES safety protocol.
Area ignition	Ignition of several individual fires throughout an area, either simultaneously or in rapid succession, and so spaced that they add to and influence the main body of the fire to produce a hot, fast-spreading fire condition. [2]
Area of Special Scientific Interest	A statutory designation in Northern Ireland relating to areas of land that have been identified as being of the highest degree of conservation value.
Area of origin	General geographical location within a fire scene where the point of ignition is believed to be located.
Arson	The wilful or malicious burning of a fuel with criminal intent to cause damage.
Assigned resources	Resources that have been allocated work tasks at a wildfire incident.
Assignment	A task allocated to an individual or team to complete.
Aspect	The direction a slope faces in relation to the sun.[3] Aspect is a force of alignment.
Attack a Fire	A generic term for the various methods that can be used to suppress a fire or parts of a fire, including: ▪ ***Direct attack*** – An offensive fire suppression tactic which involves an attack being made at or near the fires edge. This technique normally relies on the use of hand tools and or water. ▪ ***Indirect attack*** – Any suppression methods implemented away from the fire edge. ▪ ***Aerial attack*** – Fire suppression operation involving the use of aircraft to drop water or retardant on or near a wildfire. ▪ ***Flank attack*** – Attacking the fire along the flank or both flanks simultaneously. ▪ ***Parallel attack*** – Method of fire suppression in which a control line is constructed approximately parallel to and some distance away from the fire edge.
Aerial Fuels	Any fuel found at a height of more than 3.5 metres above the ground surface.
Aerial Resources	Aircraft including helicopters, aeroplanes and drones that can be used to attack the fire or observe its development. It also includes supporting personnel and equipment.

2 Source: National Wildfire Coordinating Group (2008) *Glossary of Wildland Fire Terminology* (National Wildfire Coordinating Group, Boise), page 29.

3 A slope receiving direct sunlight at a particular point in time is described as being in aspect, while a slope not receiving direct sunlight at a particular point in time is described as being out of aspect.

Glossary of Wildfire Terminology	
Anemometer	An instrument that measures wind speed.
Available Fuels	The proportion of the total fuel that would burn under specified burning and fuel conditions.
Back burn	An operational burn ignited along the inner edge of a control line to consume the fuel in the path of an advancing wildfire or to change the direction of force of the wildfire's convection column.
Backing Fire	A lower intensity fire or part of a fire which burns against the wind and/or down slope.
Baseline	The initial line of fire ignited along a control line to contain and control subsequent burn operations.
Bearing	The horizontal direction to or from any point, usually measured clockwise from true north, or some other reference point, through 360[4] degrees.
Beaufort Wind Scale	A system for estimating wind speeds based on observation of visible wind effects. A series of descriptions of visible wind effects upon land objects or sea surfaces is matched with a corresponding series of wind speed ranges, each being allocated a Beaufort number.[5]
Black Area	An area of fuel that is black in appearance because some or all of the fuel has been burnt. A black area may support a second burn if some fuel remains and this could represent a safety risk to suppression personnel.
Blind area	An area in which neither the ground nor its vegetation can be seen from an observation point.
Bog	A permanently saturated area of spongy ground with poor drainage. Bogs are usually found in upland areas experiencing cool temperatures and high rainfall. Slow decomposition of the plants found within bogs leads to the formation of peat.
Breakout	The escape of a fire from an area of containment
Briefing	A meeting during which relevant information is exchanged
Broadleaves	Trees that are characterised by their broad leaves, most of which are deciduous.
Build Up	a) A sustained increase in fire intensity b) An accumulation of fuel available to burn
Burn	a) To be on fire. b) An area of fuel consumed or partly consumed by a fire. c) An injury to flesh caused by a cauterizing agent, heat from a fire, or a heated object. d) A managed fire (i.e. an operational burn or prescribed burn)

4 Source: Global Fire Monitoring Centre (2010) *International Multi-Lingual Fire Management Terminology* (Global Fire Monitoring Centre, Freiburg), page 29.

5 Source: Australasian Fire and Emergency Service Authorities Council (2009) *Wildfire Glossary* (Australasian Fire and Emergency Service Authorities Council, Melbourne)

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Burn plan	A pre-determined strategic scheme or programme of activities which is formulated in order to safely and effectively accomplish the objectives of a managed burn. A burn plan will outline the selection of tactics, selection of resources, resource assignments and how performance will be monitored during a managed burn. It should be noted that a burn plan may need to be dynamic to take into account any changes in conditions or circumstances.
Burn Crew/team	A group of individuals with the collective competencies to safely and effectively carry out an operational burn.
Burning Conditions	The state of the combined components of the fire environment that influence fire behaviour within available fuels. Burning conditions are usually specified according to the factors of aspect, weather, slope/ topography, and fuel type and load.
Burning Out	The intentional burning of parcels of fuel to prevent fire spread. This is normally carried out to consume fuel between a control line and the fire edge.
Burning Period	The dates/months of the year when land management burning is legally permitted.
Burning regulations	Rules and restrictions concerning the use of operational burns as a fire suppression tactic.
Canopy	The upper layer of aerial fuels which will contain the crowns of the tallest vegetation present (living or dead).
Catch trench	A small ditch constructed below a fire on sloping ground to catch burning material rolling down slope.
Cause of Fire	The sequence of events and actions that brings an ignition source into contact with materials first ignited which leads to sustained combustion.[6] For statistical purposes, causes of fire are usually grouped within a standard classification.
Centre burn	An ignition technique where a fire or a number of fires are ignited in the middle of an area of fuel. The intention of a centre burn is to create a strong convection plume that allows subsequent ignitions to be lit drawing the resulting fires inwards, normally away from any existing control lines.
Chain of command	The line of authority and responsibility along which operational orders are passed. Also commonly referred to as “line of command”.
Check in	The process whereby resources first report to an incident.
Clean burn	A fire that consumes all vegetation and litter above the ground exposing the mineral soil.

6 With thanks to Paul Steensland, Paul Steensland and Associates LLC (USA) and Richard Woods, Australian Capital Territory Rural Fire Service (Australia).

Glossary of Wildfire Terminology	
Cloud types	A visible body of fine water droplets or ice particles suspended in the atmosphere. There are a significant number of different types of clouds; however, there are three key cloud types that are particularly important for wildfire suppression because they can be used as a visual indicator of atmospheric stability: ▪ ***Stratus clouds*** – low altitude (below 6,000 feet) clouds with a flat or sheet-like appearance which develop within a stable layer of the atmosphere. ▪ ***Cumulus clouds*** – clouds with strong vertical development (below 6,000 feet) which develop within an unstable layer of the atmosphere. ▪ ***Cumulonimbus clouds*** – clouds with very strong vertical development which develop within an unstable layer of the atmosphere. The base of cumulonimbus clouds is near to ground level and they can extend vertically beyond 50,000 feet. ▪ ***Fog*** – A cloud with its base on the ground surface.
Coarse fuels	Fuels that are more than 6mm in diameter. Due to their size and shape they burn more slowly and ignite less readily than finer fuels. Examples of coarse fuels include thick stems, logs, and branches. Coarse fuels can either be living or dead.
Condensation	The process by which a gas is transformed to a liquid.
Control Line	An inclusive term for all constructed or natural barriers and treated fire edges used to control a fire.[7]
Combustibility	Relative ease of fire spread within a fire environment.
Combustion	The rapid oxidation of fuel in which heat and usually flame are produced
Compactness	The density of fuel particles. Compactness can influence ignition and fire behaviour
Competency	When a person has the authority and sufficient technical knowledge, training and experience to carry out their assigned tasks safely and effectively.
Command	The authority of an agency to direct and control resources. Command is delegated to an individual.
Condition of Vegetation	Stage of growth or degree of flammability of vegetation that forms part of a fuel complex. This will be dependent upon time of year, amount of curing and weather conditions.
Coniferous trees	Trees that are characterised by their needle- or scale-like leaves. Most conifers are evergreen.
Conduction	The transfer of thermal energy by direct contact.
Containment	An area of a fire where control has been established and no breakout is anticipated.

7 Source: National Wildfire Coordinating Group (2008) *Glossary of Wildland Fire Terminology* (National Wildfire Coordinating Group, Boise), page 50.

Glossary of Wildfire Terminology	
Contingency plan	A pre-prepared alternative plan which can be implemented if circumstances change.
Controlled fire	A fire with a secure perimeter, where no breakouts are anticipated.
Control Line	An inclusive term for all constructed or natural barriers and treated fire edges used to control a fire.
Contour line	A line on a map connecting points of equal elevation.
Convection	The transfer of heat by the movement of a gas or liquid. In meteorology, convection is the predominantly vertical movement of warmed air.
Convection Column	A rising column of pre-heated smoke, ash, particles and other debris that is produced by a fire.
Convection driven fire	A fire that is spread predominately by the intensity of the convection plume.
Cool fire	A low intensity fire or part of a fire.
Cooperating agency	Any organisation supplying resources to assist with the implementation of a fire suppression plan. A cooperating agency differs from a partner agency in the sense that it only comes to the assistance of a suppression agency when a wildfire occurs.
Co-ordinates	Alphanumeric characters that are used to describe the precise geographic location of a point on the earth's surface.
Counter burn	A planned operational burn which is ignited to burn into a wildfire and to take advantage of in-drafts towards the fire front. Alphanumeric characters that are used to describe the precise geographic location of a point on the earth's surface.
Creeping Fire	A slow burning fire with low flame activity. This type of fire may occur due to the condition of vegetation, fuel type or because a fire is burning out of alignment.
Crew	The term for a fire service unit consisting of a number of personnel.
Critical Point	This is a point in time or space when/where there will be a significant influence on fire spread, rate of spread and/or fire intensity.
Crown	The upper foliage of trees and shrubs, normally containing large amounts of fine fuels.
Crown fire/Crowning	When a fire burns freely in the upper foliage of trees and shrubs. There are three different types of crown fires: ■ **Active Crown Fire** – A fire that advances as a wall of flame engulfing all surface and aerial fuels. ■ **Independent Crown Fire** – A fire that advances through aerial fuels only. ■ **Intermittent Crown Fire** – A surface fire involving torching behaviour but without sustained crowning activity. Rate of spread is controlled by the surface fire.

Glossary of Wildfire Terminology	
Curing	A process that leads to the reduction in moisture content of dead vegetation.[9] This usually causes the vegetation to turn brown in appearance.
Dead fuels	Fuels with no living tissue. The moisture content of dead fuels is mostly controlled by external weather conditions, for instance, relative humidity, precipitation, temperature, and solar radiation.
Debris fuels	Dead and dying fuel, consisting of both fine and coarse fuels, and inclusive of twigs and any vegetation. Debris is usually found lying on the ground but can also be found at various levels within the vertical arrangement of fuels.
Deep-seated fire	An established ground fire burning 0.5 metres or more below the surface. This type of ground fire is particularly challenging to extinguish.
Depth of burn	The vertical reduction in surface and ground fuels due to consumption by fire.
Dew	The moisture which collects in small droplets on the surface of vegetation through the process of condensation. Dew predominantly forms at night.
Dew point	The temperature at which air must be cooled in order for atmospheric saturation to occur and, subsequently, for dew to form. Dew point can therefore be used as a measure of the moisture content of the air.
Direct Attack	An offensive fire suppression tactic which involves an attack being made at or near the fires edge. This technique normally relies on the use of hand tools and or water.
Drip Torch	A hand tool used to drop flaming fuel onto the ground to intentionally ignite a fire as part of an operational or prescribed burn.
Drought	A prolonged period of abnormally low precipitation within a particular area.
Duff	A surface fuel consisting of partly or fully decomposed organic material lying on the mineral soil.
Dynamic risk assessment	The continuous process of identifying hazards, assessing risk, taking action to eliminate or reduce risk, monitoring and reviewing, in the rapidly changing circumstances of an operational incident.[10]
Elevated fuels	Any fuel found at a height of 1.5-3.5 metres. The presence of elevated fuels will increase the risk of vertical fire spread into aerial fuels and the canopy.
Elevation	Height above sea-level.
Escape plan	A predetermined list of actions to be enacted in the event of unforeseen hazardous circumstances (for instance, an unexpected change in fire behaviour). An escape plan must include an escape route. The development of an escape plan is a key element of the LACES Safety Protocol.
Escape route	A pre-planned route to be taken in the event of unforeseen hazardous circumstances (for instance, an unexpected change in fire behaviour). An escape route is an important part of an escape plan and is a key element of the LACES Safety Protocol.

9 Including dead parts of living vegetation.

10 HM Government (2008) *Fire and Rescue Manual - Volume 2 Fire Service Operations: Incident Command* (3rd Edition) (London, TSO), p142.

Glossary of Wildfire Terminology	
Evacuation	The removal of people from dangerous or potentially dangerous areas and their relocation to safe areas.
Extinction	The ceasing of the combustion process, either naturally or as a result of suppression activities.
Extreme fire behaviour	Fire behaviour that becomes erratic or difficult to predict due to its rate of spread and/or flame length. This type of fire behaviour often influences it environment.
Fine fuels	Fast-drying dead fuels which are less than 6mm in diameter. Fine fuels ignite readily and are rapidly consumed by fire when dry. Examples of fine fuels include: grass, leaves, ferns, mosses, pine needles and small twigs. When dried, fine fuels are referred to as flash fuels.
Fine fuel moisture	The moisture content of fast-drying fuels. Measurement of moisture content will indicate the relative ease of ignition and flammability of a fine fuel.
Fire Environment	The surrounding conditions, influences, and modifying forces of topography, fuel, and weather that determine fire behaviour, fire effects and fire impact.
Fingers of Fire	An elongated burned area projecting from the main body of the fire resulting in an irregular fire perimeter. The pattern on the ground may resemble fingers on a hand, hence the name.[11]
Fingers of fire ignition	An ignition pattern which involves igniting lines of fire at right angles to a control line and parallel to the wind.
Fire activity	Description of a fire based on an assessment of visible evidence, including the rate of spread, flame length, fire severity, and fire behaviour.
Fire analysis	Process of reviewing the behaviour and effects of a specific fire or group of fires and/or the actions taken to suppress it/them.
Fire behaviour	The reaction of a fire to the influences of fuel, weather, and topography. Different types of fire behaviour include: ▪ ***Smouldering fire*** – A fire burning without flame and with minimal rate of spread. ▪ ***Creeping fire*** – A fire with a low rate of spread and generally with a low flame length. ▪ ***Running fire*** – A fire with a high rate of spread. ▪ ***Torching*** – A single tree or small parcel of trees that burn from the base through the surface and aerial fuels and into the canopy of the vegetation. ▪ ***Spotting*** – fire behaviour where sparks and hot burning embers are transported by the wind or convection column to land beyond the fire perimeter resulting in spot fires. ▪ ***Crowning*** – When a fire burns freely in the upper foliage of trees and shrubs.

11 This term should not be confused with the term "fingers of fire ignition", which describes a low intensity back burn which is achieved by lighting fires in lines at right angles to a control line and parallel to the wind.

Glossary of Wildfire Terminology	
Fire behaviour forecast	A prediction of probable fire behaviour to be used to inform fire suppression operations.
Firebrand	Particles of ignited fuels that are carried by the wind or the air currents of a convection plume.
Firebreak	An area on the landscape where there is a discontinuity in fuel which will reduce the likelihood of combustion or reduce the likely rate of fire spread.
Fire concentration	The number of fires per unit area for a given period.
Fire damage	The loss that is caused by the fire. This loss will normally include financial costs, but will also include other direct and indirect costs to the environment and society.
Fire danger	A general term used to express an assessment of both fixed and variable factors of the fire environment that determine the ease of ignition, rate of spread, difficulty of control, and impact. Fire danger is often expressed as an index.[12]
Fire danger index	A quantitative indicator of fire danger, expressed either in a relative sense or as an absolute measure. Fire danger indexes are often used to guide fire management activities.
Fire ecology	The study of the relationships and interactions between fire, living organisms and the environment.
Fire edge	Any section of the fire perimeter.
Fire effects	The physical, biological, and ecological impacts of fire on the environment. [13]
Fire environment	The surrounding conditions, influences, and modifying forces of topography, fuel, and weather that determine fire behaviour, fire effects and impact.

12 Source: Global Fire Monitoring Centre (2010) *International Multi-Lingual Fire Management Terminology* (Global Fire Monitoring Centre, Freiburg), page 121.

13 Source: National Wildfire Coordinating Group (2008) *Glossary of Wildland Fire Terminology* (National Wildfire Coordinating Group, Boise), page 74.

Glossary of Wildfire Terminology	
Fire fighting chemicals	Substances that have the ability to prevent, reduce or inhibit combustion. They can be applied from the air or from the ground and may be applied directly onto a fire or an area of unburned fuel. Common types of fire fighting chemicals include: ▪ ***Foam*** – a mass of bubbles formed by mixing specific proportions of air with water and a foam concentrate. It is can be applied in order to smother and cool parts of a fire and/or to prevent ignition within a fuel. ▪ ***Gels*** – A chemical which is added to water to make it thicken. When used as an extinguishing agent the mixture is able to absorb more heat than water and sticks to the surface of the fuel. ▪ ***Wetting agents*** – which act to decrease the surface tension of water and therefore enable greater penetration into fuels. ▪ ***Retardants*** – a group of chemicals that are usually mixed with water which have the ability to reduce or inhibit combustion either in the long or short term: ▪ ***Long term retardants*** – have the ability to reduce or inhibit combustion even after the water that they contain has evaporated. ▪ ***Short term retardants*** – are primarily used to inhibit combustion through the more immediate cooling and/or smothering of a fire.
Fire footprint	Outer shape of the fire perimeter at a given point in time.
Fire front	Any part of the fire perimeter that displays continuous flaming combustion.
Fire growth	The evolution of a fire from ignition to self-sustaining propagation and its movement through available fuels.
Fire history	The reconstruction and interpretation of the chronology of wildfire occurrence and the causes and impacts of wildfires within a specified area.
Fire intensity	The rate at which a fire releases energy in the form of heat at a given location and at a specific point in time, expressed as kilowatts per metre (kW/m) or kilojoules per meter per second (kJ)
Fire investigation	The process of determining the origin, cause, and development of a fire.[14]
Fire management Plan	A plan detailing predetermined fire suppression strategies and tactics to be implemented following the occurrence of a wildfire within a particular area.
Fire model	A computer program which will predict or reconstruct fire behaviour and rate of spread of a fire from a point of ignition or area of origin.
Fire perimeter	The entire outer boundary of a fire.
Fire prediction system	A method or tool used to forecast future behaviour of a fire.
Fire prevention	A collective term for all proactive activities that are implemented with the aim of reducing the occurrence, severity and spread of wildfires.

14 Source: NFPA (2011) NFPA 921 – Guide for Fire and Explosion Investigations (NFPA, Quincy, Massachusetts), page 14.

Glossary of Wildfire Terminology	
Fire regime	The pattern of fire occurrence, fire frequency, fire seasons, fire size, fire intensity, and fire type that is characteristic of a particular geographical area and/or vegetation type.
Fire restrictions	Measures taken to limit or prevent particular activities to reduce the likelihood of a wildfire or forest fire occurring within a particular area. These measures can include: ▪ ***Permanent restrictions*** – measures that are applied all year round within a particular area. ▪ ***Fire season restrictions*** – measures that are applied only during the normal fire season within a particular area. ▪ ***Temporary restrictions*** – measures that are only applied when the fire risk/danger index passes a pre-determined threshold within a particular area. Temporary restrictions are usually removed once the fire risk/danger index falls below a predetermined threshold.
Fire risk	The calculation of the probability of a wildfire occurring and its potential impact on a particular location at a particular time. Wildfire risk is calculated using the following equation: Fire risk = probability of occurrence x potential impact.
Fire scar	a) The overall shape of the area burned by a wildfire or, b) A healing or healed injury or wound to woody vegetation which has been caused or accentuated by fire.
Fire season	The period or periods within a year when wildfires are most likely to occur.
Fire severity	Fire severity can be defined in two ways: ▪ The degree to which a site has been altered or disrupted by fire.[15] ▪ The capacity of a fire to cause damage.[16] Fire intensity and the amount of time a fire burns within a particular area, among other possible factors, will influence fire severity.
Fire severity Index	The Met Office Fire Severity Index is an assessment of fire severity for the current day and a forecast of fire severity for the coming five days.
Fire spread	The movement of a fire through available fuels arranged across the landscape.
Fire storm	Violent convection caused by a large continuous area of intense fire.
Fire suppression	The activities undertaken to extinguish a fire.
Fire suppression plan	A pre-determined scheme or programme of activities which is formulated in order to safely and effectively accomplish fire suppression objectives. A fire suppression plan will outline the selection of tactics, selection of resources, resource assignments and how performance and safety will be monitored and maintained at a particular incident. Fire suppression plans need to be dynamic to take into account any changes in conditions or circumstances.

15 Source: National Wildfire Coordinating Group (2008) *Glossary of Wildland Fire Terminology* (National Wildfire Coordinating Group, Boise), page 78.

16 British Standards Institution (2010) *Fire Safety Vocabulary* (ISO 13943: 2008; BS EN ISO 13943:2010), (BSI Standards Publication, London), 4.130, p15.

Glossary of Wildfire Terminology	
Fire types	There are three different schemes for classifying fire type: 1. Classification of a fire or section of fire according to the fuel level within which it occurs. For example, aerial, crown, understory, surface and ground fires. 2. Classification of a section of fire according to its position along the fire perimeter. For example, head, tail and flank fires. 3. Classification of a fire or section of fire according to the visual characteristics it displays. For example, smouldering, creeping, backing, running, torching, spotting, crowning, fire whirl, convection driven fire etc.
Fire whirl	Spinning vortex column of ascending hot air and gases rising from a fire and carrying aloft smoke, debris, and flame.[17]
Fire wind	The inflow of air close to a fire caused by the action of convection.[18] Fire winds influence fire spread.
Flame angle	The angle of a flame measured in relation to the ground surface. Flame angle is expressed in degrees.
Flame depth	The distance from the rearmost to the foremost parts of the fire front, usually expressed in metres.
Flame height	The vertical extension of a flame. Measurement of flame height is calculated perpendicular from ground level to the tip of the flame. Flame height will be less than flame length if flames are tilted due to wind or slope.
Flame length	The total length of a flame measured from its base at ground level to the flame tip. Flame length will be greater than flame height if flames are titled due to wind or slope.
Flame risk	An assessment of risk to fire suppression personnel which is calculated using flame length.
Flaming combustion	The production of flames as part of the combustion process.
Flaming Front	The area of a moving fire where combustion is primarily flaming. The flaming front normally consists of the fire front and the flaming zone.
Flaming Zone	The flaming zone is located behind the fire front and is primarily characterised by flaming combustion. The flaming zone is where coarser fuels are consumed and where fire behaviour is typically less dynamic and more static. Depending on the fuels present, the fire can burn for a considerable length of time within this zone.
Flammability	Relative ease with which a given fuel will ignite and burn with a flame.
Flanks	The parts of a fire's perimeter that are roughly parallel to the main direction of fire spread.[19] The flanks usually have less fire intensity than the head fire because they have a weaker alignment with wind or slope.
Flank attack	A method of fire suppression which involves attacking a wildfire along the flank or both flanks simultaneously.

17 Source: National Wildfire Coordinating Group (2008) *Glossary of Wildland Fire Terminology* (National Wildfire Coordinating Group, Boise), page 79.

18 Source: Australasian Fire and Emergency Service Authorities Council (2009) *Wildfire Glossary* (Australasian Fire and Emergency Service Authorities Council, Melbourne), page 13.

19 Source: National Wildfire Coordinating Group (2008) *Glossary of Wildland Fire Terminology* (National Wildfire Coordinating Group, Boise), page 83.

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Flare up	A short and sudden increase in fire activity.
Flash fuels	Fine fuels that have been dried and which will ignite very readily and rapidly.
Fog	Low lying parcels of air with high levels of moisture content. Fog is a cloud that has its base on the earth's surface.
Fogging System	Pressurized water system which produces a fine mist or micro droplets of water to enhance the heat absorbing and steam generating capability of water.
Forces of Alignment	A collective term for the forces that have a significant impact on wildfire behaviour. These forces can support or hinder fire development and can be used to predict likely fire behaviour, including fire spread and fire intensity. Wind, slope and aspect are considered to be key forces of alignment.
Fragmentation	The process of transforming large continuous areas of vegetation and fuel into smaller discontinuous areas. Fragmentation leads to a change in fire regimes through the alteration and discontinuity of fuels.
Fuel	Any material that can support combustion within a wildfire environment. Fuel is usually measured in tonnes per hectare.
Fuel Arrangement	The horizontal and vertical distribution of all combustible materials within a particular fuel type.[20] ▪ ***Horizontal fuel arrangement*** – A description of the distribution of fuels on the horizontal plane. The horizontal arrangement of fuels will influence the relative ease with which fire can spread horizontally across an area of land. ▪ ***Vertical fuel arrangement*** – A description of the distribution of fuels on the vertical plane, from the ground up to the canopy levels of vegetation. The vertical arrangement of fuels will influence the relative ease with which fire can spread vertically through the fuel layers.
Fuel assessment	The estimation or calculation of total and available fuel that is present within a specific area.
Fuel complex	The type, quantity, condition, arrangement and continuity of fuel available to burn.
Fuel condition	Relative flammability of a fuel, as determined by fuel type and environmental conditions.[21]
Fuel Continuity	The extent to which fuel arrangement will support fire spread.
Fuel consumption	The amount of a fuel that is removed by a fire, often expressed as a percentage of the fuel load.
Fuel hazard	A fuel complex defined by type, alignment, arrangement, volume, continuity, condition etc. that forms a special risk.

20 Source: Global Fire Monitoring Centre (2010) *International Multi-Lingual Fire Management Terminology* (Global Fire Monitoring Centre, Freiburg), page 166.

21 Source: National Wildfire Coordinating Group (2008) *Glossary of Wildland Fire Terminology* (National Wildfire Coordinating Group, Boise), page 87.

Glossary of Wildfire Terminology	
Fuel layers	The classification of fuels according to their height relative to the ground surface. There are five general fuel layers: ▪ **Aerial fuels** ▪ **Elevated fuels** ▪ **Near surface fuels** ▪ **Surface fuels** ▪ **Ground fuels**
Fuel Load	The amount of fuel present within a particular area. Fuel load is measured in weight per area measured (usually in kilograms per square metre). Fuel loading is expressed in relative terms as either "heavy fuel loading" or "light fuel loading".
Fuel management	The process of managing fuel or fuel arrangement. The aim of fuel management is usually to create a discontinuity in fuels to achieve fragmentation.
Fuel moisture content	Water content of a fuel expressed as a percentage of fuel weight when oven dried.
Fuel profile	Vertical cross-section of a fuel bed.
Fuel properties	The physical characteristics of a fuel; for example, volume, size, shape, compactness and arrangement.
Fuel separation	The distance between fuel layers or fuel particles.
Fuel type	A group of fuels that will respond to fires in a similar way.
Fuel type pattern	A mosaic of distinct fuel types within a particular area.
Fuel type classification	The division of wildland fuels into different fire hazard classes.
Geographic Information System (GIS)	A system designed to capture, store, manipulate, analyze, and present geographically referenced data.
Global Positioning System (GPS)	A global navigation system that provides very precise positioning information about the location of any point on or near the Earth's surface.
Glowing combustion	Low intensity combustion, when there is little or no flame and little or no fire spread. Glowing combustion will usually occur shortly before extinction, during the final stages of a fire.
Gradient	The angle or steepness of a slope.
Grassland	An area predominantly covered in one or more species of grass.
Ground crew(s)	Any crew(s) operating on the ground. Usually only required as a term of reference if an incident involves aerial operations.
Ground Fire	A fire burning below the surface fuel layer.

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Ground fuel	Any fuel below the surface fuel layer, normally within the soil. Examples of ground fuels include: duff, tree roots, shrub roots, rotting wood, peat etc.
Hand line	A control line constructed using hand tools.
Head Fire	The leading part of an advancing wildfire at a particular point in time. The head fire will usually exhibit the highest level of fire activity of any part of the fire.
Heat Transfer	The process by which heat is imparted from one body or object to another. In wildfires and forest fires, heat energy is transmitted from burning to unburned fuels by: - ***Convection*** – Transfer of heat by the movement of masses of hot air; the natural direction is upwards in the absence of any appreciable wind speed and/or slope. Convection can include spotting behaviour. - ***Radiation*** – Transfer of heat in straight lines from warm surfaces to cooler surroundings. - ***Conduction*** – Transfer of heat through solid matter.[22]
Heathland	An area of open uncultivated land which is dominated by dwarf shrubs and which is usually characterised by poor acidic sandy soil. Heathland is similar in appearance to moorland, although heath is normally found on well-drained sandy soils at lower altitudes.
Helibase	The main location for parking, fuelling, repairing/maintaining, and loading of helicopters during a wildfire incident.
Holding area	Location established at an incident where resources can be placed while awaiting assignment.
Horizontal Fuel Arrangement	A description of the distribution of fuels on the horizontal plane. The horizontal arrangement of fuels will influence the relative ease with which fire can spread horizontally across an area of land.
Hot fire	When prevailing conditions cause fuels to burn and produce a high intensity fire or part of a fire.
Hot Spot	A small burning area which requires suppression action as part of the mop-up phase of suppression.
Humidity	A generic term used to describe the amount of water vapour in the air.
Hygrometer/ Psychrometer	An instrument used for measuring the relative humidity of the air.
Ignition	The initiation of combustion.
Ignition method	The means by which a fire is ignited.

22 Source: Global Fire Monitoring Centre (2010) *International Multi-Lingual Fire Management Terminology* (Global Fire Monitoring Centre, Freiburg), page 188.

Glossary of Wildfire Terminology	
Ignition patterns	A generic term for the three key techniques for igniting a managed burn: ▪ **Line ignition** – igniting a burn in strips along a control line and the adjacent fuel. ▪ **Points of fire ignition** – igniting a number of fires within an area of fuel. The aim of this technique is for the individual fires to burn into one another. ▪ **Fingers of fire ignition** [23] – a low intensity back burn which is achieved by igniting lines of fire at right angles to a control line and parallel to the wind.
Ignition point	The precise physical location within the area of origin where a wildfire was first ignited.
Ignition temperature	The minimum temperature at which ignition can take place and sustained combustion can occur.[24]
Incendiary	A device that is designed to ignite a fire.
Incident	An occurrence or event that requires action to prevent or minimise loss of life, damage to property or damage to the environment.
Incident Commander	The nominated competent officer who has overall responsibility for safety, tactics and management of resources at a wildfire incident.[25]
Incident Command System	A standardized emergency management system which is specifically designed to allow its users to adopt an integrated organisational structure equal to the complexity and demands of single or multiple wildfire incidents. An ICS provides a standard framework within which individuals and teams present at an incident can work together safely and effectively.
Incident support	A group or organisation responsible for providing personnel, equipment and/or welfare facilities and supplies in support of suppression operations.
Indirect attack	Any suppression methods implemented away from the fire edge.
Initial Attack	Suppression work completed by first responders arriving at a wildfire incident. The intention of any initial attack will always be to quickly gain control of a fire. If an initial attack is unsuccessful then a prolonged attack strategy might be required.
Initial response	The first suppression resources mobilised to an incident following the detection of a wildfire. These resources will be available to participate in initial attack operations.
Islands	Areas of unburned fuel within a fire perimeter.
Isobar	A line on a weather map which connects points of equal atmospheric pressure.
Isotherm	A line on a weather map which connects points of equal temperature.
Junction zone	An area where two separate fires move together. The junction zone is usually characterised by increased fire activity.

23 This should not be confused with the term *"fingers of fire"* which is defined within this glossary as "An elongated burned area projecting from the main body of the fire resulting in an irregular fire perimeter"

24 Source: Global Fire Monitoring Centre (2010) *International Multi-Lingual Fire Management Terminology* (Global Fire Monitoring Centre, Freiburg), page 203.

25 HM Government (2008) *Fire and Rescue Manual – Volume 2 Fire Service Operations: Incident Command* (3rd Edition) (London, TSO), p142.

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Junction Zone affect	This is the term used to describe the increased fire activity that occurs when two separate fires move together.
Katabatic Wind	Down slope winds. Katabatic winds occur when air at higher elevations is cooled (often at night) and is subsequently pulled down slope by the force of gravity.
Knapsack Sprayer	A portable hand operated water pump with a nozzle that can be carried on the back by personnel, used to apply water as a spray or a small. Often used to knock down the intensity of a fire or extinguish hot spots during the mop up phase.
Knock Down	To reduce the flame or heat of burning parts of a fire.
LACES	An essential safety protocol which should be implemented at wildfire incidents to address risks and hazards. The correct implementation of LACES helps to ensure that suppression personnel are appropriately supervised, informed and warned of risks and potential hazards and that they are aware of how and where to escape should a high risk situation occur. LACES is an acronym for: ▪ L = Lookouts ▪ A = AwarenessError! Bookmark not defined. or Anchor Point ▪ C = Communication ▪ E = Escape route and plan ▪ S = Safe area
Ladder fuel	Fuels that provide vertical continuity which allow fire to move through the vertical fuel arrangement.
Land breeze	A local night time breeze which occurs when cooler, higher pressure air above the land surface moves offshore to replace warmer air rising above coastal waters.
Landscape	The physical appearance of the land comprising of the features of terrain, vegetation and the human impact caused by variations in land use.
Latitude	The angular distance north or south between a point on the earth's surface and the equator. Latitude is usually measured in degrees, minutes and seconds.
Litter	The top layer of debris fuels consisting of twigs, sticks and branches, it can also include recently fallen leaves and needles. The structure of the material within the litter layer has not been altered significantly by the process of decomposition.
Live fuels	Fuels with living tissue. The moisture content of live fuels is controlled largely by internal physiological mechanisms.
Lookout	A person that has a good understanding of wildfire behaviour and who acts as the safety officer for an individual team. He/she will observe the fire and the actions of the team and will be responsible for ensuring the safety of the whole team. Lookouts are a key element of the LACES safety protocol.

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Managed burn	A planned and supervised burn carried out for the purpose of removing fuel either as part of a Fire SuppressionError! Bookmark not defined. Plan (an operational burn) or a land management exercise (a prescribed burn).
Meteorological winds	Meteorological winds are caused by differences in atmospheric pressure within upper level air masses which generate regional weather patterns.
Mineral Earth	A soil layer that does not contain organic material which could support combustion.
Mixed Woodland	A mixture of deciduous and coniferous tree species.
Moorland	An area of open uncultivated land which is dominated by dwarf shrubs and other low-lying vegetation. Moorland is similar in appearance to heathland; although moorland is found in wetter areas where mosses help retain water content.
Mop Up	The act of extinguishing a fire after it has been brought under control.[26] Mop up involves carrying out all necessary actions to prevent re-ignition.
Multi-agency Incident	An incident involving more than one agency.
Multiple Ignition Points	More than one point of ignition. Multiple ignitions may be lit simultaneously or successively and could be indicative of spot fires or fires set deliberately by humans.
Natural fuels	Fuels created and developed through natural processes and which have not been directly generated or altered by land management practices.
Near surface fuels	Any fuels found at a height of 0.5-1.5 metres above the ground surface. Near surface fuels are found above surface fuels and have a vertical component to their structure.
Operational burn	A controlled supervised burn which is carried out by a burn team as part of a fire suppression plan. An operational burn can be classified as either offensive or defensive, depending upon its purpose: ▪ **Offensive operational burn** – ignited along a control line to burn into an advancing flame front. ▪ **Defensive operational burn** – ignited along a control line to strengthen/expand the control line, but will be extinguished prior to the arrival of an advancing wildfire.
Parallel Attack	A method of fire suppression involving the construction of a control line approximately parallel to and some distance away from the fire edge. The intervening strip of unburned fuel may or may not be burned out as the control line proceeds. This decision will be influenced by an assessment of whether the unburned fuel is considered to pose a threat to the control line.
Partner agency	Any organisations that work together to prevent, investigate and/or suppress wildfires. Partner agencies will work together on preparedness activities and plans and are likely to have formulated pre-agreed partnership agreements.

26 Source: Global Fire Monitoring Centre (2010) *International Multi-Lingual Fire Management Terminology* (Global Fire Monitoring Centre, Freiburg), page 142 (defined within the term “Fire Suppression”).

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Patrol	The act of supervising a specified area in order to prevent, detect and/or suppress wildfire.
Peat	An organic fuel layer consisting of a light, spongy material formed in temperate humid environments through the accumulation and partial decomposition of vegetation debris. Peat is formed by decomposition in the absence of oxygen (anaerobic decomposition). Peat forms in areas that are seasonally or permanently inundated with water. Fires in peat burn by smouldering combustion and generate high levels of heat energy per unit area.
Pinching	Attacking a fire by working along the flanks either simultaneously or successively from a less active or anchor point and endeavouring to connect the two lines at the head.[27]
Plantation	An area of trees created through artificial regeneration.
Points of fire ignition	A fire ignition pattern which involves igniting a number of fires within an area of fuel. The aim of this technique is for the individual fires to burn into one another.
Precipitation	All forms of water, whether liquid (e.g. rain) or solid (e.g. snow or hail), that fall from the atmosphere and reach the ground.
Preheating	Preliminary phase of combustion where fuels ahead of an advancing fire are heated and dried. During pre-heating, fuel temperatures are raised either by the advancing fire and/or by weather (i.e. solar radiation, aspect).
Preparedness plan	A pre-determined strategic scheme or programme of activities which is formulated in order to satisfactorily prepare an organisation or a geographic area to respond effectively to wildfire incidents.
Pre-treat	The application of water, foam or retardant along a control line.
Prescribed burn	A planned and supervised burn carried out under specified environmental conditions to remove fuel from a predetermined area of land and at the time, intensity and rate of spread required to meet land management objectives.
Prevailing wind	The predominant wind direction.
Public access	Land open to the public for recreational or educational use.
Rate of Spread	A measurement of the speed at which a fire moves across a landscape. Rate of spread is usually expressed in metres per hour.
Re-burn	Subsequent burning of an area that has already been burnt.
Rendezvous point	A pre-arranged location where resources arriving at a wildfire incident will report.
Reserve resources	Resources not assigned to a specific task, but available for deployment.
Resilience	The ability of an ecosystem or species to return to its original state after being affected by a wildfire.

27 Source: Global Fire Monitoring Centre (2010) *International Multi-Lingual Fire Management Terminology* (Global Fire Monitoring Centre, Freiburg), page 153 (defined within the term "Flanking Fire Suppression").

Glossary of Wildfire Terminology

Relative Humidity	The amount of water vapour present in the air expressed as a percentage of the amount of vapour needed for saturation to occur at the same temperature. Saturated air is referred to as 100% relative humidity.
Resources	Personnel, equipment, services and supplies which are either available or potentially available for assignment to a wildfire incident.
Response	Response encompasses the actions taken to deal with the immediate effects of a wildfire emergency. In many scenarios it is likely to be relatively short and to last for a matter of hours or days – rapid implementation of arrangements for collaboration, co-ordination and communication are, therefore, vital. Response encompasses the effort to deal not only with the direct effects of the emergency itself but also the indirect effects.
Responsibility	The duty or obligation to satisfactorily perform or complete an assignment.
Restricted area	An area in which specified activities or entry are temporarily or permanently restricted in order to mitigate risk to human health or safety by potential or on-going wildfires. A restricted area may also be temporarily or permanently established in order to reduce the risk of a wildfire igniting within a specified location.
Ring burn	A fire started by igniting the full perimeter of the intended burn area so that the ensuing fire fronts converge toward the centre of the burn.[28]
Risk assessment	A process involving the identification of risk, an assessment of probability and an assessment of potential impact. The process will establish information regarding acceptable levels of risk and actual levels of risk posed to an individual, group, society or the environment.
Risk management	A process involving the systematic application of policies, procedures and practices to identify, analyse, evaluate, manage, control, communicate and monitor risks.[29]
Role rotation	The act or process of periodically changing the assignments provided to individuals working at a wildfire incident to ensure adequate rest breaks and appropriate variety in the physical and mental intensity of tasks completed by all team members.
Running Fire	A fire that is rapidly spreading with a well-defined head.
Safe area	An identified area of safety where people will find refuge. The identification of a safe area is a key element of the LACES safety protocol.
Safe systems of work	A formal procedure which results from systematic examination of a task in order to identify potential hazards and risks. The resulting document produced will describe the safest way(s) of completing a task to ensure hazards are eliminated or that risks are controlled as far as possible.
Safety	When exposure to hazards has been controlled to an acceptable level.
Safety Officer	An officer that is appointed to manage risk.

28 Source: National Wildfire Coordinating Group (2008) *Glossary of Wildland Fire Terminology* (National Wildfire Coordinating Group, Boise), page 149 (defined within the term "Ring Fire").

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Glossary of Wildfire Terminology	
Scratch Line	A preliminary control line that has been hastily constructed as an emergency measure to prevent fire spread.
Scrubland	Area of mixed vegetation predominantly consisting of shrubs, bushes and grasses. Scrubland may be found on the fringes of other fuel types, but it may also be found in isolated pockets within other fuel types.
Sea breeze	A daytime breeze in which cooler, higher pressure air from over coastal waters moves on shore to replace heated air rising off the warmer land mass.[30]
Sector	A specific area of an incident which is under the control of a Sector Commander.
Shrub	A woody perennial plant characterised by its low stature (less than 3 m high) and habit of branching from the base. Shrubs normally contain a high quantity of fine fuels.
Situational Awareness	The perception of the surrounding environment within the context of both time and space. It includes the comprehension of meaning of observed phenomena and patterns and the provision of information relevant to a team or individual's situation. It also includes the projection and prediction of what will happen within the surrounding environment in the future.
Site of Special Scientific Interest	A statutory designation in Great Britain that offers protection to habitats, species and geographical features.
Slash	Debris left lying on the ground after logging, pruning or thinning operations within woodland. Slash may consist of both course and fine fuels and sometimes forms a significant surface fuel (It is often referred to as Brash or Hagg in Scotland).
Sleeper fire	A fire that remains dormant for a period of time.
Slope	An incline of the ground.
Slope affect	Variations in fire behaviour induced by slope. Slope can both support and hinder fire spread and development and the angle of the slope will have an important influence on the degree of effect. The following descriptions explain the general slope effect that would be expected from a fire spreading upslope and a fire spreading down slope: ▪ **Fires spreading upslope** –The flames of a fire spreading upslope will be angled towards the unburned fuel above it which will pre-heat the fuel in front of the advancing fire. This pre-heating increases combustibility and rate of spread for fires travelling upslope. ▪ **Fires spreading down slope** – The flames of fires burning down slope will be angled away from the fuel and will, therefore, lead to less preheating of the fuel in front of the fire. Consequently, the effect of slope on a fire burning down slope is a reduction in combustibility and rate of spread.

30 Source: Global Fire Monitoring Centre (2010) *International Multi-Lingual Fire Management Terminology* (Global Fire Monitoring Centre, Freiburg), page 296.

Glossary of Wildfire Terminology	
Slope winds	Highly localised convective winds that occur due to heating and cooling of a slope. ▪ Katabatic winds – Down slope winds. Katabatic winds occur when air at higher elevations is cooled (often at night) and is subsequently pulled down slope by the force of gravity. ▪ Anabatic winds – Upslope winds. Anabatic winds occur when daytime solar radiation heats air at lower elevations causing it to flow upslope.
Smoke	The atmospheric suspension of small particles of solids and liquids produced by combustion
Smouldering combustion	Low intensity combustion, when there is no flame and little or no fire spread.
Smouldering fire	A fire burning without flame and barely spreading.
Solar radiation	Energy emitted by the sun which indirectly heats the earth's surface. Solar radiation has a significant influence on weather.
Spark	An ignited particle thrown from burning material.
Special Area of Conservation	Area designated under the EU Habitats and Species Directive.
Special Protection Area	Area designated under the EU Birds Directive.
Spot Fire	A fire outside the main fire perimeter which is caused by flying embers transported by the wind or convection column.
Spotting	Fire behaviour characterised by sparks and embers that are transported through the air by the wind or convection column. Spotting can be classified as short range or long range.
Stand	Trees of one type or species grouped together within woodland.
Standard Operating Procedures (SOPs)	SOPs are written instructions that detail the necessary steps that must be taken when completing a particular process or activity. The purpose of a SOP is to ensure that a particular process or activity is always carried out safely, effectively and in the same manner.
Standing fuel	Part of vegetation, living or dead, that is supported by a stem, branch or trunk.
Statutory responsibility	A legal obligation to satisfactorily perform or complete a particular task related to wildfire suppression or prevention.
Supplies	Minor items of equipment and all expendable items assigned to an incident. [31]
Supply area	The location, at which the primary logistics functions and supplies required for a wildfire incident are temporarily stored, coordinated and administered.
Suppression	All work involved in controlling and extinguishing a wildfire.
Surface Fire	A fire that burns within the surface fuel layer.

31 Source: National Wildfire Coordinating Group (2008) *Glossary of Wildland Fire Terminology* (National Wildfire Coordinating Group, Boise), page 166 (defined within the term "Ring Fire").

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Surface Fuel	Any fuels found at a height of 0-0.5 metres above the ground surface.
Swipe	Used to cut small shrubs such as heather down to ground level. Depending on local conditions the resulting break in the vegetation can either act as a barrier to fire spread, or reduce fire behaviour significantly.
Tail fire	The rear most part of a wildfire/forest fire, it is normally out of alignment with wind and slope, and consequently will usually demonstrate less fire activity than the head fire because it usually has less support from wind or slope. Sometimes referred to as the heel part of the fire.
Tactics	The deployment of resources at a wildfire incident to achieve the aims of a strategic plan.
Tactical lookout	A person with an advanced understanding of wildfire behaviour who acts as a safety officer at a wildfire incident. He/she will observe the fire and the action of teams involved in fire suppression. He/she will maintain close communication with suppression teams and supervisors and will be responsible for ensuring the safety of all individuals present at the incident. Lookouts are a key element of the LACES safety protocol.
Test burn	A small burn which is ignited to observe and evaluate fire behaviour prior to igniting a larger operational or managed burn.
Thermograph	A thermometer that automatically and continuously records air temperature on a chart.
Thermometer	An instrument used to measure air temperature.
Time lag	The time it takes for fuel of various sizes to gain or loose moisture due to changes to the environment.
Topographic wind	When the direction and/or speed of a meteorological wind is altered by the shape of the landscape. Importantly, topographical winds are a general wind adaptation and they occur on a larger scale than more localised slope winds.
Topography	The description and study of the shape and features of the land surface.
Tree	A tree is a perennial woody plant with a single main stem or trunk which supports branches above the ground. Trees usually have a distinctive crown.
Trigger Point	A pre-designated point in time or place whereby a predicted change in fire behaviour will influence tactical decision-making. For instance, if a wildfire reaches a particular trigger point on the landscape, the Incident Commander may decide it is necessary to adopt alternative tactics in order to maintain safety and effectiveness.
Torching	A fire that burns from the ground through the surface and aerial fuels and into the crown of a single tree or small parcel of trees.
Understory	Vegetation found beneath the canopy, but which is normally found growing or lying on the ground.

Glossary of Wildfire Terminology	
Uniform fuels	Identical or consistent fuels distributed continuously across an area or landscape. It is usually easier to predict fire behaviour for fires burning in uniform fuels than it is for fire in mixed vegetation types.
Vegetation	A term used to describe all forms of plant life.
Vertical Fuel Arrangement	A description of the distribution of fuels on the vertical plane, from the ground up to the canopy levels of vegetation. The vertical arrangement of fuels will influence the relative ease with which fire can spread vertically through the fuel layers.
Weather	The state of the atmosphere at a given time and place with respect to atmospheric stability, temperature, relative humidity, wind speed, cloud cover and precipitation.
Weather Station	A collection of sensors and monitors which gathers, records and reports meteorological data. Weather stations may be permanent structures or hand-held/semi-portable/portable units.
Wet line	A line of water, or water mixed with fire fighting chemicals, which is sprayed along the ground to serve as a temporary control line from which to ignite an operational burn or to stop a low-intensity fire.
Wildfire	Any uncontrolled vegetation fire which requires a decision or action regarding suppression. Wildfires are commonly classified according to size and/or impact upon suppression resources.
Wildfire Prediction System	A method used to analyse a fires potential alignment with wind, slope and aspect as it moves across the landscape and predict its likely fire behaviour within the available fuel.
Wildland	An area in which development is essentially non-existent, except for the presence of basic infrastructure such as roads, railroads and power lines. Any buildings and structures will be widely scattered.
Wildland Urban Interface	The zone of transition between wildland and human settlements and/or development.
Wind	The horizontal movement of air within the atmosphere. Wind has a strong influence on fire behaviour and is one of the key forces of alignment.
Wind direction	The direction from which the wind is blowing. A change in average wind direction is termed a “wind shift”.
Wind shift	A change in average wind direction.
Wind speed	The rate at which air moves horizontally past a particular location at a particular point in time.
Window of opportunity	A period of time or location on the landscape when/where it will be particularly advantageous to adopt particular suppression tactics or actions.
Windrow	Woody debris that has been piled into a long continuous row.

Glossary of Wildfire Terminology	
Woodland	A generic term for any area of land which is predominantly characterised by trees, whether in large tracts or smaller units.[32] Woodland can be categorized according to the types of species it contains, for instance: ▪ **Coniferous woodland** – containing predominantly coniferous tree species. ▪ **Deciduous woodland** – containing predominantly deciduous tree species. ▪ **Mixed woodland** – Woodland containing a mixture of coniferous and deciduous tree species. Woodland can also be categorized according to the degree to which humans manage the area, which has an influence on the type of fire behaviour that may be observed: ▪ **Planted woodland** – An area of managed woodland (often artificially established) where trees are grown for sale as timber and/or for the commercial production of other forest products. Planted woodland is often characterised by a single species and continuity in both the horizontal and vertical fuel arrangements. **Natural woodland** – Trees that have germinated and grown in their natural state without the influence of human actions. Natural woodland is likely to contain multiple species of trees which leads to less continuity of fuels than is found in planted woodland.

32 Woodland can be classified as "forest" if the minimum percentage of canopy cover, as stipulated within national or international guidelines/stipulations, is exceeded.

Acronyms

Acronym	Description
AFFF	Aqueous Film Forming Foam
ALARP	As Low As Reasonably Practicable
AONB	Area of Outstanding Natural Beauty
ARA	Analytical Risk Assessment
ASC	Aerial Sector Commander
ATV	All-Terrain Vehicle
BHC	Broad Habitat Classification
CE	Conformité European (European Conformity)
CFA	County Fire Authority (Australia)
CFOA	Chief Fire Officers Association
CFOAS	Chief Fire Officers Association Scotland
CLG	Department for Communities and Local Government
CPS	Campbell Prediction System
CRR	Community Risk Register
EA	Environment Agency
EWWF	England and Wales Wildfire Forum
FAO	Food and Agriculture Organization (United Nations)
FC	Forestry Commission
FP	FluoroProtein (Foam)
FFFP	Film Forming FluoroProtein (Foam)
FRA	Fire and Rescue Authority
FRS(s)	Fire and Rescue Service(s)
FRSA	Fire and Rescue Services Act (2004)
F(S)A	Fire (Scotland) Act (2005)
FSI	Fire Severity Index
F0	Factor Zero
F1	Factor One
F2	Factor Two
F3	Factor Three
GPS	Global Positioning System
GRA	Generic Risk Assessment

Acronym	Description
HSE	Health and Safety Executive
HVP	High Volume Pump
IC	Incident Commander
ICS	Incident Command System
IRMP	Integrated Risk Management Plan
LACES	Lookouts, Awareness, Communication, Escape Routes, Safety Zone
LRF	Local Resilience Forum
MDT	Mobile Data Terminal
NE	Natural England
NVC	National Vegetation Classification
OC	Operations Commander
ODPM	Office of the Deputy Prime Minister
OS	Ordnance Survey
PPE	Personal Protective Equipment
RH	Relative Humidity
SA	Situational Awareness
SAC	Special Area of Conservation
SC	Sector Commander
SEPA	Scottish Environmental Protection Agency
SMEAC	Situation, Mission, Execution, Administration, Command and Control
SNH	Scottish Natural Heritage
SOP	Standard Operating Procedure
SPA	Special Protection Area
SSSI	Sites of Special Scientific Interest
SMA	Subject Matter Advisor
SWF	Scottish Wildfire Forum
UK	United Kingdom
UN	United Nations
WPS	Wildfire Prediction System
WUI	Wildland / Urban Interface

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