FIRE BEHAVIOUR

THE CAUSES OF FOREST FIRES

There are about 2,000 wildfires every year in British Columbia. The Ministry of Forests Protection Branch calculates that lightning causes about 55% and people cause the other 45%.

WHY A FIRE BURNS

Successful firefighting is based on knowing why a fire burns and what makes it spread. The understanding of this fundamental process will assist in better control of forest fires.

The Fire Triangle
To have a fire, you must have a combination of three things: *fuel*, *oxygen* and *heat*.

- The fuel is the forest
- The oxygen comes from the air
- The heat comes from lightning or from man.

If any one of these three elements is missing, there can be no fire. *The basic principal of firefighting, therefore, is to remove one or more of these elements in the quickest and most effective way.*

There is no other way to suppress fire.

WHY A FIRE SPREADS

The primary factors that influence the spread of fires are *fuels*, *weather* and *topography*.

Light, small or fast-burning fuels
Dry grass, dead leaves and tree needles, brush and small trees. Light fuels ignite quickly and cause rapid spread of fire. They serve as kindling for heavier fuels and burn out faster. Some green fuels such as tree needles have a high oil content and are fast-burning when they are not in an active growing stage.

Heavy, large, or slow-burning fuels
Logs, stumps, branch wood and deep duff (the topsoil or partly decayed leaves and tree needles found under dense stands of brush or trees). Heavy fuels take longer to ignite, spread slower, burn longer and throw off large volumes of heat when dry.

Snags
Because of the abnormally high percentage of forest fires that start in snags, they must be placed in their own category. Snags are drier and always ready for ignition. Fires burning in snags must be controlled promptly through a series of recommended procedures which will be covered later.
The ease of ignition and rate of burning are influenced by the *size of fuels*.

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Spacing
Fuel spacing describes the distribution of fuels in a given area. Fuel continuity is an important factor in the behaviour of fire because it indicates how quickly and why a fire may spread.

A wide range of fuel continuity conditions will be found in most forested areas. However, for simplicity in determining fire behaviour, two broad classifications of fuel spacing will be discussed: horizontal and vertical.

Horizontal spacing is the spacing of the fuel as it lies on the ground. When fuels are close together, the fire will spread faster.

When fuels are *patchy*, scattered or separated by natural barriers such as rock, outcropping, streams, or areas of bare ground, the fire will be irregular and spread more slowly.

A common method used in fire suppression is to break the continuity of the fuel by separating burning fuels from unburned fuels.

When fuels are closely spaced *vertically*, fire will spread rapidly as the fuels are pre-heated prior to ignition.

When fuels are spaced far apart vertically, the heat is not sufficient to ignite the fuels above.

Quantity
As the amount of flammable material in a given area increases, the amount of heat produced by the fire also increases. The hottest fires, as well as those most difficult to control, occur in areas containing the greatest *quantity of fuel.*

In evaluating fuel volume, it should be noted that a lot of small material such as fine deadwood, means that there is a lot of kindling material to light other fuels. A lot of either small or large-sized material means that there is a good chance of a hot fire. When fires start in areas containing a lot of large-sized material, there will be intense heat transfer to fuels lying in the path of the fire.

Weather
One of the most important factors affecting the behaviour of a fire is *weather*. The three most important components of weather are:

- *wind*
- *temperature*
- *humidity*

Wind
The stronger the *wind*, the faster the spread of the fire. Wind brings an additional supply of air to the fire. It flattens the flame which pre-heats the fuel ahead and causes spot fires by blowing sparks and embers ahead of the main fire into a new source of fuel.

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Winds generally blow upslope at 5 to 10 miles per hour during the day because sun-warmed air rises. At night, they reverse and blow downslope because cooler night air sinks. The wind at night is not usually as strong as the wind during the day.
When you are planning a fire attack, the direction of *canyon and slope winds* should be carefully considered. Air currents flow up a canyon and slope during the day and down during the night.

Other wind behaviour characteristics which must be considered:

- prevailing winds usually blow from late morning to late afternoon and may blow at 15 to 30 km per hour or higher by mid-afternoon;
- cumulus clouds may indicate possible change in wind speed and direction;
- winds usually flow out from the edges of a thunderstorm and may reach speeds of 115 km per hour; and
- gusty winds are very hazardous to fire-fighters because they change speed and direction rapidly.

Temperature
Fuels pre-heated by the sun burn more rapidly than cold fuels. The *temperature* of the ground also affects the movement of air currents, as explained previously. Prolonged high temperatures also affect the endurance and efficiency of the firefighters.

Humidity
Moisture in the form of water vapour is always present in the air. The measurement of that moisture is called *humidity* and is always expressed as a percentage.

Warm air absorbs more moisture and produces a lower humidity. As air cools, the humidity increases. The amount of moisture in the air affects the moisture in the fuel. This is an important factor in firefighting, since wet and most green fuels will not burn freely. Air is usually drier during the day than at night. Fires, then, burn more slowly at night, under normal circumstances, because the fuels absorb moisture from the damp night air.

This partially explains why a fire burns out of control in the afternoon and yet may be controlled by the same crew at night. Every effort should be made to control a fire before burning conditions build up the next day. In British Columbia, the goal of all firefighters is to control or extinguish any fire within the first burning period.
This doesn't mean that an attempt to suppress a fire should not be made during the day. Most fires are controlled during the day. If a fire cannot be controlled during the day, an all-out effort must be made at night.

Topography
The 'lay of the land' is called *topography*. This is an important factor in the rate and direction of fire spread and is usually broken into three categories:

- Slope
- Aspect

- Terrain

Slope
Slope is the steepness of the land and has the greatest influence on fire behaviour. The steepness of the slope affects both the rate and direction of the fire spread. Fires usually move faster uphill than downhill and the steeper the slope, the faster the fire will move. This is because:

- on the uphill side, the flames are closer to the fuel;
- the fuels become drier and ignite more quickly than if on the level ground;
- wind currents are normally uphill and this tends to push heat flames into new fuels;
- convected heat rises along the slope causes a draft which further increases the rate of spread; and
- burning embers and chunks of fuel may roll downhill into unburned fuels, increasing spread and starting new fires.

Aspect
Aspect is the direction the land faces - north, south, east or west. The aspect of a slope influences a fire's behaviour in several ways:

- southern aspects receive more direct heat from the sun, drying both the soil and the vegetation;
- fuels are usually drier and less dense on southern slopes than fuels on northern slopes;
- heating by the sun also causes earlier and stronger slope winds; and
- on south-facing slopes, there will normally be higher temperatures, stronger winds, lower humidity, and lower fuel moistures.

These are all the conditions needed for quick starts and a rapid rate of fire spread.

Terrain
Terrain or special land features may control wind flow in a relatively large area. Wind flows like water in a stream and will try to follow the path of least resistance.

Ridges, trees, and rocks may alter wind flow and cause turbulence or eddies to form on the windward side of obstructions. Also, when wind flows through a restriction, such as a narrow canyon, it increases in strength.

Wind movement can be critical in chutes or steep v-drainages. These terrain features create a chimney effect, causing a forced draft, as in a stove chimney. Fires in these chutes or drainages spread quickly and are very dangerous.

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Successful firefighting is based on knowing why a fire burns and what makes it spread. For example, sometimes the layout of fuel is more important than the amount of fuel. If fuels are patchy, the spread may be uneven and slow. If these same fuels are partly on the ground and partly upright (snags), spread may be spotty and, with severe winds, cause a difficult fire.

It is important for the first crew member arriving at a fire to size it up and be able to give a detailed report on the size and possible outcomes of the fire.

The following factors, as previously mentioned, influence fire behaviour and how this behaviour may change:

- fuels;
- weather; and
- topography.

It pays to look carefully at all conditions in sizing up a fire.

Unless a forest fire is properly analysed at the first approach, proper suppression cannot take place.