Topography alters the normal heat transfer process and modifies general weather patterns producing localized weather conditions that influence the types of vegetation or fuels. Topography directly or indirectly affects fuels and their availability for combustion, wind speed, local direction, and convection columns.

**ELEVATION ABOVE SEA LEVEL**

Elevation above sea level influences general climate and thereby affects fuel availability by:

- Amount of precipitation received
- Snow melt dates
- Fuel types and loadings
- Dates of curing of vegetation
- Length of the fire season
- General fire danger

**POSITION OF FUELS ON SLOPE**

Temperature variations between the valley bottoms, mid-slopes and upper slopes result in variations in relative humidity also. This allows for fuel types, fuel loadings, and fuel moistures to vary.
A major concern when working with fires on steep slopes is the possibility of burning material rolling downhill that can ignite fuel below the main fire.

The position of the fire in relation to the topography is a major factor in the resulting fire behavior. A fire on level ground is influenced primarily by the fuels and wind. A fire that starts near the bottom of a slope during normal upslope, daytime wind conditions normally will spread faster and burn more area than a fire that starts near the top of the slope, because it has a longer uphill run.

**ASPECT**

Aspect is the direction a slope is facing. Aspect affects fire occurrence and burning conditions of fires through variations in the amounts of sunshine and wind different aspects receive.

**South and Southwest Aspects**

In general, south and southwest aspects are most favorable for fire start and spread. These aspects receive more direct sunshine, and therefore have lower humidity’s, summer winds, and higher fuel temperatures. Over much of the United States, summer winds from the southwest are hot and dry. These events result in fuels that are more available, more sparse, because they are smaller and drier than those on a northern aspect.
Daily Variations

During the day, sunlight moves across different aspects, and air temperature, relative humidity, fuel moisture, and fuel temperature all change. An inactive surface fire on a southwest aspect in the early morning may become an active crown fire that afternoon. After the sun sets, the same fire may again become a surface fire with approachable fire intensities.

Site Specific Conditions

We've discussed fire potential in general areas or zones. It's important to recognize that fire danger can change due to the micro-climate conditions at all elevations. The type and availability of fuels can be affected by micro-climate conditions due to the following:

- Localized weather patterns
- Product of accumulative weather
- Local soil and terrain factors

The general shape of the country and various aspects contribute greatly to the resulting climates of small areas and resulting fuel situations.

A combination of topographic factors is usually present to influence fuel availability and the manner in which fire spreads. Slope percent, aspect, and position on the slope are all important factors here.

SLOPE

Slope is important in the study of fire behavior. It is one of the primary factors that affect fire ignition and spread by preheating the fuels upslope and enabling spotting to occur from rolling and aerial firebrands.
Slope has a direct effect on flame length and rate of spread. If fuels and wind are constant, the flame length and rate of spread will increase as the slope becomes steeper.

The steeper the slope, the more likely a fire will run in a wedge shape with a narrower head. Spotting ahead of the front is more likely. Slope reversals occur when the fire crosses onto a slope of opposite direction. Two common examples are when a fire running to the top of a ridge begins to back down on the opposite slope, and when a fire backing down a slope crosses a drainage and begins to run up the next ridge.

RIDGES
As a fire runs to the ridgetop, it encounters opposing upslope airflow from the other side of the ridge. This effect can slow the fire spread and limit the spotting problem on the opposite slope. Often a ridge provides firefighters with a safe and effective fire line location.

The downside is that the effect of erratic winds caused by various winds converging at the ridgetop can contribute to spotting. This is especially likely if the windward side of the ridge has stronger winds than the leeward upslope airflow. A wildland fire burning near the top of the windward slope can spot across the ridgetop and onto the other slope.

NARROW CANYONS
Increased fire intensity often produces crowning and spotting, and fire crosses to the opposite slope, that has been preheated by radiation. This crossing can happen in a matter of a few minutes, giving little warning to firefighters working in the canyon. Such crossings can occur progressively, at multiple points, creating a hazardous situation for crew. Obviously, firefighters need to recognize when these situations can occur.

Air Flow
The canyon, following the canyon’s direction, forms eddies and strong upslope currents at its sharp bends and will usually shape surface winds.
Wide Canyons

Prevailing wind direction can be altered by the direction of the canyon. Cross-canyon spotting of fires is not common except in high winds. Strong differences will occur between general fire conditions on north and south aspects. Ridges: Fires burning along lateral ridges may change direction when they reach a point where the ridge drops off into a canyon. This change of direction is caused by the flow of air in the canyon. In some cases, a whirling (eddying) motion by the fire may result from a strong flow of air around the point of a ridge. These push fire in many directions.

Saddles

Wind blowing through a saddle or a pass in a mountain range can increase in speed as it passes through the constricted area and spreads out on the lee (downwind) side with a probable eddy action.

INTERSECTING DRAINAGES

In which directions will the fire spread? Where drainages intersect, fire might follow one or both drainages, depending on the following:

- The direction of canyon winds as determined by aspect and time of day.
- The dominant winds in the canyon.
- Wind eddies at the fork of the canyon.
- The availability of fuels in the forked area.
The interaction or combination of these variable factors often makes prediction of fire spread very difficult at this point.

**BARRIERS**

An important terrain feature is barriers, whether natural or artificial. Areas that lack available fuels, because of higher fuel moistures or sparse fuels are either full or partial barriers to fire spread. Barriers can help to limit the direction of fire spread and provide opportunities for easier control.

**Types of Barriers**

Barriers that either retard or stop the spread of fire are the following:

- Rocks or bare soil conditions
- Lakes, streams and moist soil situations
- Roads, trails, and other improvements
- Change in fuel type and fuel moisture conditions
- Previous burned areas

The interaction or combination of these variable factors often makes prediction of fire spread very difficult at this point.

**Partial Barriers**

A change in fuel conditions may offer only a partial barrier by slowing the spread of fire. For example, in early morning, when the cured grasses are still damp with dew, the fire spreading in the dry litter under the canopy will be retarded in its advance across the meadow until the afternoon. Drainages on north-facing slopes early in the season may also act as partial barriers to fire spread.

The "chimney effect" has claimed the lives of firefighters. A chimney, as the name suggests, depicts topographic features that form steep narrow chutes with three walls similar to a box canyon. Normal upslope airflow is rapid and funneled to the chimney's shape. Because of upslope reheating and cross-canyon radiation, these chimneys draft a fire, much like an actual stove chimney. Extreme rates of spread can occur, spotting is likely, and difficulty is experienced in establishing and moving to safety zones in chimneys.
Chimney Effect

Chimney Occurs Following

— Unstable air conditions at the surface cause a convection current through the canyon.
— Air is drawn in at the base of the canyon to support the convection currents.
— Fuels are available to support a rapid burnout in the head of the canyon.

It is much easier to predict the influences that topography will have on a fire than to predict the influences of fuel and weather. The principles that affect the spread of wildland fire apply equally whether the variations in elevation and topography are minimal or extreme (hills or mountains). These principles are valid and contribute wherever there is any variation in elevation.