What is fire behavior?

Fire Vocabulary

Crowning—active fire movement through the tree canopy.

Extreme Fire Behavior—fire that precludes methods of direct control.

Extreme Fire Weather—high temperatures, low humidity, low fuel moisture, and high winds that can lead to extreme fire behavior.

Fire Behavior—rate of spread (in feet/hour) and intensity.

Fire Duration—rate of spread plus smoldering time.

Fire Ecology—the study of fire in the context of its environment.

Fire Frequency—average number of years between fires at a specific location.

Fire Intensity—amount of energy or heat released; temperature and flame length.

Fire Regime—frequency, extent, intensity, severity, and seasonality of fires within an ecosystem.

Fire Severity— degree to which a site has been altered by fire; postfire appearance of soil, litter, vegetation, or other resource of interest; proportion of overstory trees killed.

Fire Weather Outlook—air temperature, relative humidity, precipitation, wind conditions.

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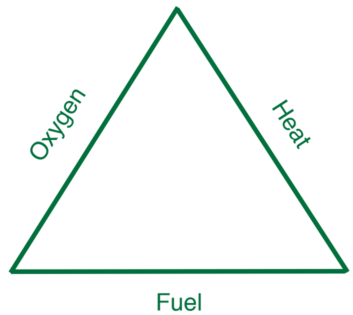
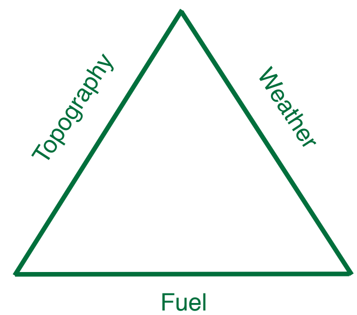
The Fire Triangle



The Fire Behavior Triangle



Simply put, fire behavior is the manner in which a fire reacts to the influences of fuel, weather, and topography. But that's not to say it's simple.

Fire science is extremely technical with a language all its own. You'll need to understand some of that vocabulary and science to give you a framework for management decisions. But for now, let's just start with the basics.

Tale of two triangles

The Fire Triangle. A fire needs three things to burn: oxygen, heat, and fuel. Take away any one of these and there is no fire. Firefighters rely on this triangle. They either smother the fire to take away its oxygen, cut off the fuel supply, or cool it below the ignition point. For example, when firefighters create a fire line down to mineral soil they are removing the combustible surface fuels. Fire retardants both cool the fire and smother it.

The Fire Behavior Triangle. The fire behavior triangle also involves three factors: fuel, weather, and topography. These determine a fire's magnitude, direction, and intensity of spread.

Fires behave in various ways, and some of these have names. A fire that spreads slowly with low intensity is called a *creeping fire*. A rapidly spreading, low-intensity fire is *running*. A fire that spreads rapidly with low intensity is *flashy*. And a high-intensity fire is often referred to as a *conflagration* or *firestorm*.

The fire behavior triangle offers insights into changing fire behavior and possible solutions. We are currently seeing major changes in two sides of the triangle: fuel loads and weather patterns. Since there is little we can do to change weather or topography, we have to focus on the fuel side of the triangle. There are many ways to manipulate fuel. We can remove it, burn it, adjust its density, modify its arrangement, masticate it, and more.

Fire regime change

Natural fires generally occur at a frequency, intensity, severity, and seasonality that is characteristic of the location. This long-term pattern is known as the *fire regime*. Fire regime is specific to the ecosystem and varies by forest characteristics including topography, species composition, climate, elevation, aspect, and other factors. The fire regime in the mixed conifer forest, for example, is very different from that of the redwood forest.

Changes in the fire regime can have profound effects on the forest ecosystem. Years of excluding fire from our forests have left them overcrowded, stressed, and with altered species composition. Both vegetation and wildlife are affected.

Frequency. Also known as the *fire return interval*, fire frequency is the average number of years between fires. For example, before suppression, fire occurred in the mixed conifer on average every 10 years. The frequent burns kept fuels from accumulating on the ground and removed excess growth so fires tended to be low to moderate in intensity. Now, after decades without fire, these forests have large accumulations of ground fuel, plus dense living biomass. Lack of fire has changed many characteristics of the ecosystem.

Intensity and Severity. *Fire intensity* is a measure of how hot a fire burns. *Fire severity* is more difficult to quantify; it refers to the fire's effects on vegetation, litter, soils, etc. Fire severity depends not only on the fire's intensity, but also on its duration. A long-lasting creeping fire may actually transfer more heat and could have a more severe effect on soil and vegetation than a fast-moving intense fire.

Generally speaking, *low-intensity fires* do not burn into the forest canopy. They clear out the

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underbrush, thin out young trees, and reduce the fuel accumulated on the forest floor. *Moderate-intensity fires* burn into the forest canopy, but typically don't kill the large trees. *High-intensity fires* consume all the ground cover and much of the forest canopy.

All fires are complex. Due to differences in topography, weather, and fuels, fires burn in a mosaic of low-, moderate-, and high-intensity areas. Historically, in mixed-conifer forests only a small percentage of a fire burned at high intensity. Recent wildfires have been a lot hotter: 40% of the Rim Fire burned at high intensity and 50% of the King Fire.

Seasonality. *Fire season* is the period when fires are expected to occur, based on knowledge of long-term climate patterns. This is when fire agencies gear up to fight fires.

With long-term patterns changing, short-term weather conditions are less predictable. Due to the incendiary condition of California forests right now, large fires can occur almost any time of year.

The typical fire season in California is from May to November, with the most intense fires in late September and October (although intense fires can occur in July and August too). But fire season has been expanding. It is now about 70 days longer than 40 years ago.

Invasive species. Nonnative invasive species can change the fire regime of the plant communities they invade. For example, Scotch broom and cheatgrass are extremely flammable and can increase the fire frequency in an ecosystem. This can make it more difficult for native plants—which are adapted to a specific local fire regime—to survive and reproduce. Identifying and removing invasive species can help maintain healthy forest ecosystems.

Fire Types

Fires are classified by where in the fuel strata they burn: surface fires, understory fires, and crown fires. *Surface fires* are the most common. Depending on the fuels, weather, and topography, these fires can be low to high intensity. *Understory fires* have flame lengths up to 10 feet. They consume surface fuels, small trees, brush, and lower branches of overstory trees. *Crown fires* reach into the crowns of trees with flame lengths more than 10 feet. Their behavior is often unpredictable. Crown fires are the most difficult to control as they can spread quickly from crown to crown with high intensity. *Torching* is limited to burning the crown of a single tree.

Fuel

Fuel is the material that burns. It is characterized by its size, moisture content, flammability, and location.

Changes in the moisture content of dead and downed wood is used to predict fire behavior

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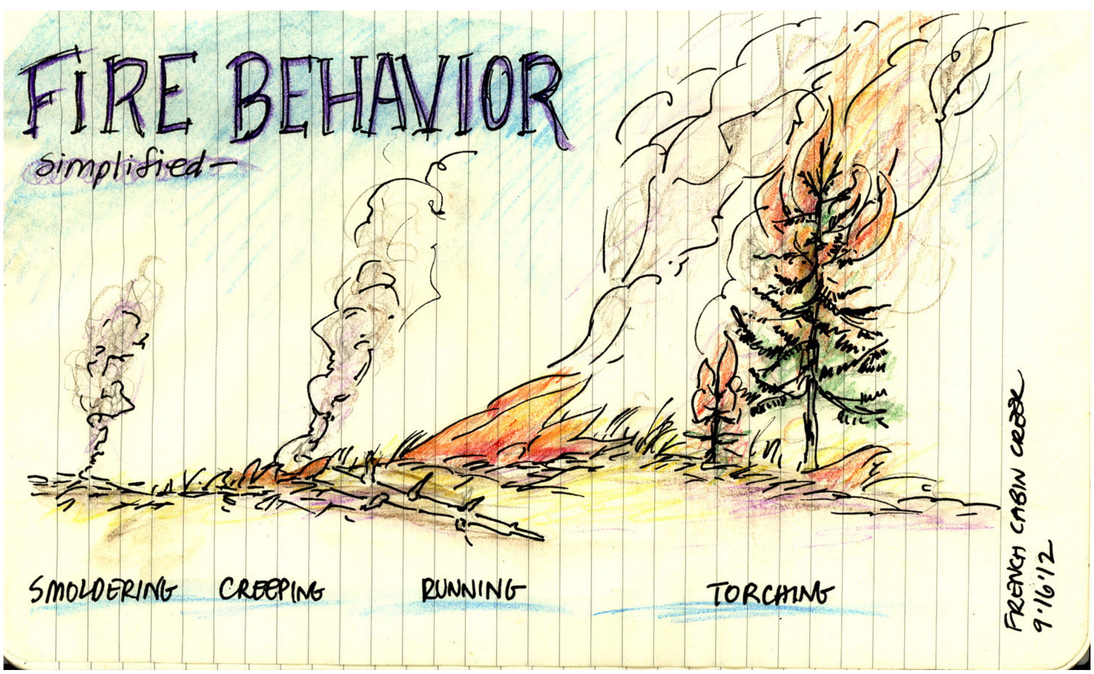

Illustration courtesy Debra Davis

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Fire Whirls—upward-spinning columns of air that carry flames, smoke, and embers aloft; whirls often form in heavy fuels on the downwind side of ridges; in extreme conditions can be powerful enough to twist off entire trees.

Fuel Moisture—moisture content of vegetation.

Foehn Wind—dry, warm downslope wind that occurs in the downwind side of a mountain range.

Ladder Fuels—fuels that connect surface fuels to crown fuels.

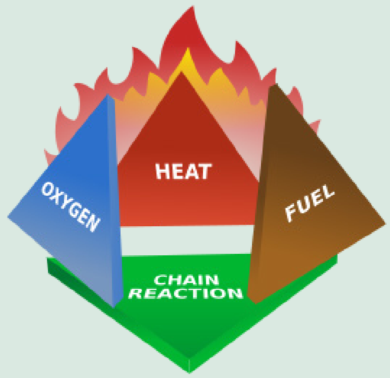
Santa Ana Wind—strong, extremely dry downslope winds that blow through mountain passes in southern California.

Spotting—firebrands (glowing embers) lofted up and ahead of the main fire front, igniting multiple spot fires that then feed back into the main fire front to create extreme and dangerous fire conditions.

Torching—movement of a surface fire up into the tree crown.

—more fire definitions at the Glossary of Wildland Fire Terminology (gacc.nifc.gov/nrcc/dc/idgvc/dispatchforms/glossary.pdf) and NOAA's Fire Terms and Definitions (www.erh.noaa.gov/gyx/firewx_definitions.html)

Be aware: factors that can affect fire behavior



Topographic Factors

Chimneys, chutes, gullies, and canyons: Topographical depressions, no matter how slight, can draw the leading edge of the fire. Convection currents of heated gases travel ahead of the fire.

Saddles: Saddles are at the top of canyons. Running fires are drawn to saddles. Expect more fire intensity here than anywhere else along the ridge-top.

Canyon mouths: During foehn (or Santa Ana) wind-driven fires, fire behavior at the low end of canyons is similar to that of the saddles during slope-driven fires (*see above*). Expect the greatest intensity there.

Aspect: Always note the aspect and time of day to help predict potential burning conditions for the daylight hours.

Fuel Factors

Flashy fuels: expect spot fires with sudden ignition and a rapid rate of spread.

Low dead fuel moisture: Expect greater fire intensity.

Low live fuel moisture: Contributes to faster spread and greater intensity.

Shrub and timber fuels: May create extreme fire intensity.

Weather Factors

Winds: Expect sudden changes in slope and valley winds from topographic features or fire behavior (e.g. eddies, roll eddies, fire whirls).

Unstable air: Visible signs of unstable air may portend the possibility of large fire whirls and extreme fire behavior.

Temperature and moisture: Rising temperature, dropping relative humidity (RH), and dropping fine fuel moisture (FFM) may increase spot fires and rapid rates of spread.

Frontal systems and thunderstorms: As they form or approach, these systems may set the stage for sudden and extreme fire behavior changes.

Alignment of Forces

Any one of the above factors can lead to a sudden change in fire behavior that can catch you off guard. When your position includes several of these, the potential can be great.

—adapted from CA Professional Firefighters, www.cpf.org/go/cpf/health-and-safety/wildland-firefighter-safety/fire-behavior-factors/

changes throughout the day. For that purpose, dead fuels are grouped into four size classes: 1 hour = up to 1/4 inch in diameter, 10 hour = 1/4 to 1 inch diameter, 100 hour = 1 to 3 inches diameter, and 1000 hour = 3 to 6 inches diameter.

Moisture content is critical to how easily a fire burns. Larger fuels take longer to absorb or lose moisture. Drier fuel fires generally spread faster, are more intense, and are consumed faster. Right now, in year 4 of drought, moisture is at an all-time low and our forests are primed to burn.

Weather

Weather is one of the major determinants of fire behavior. *Weather* is the day-to-day condition of precipitation, relative humidity, etc. *Climate* is the long-term average of daily weather conditions. With a warming climate, weather patterns have become more unpredictable, with more periods of extreme and uncharacteristic weather.

Extreme Fire Behavior

Extreme fire behavior includes one or more of the following: high rate of spread, prolific crowning and/or spotting, presence of fire whirls, and strong convection columns. Under extreme conditions, fire behavior becomes difficult to predict because the fires can often create their own weather and behave in erratic, sometimes dangerous, ways. These fires are extremely difficult to control.

Fuels ignite in two ways: by lightning and by human activity. We have no control over lightning, but we can reduce human-caused ignitions, including equipment use, vehicles, smoking, campfires, power lines, and arson.

Photo: Lenya Quinn-Davidson

Redwood National Park during the Fall 2013 TREX. Prescribed fire is used to limit conifer encroachment into oak woodlands, conserve biodiversity, and maintain natural processes.