# Grassland Wildfire Operations (S-100G)

Alberta Government

2017

ALBERTA FIRE CHIEFS ASSOCIATION

# Course Description

## Grassland Wildfire Operations (S-100G)

### Course Description:

Grassland Wildfire Operations (S-100G) is designed to meet the training needs for municipal and wildland fire personnel conducting grassland wildfire suppression operations. This course is adapted for use from the *Grassland Fire Operations* training course developed by Saskatchewan Environment and Parks Canada (2003) and the *Wildfire Orientation* training course developed by Alberta Environment and Sustainable Resource Development.

### Course Objectives:

This course provides the student with the skills and knowledge to:

- Size-up a grassland wildfire incident;
- Evaluate the potential situation;
- Order and deploy the necessary resources;
- Apply safe and effective strategies and tactics to contain and extinguish grassland wildfires.

**Course Length:** 8 hours

**Target Group:** Municipal Fire Officers and Fire Fighters
Municipal Public Works Personnel
Wildland Type 1 Crew Leaders and Members

**Recommended Course Pre-requisites:** Introduction to ICS (I-100)

**Examination** The examination process will include a 25 question open-book written exam. The required passing mark is 80%. If a student fails to pass the exam, a supervised rewrite will be offered. Failure to pass the rewrite will result in repeating the course. One (1) hour is allotted for the exam. Examination time is included in the course length of eight (8) hours. Students will also participate in the group exercises throughout the training course.

# Table of Contents


Course Description ……. ii

Unit 1 – Grassland Wildfire Awareness …….. 1
- 1.1 Introduction ……. 2
- 1.2 Jurisdictional Responsibilities …… 3
- 1.3 Incident Command System Overview ……..... 4
- 1.4 Initial Operations …… 6
- 1.5 Summary …… 10

Unit 2 – Grassland Wildfire Behaviour …… 11
- 2.1 Fire Triangle ……..… 12
- 2.2 Heat Transfer ……..... 13
- 2.3 Fire Behaviour Triangle ……... 13
- 2.4 Fire Behaviour Terms ……..…… 21
- 2.5 Parts of a Fire …….. 21
- 2.6 Canadian Forest Fire Danger Rating System ……..…… 22
- 2.7 Grassfire Behaviour Field Guide …… 25
- 2.8 Summary ……. 27

Unit 3 – Grassland Wildfire Operations ……..… 28
- 3.1 Safe Work Procedures – LACES …… 29
- 3.2 Grassland Wildfire Assessment …….. 30
- 3.3 Grassland Wildfire Operations ……..…….. 32
- 3.4 Summary ……. 47

Unit 4 - Firefighter Safety ……..……. 48
- 4.1 Vehicle Accidents …….. 49
- 4.2 Health Effects …… 49
- 4.3 Grassland Wildfire Entrapment …….. 50
- 4.4 Aircraft/Heavy Equipment ……. 52
- 4.5 Wildland/Urban Interface ……..…. 52
- 4.6 Summary ……. 52

# Grassland Wildfire Operations (S-100G)

## Unit 1 – Grassland Wildfire Awareness

**Objectives: Upon completion of this lesson, the trainee will be able to:**

- Discuss jurisdictional responsibilities for grassland wildfire in Alberta
- List the five primary management functions in ICS and discuss the concept of Unified Command on a grassland wildfire incident
- List initial action priorities to be considered on a grassland wildfire incident

# 1 Grassland Wildfire Awareness

## 1.1 Introduction

Grassland wildfires occur in forested and non-forested settings, typically in the spring and fall seasons, when grass fuels are cured and present unique challenges to fire suppression personnel.

Rapid rates of spread, intense wildfire behaviour, significant values at risk, and multiple agencies responding result in complexities that challenge first responders.


CALGARY HERALD

ONLINE www.calgaryherald.com MONDAY, DECEMBER 15, 1997

Southern ranchers lose homes | Villagers flee oncoming flames | Blazes rage in Alberta forests

Aerial view of a massive prairie fire northwest of Lethbridge Sunday. Residents were forced to flee the flames and some farm buildings were destroyed

Wildfires scorch parched prairie

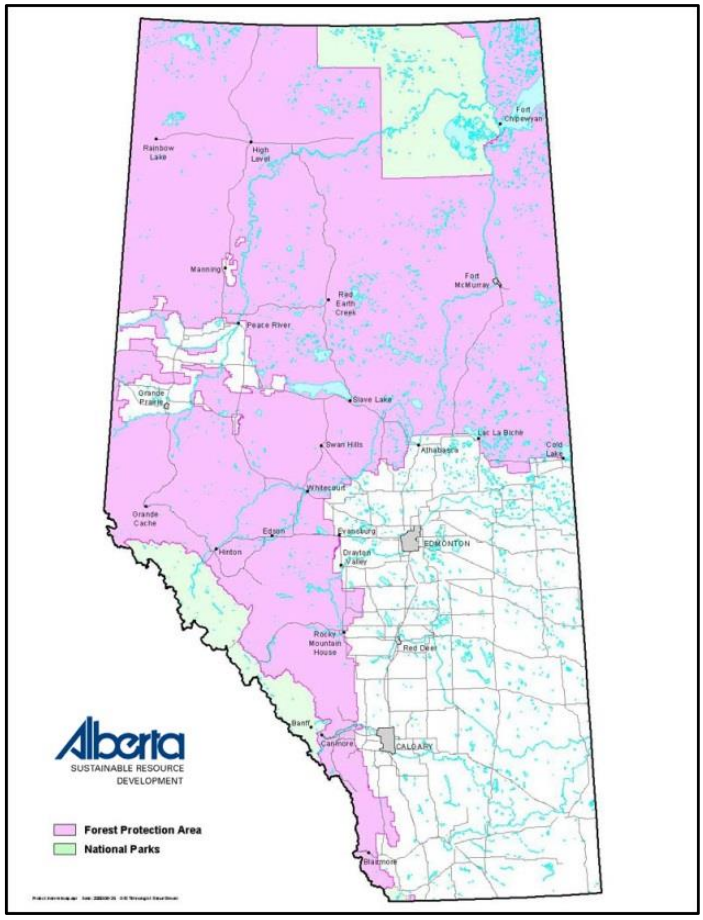
There are many factors that will affect critical decision-making and require situational awareness for firefighter safety on grassland wildfires.

- Jurisdictional responsibilities
- Command and control structures
- Resource accountability
- Incident communications planning

## 1.2 Jurisdictional Responsibilities

There must be a clear understanding of jurisdictional responsibility by each agency responding to any wildfire incident. Responsibility and authority for taking action or not taking action on a wildfire incident are provided for under provincial and/or federal legislation. In Alberta, two pieces of provincial legislation apply; these include the *Forest and Prairie Protection Act* and the *Municipal Government Act*. It is up to each agency to clearly understand their jurisdictional responsibilities and requirements. Also, many agencies will have policy that clearly states how they will conduct their operations and manage wildland fire incidents within their own respective jurisdictions.

Wildfires within the Forest Protection Area of Alberta are managed by the Provincial government and wildfires outside the Forest Protection Area are managed by the local authority.




When an agency responds to a wildfire incident under another jurisdiction, they should be doing so under the request of the appropriate authority and respond as an assisting agency only. The overall responsibility for the management of any wildfire incident lies with the agency that has the legal jurisdictional mandate for controlling and managing the incident.

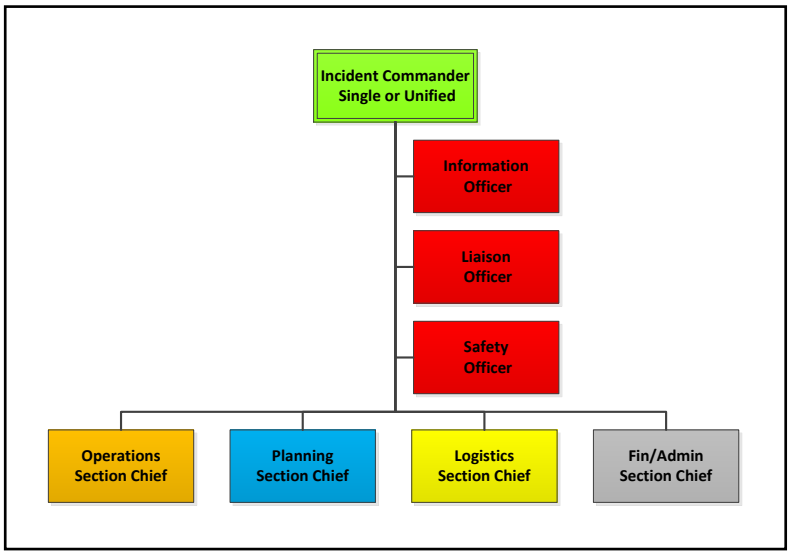
Local authorities often have mutual-aid agreements with other fire departments to assist or respond to wildfires in their areas, however, there are many other cases where no agreements exist and this may present problems including:

- Who is going to pay for what
- What are the cost recovery procedures
- Who accepts liability
- Who approves the level of action required
- Are the actions taken by the responding agency acceptable

Where wildland fire incidents cross over multi-jurisdictional boundaries, a Unified Command structure should be considered. This will allow all agencies with jurisdictional responsibility to manage the incident collaboratively.

# 1.3 Incident Command System Overview

The Incident Command System is a standardized on-scene, all-hazards emergency management system that allows users to adopt an integrated organizational structure equal to the complexity and demands of single or multiple incidents, without being hindered by jurisdictional boundaries.

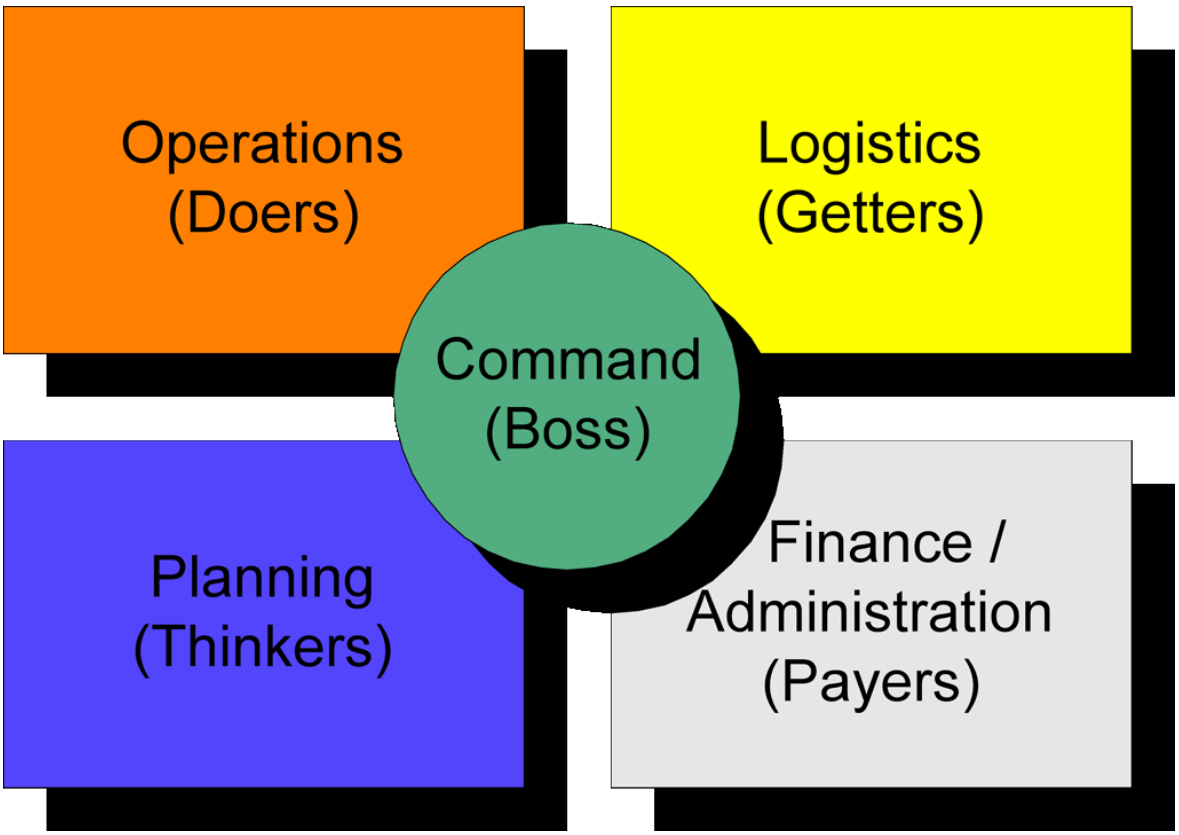



ICS is effective for the following reasons:

- Is accepted as the standard incident management system within Canada
- Works for all incidents – big and small
- Wildland fire, structural fire, and enforcement/public safety agencies may all work together under the same incident organization to achieve common incident objectives.
- Clearly defines responsibility of an Incident Commander and provides a mechanism to define "who is in charge"
- Provides common terminology and practices for incident management
- Addresses multi-agency and multi-jurisdictional incidents through the Unified Command concept:
    - Unified Command is "a command structure which provides for all agencies or individuals who have geographical or functional jurisdictional responsibility to jointly manage an incident through a common set of objectives."
    - When responding to a multi-jurisdictional incident, the command function may be comprised of an individual from each agency. These individuals form the command function and will work together to make decisions by consensus.

ICS uses five primary management functions:

- **Command** – The Incident Commander is responsible for all incident activity. This is the only function that must be filled for every incident response and if so, then the Incident Commander is also responsible for the other functions. Incident Command may be Single or Unified.
- **Operations** – The Operations Section is responsible for directing and conducting the tactical actions to meet the incident objectives.
- **Planning** – The Planning Section is responsible for the collection, evaluation, and display of incident information, maintaining resource status, and preparing the Incident Action Plan and incident-related documentation.
- **Logistics** – The Logistics Section is responsible for providing adequate services and support to meet all incident needs.
- **Finance/Administration** – The Finance/Administration Section is responsible for keeping track of incident-related costs, personnel and equipment records, and administering procurement contracts associated with the incident.



## 1.4 Initial Operations

Initial on-scene firefighting resources often encounter a chaotic situation including multiple incoming resources, congested radio communications, panicked residents, and traffic congestion from vehicles moving in and out of the fire scene.

The first on-scene Incident Commander must quickly conduct size-up, set priorities, develop a mental action plan, and delegate responsibilities.

**Maintain situational awareness, develop needed intelligence, organize available resources and order additional support. Maintain the "*big picture*" at all times.**

### 1.4.1 Initial Action Priorities

- Conduct size-up and report back to dispatch
- Notify local authority Director of Emergency Management if incident support is required
- Identify escape routes and safety zones and communicate them to firefighters
- Post lookouts to provide updated information on the proximity of the fire front if not obvious
- Establish a Staging Area and Check-In process for incoming resources and designate a Staging Area Manager
- Provide operational briefings to resources prior to tactical assignment
- Request assistance from law enforcement agencies for evacuation and traffic control
- Establish separate Command and Tactical radio frequencies if needed

### 1.4.2 Resource Accountability and Staging Areas

Resources and personnel, including volunteers, arriving at a grassland wildfire incident must go through a check-in process to ensure they are accounted for. In some cases, especially at the beginning of an incident, resources and personnel may be requested to report directly to the fire for tactical assignment. In this situation, the immediate supervisor(s) on the grassland wildfire are responsible for the resource check-in process.

The check-in process allows for:

- Personnel accountability and safety
- Resource coordination and organization
- Briefings to be conducted prior to being tactically assigned

The check-in process may occur at any of the following locations:

- Incident Command Post
- Staging Areas

The Staging Area is the location where resources available for tactical assignment are held until needed. Staging Areas allow for resources and personnel to be organized, coordinated and to be provided with direction prior to deployment on the grassland wildfire. Staging Areas established near the incident will allow all incoming personnel and resources to gather at these areas allowing the Incident Commander or Operations Section Chief to effectively organize resources and personnel into effective work units. Requesting operational resources and personnel to arrive at a Staging Area will provide for more resource control and prevent resources and personnel from "freelancing".

The Staging Area will be given a name that describes their general location. The Staging Area will be assigned a Staging Area Manager who will coordinate and dispatch resources as requested by the IC, Operations Section Chief or their designate. The Staging Area Manager reports directly to the Operations Section Chief or to the IC if the Operations Section Chief position has not been activated.

Staging Areas should:

- Be situated out of any direct line of threat to minimize risk
- Be relocated if necessary
- Be large enough to accommodate available resources and have room for growth
- Be clearly marked
- Have necessary security controls
- Be located to minimize environmental damage
- Have different access routes for incoming and outgoing resources

## 1.4.3 Briefing and Deployment

Prior to tactical assignment resources must be given a thorough operational briefing to ensure that resources understand the incident objectives and their assignments to achieve those objectives. Operational briefings may be provided at the Staging Area during the early hours of an incident or at the Incident Command Post during the extended-attack phase of the incident and should include:

- Tactical assignments
- Chain-of-command, who they will report to, and their supervisory responsibilities
- Communications plan – consider Command and Tactical frequencies
- Medical emergency procedures
- Contingency plans
- Ensure everyone understands their assignments
- Provide maps if available
- Stress safety and situational awareness

## 1.4.4 Radio Communications

Effective communication is a critical component of safe and effective grassland wildfire operations. Grassland wildfires often involve significant numbers of resources from different fire departments and agencies responding in a very short time period, resulting in the inability to communicate with resources due to overloaded or unknown frequencies.

Firefighters must be familiar with the Incident Communication Plan. Communications plans may be pre-determined in pre-attack plans or may be determined on the incident based on the resources on-scene and incident size and complexity. It is not always necessary or practical to have a written communications plan on small low complexity incidents however, as the incident becomes more complex, the Incident Commander should consider a written communications plan. In any case, it is the responsibility of the Incident Commander, all supervisors, and each individual to ensure that the communications plan is known and understood by every person on the incident.

***Meet with your mutual-aid partners prior to the incident to discuss interface incident communications.***

Radio networks for large incidents may be organized as follows:

| | |
|---|---|
| **Command Net** | This net should link together Incident Command, Command Staff, Section Chiefs, Branch Directors, Division and Group Supervisors |
| **Tactical Nets** | There may be several tactical nets established around agencies, geographical areas, or specific functions |
| **Support Net** | A support net may be established primarily to handle status changing for resources as well as logistical requests and on non-tactical functions |
| **Air-to-Ground Net** | A tactical frequency may be designated to coordinate air-to-ground traffic |
| **Air-to-Air Net** | Air-to-Air nets will normally be pre-designated and assigned for use at an incident |

The Alberta Provincial Mutual-Aid Fire channel is a VHF frequency (156.855 MHz) that many municipal fire departments and all Alberta ESRD wildfire personnel have programmed on their radios. This channel is the recommended Command frequency for mutual-aid communications between municipal and provincial supervisory fire personnel in the early stages of mutual-aid wildfire. **The Provincial Mutual-Aid Fire channel should always be programmed as wide-band (25khz).** Communication issues including one-sided, garbled, intermittent, or non-existent transmissions have been found between radios programmed with the Provincial Mutual-Aid Fire channel in wide-band and narrow-band.

On complex grassland wildfire incidents, it is recommended to develop separate Command and Tactical nets at a minimum, to reduce the congestion on radio channels.

**Exercise/Discussion**

**Take 10 minutes to brainstorm and discuss the type(s) of communications systems used in your local area. Answer these questions as a group:**

- **What methods are used (cellular, satellite phone, FM radio – VHF or UHF)?**
- **How will you communicate with air-tanker resources on the fire?**
- **What are the current "gaps" in communications between agencies and stakeholders who will most likely be involved in an incident**
- **How can these communication "gaps" be improved by using the currently available communications equipment and systems?**

## 1.5 Summary

There are many factors that will affect critical decision-making and require situational awareness for firefighter safety on grassland wildfires.

- Jurisdictional responsibilities
- Command and control structures
- Resource accountability
- Incident communications planning

There must be an understanding of jurisdictional responsibility by each agency responding to any wildland fire incident and a clear Incident Command System organization to provide resource accountability, unity and chain of command, incident action planning, and communications planning and processes.

# Grassland Wildfire Operations (S-100G)

## Unit 2 – Grassland Wildfire Behaviour

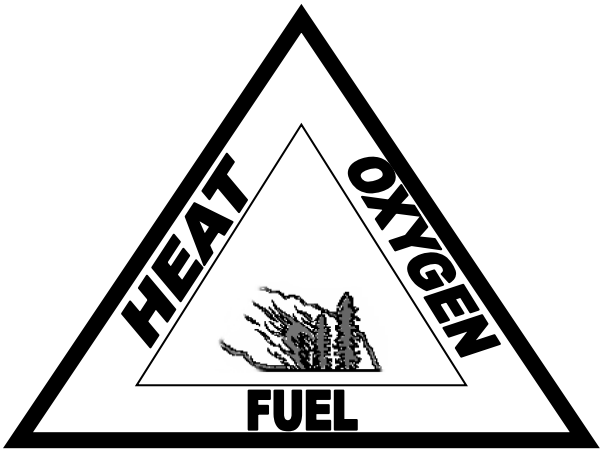
**Objectives: Upon completion of this lesson, the trainee will be able to:**

- Describe the Fire Triangle and how removing sides extinguishes grassland wildfire
- Explain the methods of heat transfer
- Name the three sides of the Fire Behaviour Triangle
- Name and describe seven terms used to describe various types of fire behaviour
- Name the parts of a fire
- Discuss the basic components of the Canadian Forest Fire Danger Rating System

# 2 Grassland Wildfire Behaviour

## 2.1 Fire Triangle

All fires are the result of a chemical process that occurs when fuel, heat and oxygen interact. Ignition will not occur and fire will not continue to burn without all three of these components present. To control or extinguish a fire it is necessary to remove one or more sides of the fire triangle - this is called breaking the fire triangle.




Some methods of breaking the fire triangle include:

- Reducing **heat** by cooling the fire with water
- Cutting off the **oxygen** supply by covering the fire with mineral soil
- Removing **fuel** by constructing a bulldozer line and burning out

**Limitations**

Each method of removing a side of the fire triangle has limitations:

- Removing **heat** by using water may not be possible due to evaporation or not enough water available for application
- Mineral soil may not completely cut off the **oxygen** supply
- Fire can often jump a **fuel** break if it is not wide enough

## 2.2 Heat Transfer

As fuel burns, heat is transferred from burning fuels to unburned fuels. The unburned fuels are preheated to their ignition temperature. The combustion process is repeated, causing the fire to spread if oxygen and fuel are still available.

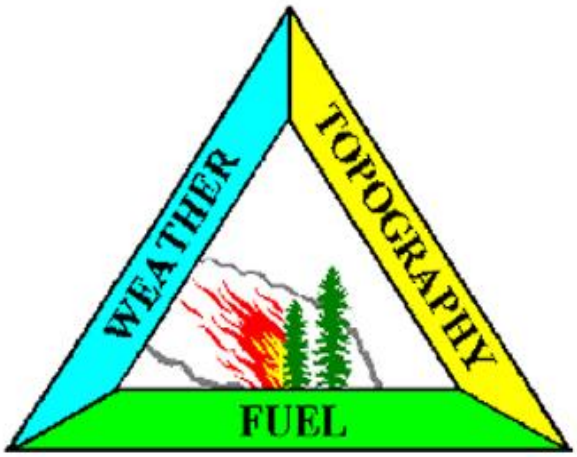
Heat is transferred from burning fuels to unburned fuels by three methods:

- **Convection -** The transfer of heat by the movement of masses of hot air
- **Conduction -** The transfer of heat through a solid
- **Radiation -** The transfer of heat, in straight lines, from warm surfaces to cooler surroundings

In a grassland wildfire, one or all three methods of heat transfer may be taking place at the same time.

## 2.3 Fire Behaviour Triangle

Fire behaviour is the manner in which fuel ignites, flame develops, and fire spreads as determined by the interaction of fuels, weather and topography.




**Factors Affecting Fire Behaviour**

There are three groups of factors that affect fire behaviour:

1. Fuel
2. Weather
3. Topography

Together they are known as the **fire behaviour triangle**.

## 2.3.1 Fuel

Fuel characteristics affecting grassfire behaviour include:

- Fuel moisture content and degree of curing
- Fuel quantity
- Fuel arrangement

**Fuel Moisture Content -** is the single most important factor that determines the potential for the fuel to burn. Flammability and burning characteristics depend on the moisture content in dead fuels - as moisture content decreases, fire behaviour increases.

Curing refers to the annual drying of native grasslands and crops as the plant dies or becomes dormant in the late season. The degree of curing is the proportion of cured and/or dead plant material in a grassland fuel complex expressed as percentage. The degree of curing has a major effect on fire spread.

- Fires will have minimal spread when grasslands are less than 50% cured – when curing is between 75-100% significant fire spread can occur
- Previous year's dead grass contributes to the percent cured, and even growing grass may be considered more than 50% cured in un-grazed or infrequently burned grasslands with many years grass litter

**<50% Cured**

**50-60% Cured**

**70-80% Cured**

**90-100% Cured**

**Use extreme caution suppressing fire in fully cured grasslands - they can be hazardous.**

**Fuel Quantity -** refers to the amount of available fuel found over a designated area - available fuel is fuel that is dry enough to burn. Areas with greater amounts of fuel will burn more intensely and give off more heat energy, preheating available nearby fuels more quickly. **Heavy grass loads can be hazardous!**

**Fuel Arrangement -** refers to the horizontal and vertical distribution of combustible materials within a particular fuel type. Fuel compactness and continuity are assessed and have a significant effect on:

- Transfer of heat
- Rate of combustion
- Rate of fire spread
- Fire intensity

*Fuel compactness* (standing or matted) affects fire behaviour. Standing grass supports higher spread rates than matted grass because heat transfer and air movement is not hindered.

**Matted Grass (O-1a) FBP Fuel Type**

**Standing Grass (O-1b) FBP Fuel Type**

*Fuel continuity* has a major influence on fire behaviour. Roads, trails, summer fallow, and grazed pastures break up fuel continuity and may limit the spread of grassfires. The effectiveness of roads as firebreaks depends on the width of the road and the fire intensity. Narrow trails are easily breached by grassfires. The presence of brush along the roadside greatly increases the probability of breaching due to firebrands.

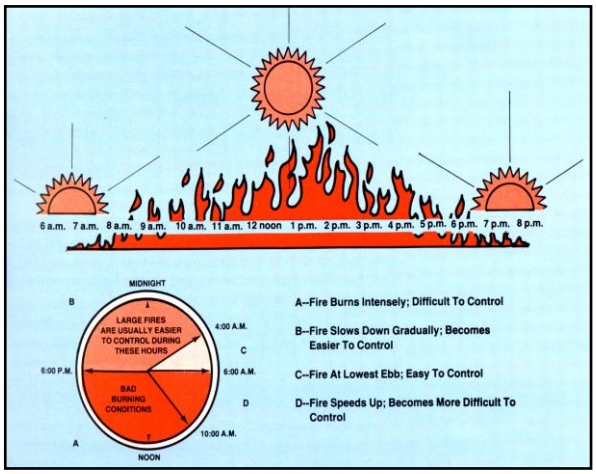
## 2.3.2 Weather

Weather features exert the biggest influence on grassfire behaviour by controlling fuel moisture and providing wind as a spread mechanism. There are five weather factors that affect grassfire behaviour:

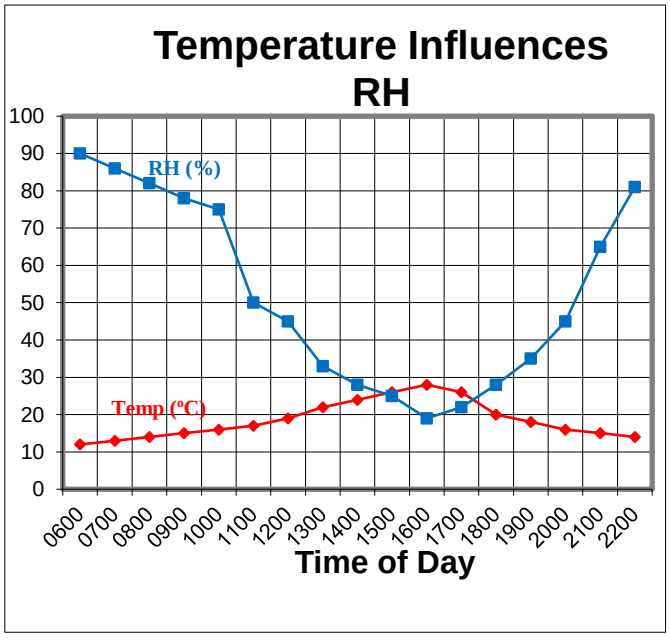
- Temperature
- Relative Humidity (RH)
- Wind
- Precipitation
- Atmospheric Stability/Instability

**Temperature**

Temperature affects the rate of evaporation of fuel moisture. As the temperature rises, more moisture evaporates and fuels become drier. An increase in atmospheric temperature also affects fuel temperature. As the temperature increases so does the temperature of the fuels which means less applied heat is needed to raise fuel to its ignition temperature.




Temperature is affected by the time of year and, more importantly, by the time of day. Temperatures are normally highest during the burning period between 10:00 and 18:00 hours.




**Relative Humidity (RH)**

RH is the amount of moisture in a parcel of air compared to the maximum amount of moisture the parcel can hold at that temperature and atmospheric pressure expressed as a percentage (%). It is affected by either a change in temperature or a change in the amount of moisture in the air.

As the temperature increases - RH decreases and vice-versa, therefore RH is affected by changes in temperature throughout the cycle of day and night (i.e., RH drops during the day and rises at night). Cured grass readily absorbs and exchanges moisture from the surrounding air thus fuel moisture follows a similar cycle, with peak burning conditions usually occurring in the late afternoon.

RH affects the moisture content of grass fuels which influences fire behaviour:

- Fire behaviour is normally low when the RH is greater than 65%
- Fire behaviour increases noticeably when the RH is less than 40%
- Fire behaviour  may become extreme when the RH is 25% or lower

Crossover occurs when temperature in Celsius is greater than relative humidity in percent and indicates the potential for extreme fire behaviour.

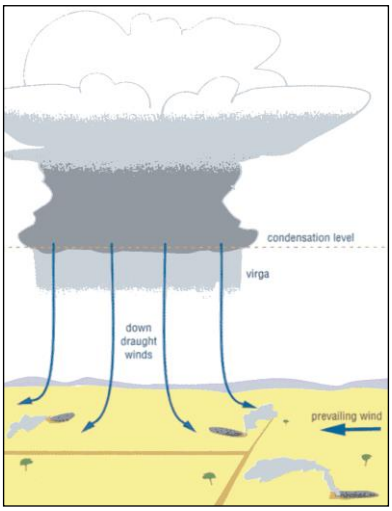
**Wind**

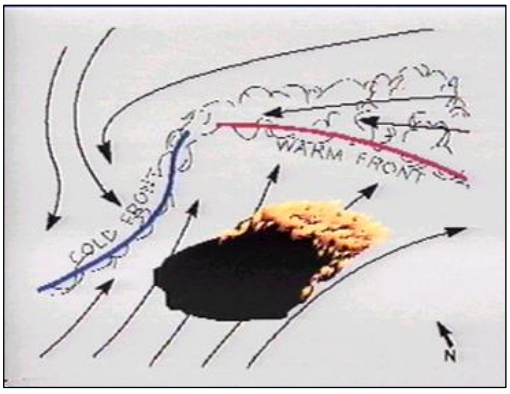
Wind has the greatest impact on fire spread direction, rate of spread, and size and shape of the fire.  The greatest spread will be in the direction the wind is blowing – if the wind is from the west the fire will be spreading to the east.  As wind speed increases, a fires rate of spread increases.

Wind speed also determines the shape of grassfires.  A fire burning with no wind will have a circular perimeter, the stronger the wind, the narrower and more elongated the fire will be.

***Thunderstorms***

Thunderstorms can be dangerous to firefighters due to downdrafts.  Downdrafts bring more oxygen to the fire and produce gusty, erratic winds.  This can increase fire behaviour causing flare-ups and changing the direction of fire spread. Firefighters should move to a safety zone during a thunderstorm.




***Cold Fronts***

A cold front may not be visible but is usually predicted in a weather forecast.  Cold fronts typically approach from the northwest.  Ahead of the cold front, winds are usually from the south or southwest.  After the cold front passes the wind will be from the north or northwest.

This wind shift can become problematic for firefighters as previously quiet portions of the fire become the head.

**Precipitation**
Lack of precipitation over a long period of time results in drought conditions. All wildland fuels become extremely dry resulting in increased amounts of fuel available to burn. More fuel available to burn means increased fire intensity and difficulty to control and extinguish.

Rain or dew quickly wets cured grass fuel to the point where it will not burn. Once the rain has stopped, grass can quickly start to dry within hours depending on the air moisture content.

Understanding and monitoring weather conditions is critical to safe and efficient firefighting. Firefighters must monitor weather conditions and be able to predict changes in the weather.

## 2.3.3 Topography

Topography refers to the physical features of the earth's surface. These features can slow or increase fire behaviour. The layout of physical features (hills, valleys, lakes) forms a topographic pattern that may funnel winds, increasing wind speed and changing wind direction.
Topographical features affecting grassland wildfire behaviour include:

- Slope
- Aspect
- Elevation
- Shape of the country

**Slope**
Fires will usually move faster uphill than downhill and the steeper the slope, the faster the fire will move. This is due to several factors:

- Flames are tilted closer to unburned fuels ahead of the fire thus pre-heating fuels
- Normal wind flow on a slope is uphill during the day which accelerates the spread
- Hot air from the fire rises up the slope increasing the convective upslope winds and pre-heating of fuels

**Be aware of grassfires on slopes below you - they want to run uphill quickly!**

**Aspect**
The aspect of a slope refers to the direction that a slope faces. Fuels are generally drier on slopes with a southern aspect because a south-facing slope is exposed to the sun longer and loses its snow cover earlier in the spring and dries quicker during the day.

South-facing slopes will receive more direct sunlight than north facing slopes and generally have:

- Higher temperatures
- Lower relative humidity
- Stronger upslope winds
- Lighter, flashy fuels

Flammability of grass fuels varies both by aspect and by the time of day. Early in the morning, east-facing slopes are flammable first. Flammability then tracks with the sun, with south and southwest facing slopes being the most flammable.

**Watch-out when the slope, the sun angle and the wind direction are all in alignment.** For example, fire on south-facing slope in the mid-afternoon with a south wind blowing.

**Elevation**
Elevation has an effect on each of the following fire behaviour factors:

- Temperature
    - Valley bottoms will typically have greater daily change in temperature:
        - Higher temperatures during the afternoon
        - Lower temperatures during the night
    - Temperatures generally decrease with elevation

- Relative humidity
    - Slopes typically have less change in relative humidity than valley bottoms
    - Valley bottoms will typically have:
        - Lower relative humidity during the afternoon
        - Higher relative humidity during the evening

- Wind
    - Winds generally increase with elevation
    - Changes in wind speed between the valley bottom and the ridge top can be dramatic

**Shape of the Country**
The general lay of the land will affect fire behaviour. Barriers may impede fire spread while terrain may alter wind direction and speed causing fire behaviour to change. Wind flows much like water in a stream and follows the path of least resistance.

Chimneys or steep draws channel fire by concentrating wind, radiation and convection. The spread rate of fire up-draws is accelerated. **Watch out!**

Other dangerous terrain features include narrow canyons and saddles which may create wind eddies and erratic fire behaviour.

Natural or constructed barriers to fire spread may include:

- Cultivated or cleared land
- Rivers or creeks
- Roads

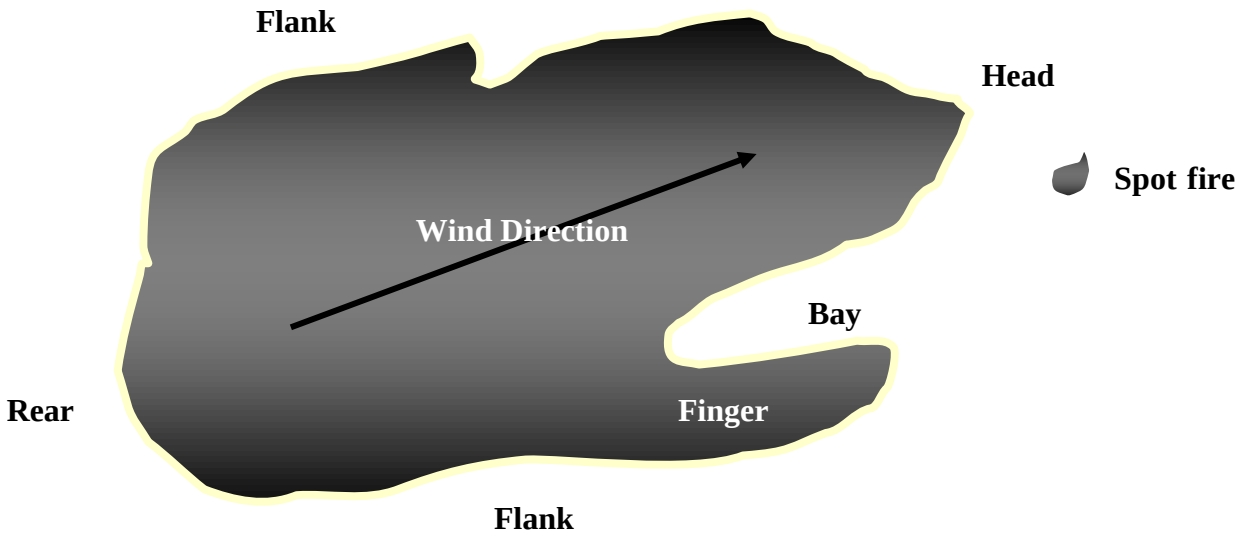
Barriers can act to slow down or change fire spread and behaviour and may allow opportunity for fire suppression personnel to contain the fire.

## 2.4 Fire Behaviour Terms

Fire behaviour is described by the following terms:

| | |
|---|---|
| Smoldering | A fire burning without visible flame and barely spreading through the fuel layers |
| Creeping | A fire spreading slowly through the surface fuels, generally with a low flame front |
| Running | A fire rapidly spreading with a well-defined front or head |
| Torching/Candling | A single tree or a small clump of trees igniting and flaring up from the base to the top |
| Spotting | Firebrands from the main fire are carried aloft by the surface wind, a fire whirl or the convection column, and fall beyond the main fire perimeter causing spot fires to occur |
| Crowning | A fire ascending into the crown of trees and spreading from crown to crown |

## 2.5 Parts of a Fire



## 2.6 Canadian Forest Fire Danger Rating System

The Canadian Forest Fire Danger Rating System (CFFDRS) is currently used by wildland fire agencies across the country as an operational decision-making aid. There are two main sub-systems:

- ***Fire Weather Index (FWI) System*** - provides numerical ratings of relative fire potential based solely on weather observations

- ***Fire Behaviour Prediction (FBP) System*** - accounts for variability in fire behaviour among fuel types, predicting rate of spread, fuel consumption, and frontal fire intensity

### 2.6.1 Fire Weather Index (FWI) System

The FWI system depends on continuous daily measurements of temperature, relative humidity, 10m open wind speed, and 24-hour cumulated precipitation recorded at noon local standard time. These weather observations are then used to determine three fuel moisture codes and three fire behaviour indexes. Moisture code values increase with decreasing fuel moisture.

| Component | Abbreviation | Definition |
|---|---|---|
| Fine Fuel Moisture Code | FFMC | A numerical rating of the moisture content of litter and other cured fined fuels. This code is an indicator of the relative ease of ignition and flammability of fine fuel |
| Duff Moisture Code | DMC | A numerical rating of the average moisture content of loosely-compacted organic layers of moderate depth. This code gives an indication of fuel consumption in moderate duff layers and medium-size woody material |
| Drought Code | DC | A numerical rating of the average moisture content of deep, compact organic layers. This code is a useful indicator of seasonal drought effects on forest fuels and amount of smouldering in deep duff layers and large logs |
| Initial Spread Index | ISI | A numerical rating of the expected rate of fire spread without the influence of variable quantities of fuel |
| Buildup Index | BUI | A numerical rating of the total amount of fuel available for combustion that combines DMC and DC |
| Fire Weather Index | FWI | A numerical rating of fire intensity that combines ISI and BUI. It is suitable as a general index of fire danger in forested areas of Canada |

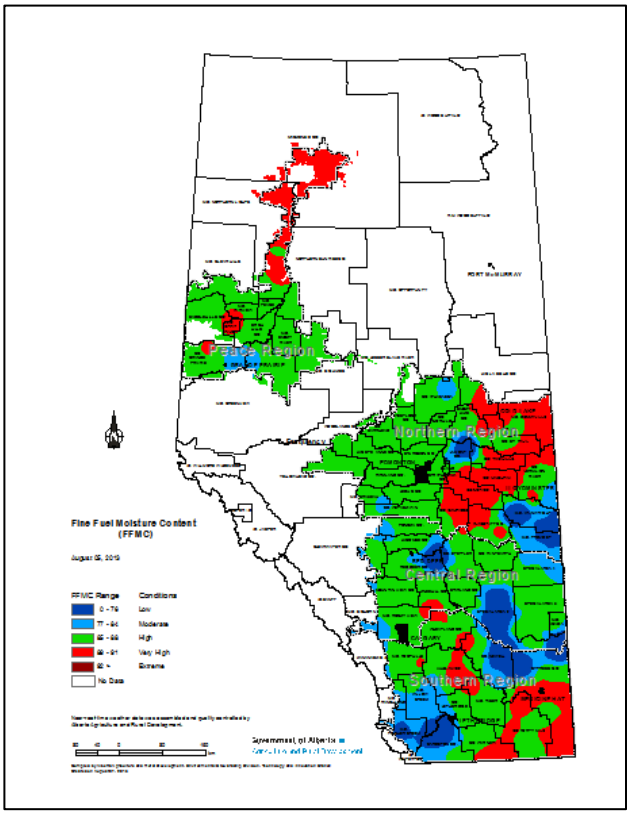
**In grassland environments, fire danger is a function of the FFMC and ISI**, as duff and deeply compacted organic matter do not contribute to fire behaviour. For aspen parkland areas the DMC, DC and BUI must also be considered.

**Fire Weather Indices and Fire Hazard Rating**

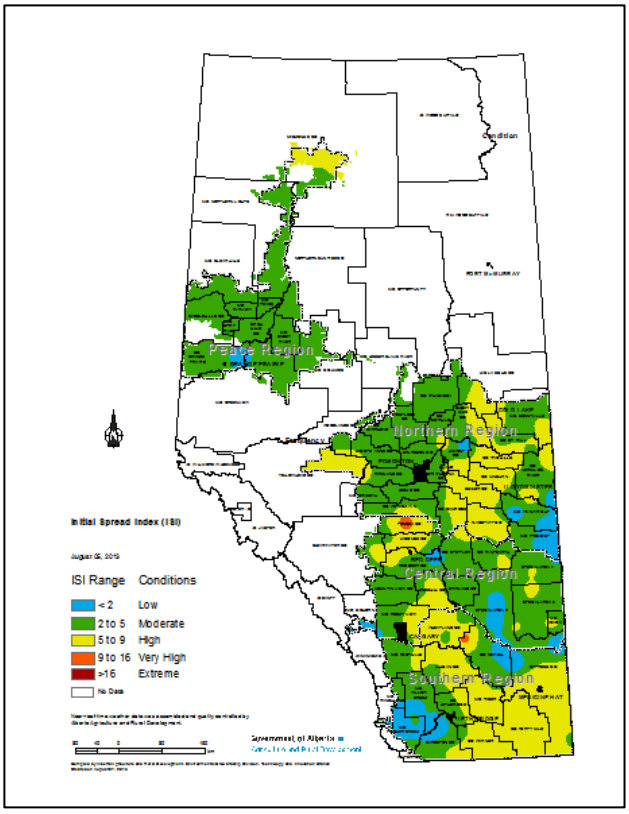
| Hazard Rating | FFMC | DMC | DC | ISI | BUI | FWI | HFI |
|---|---|---|---|---|---|---|---|
| Low | 0-76 | 0-21 | 0-79 | 0-1.5 | 0-24 | 0-4.5 | 1-2 |
| Moderate | 77-84 | 22-27 | 80-189 | 2-4 | 25-40 | 4.5-10.5 | 3 |
| High | 85-88 | 28-40 | 190-299 | 5-8 | 41-60 | 10.5-18.5 | 4 |
| Very High | 89-91 | 41-60 | 300-424 | 9-15 | 61-89 | 18.5-29.5 | 5 |
| Extreme | 92+ | 61+ | 425+ | 16+ | 90+ | 29.5+ | 6 |

## Alberta Agriculture Fire Weather Indices Maps

Fire weather monitoring requires daily observations at 12:00 hours local standard time. The ability of volunteer fire-fighting organizations to conduct such a monitoring program may be unreasonable. The Alberta provincial government provides basic fire hazard indices (FFMC and ISI) for the agricultural lands portion of the province at:
http://www.agriculture.alberta/acis/climate-maps.jsp




**Fine Fuel Moisture Code (FFMC)**




**Initial Spread Index (ISI)**

### 2.6.2 Fire Behaviour Prediction (FBP) System

The FBP system provides quantitative estimates of head fire spread rate, fuel consumption, fire intensity, and fire description. With the aid of an elliptical fire growth model, it provides estimates of fire size and shape.

The FBP system relies on series of equations, requiring either the use of a computer or a series of tables to determine fire behaviour intensity and rate of spread. For grasslands, the following inputs are required:

- Fuels - tonnes/ha, standing or matted, degree of curing
- Weather - FFMC, ISI
- Topography - slope, aspect

Head Fire Intensity (HFI) is the predicted intensity at the head of the fire, measured in kilowatts per metre of fire front and is based on rate of spread and total fuel consumption. It is one of the standard gauges by which fire managers estimate the difficulty of controlling a fire and select appropriate suppression methods.

| Head Fire Intensity Class (HFI) | Description |
|---|---|
| **1** (<10kW/m) | • New fire starts are unlikely to sustain themselves due to moist surface fuel conditions<br>• Fire starts generally do not spread much beyond their point of origin and control is easily achieved |
| **2** (10-500kW/m) | • Surface fuels are sufficiently receptive to sustain ignition and combustion from flaming and glowing firebrands<br>• Fire activity is limited to creeping or light surface burning with maximum flame heights of 1.3m<br>• Direct attack and hot-spotting is possible |
| **3** (500-2000kW/m) | • Moderate to highly-vigorous surface fires with flame heights to just over 1.5m and/or intermittent crowing and torching<br>• Moderate difficulty to control – pumps/hose lays and heavy equipment are generally required for effective action on the head |
| **4** (2000-4000kW/m) | • Burning conditions have become critical and control is very difficult<br>• Any attempt to attack the fire's head should be with aircraft dropping long-term retardant |
| **5** (4000-10,000kW/m) | • Control is extremely difficult and direct control efforts are likely to fail<br>• Suppression action with ground forces must be restricted to the flanks and rear of the fire, consider indirect attack for the head of the fire |
| **6** (>10,000kW/m) | • Fire behaviour considered as "explosive" – rapid spread rates, firewhirls, intense flame fronts will occur<br>• Serious control problems exist until burning conditions lessen<br>• The only safe and effective control actions that can be taken by ground forces are at the flanks and rear of the fire |

## 2.7 Grassfire Behaviour Field Guide

New Zealand fire behaviour specialists developed a field guide for the prediction of grassland fire behaviour in periods of extreme fire danger. Key elements of both the FWI and FBP systems as they apply to grassland fire environments were combined to produce the simple field guide. The guide is useful for judging the potential fire behaviour in grasslands under severe burning conditions. The guide assumes the following:

- 100% cured standing grass (O-1b)
- Average fuel load of 3.5 tonnes/ha
- Level or undulating terrain
- Fire at equilibrium
- Grass moisture content 7.5%

These assumptions may result in the both the over-prediction and under-prediction of grassfire behaviour. Nonetheless, the card is an excellent aid for rapid assessment of fire potential.

The only input required for grassfire behaviour prediction is an estimation of wind using the Beaufort Wind Force scale.

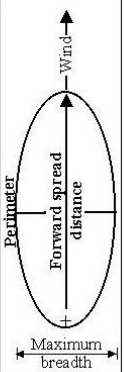
**Keep this card handy and use it before fire engagement!**

**Exercise:**
Based on a wind speed of 50 kmh, determine the grassfire rate of spread, intensity class, and the length and breadth of the fire in two-hours

**A SIMPLE FIELD GUIDE FOR ESTIMATING THE BEHAVIOUR AND SUPPRESSION REQUIREMENTS OF FIRES DRIVEN BY WIND COMING FROM A CONSTANT DIRECTION, IN OPEN, FULLY CURED GRASSLANDS AT LOW FUEL MOISTURE.**

**Caution:** Flame heights at the fire's head will be greater than 2.5 metres. Under NO circumstances should direct attack be mounted on the head fire. Any containment action must begin from a secured anchor point and progress along the flanks toward the head as the fire edge or perimeter is "knocked down".

| Beaufort Wind Force[a] | Forward spread distance/perimeter length/maximum breadth versus elapsed time since ignition ----------kilometres---------- 0.5 hour | 1 hour | 1.5 hour | 2 hour | Head fire intensity --kW/m-- | Head fire flame length -metres- | Minimum firebreak width required to stop head fire[b] -------metres------ Trees absent | Trees present |
|---|---|---|---|---|---|---|---|---|
| 0-1 | 0.7/2.4/0.4 | 1.3/4.9/0.7 | 2.0/7.3/1.1 | 2.6/9.8/1.4 | 2300 | 2.7 | 5 | 12 |
| 2 | 1.0/2.7/0.4 | 2.0/5.5/0.7 | 2.9/8.2/1.1 | 3.9/10.9/1.5 | 3450 | 3.3 | 6 | 13 |
| 3 | 1.6/3.7/0.4 | 3.2/7.4/0.8 | 4.8/11.1/1.2 | 6.3/14.8/1.6 | 5550 | 4.1 | 7 | 15 |
| 4 | 2.7/5.7/0.6 | 5.3/11.5/1.1 | 8.0/17.2/1.7 | 10.7/22.9/2.2 | 9350 | 5.2 | 8 | 30+ |
| 5 | 4.4/9.1/0.8 | 8.7/18.2/1.5 | 13.1/27.3/2.3 | 17.5/36.4/3.1 | 15 300 | 6.5 | 10 | 30+ |
| 6 | 6.1/12.5/1.0 | 12.2/25.0/1.9 | 18.2/37.5/2.9 | 24.3/50.0/3.8 | 21 300 | 7.6 | 12 | 30+ |
| 7 | 7.2/14.8/1.0 | 14.5/29.5/2.0 | 21.7/44.3/3.1 | 28.9/59.1/4.1 | 25 300 | 8.2 | 13 | 30+ |
| 8 & higher | 7.5/15.2/1.0 | 15.0/30.5/2.1 | 22.5/45.7/3.1 | 30.0/60.9/4.1 | 26 200+ | 8.4+ | 14+ | 30+ |




[a] See reverse side for details on the Beaufort Wind Scale.

[b] The "Trees absent" and "Trees present" classes refer to the absence or presence of trees/scrub within 20 meters of the windward side of the firebreak. The presence of trees or scrub has a significant influence on firebreak effectiveness because they supply woody material for firebrands which can spot across the break.

**Beaufort Wind Scale for estimating 10 - m open wind speed over land**

| Beaufort Wind Force | Descriptive Term | 10 - m wind speed ---km/h--- | Observed wind effects |
|---|---|---|---|
| 0 | Calm | < 1 | Smoke rises vertically. |
| 1 | Light air | 1 to 5 | Direction of wind shown by smoke drift but not by wind vanes. |
| 2 | Light breeze | 6 to 11 | Wind felt on face; leaves rustle; ordinary vanes moved by wind. |
| 3 | Gentle breeze | 12 to 19 | Leaves and small twigs in constant motion; wind extends light flags. |
| 4 | Moderate breeze | 20 to 28 | Wind raises dust and loose paper; small branches are moved. |
| 5 | Fresh breeze | 29 to 38 | Small trees in leaf begin to sway; crested wavelets form on inland waters. |
| 6 | Strong breeze | 39 to 49 | Large branches in motion; whistling heard in telephone wires; umbrellas used with difficulty. |
| 7 | Moderate gale | 50 to 61 | Whole trees in motion; inconvenience felt when walking against wind. |
| 8 | Fresh gale | 62 to 74 | Breaks twigs off trees; generally impedes progress. |
| 9 | Strong gale | 75 to 88 | Slight structural damage occurs (e.g., TV antennas and tiles blown off). |
| 10 | Whole gale | 89 to 102 | Seldom experienced inland; trees uprooted; considerable structural damage. |


**Note:** Fire behaviour predictions in this guide are based on head fire rate of spread in fully cured standing grasslands (Fire Behavior Prediction System Fuel Type O-1b) on flat to undulating terrain, assuming a fuel load of 3.5 t/ha, a Fine Fuel Moisture Code of 93.2, and the midpoint of the wind speed range associated with each Beaufort Wind Force. Use of the Guide is at the reader's sole risk.

NEW ZEALAND FOREST RESEARCH INSTITUTE

FIRE

## 2.8 Summary

All fires are the result of a chemical process known as the Fire Triangle, which occurs when ***fuel***, ***heat*** and ***oxygen*** interact. To control or extinguish a fire it is necessary to remove one or more sides of the fire triangle - this is called breaking the fire triangle.

Fire behaviour is the manner in which fuel ignites, flame develops, and fire spreads as determined by the interaction of ***fuels***, ***weather*** and ***topography***. An understanding of basic wildfire behavior is important to ensure the safety of wildfire response personnel and to be more successful at grassland wildfire containment.

The Canadian Forest Fire Danger Rating System (CFFDRS) is used to determine relative fire potential and predict fire behaviour among different fuel types. In grassland environments, the FFMC and ISI are the critical FWI indices.

The Grassfire Behaviour Field Guide is a handy tool for firefighters to determine fire intensity, flame length, length to breadth spread rates, and firebreak width requirements.

# Grassland Wildfire Operations (S-100G)

## Unit 3 – Grassland Wildfire Operations

**Objectives: Upon completion of this lesson, the trainee will be able to:**

- Describe the key components of a grassland wildfire assessment
- Describe grassland wildfire strategies and attack methods
- Discuss tactics available to contain and extinguish grassland wildfires

# 3 Grassland Wildfire Operations

## 3.1 Safe Work Procedures - LACES

Responder safety is the first priority in all grassland wildfire operations and safe work procedures-LACES must be followed.

### Lookouts

- Lookouts must be trained firefighters capable of assessing fire hazards
- When fireline hazards endanger the crew, lookouts warn firefighters
- In mountainous or hilly terrain, the lookout can be positioned on a slope opposite the fire area so that the lookout person can see the fire
- In flat terrain, a helicopter may be used as a lookout. In this situation the Unit leader must change tactics when the helicopter needs to leave the area

### Anchor Points

- An advantageous location, usually a barrier to fire spread, from which to start or finish construction of a control line
- Anchoring will reduce the possibility of being outflanked by the fire in the case of flare-ups
- Anchor points can be burned over areas, roads, rivers, non-burnable areas of rock or retardant

### Communications

- Make sure the crew leader's instructions are understood
- Firefighters must be in constant communication with the other members of their crew
- Working alone, out of earshot or with no radio is not recommended
- Every firefighter is responsible for alerting other firefighters to any hazard

### Escape Routes

- Escape routes are retreat paths that lead to safety zones
- The most common escape route, or part of one, is the controlled fireline
- Escape routes usually lead away from the fire, downhill or in the opposite direction of spread
- All firefighters are responsible for knowing the locations of escape routes and safety zones
- Escape routes and safety zones should be reassessed as the crew progresses along the fireline

### Safety Zones

A safety zone is an area firefighters can retreat to that will provide protection from the fire. A safety zone can be:

- The burned fire area
- Water sources (rivers/creeks/ponds/marshy or boggy areas)
- Large clearings or areas of sparse fuel, including human-made clearings

Safety zones must be assessed to make sure that they are:

- Large enough (four times the flame length and larger if on a slope)
- Close enough

## 3.2 Grassland Wildfire Assessment

Fire assessment is the ongoing process of sizing up a grassland wildfire by analyzing all available information, including weather, fire behaviour, values at risk and suppression resources **to determine the best plan of attack with safety as the priority**.

Accurate and timely grassland wildfire assessments must be constantly made in order to ensure safe, effective, and efficient grassfire operations. The goal of conducting assessments is to allow responders to properly set priorities, define objectives and allocate resources.

Continual fire assessment must be done on every fire, no matter the size or status of the fire. Proper fire assessment is the first step in ensuring safe, effective and efficient fire operations are undertaken.

### 3.2.1 Initial Assessment – Critical Factors

Initial size-up must provide enough information to report the situation and determine what additional resources are needed.

- Look for fuel types burning and ahead of fire, flashy, fine fuel or heavy slow fuels
- Is the grass cured and is it matted or standing
- Look at topography, natural or man-made barriers, steep slopes, ravines/gullies
- Look at the smoke colour - white (low intensity), grey (medium intensity) or black (high intensity) and column – straight up or leaning
- Consider current and forecasted weather - wind, temperature, humidity, and time of day
- Consider danger points, most vital points of attack and whether personnel can work safely

**If fuels, weather and topography are causing the fire to spread more rapidly than the resources can control, request more resources for assistance.**

### 3.2.2 Provide a Quick Assessment to Dispatch:

- Size of fire in hectares
- Fuel type
- Topography
- Weather
- Fire Behaviour
    - Type of fire – smouldering, running, candling, torching, spotting, crowning
    - Intensity/flame length
    - Rate of spread (metres/min)
- Values at risk
- Incident Commander name, Incident Command Post location, and communication channel

## 3.2.3 Incident Action Planning


Once the initial assessment has been completed, the Fire Officer/Unit Leader will develop a safe plan of attack including incident objectives, strategies and tactics and resources required to accomplish.

Fire behaviour largely determines the appropriate strategy and tactics. Direct attack is possible at lower intensities, using flame length as a guide. With longer flame lengths or when perimeter growth is faster than the perimeter can be controlled, perimeter containment becomes the strategy. Risks to both firefighters and surrounding values must be considered in the selection of an appropriate strategy.

Once the incident action plan has been developed it is time to go to work. Before your personnel engage in suppression action it is imperative that they are fully briefed on:

- Incident objectives, strategies, and tactical assignments
- Chain of command
- Communications plan
- Safety plan - escape routes/safety zones/safety concerns

# 3.3 Grassland Wildfire Operations

## 3.3.1 Strategies

**Offensive Strategies**
Offensive strategies are used by firefighters when there is an opportunity to attack the wildland fire with a method that will control or stop its spread completely and/or put it out. The most common type of offensive action is to attack the wildland fire by extinguishing it. For this type of action to be successful, it will require enough personnel and equipment to be on the scene or readily available. Most small wildland fires are handled with this type of strategy, but this can be used on any size of wildland fire. The key element is to have sufficient resources available to achieve quick control and completely extinguish the fire in the shortest amount of time as possible.

**Defensive Strategies**
Defensive strategies are used when wildland fire is threatening structures in isolated areas or in the rural environment where homes and buildings are spread far apart. Another example would be the protection of small communities or subdivisions from the threat of being overrun by wildland fire. Defensive actions may be used to protect powerlines, sub-stations, communication towers or sites, etc. Defensive strategies can also be utilized to turn the head of a wildland fire from one direction to another. This may be necessary to prevent the wildland fire from getting into rougher, steeper terrain, moving into heavier fuels or moving towards communities, etc. The use of air tankers dropping retardant to slow a fire down until ground forces reach the scene is an example of a defensive strategy.

## 3.3.2 Attack Methods

Fire behaviour, resource availability and priorities are some of the considerations firefighters will account for when developing an attack plan for a fire. Suppression efforts will fall in to two general methods of attack:

1. Direct Attack
2. Indirect Attack

Ground crews, apparatus, heavy equipment, aircraft, and/or controlled fire operations can be used for both methods.

## 1. Direct Attack

This method involves suppression action taken on the actual burning perimeter of the fire. Generally, the flame length is short and low in intensity, allowing for safe action on the fire. This is the most common method of attack used and involves the actual suppression of the fire.

***Hot-spotting*** is a direct attack method to control a fire at specific points that exhibit the most rapid spread, greatest intensity or that otherwise pose some special threat to containment. It is normally used on smaller fires during initial attack where direct attack can be carried out with little or no danger to personnel from heat or smoke. The intent is to contain the fire in the shortest time and move on to the next "hot-spot" as soon as it is practical and safe.

The greatest advantage of hot-spotting is the rapid reduction in the rate of spread of the fire perimeter, bringing the fire under control in its earliest stages. The greatest disadvantage is that fire crews are subjected to the portions of the fire perimeter that pose the greatest risk to safety.

**Examples of Direct-Attack Grassfire Tactics:**

- Crews with apparatus
- Crews with pumps and hose and/or hand-tools
- Direct aerial-application of water and foam from helicopters and/or air-tankers

The following are a list of tactical considerations when applying the direct attack method to control a grassland wildfire:

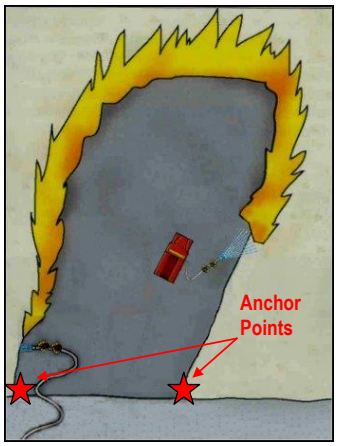
- Always observe **LACES** (**L**ookout, **A**nchor points, **C**ommunications, **E**scape routes, **S**afety zones)
- Do not direct attack on the head of fast moving and/or hot fires
- Firefighters utilized for hot-spotting need to be carefully monitored and should be supported with air tankers and/or heli-buckets
- Always ensure that there is a safety reserve of water left in the Engine for apparatus and firefighter protection
- Use foam application wherever possible to stretch out your water supply and to increase its wetting action
- Use strategically-placed relay tanks along the flanks and rear of the fire to ensure that Engines have a constant supply of water

Basic methods for implementing a direct initial attack on a grassland wildfire include:

- Flanking attack
- Tandem attack
- Frontal attack

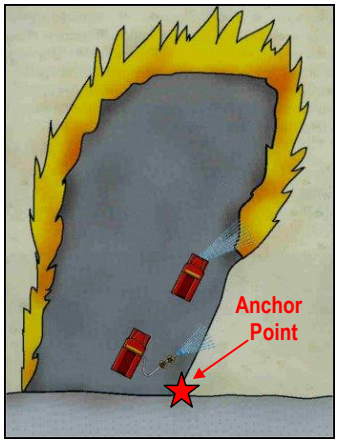
Direct attack should be taken from the "black" whenever possible – if attacking from the "green" **you must ensure that safe work procedures - LACES are strictly followed.**

**Flanking Attack**



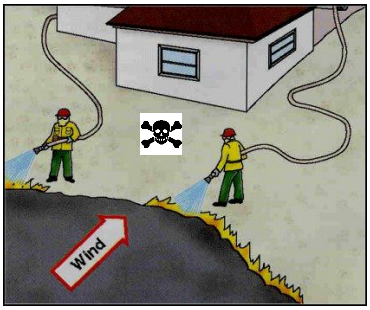

- Starts at a secure anchor point on one or both flanks of a fire and works towards the head, extinguishing the perimeter as you progress
- The flanks may be attacked simultaneously or successively, depending on fire behaviour and resources available
- Careful attention must be paid to securing the line before progressing too far down the flanks to ensure that the fire can be held and to prevent it from slopping over the control lines and out-flanking the crews

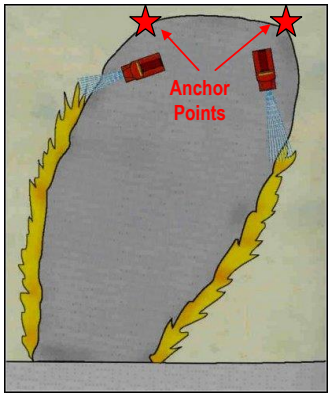
**Tandem Attack**




- Flanking attack along a part of the fire perimeter by more than one engine, heavy equipment, hand crews, or aircraft working together in coordinated effort to achieve greater effectiveness
- Selected when fuels are heavy or matted with a high probability of re-starting following a single engine passage
- Must start from a secure anchor point normally near the rear of the fire
- A common application of the tandem attack includes two engines working one in front of the other, the first engine is used to knock the flame down, while the second engine follows behind and secures the line, putting the fire out and ensuring no slop-over has occurred
- **Good communications and teamwork between resources is required when using tandem attack**

**Frontal Attack**



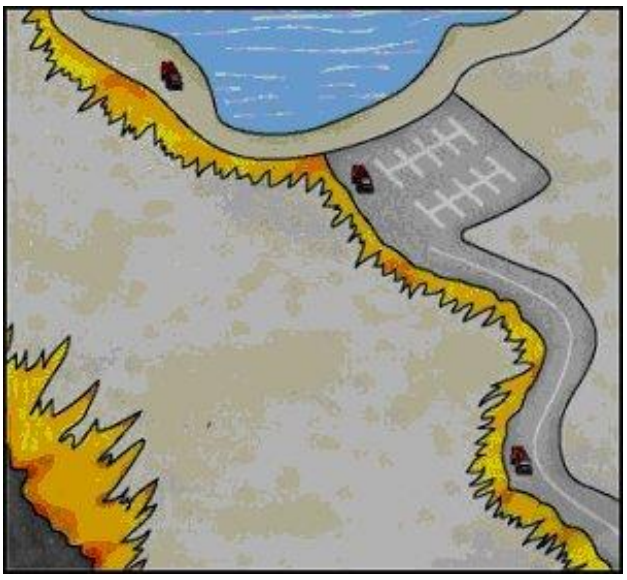

- A frontal attack takes action directly on the head of a fire or on the head of fingers extending from the main fire - **this approach is extremely dangerous because there are no anchor points to start from**
- The attack usually starts near the head of the fire and then proceeds to the flanks
- The objective is to slow the head of the fire and is often performed to protect properties and structures
- **A frontal attack will limit the spread of a fire; however, factors such as wind, fire intensity, slope, and fuel types may this tactic too dangerous to attempt except by aircraft.** If the fire is too hot or intense other methods of attack should be utilized such as the flanking action

## 2. Indirect Attack

Under extreme burning conditions, indirect attack may be the only effective way to manage a fire. This method involves containing the fire by removing fuel in the fire's spread path. Distance between fire and the indirect fuelbreak may be a few hundred metres or more away.

**Examples of Indirect-Attack Grassfire Tactics**

- Using existing or constructing new fuelbreaks with ground-crews and/or heavy equipment
- Burnout or backfire from fuelbreaks
- Aerial-application of fire retardant from air-tankers or helicopters
- Protecting values at risk (structures/infrastructure)



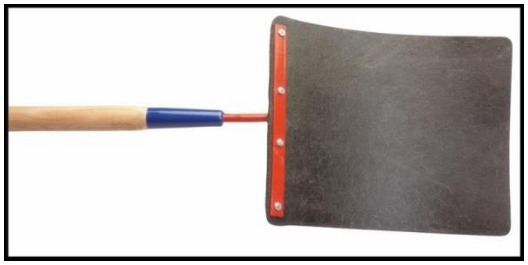
## 3.3.3 Grassland Wildfire Tactics

Resources and tactics that may be used for grassland fire operations include ground crews with handtools, apparatus, heavy equipment, aircraft, and controlled fire.

### Hand Tools and Equipment

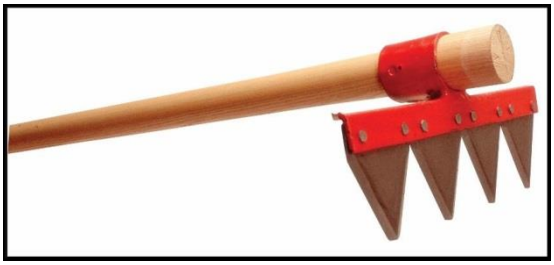
**Fire Swatter/Broom**

This tool is used in direct attack, primarily for smothering flame along the edge of low intensity grass or grain fires. The rubber belting is dragged along the fires edge smothering the flames in a sweeping motion. Do not beat at the flame, as this will tend to fan the fire and disperse hot embers. It is best used in conjunction with other tools, such as the water backpack hand spray pump.



**McLeod Tool/Fire Rake**

Designed for the removal of light duff and litter layers to expose mineral soils. It is an excellent tool for quickly removing light grass fuels, for breaking up smoldering cow patties and debris, and for raking back charred material into the burned area to ensure no hot embers are left along the edge of the unburned fuels.



**Fire Shovel**

A fire shovel is designed for cutting through heavy layers of sod, roots, litter and debris and to separate burning from unburned fuels when working directly on the fire's edge. The sharp blade is used to cut and clear light surface brush/roots and organic duff layers and to dig out deep burning ground fire.

**Pulaski**
This tool is used for grubbing out fireline, digging out hot spots, limbing, and cutting roots or brush. The pulaski was designed specifically for fire suppression purposes and has become standard equipment for most wildland fire operations.

**Water Backpack and Hand-Pump**
This tool consists of a backpack that holding approximately five gallons of water and a hand-operated pump. This is an effective tool for wetting down fuels and extinguishing hot spots with either a straight or spray stream. A backpack pump is most effective when used in conjunction with a hand-tool such as a shovel, pulaski, or swatter.

**Portable Pumps and Fire Hose**
Portable pumps and wildland fire hose are commonly used to provide wildland fire suppression water supply from natural sources or from strategically placed relay tanks. Single-jacket 38mm hose with forestry quick-couple connections is recommended. Combination nozzles are recommended to provide adequate fire stream while conserving water

## Apparatus

The main purpose of fire apparatus on grassland wildfires is to provide adequate and mobile water supply to firefighters but may be limited in their effectiveness based on size and off-road capability. Engines and water tenders are classified by ICS resource type, referring to size or capability of the piece of apparatus, with Type 1 being the largest.

### Engine Typing*

| | Engine Type | | | | | | |
|---|---|---|---|---|---|---|---|
| | Structural | | Wildland | | | | |
| **Requirements** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| Pump minimum flow (US gpm) | 1000 | 500 | 150 | 50 | 50 | 50 | 10 |
| Tank minimum capacity (US gal) | 300 | 300 | 500 | 750 | 400 | 150 | 50 |
| @ Rated pressure (psi) | 150 | 150 | 250 | 100 | 100 | 100 | 100 |
| Hose 65mm (ft) | 1200 | 1000 | - | - | - | - | - |
| Hose 38mm (ft) | 500 | 500 | 1000 | 300 | 300 | 300 | - |
| Hose 25mm (ft) | - | - | 500 | 300 | 300 | 300 | 200 |
| Ladders as per NFPA 1901 | Yes | Yes | - | - | - | - | - |
| Master Stream – 500 US gpm min. | Yes | - | - | - | - | - | - |
| Pump & roll | - | - | Yes | Yes | Yes | Yes | Yes |
| Maximum GVWR (lbs) | - | - | - | - | 26,000 | 19,500 | 14,000 |
| Minimum personnel | 4 | 3 | 3 | 2 | 2 | 2 | 2 |

### Water Tender Typing*

| | Water Tender Type | | | | |
|---|---|---|---|---|---|
| | Support | | | Tactical | |
| **Requirements** | **S1** | **S2** | **S3** | **T1** | **T2** |
| Tank minimum capacity (US gal) | 4000 | 2500 | 1000 | 2000 | 1000 |
| Pump minimum flow (US gpm) | 300 | 200 | 200 | 250 | 250 |
| @ Rated pressure (psi) | 50 | 50 | 50 | 250 | 250 |
| Maximum refill time (min) | 30 | 20 | 15 | - | - |
| Pump & roll | - | - | - | Yes | Yes |
| Minimum personnel | 1 | 1 | 1 | 2 | 2 |

***from NWCG#006-2008 Engine and Water Tender Typing Standards**

**Engines**

Structural engines (Types 1 and 2) are effective on grassland wildfires for fire operations next to roadways and for structure protection activities.

They are limited on grassland wildfires due to:

- Lack of off-road capability
- Lack of pump and roll capability
- Limited tank capacity

Wildland engines (Types 3-7) have:

- Greater off-road capability (4WD)
- Pump-and-roll capability
- Larger tank capacity
- Ability to draft from a static water supply

Wildland engines are effective at providing an off-road pump-and-roll water supply to firefighters during initial attack and mop-up operations.

**Water Tenders**

Water tenders are used to transport adequate water supply from a water source to the fire scene and are capable of drafting water from a natural or man-made water source. Water tenders are classified as Support (S1/S2/S3) or Tactical (T1/T2) based on tank size, pump capacity, and pump-and-roll capability.

Water tenders may be used to directly fill engine booster tanks or may fill portable relay tanks for Engines or firefighters to use.

## Heavy Equipment

**Graders**
Graders may be used for constructing fuelbreaks or for improving access to fires. A grader can quickly blade a new fuelbreak or widen an existing one to stop or slow down a fire by removing fuels down to mineral soil. With graders, fuel is pushed away from the fire and the fuelbreak may be widened by using several passes or by the use of foam and water.

**Tractors, Discs, and Cultivators**
Cultivating a fuelbreak is an effective way of reducing fuels available for the fire to burn. Using farm machinery is slower and it has its limitations going through rough terrain.

**Front-End Loaders/Tractors**
The most common method that loaders and tractors are used in grassland firefighting is back-blading along the edge of the fire to flatten down fuels thereby slowing down the rate of spread and smothering flames. They are also useful when encountering rough terrain, filling in washouts and ditches to provide better access to the fire.

**Dozers**
Dozers may be used to construct fuelbreaks similar to the use of graders. Dozer-guard construction is slower than rubber-tired equipment but may be used in steeper terrain.

## Aircraft

Air tankers and helicopters are effective resources in grassland wildfire suppression. Air attack operations must be coordinated with ground units to ensure safe and effective fire suppression operations. Air tanker and helicopter tactics may include direct or indirect action on the grassland fire or for structure/infrastructure protection, spot fire suppression in the vicinity of values, laying guard for control or burnout operations, and incident reconnaissance and operations coordination.

**Aircraft Coordination**

- If you identify that aircraft are necessary, order as soon as possible using your standard operating procedures – don't be afraid to make the request
- Coordination of air and ground operations is essential – ensure pilots have communication with ground units for maximum safety

**Helicopters**

Helicopters are used in firefighting for:

- Personnel and equipment transport
- Reconnaissance
- Water, retardant and foam delivery with a bucket
- Aerial ignition

Helicopters provide excellent overhead views of the incident. Helicopters are often used as a platform for incident operations coordination and reconnaissance and give overhead staff a good view of the incident from the air.

Heli-bucketing refers to the attachment of a specialized bucket to the belly of a helicopter using a long or short cable. This allows the pilot to scoop up a bucketful of water or retardant and fly it to the fire for direct or indirect fire suppression actions.

- Direct attack - Bucketing directly on the flame front
- Indirect attack - Bucketing, usually with retardant, to tie in broken parts of the retardant line constructed by fixed-wing airtankers

Heli-bucketing is followed up by firefighters to ensure the grassland wildfire is extinguished.

**Airtankers**

Airtankers are an effective tool on grassland wildfire operations. The following items apply to airtanker operations:

- Must be followed up by ground suppression action
- Are limited by availability of suitable airports and facilities for wheeled aircraft, and by suitable lakes or other water surfaces for float or amphibious aircraft, within effective range of the fire
- Airtankers may use direct and/or indirect attack strategies

**Direct Attack -** water and foam is dropped directly on flaming fuels. This is the most common strategy for skimmer aircraft. The airtanker pilot's put their load half-on the fire and half-on the green fuel to reduce the fire intensity.

**Indirect Attack –** long-term retardant is used to build a line that will either stop the fire or be used to backfire from. Long-term retardant is generally dropped in the green fuel ahead of the fire to remove the fuel the fire can burn. The standard procedure is to cut the head off and then work down the flanks and finally tie off the rear.

**Aircraft Safety Considerations for Ground Personnel**

Working around aircraft can be potentially hazardous for incident personnel. Anyone working around helicopters and fixed-wing aircraft must be properly trained and briefed.

- Ensure you have been adequately trained and briefed on the type of aircraft you are travelling in and follow the instructions of your pilot
- Ensure that all ground crews are informed of ongoing air operations in their work area
- Confirm that all ground personnel are repositioned well away from airtanker and helicopter drop locations

**Helicopter Safety**
The helicopter pilot's pre-flight briefing includes the safety features of the helicopter as well as instruction on the basic operations of the doors, seat belts, cargo restraints and radios. This must be done for every helicopter even those of similar makes and models because some of the features and the location of some of the equipment may be different. The pre-flight points to be covered include:

- Approach to and departure from the helicopter
- Main rotor and tail rotor hazards
- Operation of doors and seat belts
- Loading and unloading cargo
- Location of the first aid kit and survival gear
- Location and operation of the Emergency Locator Transmitter
- Location and operation of the fire extinguisher
- Location and operation of the emergency electrical and fuel shut off
- Fueling safety procedures

**Airtanker Drop Safety Procedures**
Retardant drops can be hazardous to firefighters on the ground due to its considerable weight and tendency to throw debris around. Because of these dangers it is important that people remain clear of the immediate drop area. Good communications are required between the air and ground to ensure all personnel are aware of when and where drops will occur. The Air Attack Officer and Incident Commander must maintain radio contact. Firefighters who do not have radios must listen for the birddog aircraft siren.

**"Yelp"** (intermittent) mode followed by a sharp pull-up:

- Meaning: Airtanker will approach target within three minutes from the same direction and make drop at the point indicated at pull-up
- Action: Clear the drop area at least 100 metres at right angles from the intended run. Do not return to the fireline until the "all clear" siren is heard

**"Wail"** (continuous) mode:

- Meaning: All clear, return to fireline
- Action: Return to the fireline and resume suppression action

**Note:** The **yelp** siren may only be used once on a target even though several drops may be made - do not return to the fireline until the **Wail** siren is heard

**Procedures to Follow if Caught in a Drop Area**

If caught in a drop area, the following points need to be remembered.

1. Do not panic and run - you may run the wrong way or trip and injure yourself
2. Lie face down towards the tanker or drop area and cover your head
3. Place hand tools behind you
4. Try to shelter yourself behind objects that will not be moved by force of the drop
5. Stay clear of snags and dead branches - they can be broken off and fall on you
6. Exit the area immediately after the drop to avoid subsequent drops

## Controlled Fire Operations

**Burnout**

Burnout removes the unburned fuels between the fire's edge and the control line. This technique is normally conducted on the upwind side of a fire, and is used to move the flanks or the rear of a fire toward pre-built or natural firebreaks. Burnout needs to begin from well-established anchor points.

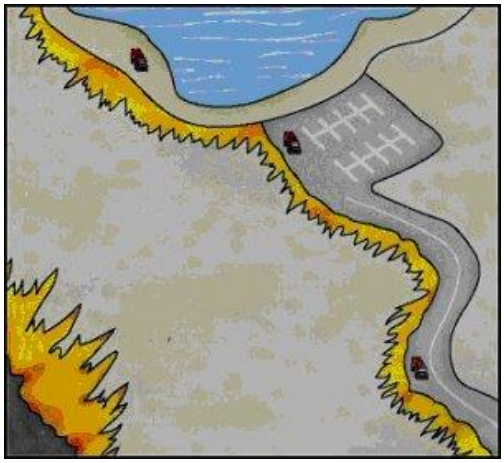
Another application of burnout is where dozers or road graders are used to build control lines and ignition crews immediately follow behind, burning out the fuels between the control line and the fires edge.

Burnout techniques can also be used to protect structures in advance of an oncoming grassland wildfire.

**Burnout operations need to be conducted under strict supervision and firefighters utilizing this technique need to be well trained, experienced, and have a good understanding of fire behaviour.**

**Backfire**

Backfiring is a more complex firing operation, where extensive fire is set along the inner edge of a control line or natural barrier, usually some distance from the grassland wildfire, and taking advantage of in-drafts to consume fuels in the path of the fire and thereby halt or retard the progress of the fire front. Backfiring is often conducted by aerial ignition specialists using helicopter aerial ignition devices.



Backfires should be lit as close as possible to the main front of the fire in order to take full advantage of the in-drafts, and to reduce the overall fires intensity at the edge of the control line.

**Backfiring operations require careful planning and consideration has to be given for sufficient time in order to place control lines in the proper locations**. ***All backfiring operations require the approval of the Incident Commander or Operations Section Chief.***

**Burning-out and backfiring under extreme conditions is risky - watch out for:**

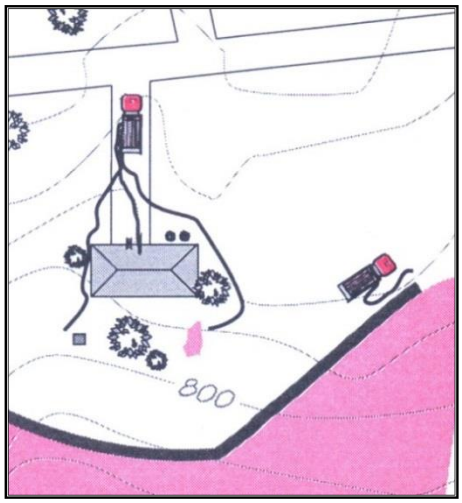
- Firing in narrow draws, through saddles, across long slopes, and/or near high value areas
- Where fuels vary, e.g. heavy fuels near line
- Line located mid-slope or has sharp bends in it
- Weather is changing, wind variable or shifting, thunderheads in area
- Wind speeds in excess of 25 km/hr – firing objectives become questionable
- Poor communications, not enough firefighters or equipment

## Structure Protection

Protection of structures and infrastructure is often required in grassland wildfire operations.

### Engine Crews

Engines are commonly stationed at structures to provide offensive and defensive strategies to protect the structure




- Establish the perimeter hose lay to cover the site perimeter and the structure - deploy two perimeter lines, one around each side of the structure – they must be long enough to meet behind the structure
- Deploy lines behind the Engine to prevent hoses from wrapping around a wheel during rapid egress situation
- A combination nozzle is the most versatile, providing for conservation of limited water supplies in fog-mode and for knock-down power with the straight-stream
- Scout access roads before committing large apparatus
- Do NOT block travel routes for other equipment or evacuating vehicles - park off the road
- Do not park over flammable vegetation,  under power lines, or near LPG tanks

### Sprinklers

Sprinkler systems may be used to directly wet the structures or as a community perimeter system to wet the vegetation surrounding the community or structure prior to and during grassland wildfire impingement.

### Class A Foam

Foam will cling to walls and roofs and under eaves to provide the insulating barrier needed to protect the structure from radiant heat and flying embers. ***Apply wet foam first for moisture penetration followed by a layer of dripping or dry foam to cover and help insulate the structure.***

## 3.4 Summary

Fire assessment is the ongoing process of sizing up a grassland wildfire by analyzing all available information, including weather, fire behaviour, values at risk and suppression resources **to determine the best plan of attack with safety as the priority**.

Fire behaviour, resource availability and priorities are some of the considerations firefighters will account for when developing an attack plan for a fire. Suppression efforts will fall in to two general methods of attack:

1. Direct Attack
2. Indirect Attack

Ground crews, apparatus, heavy equipment, aircraft, or controlled fire operations can apply to either of the above methods.

Before your personnel engage in suppression action it is imperative that they are fully briefed on:

- Incident objectives, strategies, and tactical assignments
- Chain of command
- Communications plan
- Safety plan - escape routes/safety zones/safety concerns

# Grassland Wildfire Operations (S-100G)

## Unit 4 – Firefighter Safety

**Objectives: Upon completion of this lesson, the trainee will be able to:**

- Identify threats to firefighter safety that may lead to injury or fatality when exposed to grassland wildfires.
- Learn how to mitigate injury or fatality through the application of safe work procedures and entrapment survival techniques.

# 4 Firefighter Safety

Wildland firefighters must understand the hazards associated with grassland wildfire and be aware of the safe work procedures that are designed to reduce these hazards.

A study of wildland firefighter fatalities in the United States found the major causes of wildland firefighter fatalities included:

- Vehicle accidents
- Heart attacks
- Wildfire entrapment

## 4.1 Vehicle Accidents

Vehicle accidents are a leading cause of injuries and fatalities to firefighters. Interface fires increase the risk of vehicle accidents with public panic, congested roads, and poor visibility.

**Recommended Safe Work Procedures:**

- If you can't see what is ahead – STOP!
- Drive with caution - anticipate hazards in the road
- Use seatbelts at all times
- Do not ride on the outside of the apparatus
- Do not work hose lines in front of moving apparatus
- Use headlights and emergency flashers while moving or stationary
- Monitor and mitigate fatigue factors before driving back to the station

## 4.2 Health Effects

Heart attacks, dehydration, and heat stress continue to be a leading cause of injury and death among wildland firefighters due to long hours under a physically demanding and stressful environment.

Dehydration and heat stress go hand-in-hand. Fluids must be replaced in order to maintain your work capacity and to avoid heat stress. Do not rely on thirst to indicate dehydration. A conscious effort must be made to replace fluids frequently throughout the day.

**The body can lose 12 to 15 litres of water in an eight-hour day.**

Heat stress occurs when the body temperatures rise over safe limits. It occurs when humidity, air temperature, radiant heat, and too little fresh air combine with heavy work and clothing.

**The following measures can be taken to prevent significant health effects:**

1. Maintain a high level of physical fitness
2. Replace fluids regularly
3. Replace lost salt and potassium
4. Pace yourself – take regular rest periods
5. Wear wildland fire PPE rather than structural turn-out gear on grassland wildfires, based on Agency standard operating guidelines

## 4.3 Grassland Wildfire Entrapment

Fire entrapment occurs when firefighters are surrounded by grassland wildfire and are unable to access established safety zones via pre-determined escape routes. Firefighters must use extra caution anytime they are working on fires in flashy fuel types (grass), above fires or when spot fires could be started below their location. Gullies, draws or other steep-sided terrain increase the fire entrapment hazard. In the event of accelerated fire activity, firefighters may be trapped and unable to outrun the fire in the steep terrain.

**Common Denominators of Fire Behaviour on Tragedy and Near-Miss Wildland Fires**

1. Most incidents occurred on relatively **small fires or within isolated areas** of larger fires.

2. Flare-ups occurred in **deceptively light fuels**, such as grass and light brush.

3. Most fires were innocent in appearance before **unexpected shifts in wind direction and/or speed** resulted in flare-ups.

4. Fires respond to large-scale and small-scale **topographic conditions**, running uphill in chimneys, gullies or on steep slopes.

Extreme fire behaviour that is obvious to everyone does not usually cause safety problems - **it is the sudden changes in fire behaviour that catches people off guard and leads to entrapment.**

**Recommended Safe Work Procedures:**

- **"Do up your LACES"** before and during every deployment
- Watch out for light fuels, wind shifts, and steep terrain
- Always keep "one foot in the black"
- Maintain constant communication with your crew members

## Grassland Wildfire Entrapment Survival

Personnel must recognize that in some instances there may be no chance to escape a fire - light fuels such as grass is one of the common denominators to many fire entrapment situations. In instances where entrapment is imminent, **injuries or death may be avoided** by following entrapment procedures:

1) **DO NOT PANIC** - It is natural for most people to be afraid when trapped by fire. Accept this fear as being natural. Once this has been done, clear thinking and intelligent decisions are possible.

2) **KNOW YOUR ESCAPE ROUTES** - Escape routes are retreat paths that provide rapid access to safety zones where firefighters can shelter from the threat of grassland wildfire hazards such as heat, smoke, falling trees or rocks. Initially, the most common escape route is the fireline, then leading away from the fire downwind. Ensure there is always more than one escape route! Do not run blindly or needlessly. Unless the path of escape is clearly indicated, do not run. Move toward one of the flanks of the fire, traveling downhill where possible. If the situation is serious, drop all tools and equipment in favor of speed in escaping; consider retaining ignition devices (fusees) if they do not slow you down. Conserve your strength.

3) **ENTER THE BURNED AREA** - In grassland fuels types do not delay if escape means passing through the flame front into the burned area. After covering exposed skin and taking several breaths, move through the flame front as quickly as possible. If necessary, get on the ground to get underneath smoke for improved visibility and to obtain some fresh air for the next move into the burned area.

4) **BURN OUT -** In cured grass, when the approaching flames are too high to run through, burnout as large an area as possible between you and the fire edge. Step into the burned out area, cover as much exposed skin as possible and lie prone. This action requires time for fuels to burn out.

5) **REGULATE BREATHING** - Avoid inhaling dense smoke and regulate breathing to coincide with availability of fresh and relatively cool air – a dry handkerchief held over the nose and mouth will help with dust and embers.

6) **PROTECT AGAINST RADIATION** - Many people who become victims of a grassland wildfire actually die before the flames reach them. Radiant heat quickly causes heat stroke, a state of complete exhaustion. Shielding from the heat rays must be found quickly and in an area that will not burn. A shallow trench, crevice, large rock, running streams, large ponds, vehicles and buildings, and the shore waters of lakes may provide this. For protection against radiation, cover the head and other exposed skin with clothing or dirt.

7) **LIE PRONE** - In a critical emergency, lie flat on an area that will not burn with your head down. A person's chance of survival is greater in this position than standing upright or kneeling.

8) **TAKE REFUGE IN BUILDINGS OR VEHICLES** - Much of the heat from a fire is radiant energy. While intensity at a given location may be very high, it lasts only a short time. Because radiant heat travels in straight lines, it does not penetrate solid substances and is easily reflected, seeking refuge in buildings and vehicles is often life-saving.

## 4.4 Aircraft/Heavy Equipment

Fireline operations often involve working with resources such as helicopters, air tankers, and heavy equipment that can be potentially hazardous to incident personnel.

**Recommended Safe Work Procedures:**
Aircraft:

- Ensure you have been adequately trained and briefed on the type of aircraft you are travelling in and follow the instructions of your pilot
- Ensure that all ground crews are informed of ongoing air operations in their work area
- Confirm that all ground personnel are repositioned well away from airtanker and helicopter drop locations

Heavy Equipment:

- Approach only from the front after blade has dropped and the operator signals OK
- Never work downslope or within two tree-lengths of heavy equipment
- Only the operator is permitted on the equipment - do not ride on heavy equipment
- Wear "hi-vis" vest or clothing when working near heavy equipment

## 4.5 Wildland/Urban Interface

When firefighters are working in wildland/urban interface areas, hazards such as collapsing structures, barb-wire fences, toxic chemicals or gases including hydrogen sulphide (near gas wells), propane tanks, gas lines, pets and livestock, power lines, inadequate bridge limits and road widths, and evacuating public may be present. Be aware of the interface hazards and revise your actions appropriately.

## 4.6 Summary

Multiple hazards may exist in the grassland wildfire environment resulting in the potential for firefighter injury. Firefighter safety must always be the primary objective of any fire operation.

Firefighters must be vigilant and aware of hazard factors and the risk to themselves and others at all times. **Never let your guard down.**