LOOK UP, LOOK DOWN, LOOK AROUND

THE FIRE ENVIRONMENT

The fire environment is the conditions, influences, and modifying forces that control fire behavior. The fire environment has been described with a triangle showing fuels, topography and air mass.

We will use the term Air Mass instead of Weather. Some weather observations actually measure fuel conditions. In examining Air Mass, we will focus strictly on how the air around a fire will influence the spread and growth of that fire.

There are seven factors within the fire environment that fire line personnel must monitor:

— Fuel Characteristics
— Fuel Moisture
— Fuel Temperature
— Terrain
— Wind
— Stability
— Fire Behavior

Fire Behavior is what we want to predict or anticipate, but fire behavior is also a factor to monitor. Fire can be considered a heat source. It influences and modifies the fire environment.

Indicators are the clues used to size-up the fire environment and predict or anticipate fire behavior. There are several indicators for each of the seven fire environment factors. You must look up, look down and look around on the fire line to recognize the indicators. Then you must understand the effect or what the indicator means to you. Remember, these indicators interact with each other and are accumulative.
Problem Fire Behavior

“Fire behavior can be described as behavior that presents a potential hazard to fire line personnel, if the tactics being used are not adjusted.”

The prediction or anticipation of fire behavior is the key to good safety and tactical decisions. Anticipating site-specific fire activity is as important as anticipating a fire's overall behavior. A normal rapid upslope fire run can be problem fire behavior if fire line personnel are in the wrong place when it occurs.

Extreme fire behavior is the highest level of problem fire behavior and it can be described with specific elements:

- Rapid rate of spread
- Intense burning
- Spotting
- Crowning

“Fire accidents occur because of what we didn't know; and also because of what we knew and ignored.”

FUEL CHARACTERISTICS

Fuel characteristics determine the potential fire intensity and spread rate.

Fuel characteristics change slowly over time, but fuel types (and therefore fuel characteristics) can change quickly over distance as a fire burns into new fuels.

The approximate ignition temperature for most wildland fuels is 500°-800° F.

Fuel Characteristics Indicators

Continuous Fine Fuels

Continuous fine fuels provide potential for rapid rate of spread. Fine fuels are the primary carrier of fire spread.

This is one of the Four Common Denominators of Fatality Fires.

Heavy Loading of Dead and Down Fuels

Accumulation of dead and down fuels provides the potential for intense burning conditions.
Older age stands of vegetation tend to have a higher loading of dead and down fuels (dead to live ratio).

**Ladder Fuels**

Ladder fuels provide the potential for surface fires to move into the crowns above.

Higher surface fire intensity means that less of a ladder fuel condition will be needed for a fire to move into the crowns.

**Tight Crown Spacing**

Tight spacing of crowns provides potential for a fire to move from crown to crown.

This is equally important in brush fuel types and timber fuel types.

**Special Considerations**

A special or abnormal condition may contribute unusual fuels to a fuel type. This could include:

- Fuels that are not normally considered to be a problem, but have undergone change due to environmental conditions.
- Fuels that are normally a problem, but are not recognized as a problem due to fire line personnel being in an unfamiliar situation. Remember to ask when in unfamiliar situations.

A serious freeze can kill vegetation thus contributing to the dead fuel load and increasing the dead to live ratio. An invasion of insects can kill large sections of a forest. In southern California, many species are "drought deciduous" meaning they lose their leaves in the summertime when it is dry and hot. These are significant contributors to fire behavior which firefighters traveling across the country would not normally be aware of.

**Fuel Moisture**

Fuel moisture content determines if fuels are available to burn.

Fuel moisture content changes diurnally, seasonally, and also in an accumulative manner over several seasons or years. Fuel size determines the rate of drying.
Fuel Characteristic Indicators

**Low Relative Humidity**
Fine fuels (1 hour fuels) become more flammable as the relative humidity (RH) drops. The importance of fine fuels was discussed earlier.

Use 25 percent RH as a rule of thumb; it means pay attention and expect increasing fire behavior as the RH drops below this level. In some areas, this indicator can vary. In the eastern part of the U.S. and in Alaska R.H.’s of 30 to 40 percent are considered to be low.

Don't forget personal indicators, you may just "feel it getting warmer and drier."

**Low 10-hour Fuel Moisture**
10-hour fuel moistures below 7 percent are an indication of dry conditions. This is a measure of how dry the small sticks and twigs are; these play a role in fire spread.

Again, this can vary by area. In Alaska and the East 10 percent is considered very low.

**Drought Conditions**
Drought will cause large dead and down fuels and the live fuels to become available to burn. The effect of drought is accumulative over several seasons or years.

For a reference, 1000-hour fuels begin to burn at 20 percent fuel moisture content; they are considered very dry at 13 percent.

Live fuels will have a wide range of critical moisture content levels depending on the area and fuel type. Typically, in southern California, 60% is considered critical live fuel moisture content.

**Seasonal Drying**
Normal seasonal drying will cause more fuels to become available to burn as time passes through the fire season. Existing drought conditions can accelerate this seasonal drying process.

**Fuel Temperature**
Fuel temperature contributes to fuel availability. This is particularly important in fuel types that are dominated by fine fuels.

Fuel temperature changes frequently. Diurnal temperature changes and amount of direct sunlight will determine fuel temperature.
Fuel Temperature Indicators

**High Temperatures**
High temperature will increase the flammability of fine fuels.

**Fuels in Direct Sunlight**
Fuels that receive continual direct sunlight will have accelerated drying rates in comparison to similar adjacent fuels that are mostly or partially shaded by a canopy cover.

**Aspect with Increase Fuel Temperatures**
Fine fuel flammability will change as fuel temperature changes. These changes will occur when slopes undergo transitions between shade and sunlight.

As the sun passes overhead during the day; anticipate these transitions between shade and sunlight. Are the fuels in an area about to change from being in the shade to being in sunlight? If so, expect an increase in fire behavior.

A west aspect would experience more severe fire behavior at 1500 hours than other aspects. The fuel temperature on the west aspect will be increasing into the afternoon.

**Terrain**
Terrain features will influence fire spread.

Terrain does not change significantly over time, but terrain can change quickly over distance as a fire burns into new areas.

Terrain Indicators:

**Steep Slopes**
Steep slopes provide potential for rapid upslope rates of spread.

Downhill spotting problems are a concern on steep slopes due to rollouts of burning material.

Steep terrain is one of the Common Denominators of Fatality Fires.
Box Canyons and Chutes
Box canyons and chutes provide potential for very rapid upslope rates of spread by combining steep terrain with updrafts of air. Remember the “Chimney Effect” from earlier discussion?

These features are commonly found below or adjacent to fire lines.

Saddles
Saddles provide potential for rapid rates of spread as fires are pushed through saddles faster during upslope fire runs.

Fire lines constructed on ridges often drop into saddles.

Narrow Canyons
Narrow canyons provide potential for rapid rates of spread from two sources:

- Radiant or convective spotting can occur across narrow canyons due to the short distances involved. This can cause multiple spot fires leaving you in the middle.
- A slope reversal can occur when a fire backing downhill reaches the opposite slope and begins a rapid upslope run.

Another caution when working in narrow canyons intersecting drainages. The wind eddies that occur in these intersections or forks can cause very erratic fire behavior.

Wind
Wind is the primary factor that influences fire spread. This includes both the rate and direction of spread.

Winds change frequently. The change can be diurnal, caused by the movement of fronts, or the result of gradients between pressure systems.

WIND INDICATORS

Strong Surface Winds
Strong surface winds provide a means for wind driven fire runs and the transport of firebrands.

“A rule of thumb for converting 20-foot wind speeds to eye level wind speed is divide the 20-foot wind speed by half.”
Lenticular Clouds

Lenticular clouds indicate high winds aloft with potential to surface and produce strong downslope winds.

High Fast Moving Clouds

High fast moving clouds indicate potential wind shifts, particularly if the clouds are moving in a direction different from the surface winds.

Approaching Cold Front

Winds will shift and increase in speed as a cold front approaches. Look for a squall line of thunderstorms as a visual indicator.

A Lenticular cloud formation.

A dry cold front passage will have no squall line; the only indicator will be the shift in the wind direction.

Cumulonimbus Development

Thunderstorms present the potential for strong, erratic downdraft winds. If you see cumulus clouds building into a thunderstorm, anticipate possible downdraft winds.

Thunder and lightning are associated with these storms. Also, virga may be observed. Virga is the rain that does not reach the ground. This is a good indication that downdrafts have begun.

Battling Winds or Sudden Calm

When a gravity or foehn wind interacts with a local wind, significant wind reversals are likely. Definite indicators are winds battling back and forth causing a wavering smoke column and a sudden calm.
A decreasing foehn wind that allows a local wind to regain influence can be as dangerous as the foehn wind that overpowers a local wind. A wind reversal from a decreasing foehn wind has been a factor in several fatality fires.

Foehn winds are the result of high-pressure systems and mountainous terrain. The conditions that cause these winds are predictable by weather forecasters. Foehn winds occur in several areas of the country.

A sudden calm can be an important indicator for other situations such as prior to thunderstorm downdrafts.

**Atmospheric Stability**

When sizing up Atmospheric Stability, we are most concerned with an unstable air mass that provides the potential for vertical fire development and rapid growth.

Stability can change frequently. The change can be diurnal or caused by the movement of the air mass.

It is important to recognize both unstable air mass or and air mass that is in transition from stable to unstable.

**Thermal Belt**

The thermal belt is a zone of warm nighttime temperatures and lower nighttime R.H.’s. The behavior of a fire that is burning in a thermal belt will reflect these conditions.

A thermal belt forms at the top of a night inversion and is a case where a stable air mass can cause problem fire behavior.

**Inversion Lifting or Breaking**

When an inversion begins to lift or break, the air mass is in transition from stable to unstable. The behavior of a fire burning beneath an inversion may change abruptly when the inversion is destroyed.

An inversion lifts or breaks as a result of:

- Winds that mix with the stable air.
- The heating and lifting effect of solar radiation.

Inversions tend to set a pattern for the time of day that they lift or break; take note of this pattern.
Fire Behavior
A fire builds toward problem fire behavior in observable stages. We want to use these stages as indicators to anticipate problem fire behavior.

FIRE BEHAVIOR INDICATORS

Leaning Column
Rapid rates of spread and short-range spotting are associated with this type of column.
Typical of wind driven fires.

Sheared Column
Winds aloft may cause long-range spotting.
These winds aloft also have the potential to surface. Avoid working under a sheared column.

Well Developed Column
Intense burning and unpredictable fire spread in any direction can occur with this type of column.

When the power of the fire becomes stronger than the power of the local winds it is called a plume-dominated fire.

The danger of a plume-dominated fire is the potential for downbursts that are similar to, but stronger than, downdrafts from a thunderstorm. If a fire has a well-developed column and you feel a light rain on the fire line or experience a sudden calm you can expect downbursts.

Changing Column
A column that is changing to a darker color; beginning to rotate faster; or splits; can indicate fire behavior is increasing.

Trees Torching
Torching trees are an indicator that a fire is starting to transition from a surface fire to a crown fire.
**Smoldering Fire Picking-Up**

Observe fire activity by monitoring flame length and rate of spread.

**Fire whirls Beginning**

Fire whirls are another indicator that a fire has the potential to move from a surface fire to a crown fire.

Fire whirls also provide a mechanism for spotting to occur.

**Frequent Spot Fires**

Spot fires increase fire spread and complexity.

Beware when you are getting spot fires faster than you can get people to work on them.

**Use of Indicators**

Several adverse conditions usually are present for extreme fire behavior to occur. There are normally several indicators to observe to help you predict or anticipate problem fire behavior; these indicators are "accumulating."