Wildland Firefighting

13

Section II - Engine Company Operations

Weather, Fuel, Topography

Wildland Firefighter Safety

Wildland Fire Behavior

Wildland Strategy & Tactics

Strike Team Deployments

Revised - December 2018

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Objectives

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Introduction

Wildland fire behavior is shaped by its physical environment. Fire spread rates, fire intensity, and other characteristics of fire behavior respond to the unique and ever-changing combination of the fire environmental components. The three environmental components that influence wildland fire behavior are weather, topography, and fuels. The changing states of each of these components and their interactions with each other and the fire itself, determine the characteristics and behavior of a fire at any given moment.

Wildland firefighting is an extremely dangerous activity. Strict safety rules, such as LCES and Standard Firefighting Orders, have been established to help reduce the number of firefighter injuries and deaths each year related to wildland fires. In addition, 18 watchout situations have been established as well as numerous case studies and recommendations to learn from so that future firefighters do not make the same mistakes from the past.

Wildland strategy and tactics have been developed through many years of trial and error. It is critical that firefighters are able to determine the appropriate firefighting tactics based upon firefighter safety, current weather conditions, topography, and fuels. Tactical options such as structure triage and protection, indirect attack, and direct attack all require careful consideration and proper implementation.

Weather

Weather is the most variable component of the fire environment. It is dependent on the current air mass, the time of day, and will vary over both short and long time periods. Weather is the combined factors of temperature, wind, relative humidity, atmospheric stability, and precipitation.

Temperature

Temperature is defined as the degree of hotness or coldness of a substance. In regards to weather, air temperature is the substance that is measured and is read in degrees Fahrenheit. Air temperature changes near the surface of the earth are caused by the alternations of day and night, changing seasons, and weather systems. Typically the coldest time of the day occurs shortly after sunrise while the highest daytime temperature occurs roughly between 2pm and 4pm.

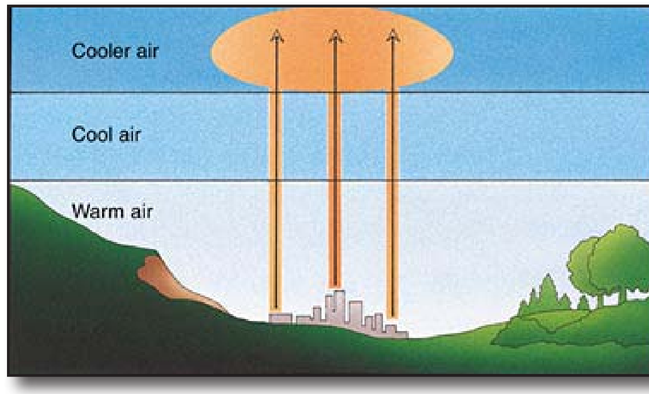


Figure 13-1 Normal weather pattern

The reason it is important to understand air temperature is because it can significantly influence a fire's behavior. As air temperatures increase, relative humidity decreases, fuel and vegetation heat up and dry-out, atmospheric conditions can become less stable and winds may increase. All of these changes result in more erratic, unpredictable, and explosive fire conditions. Conversely, as air temperature decreases, humidity rises, fuels temperatures cool and the fire behavior becomes less active.

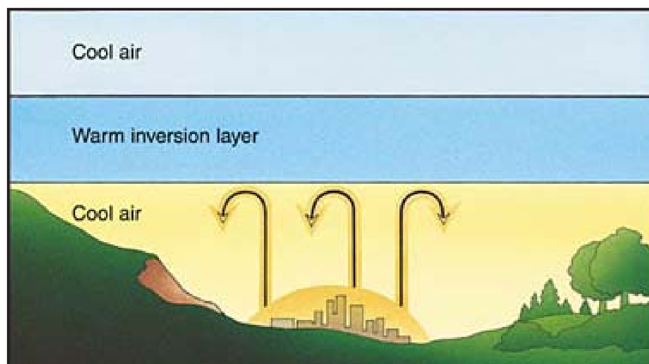


Figure 13-2 Inversion layer present

Inversion Layers

An inversion layer is a layer of air where the temperature increases with altitude. Under an inversion, the smoke and warm gases generated by a fire will only rise until their temperature equals that of the surrounding air, then, the smoke will flatten out and spread horizontally because it has lost its lift.

Inversion layers commonly form at night as cold air tends to settle in low-lying areas and valleys. Inversion layers indicate calm, settled weather and are usually easy to identify because they trap smoke, impurities, and gases resulting in poor visibility, Figure 13-3. Inversion layers break apart or

Figure 13-3 Inversion layer present pictured on left. The inversion layer has lifted pictured on right.

"lift" when the temperature of the day warms to a point where the air above the inversion layer is now cooler than the surface temperature, Figure 13-3. It is important to recognize when the inversion layer lifts because the behavior of the fire can change rapidly.

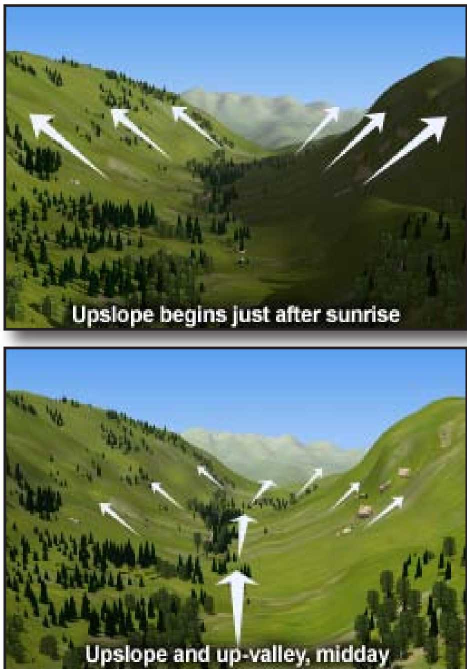


Figure 13-4 Upslope & up-valley wind

Wind

Wind is the most critical factor affecting fire behavior, the most difficult to predict, and is the most variable. Wind variability can pose safety and fire control problems that can result in firefighter fatalities. In many areas, winds behave quite predictably most of the time; however, when a fire becomes large it is often due to an unusual or unpredicted wind event.

Wind is defined as the horizontal movement of air relative to the earth's surface. Wind is the result of both small scale and large-scale temperature differences that in turn create pressure differences, also referred to as the pressure gradient. The stronger the pressure gradient, the stronger the wind will be. Wind can be compared to water in a flowing stream. Water in a stream will spill over, eddy, or swirl around obstacles or barriers, such as rocks just the same as wind will behave when it comes in contact with a mountain.

Wind direction is defined as the direction from which the wind is blowing. A north wind blows from north to south. A west wind blows from west to east. If you are facing into the wind, name the wind from that direction.

Figure 13-5 Downslope & down-valley wind

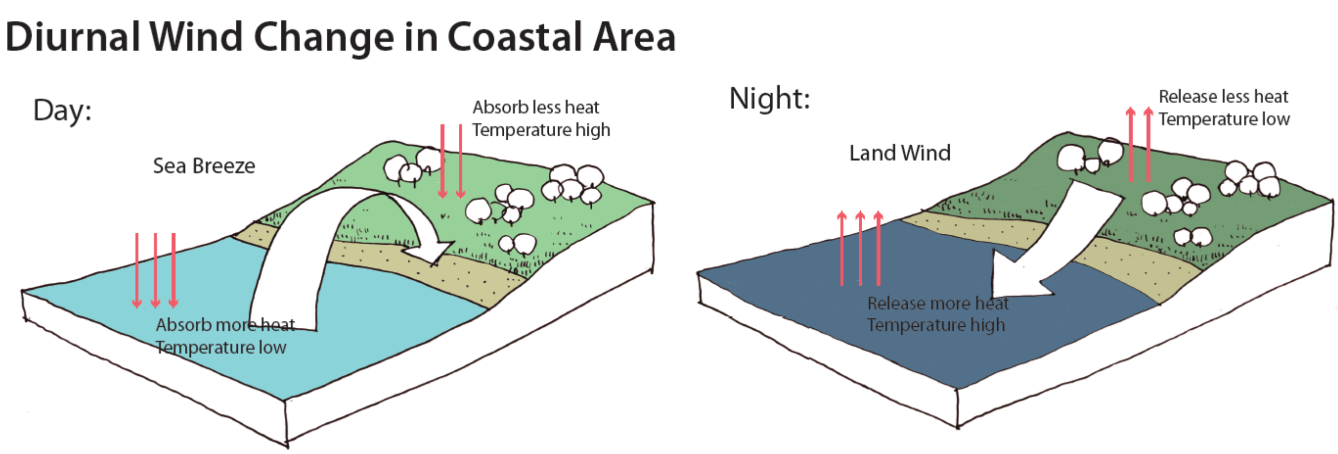
Local winds are the predominant daily winds. These winds are found at lower levels of the atmosphere and are caused by small-scale differences in air temperature and pressure. In San Diego, the ocean and the terrain have a very strong influence on our local winds. These local winds are every bit as important to understanding fire behavior as the large-scale wind events that occasionally occur. In San Diego, the local wind is considered a diurnal wind.

Diurnal Winds

Diurnal winds are characterized by a reversal of wind direction twice per day and are caused by horizontal temperature differences that develop daily. Diurnal winds found in the inland valleys and mountain areas of San Diego are characterized as an upslope/up-valley, downslope/down-valley wind. The diurnal wind in the coastal San Diego area is characterized as a land and sea breeze wind.

Upslope & Up-Valley Wind
During the day, the warm air next to a slope serves as a natural chimney and provides an upward flow of warm air, known as an upslope wind. Throughout the day as the slope heats up, this air becomes more buoyant and turbulent creating an upslope wind. Slopes that face the east generate upslope winds in the morning, while slopes that face the late day sun to the west experience the wind in the afternoon. Upslope winds typically range in speed from 3 to 8 mph. As the valley below heats up, it too generates a wind referred to as an up-valley wind. This wind typically develops midday.

Downslope & Down-Valley Wind
When the slope becomes shaded or night falls, the entire process is reversed. A short transition period occurs as the slope begins to shadow, the upslope winds die out, there is a relative period of calm, and then a gentle, smooth downslope wind begins to develop. This cooled dense air is stable causing the downslope wind to be slower and more stable, with speeds ranging from 2 to 5 mph. As the valley below cools down, it too generates a wind referred to as down-valley wind. This wind typically develops around midnight.



Land & Sea Breeze Winds

Land and sea breezes are driven by the temperature contrasts that develop between the sea and adjacent land mass. The temperature gradient develops because of the unequal heating and cooling rates of land and water. Land heats and cools more dramatically than does water, which tends to fluctuate very little in temperature. These temperature differences throughout the day drive these winds. Land and sea breeze winds are the predominant local winds associated with coastal San Diego, which is generally considered west of the I-805 corridor.

Sea Breeze – On Shore Flow
When the atmosphere is warmer over the land than over the water, a low pressure forms over the land and a sea breeze, or on shore flow, is created. Sea breezes are common during the day. They bring fog or low clouds, cooler temperatures, and high humidity inland and usually results in diminished fire activity. Sea breeze wind speeds typically range between 10 and 20 mph.

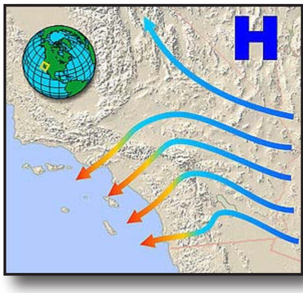


Figure 13-6 Foehn winds, aka Santa Ana winds, are caused by high pressure over the great basin and desert.

Land Breeze – Off Shore Flow

When the air over the water is warmer than the air over the land, low pressure is found over the water causing a land breeze, or off shore flow. Land breezes are common at night. These breezes are usually weaker than sea breezes and range between 3 and 10 mph.

Foehn Wind

Foehn winds are strong, warm, and dry winds that originate from areas of high pressure in mountainous regions. As this air flows downslope it picks up speed and increases in temperature, Figure 13-6. This combination of warm temperatures, low humidity, and high wind speeds can cause high rates of fire spread and serious fire control problems. Foehn wind speeds often reach 40 to 60 mph and tend to be stronger at night when they combine with the local downslope and land breeze.

Figure 13-7 Satellite image of Southern California during the 2003 wildfires and Santa Ana wind event.

"Santa Ana" Wind

In Southern California the foehn wind is commonly referred to as a "Santa Ana" wind. These winds occur when the center of high pressure is located in the Great Basin region. The Santa Ana wind blows out of the Mojave Desert through the Santa Clara River Valley and through Cajon and Banning Passes toward the Pacific Ocean. This wind creates the most critical fire weather situations in Southern California during fall and winter months. The devastating 2003 Cedar Fire and 2007 Witch Fire both occurred in the month of October and were a direct result of foehn, or "Santa Ana" winds.

Thunderstorm Winds

All thunderstorms should be considered a threat to fire operations. Thunderstorms create erratic and gusty downdrafts as well as strong outward and inward flowing wind, Figure 13-8. These winds pose a serious threat to firefighters because they can suddenly change their speed and direction, spreading the fire and increasing its intensity. Additionally hazardous, thunderstorms present the risk of lightning strikes.

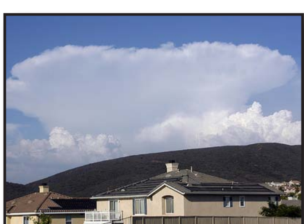


Figure 13-8 Thunder heads are easily identifiable by the anvil shaped cloud burst

Figure 13-9 Cold front system

Cold Front Winds

Cold front winds occur when a large body of cold air and low pressure approach. This is usually indicative of an approaching storm. Although cold fronts tend to bring cooler temperatures and higher humidity levels, the real danger to firefighters lies in the pre-frontal conditions. As a front approaches, wind speeds increase and can become gusty and wind direction can shift suddenly, Figure 13-9. These two pre-frontal conditions offer a favorable burning environment and may lead to large fire growth and extreme fire behavior. Don't get caught off guard during a wildfire in cooler temperatures and higher humidity; fire season is year round in San Diego.

Dust Devils

Dust devils are one of the most common indicators of unstable air, Figure 13-10. They occur on hot days over dry ground when skies are clear and the winds are light. Under intense heating, air near the ground rises in an upward-spiraling motion forming a column or chimney. The size of dust devils, or fire whirls, can range from 10 feet to 4000 feet high and up to 100 feet wide. Wind speeds often range from 20 mph all the way up to 50 mph.

Figure 13-10 Dust devils indicate an unstable atmosphere

Firewhirls

Firewhirls are generated by intense heat from fires and occur most often where heavy concentrations of fuel are burning, Figure 13-11. Firewhirls are unpredictable, but often develop on the lee side of ridgelines. Firewhirls have been known to twist off trees more than 3 feet in diameter and pick up large burning embers and spew them far across the fire line causing spot fires. This is an example of extreme fire behavior that requires firefighters to use extreme caution.

Figure 13-11 Firewhirls indicate the presence of extreme fire behavior

Effects Of Wind On Fire Behavior

Wind affects wildland fire in several ways. Wind will carry away moisture-laden air and increase the drying of wildland fuels. Once a fire ignites, wind aids combustion by increasing the supply of oxygen and will increase the fire spread by carrying heat and burning embers to new fuels (spotting). Wind also pushes the flame and convective heat toward the unburned fuels, preheating the fuels ahead of the fire front. The direction of the fire spread and smoke are determined largely by wind direction.

Figure 13-12 Wind will increase fire behavior and spread

Relative Humidity

Relative humidity is the ratio of the amount of moisture (water vapor) in the air, to the maximum amount of moisture that the air could contain if it were saturated. Relative humidity is therefore expressed as a percentage. The reason relative humidity is important to firefighters is because the amount of moisture in the air directly affects the amount of moisture in the fuel, or vegetation. Light fuels, such as grass, grain and lose moisture quickly with changes in relative humidity. Heavy fuels respond to humidity changes more slowly.

Figure 13-13 Cumulus clouds

Another danger of relative humidity is that firefighters cannot usually detect changes in humidity like they can with wind or temperature without special equipment. Even slight drops in humidity levels can significantly increase the fire's behavior. Historically, the majority of large fires have not only occurred when temperatures were above average, but when relative humidity was unusually low.

Atmospheric Stability

Atmospheric stability is defined as the resistance of air to vertical movement. Stable air is the result of a warm air mass over a cold air mass. When air is stable, there is very little upward or downward motion, resulting in poor mixing of the air. Unstable air is the result of a cold air mass over a warm air mass. When air is unstable, upward motion results in good mixing of the air. This is important because wildland fires burn hotter and more intense when the air is unstable.

$$\frac{\text{Warm Air}}{\text{Cold Air}} = \text{Stable Atmosphere}$$

$$\frac{\text{Cold Air}}{\text{Warm Air}} = \text{Unstable Atmosphere}$$

Visual indicators of an unstable air mass include:

- Clouds grow vertically and smoke rises to great heights
- Cumulus type clouds, Figure 13-13
- Gusty winds, dust devils, fire whirls
- Good visibility

Visual indicators of a stable air mass:

- Inversion layer
- Foggy or clouds in layers
- Stratus type clouds
- Lazy smoke column that drifts apart after a limited rise
- Poor visibility due to smoke or haze
- Steady winds

Fire Potential Index

The FPI is a planning and decision support tool used to quantify fire potential by utilizing state of the art technology which incorporates weather, live fuel moisture, dead fuel moisture, and greenness of the annual grasses. The FPI provides a measure of predicted local fire danger based on past wildfire events such as the Cedar Fire and situational awareness of potential for extreme fire behavior.

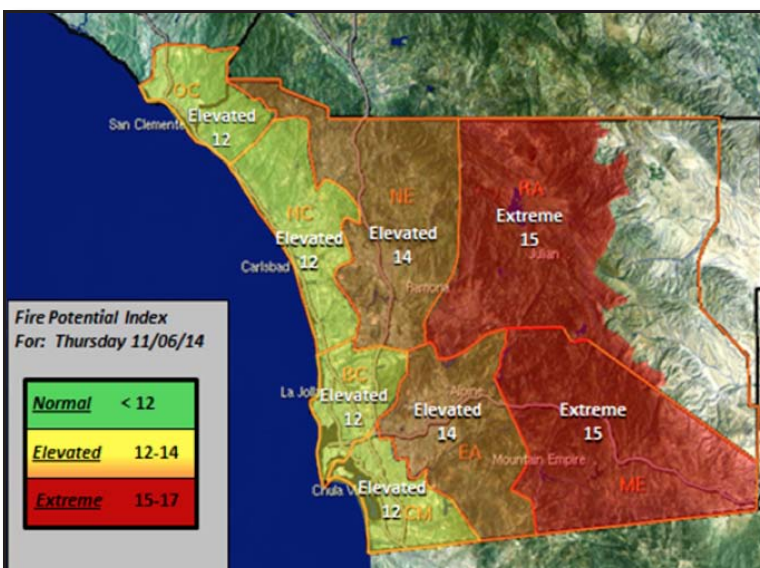
The FPI is issued daily and provides a seven (7) day outlook to inform personnel of pending weather factors influencing fire behavior and risk, as well as a support tool in making operational decisions and possible staffing modifications.

Link 13-1 Fire Potential Index PPT and Information

8 San Diego County Regions

The FPI is determined in eight geographical regions within the County of San Diego.

- ME- Mountain Empire
- RA- Ramona
- EA- Eastern
- **NE- Northeast** (San Diego City - San Pasqual & Rancho Bernardo)
- NC- North Coast
- OC- Orange County
- **BC- Beach Cities** (San Diego City)
- **CM- Construction Metro** (San Diego City)



Daily FPI Notifications

The FPI will be sent out via page to all personnel every morning at 0800 hours by the Emergency Command and Data Center. Additonally the FPI shall be sent out to your City email each morning. The daily FPI email shall consist of an executive summary, FPI for the current date, seven day FPI outlook, FPI discussion, and Santa Ana wind wildfire threat index.

Executive Summary

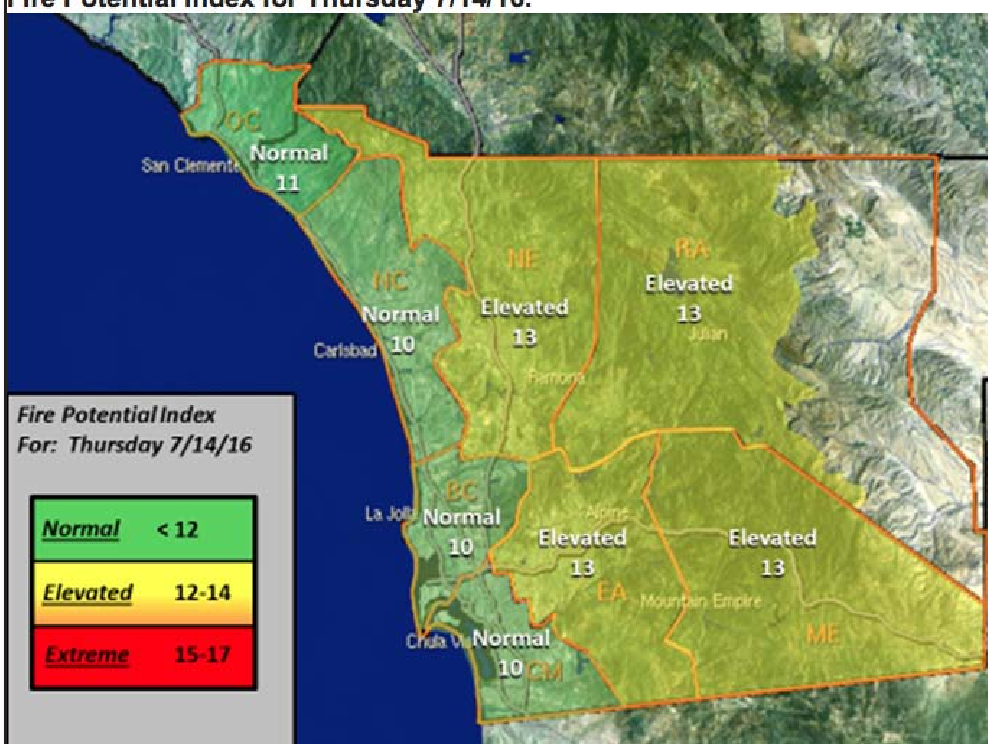
Provides a brief overview of the weather predicted for the day moving forward through the next 7 days, including FPI conditions and relevant trends.

Executive Summary:
Warmer today through Fri with inland high temperatures of 85-95 degrees Humidities of 5-15% in portions of the valleys, foothills, and mountains through Friday Slightly cooler this weekend, though temperatures will remain above normal Elevated FPI conditions for all inland areas above the marine layer through the next seven days

FPI for Current Date

Provides the FPI predctions for the day in all 8 San Diego County Regions

Fire Potential Index for Thursday 7/14/16:



Seven Day FPI Outlook

Provides the predicted seven day outlook for each of the eight San Diego County Regions

Seven Day FPI Outlook:

	Today 7/13	Thu 7/14	Fri 7/15	Sat 7/16	Sun 7/17	Mon 7/18	Tue 7/19	Wed 7/20
ME	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13
RA	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13
EA	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13
NE	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13	Elevated 13
OC	Normal 11	Normal 11	Normal 11	Normal 10	Normal 10	Normal 11	Normal 11	Normal 11
NC	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10
BC	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10
CM	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10	Normal 10

Normal	Elevated	Extreme
< 12	12-14	15-17

FPI Discussion

The FPI discussion area is used to gather more detailed information about current/predictied weather and interpreting the current FPI ratings.

Santa Ana Wind Wildfire Threat Index

Provides a wildfire threat index through the forecasting of Santa Ana wind events expected in San Diego County.

Santa Ana Wildfire Threat Index for San Diego County:

PREDICTIVE SERVICES

Today 7/13	Thu 7/14	Fri 7/15	Sat 7/16	Sun 7/17	Mon 7/18
No Rating	No Rating	No Rating	No Rating	No Rating	No Rating

No-Rating	Marginal	Moderate	High	Extreme
Santa Ana winds are not expected or will not contribute to significant fire activity.	Upon ignition, fires *may* grow rapidly.	Upon ignition, fires *will* grow rapidly and *will* be difficult to control.	Upon ignition, fires will grow *very* rapidly and will be *very* difficult to control.	Upon ignition, fires will have extreme growth and will be uncontrollable

For realtime weather and access to the most current FPI, you can access this information on the web at SDGEweather.com using any smart device.

Fuel

Fuel can simply be defined as any combustible material. Wildland fuels are typically live and/or dead vegetation. In the wildland interface you can expect to encounter a wide range of fuels, from propane to structures. However, for the purposes of this chapter, we will focus on natural vegetation. Fuel factors that influence fire behavior are the fuel type, size and shape, fuel moisture and temperature, and fuel arrangement.

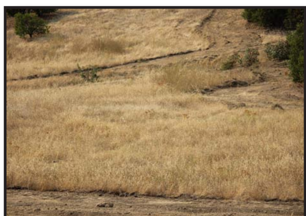


Figure 13-14 Grass

Figure 13-16 Shrub

Figure 13-15 Timber

Figure 13-17 Slash

Type

Fuels, or vegetation, vary in type from one area of the country to another and within the same area.

Fuels can be categorized into four major types:

1. GRASS – Found in most areas, but more dominant as a fuel in desert and range areas. It can become prevalent after a fire in forested areas.

2. SHRUB – Found throughout most areas in Southern California, e.g. sagebrush and chaparral.

3. TIMBER – Standing large live trees with an understory of one or more other fuel models. Unless the fire is crowning, the understory is the primary carrier of fire.

4. LOGGING SLASH – Debris left behind after logging, pruning, thinning, or shrub cutting. It may also include logs, chunks, bark, branches, stumps, and broken understory trees and shrubs.

Size & Shape

Fuels are also categorized by their size and shape. In the wildland firefighting arena, fuels generally fall into one of three categories:

Light Fuels

Light fuels range in height from 0’ to 3’. Light fuels include small shrubs, grasses, leaves, and pine needles, Figure 13-18. Light fuels burn rapidly and are quickly ignited due to high surface areas and plenty of oxygen available. Fires in light fuels spread rapidly but burn out quickly and are easily extinguished.

Medium Fuels

Medium fuels range in height from 3’ to 6’. Medium fuels include shrubs, chaparral, Manzanita, poison oak, etc., Figure 13-19 Medium fuels may also ignite rapidly but tend to burn and spread at a slower rate than light fuels. Fires in medium fuels retain more heat after the fire has passed than light fuels and require more work to extinguish.

Figure 13-18 Light Fuel 0' to 3' tall

Figure 13-19 Medium Fuel 3' to 6' tall

Figure 13-20 Heavy Fuel 6' and taller

Heavy Fuels

Heavy fuels are generally any vegetation over 6' in height. Heavy fuels include trees, large shrubs, as well as downed limbs or logs, Figure 13-20. These fuels warm more slowly than light and medium fuels leading to a slower rate of spread but a hotter and longer burn time.

Fuel Moisture

Fuel moisture is the amount of water in a fuel, expressed as a percentage of the oven-dry weight of that fuel. How well a fuel will ignite and burn is dependent on its moisture content. Dry fuels will ignite and burn more easily than the same fuels when they are wet. Before a wet fuel can burn, the moisture it contains must be converted to vapor and driven away. This process takes a great deal of heat. As fuel moisture increases, the amount of heat required to ignite and burn that fuel also increases.

Because of their various sizes and characteristics, different fuels in the same area will have various moisture levels. Light fuels take on and lose moisture much faster than heavier fuels.

Fuel Loading

Fuel loading is the quantity of fuels in the area. The quantity of fuels in any given area does not necessarily mean the fire will burn with great intensity. What is more important is the quantity of fuels available for combustion.

Many factors are involved when talking about fuel availability. In regards to the size and shape of fuels, light fuels require a lower temperature to reach their ignition point, the burn out period is shorter, and the fuel moisture changes more rapidly than in heavy fuels. The arrangement and moisture content also greatly affect the availability of a fuel to burn

Fuel Arrangement

How a fire behaves in a given fuel type depends largely on the arrangement of the fuels. This includes the vertical arrangement and horizontal continuity of the fuel.

Figure 13-21 Clean Burn

Horizontal Continuity:

Uniform Fuels

Uniform fuels include all fuels distributed continuously over the area. Areas containing a network of fuels that connects with each other to provide a continuous path for fire to spread. A uniform fuel bed will allow for complete combustion of the fuel bed; referred to as a "clean burn." Figure 13-21

Patchy Fuels

Patchy fuels include all fuels distributed unevenly over the area. This includes areas of fuels with definite breaks or barriers present, such as patches of rock outcroppings, bare ground, or areas where another dominant type of fuel is much less flammable. A fire that has burned through a patchy fuel bed and left behind unburned fuel is referred to as a "dirty burn." Figure 13-22

Figure 13-22 Dirty Burn

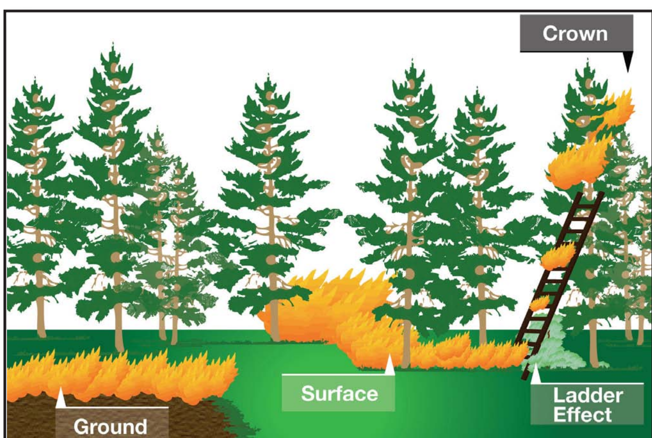


Figure 13-23 Vertical fuel arrangements

Vertical Arrangement:

Ground Fuels

Ground fuels are all combustible materials lying beneath the surface including deep duff, tree roots, rotten buried logs, and other organic material.

Surface Fuels

Surface fuels are all combustible materials lying on or immediately above the ground including needles or leaves, duff, grass, small dead wood, downed logs, stumps large limbs, and low shrubs.

Ladder Fuels

Ladder fuels are all the green and dead materials located above the surface fuels but still well below the top of the trees. Ladder fuels provide a path for fire to travel from the ground and surface fuels up to the aerial fuels.

Crown/Aerial Fuels

Aerial, or crown fuels, are all green and dead materials located in the upper canopy, including tree branches snags, hanging moss, and tall shrubs. Crown/aerial fuel fires can burn through the tops of tress independently of the surface fuel fire.

Topography

Topography, or layout of the land, is the most constant of the three fire environmental components. It is much easier to predict the influences that topography will have on a fire than the influences of fuel and weather. Topography is the combined factors of elevation, slope, aspect, and the shape of the terrain.

Aspect

Aspect is the direction in which a slope faces; a slopes exposure in relation to the sun. The aspect of a slope generally determines the amount of heating it gets from the sun and the amount, condition, and type of fuels present.

South and west slopes are more directly exposed to sunlight, generally have sparser lighter fuels, higher temperatures, lower humidity, lower fuel moisture, and are the most critical in terms for the start and spread of wildland fire, Figure 13-24.

North and east slopes are shaded from the afternoon sun, have a greater quantity of heavier fuels, lower temperatures, higher humidity, and higher fuel moisture.

A good example of the effect aspect has on vegetation in San Diego is visible from the 8 freeway in Mission Valley. Slopes with a southern aspect (on the north side of mission valley) face the direct sun most of the day; they therefore have very light to patchy vegetation. These slopes are indicative of a fast moving, flashy fire with lower heat intensity.

Figure 13-24 Slopes with a south and west aspect are exposed to more sunlight and have lighter fuels, while north and east aspects receive less intense sunlight and contain heavier fuels.

The slopes with a northern aspect (on the south side of the mission valley) are shaded more throughout the day, have higher fuel moisture, heavier fuels, and a uniform fuel bed. These north facing slops tend to burn at a slower rate of spread but burn with more heat and intensity.

Slope

Slope is defined as the amount of degree of incline of a hillside. Fires burn more rapidly uphill than downhill. Fire is also greatly influenced by its position on the slope and how steep the slope is. An additional concern regarding firefighting on steep slopes is the possibility of burning material rolling downhill below you. This can ignite fuels below the main fire and trap personnel.

Position On Slope

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 primarily influence by the fuels and the wind. A fire that starts near the bottom of a slope during normal upslope, daytime wind conditions, will normally spread faster and burn more area than a fire that starts near the top of the slope because it has a longer run uphill.

Figure 13-25 As little as a 10 degree slope incline will double the rate of fire spread

Steepness of Slope

The steeper the slope, the faster the fire burns. This is because the fuels above the fire are brought into closer contact with the upward moving flames. Fire burning on a 10 degree slope will spread twice as fast as a fire on burning on flat ground (not factoring in weather or fuels), Figure 13-25. This is primarily due to convective and radiant heat that help the fuel catch fire easily and climb the slope.

Terrain Shape

The shape of the terrain can greatly influence a fires behavior due to its effect on wind speed and direction. This in turn influences the direction of fire spread, rate of spread, and the intensity of the wildland fire.

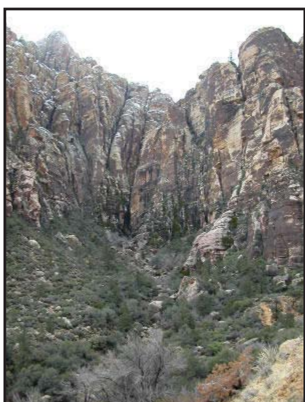


Figure 13-26 Box Canyon, aka Chimney

Box Canyons

Box canyons, also referred to as "chimneys," are where a canyon has been created by two ridgelines that sharply converge, and force the valley to curve up in a vertical direction, Figure 13-26. Fires starting near the base of a box canyon may react similar to a fire in a wood burning stove or fireplace. Air will be drawn in from the canyon bottom creating very strong upslope winds. These upslope winds create rapid fire spread up the canyon and lead to extreme fire behavior.

Draw

A draw is a more shallow upslope canyon than a box canyon. Draws can be easily identified by the area where a mid-slope road has an inside turn, Figure 13-27. This can be a shallow wide canyon or a steep box canyon. A draw gets its name because fire tends to increase and build intensity in these areas, or draw in towards the canyon.

Figure 13-27 Draws are identifiable by inside turns in roads

Narrow Canyons

Fire in a steep or narrow canyon can easily spread to fuels on the opposite side by radiation or spotting. Wind direction will normally follow the direction of the canyon. Wind eddies and strong upslope air movement may be expected at sharp bends in a canyon.

Wide Canyons

In wide canyons, the 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 in a canyon. This change of direction is caused by the flow of air in the canyon. In some cases a whirling motion by the fire may result from a strong flow of air around the point of a ridge.

Figure 13-28 Saddle

Saddles

A saddle, or pass, is the topographic feature that is formed between two nearby peaks, Figure 13-28. It gets its name from the obvious horse saddle shape that is formed by the land. Saddles cause wind speeds to increase as they pass through the constricted area and spread out on the downwind side.

Elevation

Elevation is the height of the terrain above sea level and is usually expressed in feet. Elevation plays a large role in determining the conditions of the fuel and the amount of fuel. Fuels at lower elevations dry out earlier in the year than those at higher elevation, because of higher temperatures. For every 1000’ in elevation gain, the temperature drops 5.5 degrees F. In extremely high elevations, such as high mountain peaks and ridges, fuels may become completely absent. Elevation affects fire behavior in several other ways, such as the amount of precipitation received, the exposure to winds, and its relationship to the surrounding terrain.

Barriers

Any obstruction to the spread of wildfire, either natural or man-made, is considered a barrier. Natural barriers include rivers, lakes, rockslides, and some fuels that do not burn well. Man-made barriers include roads, highways, reservoirs, dozer tracks, and fire-line built by firefighters, Figure 13-29.

Figure 13-29 Barriers, rock slide (left) and dozer line on a ridge (right).

Wildland Firefighter Safety

Figure 13-30 Trapped by fire, Orange County Firefighters deploy their fire shelters.

Wildland firefighting is an extremely hazardous activity! Each fire season firefighters lose their lives or incur serious injuries performing these duties. As with any firefighting activity, personal and crew safety must ALWAYS be the number one factor influencing your decisions and actions during wildland firefighting. In order to assist with making safe decisions, the risk management process must be used prior to every action.

Risk Management

Remember the saying: "We shall risk a lot to save a lot, we shall risk a little to save a little, we shall risk nothing to save nothing." The majority of wildland firefighting activities involve suppression of burning vegetation. Burning vegetation should be considered "nothing." It grows back and has no value. A rescue of a person is considered "a lot," while a structure should be considered "a little."

The following risk management checklist is from page 1 in the Incident Response Pocket Guide, or IRPG, and should be used to assist with your assessment of risk, Figure 13-31.

Situational Awareness

- Gather Information
  - Objectives – Are we saving a life, property, or vegetation?
  - Communication – Are effective communication systems in place?
  - Who's in Charge?
  - Previous Fire Behavior?
  - Weather Forecast & Local Factors?
- Scout the fire & surrounding area

Hazard Assessment

- Estimate potential fire behavior hazards.
- Identify tactical hazards – 18 situations that shout watchout.
- Consider the severity of the hazard vs. the probability of it occurring.

Hazard Control

- 10 - Firefighting Orders in place?

- LCES – Lookouts, Communications, Escape Routes, Safety Zones?

Decision Point

- Are controls in place for hazard identification?
  - No – Reassess situation
  - Yes – Next Question
- Are tactics based on expected fire behavior?
  - No – Reassess situation
  - Yes – Next Question
- Have clear instructions been given and understood by all?
  - No – Reassess situation
  - Yes – Proceed

Refusing Risk

Every individual has the right and obligation to report safety problems and contribute ideas regarding their safety. Supervisors are expected to give these concerns and ideas serious consideration.


Figure 13-31 IRPG

When an individual feels an assignment is unsafe they also have the obligation to identify, to the degree possible, safe alternatives for completing that assignment. Turning down an assignment is one possible outcome of managing risk. A "turn down" is a situation where an individual has determined they cannot undertake an assignment as given and they are unable to negotiate an alternative solution. The turn down must be based on an assessment of risks and the ability of the individual or organization to control those risks.

Individuals may turn down an assignment as unsafe when:

- There is a violation of safe work practices.
- Environmental conditions make the work unsafe.
- They lack the necessary qualifications or experience.
- Defective equipment is being used.

Procedure For Turning Down an Assignment

- The individual directly informs their supervisor they are turning down the assignment as given. The decision to turn down the assignment should be backed up by the 10 Firefighting Orders, 18 Situations That Shout Watchout, LCES, or other Risk Management criteria to document the turn down.
- The supervisor must notify the Safety Officer immediately upon being informed of the turn down. If no Safety Officer is assigned, this should be reported to the I.C. to provide accountability for decisions and initiates communication of safety concerns within the incident organization.

- If the supervisor asks another resource to perform the assignment, they are responsible to inform the new resource that the assignment was turned down and the reasons why it was turned down.
- If an unresolved safety hazard exists or an unsafe act was committed, the individual should also document the turn down by submitting a SAFENET or SAFECOM form in a timely manner.

These actions do not stop an operation from being carried out. This protocol is integral to the effective management of risk as it provides timely identification of hazards to the chain of command, raises risk awareness for both leaders and subordinates, and promotes accountability.

Lookouts
Communications
Escape Routes
Safety Zones

LCES

LCES is a simple acronym that has been created to assist all ranks of wildland firefighters with establishing personal safety and better situational awareness. LCES stands for lookouts, communications, escape routes, and safety zones. LCES is must be communicated prior to every operational period and updated as necessary as conditions change. Do not initiate firefighting activities unless LCES is in place and understood by all crewmembers!

Look Outs

An experienced, competent, and trusted firefighter should be used as a lookout. A lookout should never engage in any firefighting activities, as their sole responsibility is to watch out for the safety of crews operating in the area.

Lookouts shall:

- Be experienced, competent, trusted
- Have a good vantage point and have enough lookouts
- Have knowledge of the crew locations
- Have knowledge of the escape and safety locations
- Have knowledge of trigger points
- Have a map, weather kit, watch, and IAP (incident action plan)

Communications

Primary, back up, and emergency communication plans must be established. These may include the use of VHF or 800 mhz radios, cell phones, whistles, air horn blasts, or any other effective means of communication. Radio frequencies must be clearly confirmed, back up procedures should be established, and trigger point signals should be discussed. It is important to sound the alarm early, not late, to warn crews of possible danger.

Escape Routes

More than one emergency escape routes shall be established and shall lead to a safety zone. A good escape route shall avoid steep uphill slopes and should be well scouted for loose soil rocks or vegetation obstructing the route. The escape route should allow enough time for the slowest crewmember to get to safety factoring in fatigue, terrain, and weather. Escape routes may also be flagged with banner tape to assist crewmembers in not getting off track.

Safety Zones

A safety zone is an area where a firefighter can survive without a fire shelter, Figure 13-32. Considerations for effective safety zones are:

- Survivable without a shelter.
- A clean burned area or "black area" that has no potential for a reburn.
- Utilize natural features such as rock areas, water, meadows.
- Utilize man-made features such as roads, dirt lots, heli-spots.
- Safety zones located upslope, downwind, or near heavy fuels shall have more heat impact and should require a larger area.

Figure 13-32 An ideal safety zone

As a general rule, the size, or distance separation of the safety zone should be at least four times the maximum continuous flame height. Distance separation is the radius from the center of the safety zone to the nearest fuels.

Flame Height	Safety Zone Radius	Safety Zone Acres
10'	40'	1/10 acre
20'	80'	1/2 acre
50'	200'	3 acres
100'	400'	12 acres
200'	800'	46 acres

Temporary Refuge Area (TRA)

The temporary refuge area (TRA) concept is somewhat new to the wildland firefighting arena; however, it has been adopted by FIRESCOPE and is currently part of the California Department of Forestry and Fire Protection (CAL FIRE) training curriculum. In short, anything that protects firefighters from radiant or convective heat can be considered a TRA; therefore, if an escape route to a safety zone becomes compromised, firefighters should use a TRA until it's safe to move to the safety zone or safely return to work. Keep in mind, however, that a TRA is not a replacement for an identified safety zone; it is merely a temporary, short-term solution that firefighters can use when needed.

Figure 13-33 Temporarily seeking shelter in the house while the flame front passes is an example of a TRA.

The major difference between a TRA and a safety zone: TRA's may not provide continuous, adequate safety and protection because of changing fire conditions or extreme fire behavior, therefore a TRA always requires another planned tactical action. Firefighters who take shelter in a TRA must have a contingency plan in place in the event they are forced to abandon their position. For example, firefighters taking temporary refuge inside a structure must plan their next move in case the structure begins to burn and they can't remain inside. This may mean moving to an apparatus, sheltering behind a wall or rock outcropping or finding another suitable heat barrier. Potential TRA's include:

- Large turnouts, cul-de-sacs or parking lots
- On-site greenbelts, meadows, pastures, large lawns
- Lee side of structures
- Inside apparatus
- Inside structures, Figure 13-33

Standard Firefighting Orders

The 10 standard firefighting orders are simply that, they are orders! They are not suggestions or watch outs, they are requirements. They must be in place at all times during wildland firefighting.

1. Keep informed on fire weather conditions and forecasts.
2. Know what your fire is doing at all times.
3. Base all actions on current and expected behavior of the fire.
4. Identify escape routes and safety zones and make them known.
5. Post lookouts when there is possible danger.
6. Be alert. Keep calm. Think clearly. Act decisively.
7. Maintain prompt communications with your forces, your supervisor, and adjoining forces.
8. Give clear instructions and insure they are understood.
9. Maintain control of your forces at all times.
10. Fight fire aggressively, having provided for safety first.

18 Watch Out Situations

The "18 situations that shout watch out" are more specific and cautionary than the Standard Firefighting Orders and describe situations that expand the 10 points of the Firefighting Orders. If firefighters follow the Standard Firefighting Orders and are alerted to the 18 Watch Out Situations, much of the risk of firefighting can be reduced.

1. Fire not scouted and sized up.

2. In country not seen in daylight.
3. Safety zones and escape routes have not been identified.
4. Unfamiliar with weather and local factors influencing fire behavior.
5. Uninformed on strategy, tactics, and hazards.
6. Instructions and assignments not clear.
7. No communication link with crewmembers/supervisors.
8. Constructing line without safe anchor point.
9. Building fireline downhill with fire below.
10. Attempting frontal assault on fire.
11. Unburned fuel between you and the fire.
12. Cannot see main fire, not in contact with anyone who can.
13. On a hillside where rolling material can ignite fuel below.
14. Weather is getting hotter and drier.
15. Wind increases and/or changes direction.
16. Getting frequent spot fires across line.
17. Terrain and fuels make escape to safety zones difficult.
18. Taking a nap near the fire line.

Fire Shelter Deployment

The fire shelter is a mandatory item of PPE for all wildland firefighters and must be carried anytime personnel are on the fireline. Since 1977, fire shelters have saved the lives of more than 300 firefighters and have prevented hundreds of serious injuries, Figure 13-34. It is imperative that all firefighters understand and practice the proper methods for deploying these life saving devices.

Figure 13-34 Fire Shelter

The fire shelter should be used if the planned escape routes or safety zones become inadequate and entrapment is imminent. Carrying a fire shelter should never be an alternative to LCES or The Standard Firefighting Orders and is not an excuse to take unnecessary risk.

Refer to the Fire Shelter Survival Manual on the use of the fire shelter or reference the additional training material in the Wildland Refresher Manual, Fire Shelter Survival Chapter found in all fire station libraries.

Link 13-2 Fire Shelter Survival Manual

Engine & Vehicle Operation

The following guidelines apply to all vehicles operating on a Wildland/Interface incident. Failure to follow these rules can result in serious firefighter injury, loss to structures, and damage to equipment.

DO NOT:

Figure 13-35 Do not park on a midslope road

- DO NOT block roadways. Always park so all other equipment can safely get by your vehicle. This may require laying a supply line to allow room for others to pass.
- DO NOT park on midslope roads where fire is below your location with unburned fuel between you and the fire, Figure 13-35.
- DO NOT park in or near chimneys, saddles, or draws. These topographical features will channel heat and smoke and dramatically increase the intensity of fire at your location. Generally, chimneys can be identified on roads that turn "into" the hill or slope, as opposed to roads that turn "out" when driving around a spur ridge.
- DO NOT park under power lines or near exposed propane or fuel tanks.

DO:

- Park on the opposite side of the road away from the fire and have a protector line charged and in position.
- Use natural fire barriers (rocky areas, cut banks, ridges, and noncombustible structures) to your advantage to "shield" your engine from convected and radiant heat.

Figure 13-36 A good spot: facing out, not blocking the roadway, hoselines in place, and clear of fuels

- Park engine in a Safety or Survival Zone and pointing in direction of egress. This will assist egress when reassigned to other areas.
- Use a scout, if necessary, to Recon ahead rather than place your engine in an unsafe position (STL vehicles and patrols work great for Recon).
- Recon ahead of your engine when driving in unfamiliar areas. Many homes in wildland areas have overhead obstructions and private bridges, leach fields, and underground septic tanks that will not support the weight of an engine.
- Keep headlights and warnings light on for better visibility.
- Channel water with a shovel and salvage cover (if necessary) when pumping and leaking water onto an unpaved surface. This will avoid getting

your rig stuck and/or destroying the road surface.

- Use water sparingly; water on wildland fires can be limited. Locate primary and secondary water sources e.g., private tanks, pools, cisterns, lakes, streams, hydrants, etc. Note: Hydrants cannot be considered reliable on most large wildland fires.
- Have a tool at the ready that can be used to cut away hoselines from the pump panel if a quick escape is necessary.
- Shut down the engine, extinguish the fire with a CO2 extinguisher (No water or Dry Chem) and notify your STL or DIVS if the air filter on your engine catches on fire.
- Lay hose only when absolutely necessary. Laying hose on the ground takes time and energy, reduces flexibility, and may have to be left.
- If a supply line is connected to the pump panel, place a shut-off butt on the hoseline where it connects to the pump panel. This will allow the engineer to quickly disconnect from the supply line without shutting down the hydrant. Additionally, a gated wye can be used on the discharges to quickly bleed-off attack lines for a fast disconnect.
- Contact your Division or Group Supervisor (or Staging Area Manager if staged) for any needs for your engine. They will relay the message to the Ground Support Unit.

Figure 13-37 This experienced Poway crew scratched an emergency shelter deployment area, clear from large fuels and in an open meadow, as a contingency plan. Several hours later they found themselves trapped and ended up parking their brush rig in their scratch area and sheltered insided the apparatus where they remained safe and incurred no damage. Be aggressive and proactive with taking safety measures.....They Work! (North Pass Fire 2012)

Wildland Fire Behavior

Figure 13-38 Extreme Wildland Fire Behavior

Extreme Wildland Fire Behavior

In order to make safe tactical decisions, it is important for firefighters to be able to recognize the point when fire behavior turns to extreme fire behavior. Extreme fire behavior is represented by a rapid rate of spread, intense burning, spotting, fire whirls, well-established convection columns of smoke, and/or crowning. This type of extreme fire behavior, also referred to as a "blow up," behaves in an erratic, dangerous, and often unpredictable manner.

Extreme fire behavior is the result of several components of fuel, weather, and topography coming into alignment to create the ideal conditions or a type of "perfect storm." For example, an abundance of fuels, with low fuel moisture, steep slopes or strong winds, and an unstable atmosphere make ideal conditions for extreme fire behavior.

Some of the common denominators on fatal and near fatal wildland fires are that they occurred on relatively small fires or quiet areas of larger fires, in light fuels, with a wind change or gust, and when the fire makes a run up slope. The reason many of these fires turned fatal or near fatal is because firefighters failed to recognize the potential before the "blow up." In order to help firefighters set trigger points and recognize potential signs of extreme fire behavior, the following list of fuel, weather, and topography indicators for extreme fire behavior has been created.

Fuel Indicators

- Unusually dry fuels
- Large amount of continuous light fuels
- Fuels exposed to direct sunlight
- Fuels dried by prolonged drought
- Ladder fuels that will allow a surface fire to move into the crowns or aerial fuels of trees
- Crown foliage dried by surface fire over a large area
- Concentration of snags

Topography Indicators

- Steep slopes
- Chutes, draws, saddles, and box canyons that provide the condition for the "chimney effect" Figure 13-39
- Narrow canyons

Figure 13-39 Draws provide the ideal topographic environment for extreme fire bahavior

Weather Indicators

- Strong wind
- Sudden change in wind direction
- Unexpected calm; may indicate a wind shift
- Thunderstorms in the area; may lead to sudden down drafts
- Unusually high temperatures early in the day
- Dust devils

Fire Behavior Indicators

- Bent smoke column
- Many fires starting simultaneously or smoldering fires over a large area begin to pickup intensity
- Fire begins to torch small groups of trees or brush, Figure 13-40
- Frequent spot fires occurring, Figure 13-41
- Firewhirls develop inside the main fire
- Crown fires

Figure 13-40 Torching

Spot Fires

A spot fire is a fire set outside the perimeter of the main fire by flying, or rolling, sparks or embers. Frequent spot fires are one of the 18 situations that shout watchout. Frequent generally means a rate faster than crews can suppress them. Besides being a safety concern, frequent spot fires are an indicator of extreme fire behavior. Although innocent at conception, as spot fires begin to grow, they start to interact with each other, adding airflow and heat energy to their environment.

Figure 13-41 Spot Fire

Figure 13-42 Palm trees produce large amounts of firebrands during wind events and are a major cause of short and long range spotting.

Firebrands

Firebrands are any source of heat, natural or manmade, capable of igniting wildland fuels, such as flaming or glowing fuel particles that can be carried naturally by wind, convection currents, or by gravity into unburned fuels. Firebrands are a major cause of short and long-range spot fires. During the 2003 and 2007 wildfires in San Diego, firebrands, in the form of palm tree fronds on fire, were carried aloft with the winds starting spot fires up to a mile ahead of the main fire front, Figure 13-42.

Long Range vs. Short Range Spotting

The combined result of convective lifting and the wind field dictate the maximum distance a spot fire can occur from the fire front. These distances have been broken down into two main categories, long range and short range spotting, Figure 13-43.

Short Range Spotting

Strong surface winds and limited convective lifting result in short range spot fires. A short-range spot fire generally will be overrun by the main fire before increasing enough to affect the main fire spread rate.

Long Range Spotting

Long-range spot fires are characterized by large, glowing firebrands, strong convective lifting forces, and a wind field capable of igniting spot fires several miles ahead of the fire front. These fires are far enough out in front of the main body of fire where they will often have time to build large enough to create an entirely new main fire body.

Figure 13-43 Short Range Spot Fire (top), Long Range Spot Fire (bottom).

Wildland Strategy

There is a fundamental distinction between the strategic and the tactical action plan. The strategy describes the general overall approach to controlling the incident and in turn drives the tactical plan.

There are several strategies for combating a wildfire. An offensive strategy will require the direct attack and extinguishment of the fire. A defensive strategy may call for confining the fire from spreading and let it burn itself out. Providing for structure protection is another strategy. On large-scale incidents, the strategy may even be a combination of all three. The incident commander must ultimately determine and clearly state the incident strategy for each wildfire.

Wildland Tactics

Once a strategy has been clearly established, it is necessary to determine how best to accomplish them through a tactical plan. The tactical plan provides the tactical assignments required to achieve the strategic objectives.

Fire should be fought aggressively, but safety and protection of personnel and equipment must always be the number one priority! Remember to base all tactical decisions on the Standard Firefighting Orders, LCES, and the Watch Out Situations. Wildfire tactics should be prioritized in the following manner:

- FIREFIGHTER SAFETY
- Life – Rescue and protect residents and public
- Property – Structure triage and protection
- Resources – Protect land, parks, forests, sanctuaries etc.
- Confine – Keep the fire from spreading by establishing containment lines
- Extinguish – Fire suppression activities will depend on the following factors:
    - Is perimeter control possible?
    - Rate of spread
    - Fire intensity/flame length
    - Spotting?
    - Enough resources assigned?

Structure Triage

Structure triage is the process of quickly determining which houses during a wildland fire are threatened and can safely be defended by firefighters. Triaging a structure during a wildfire can prove to be a difficult decision for many firefighters. Our gut instinct is do whatever it takes to protect the property that we were sworn to protect. The hardest decision to make is often the decision to deem someone's home threatened and non-defensible; in other words turn and leave. To assist firefighters with making this decision, structures can be placed into one of the following three categories:

Not-Threatened

- Safety Zone nearby and TRA present at structure.
- Construction features/defensible space make the structure unlikely to ignite.
- Residents may/may not have to be evacuated.

Figure 13-44 Threatened Defensible: 100' of defensible space, house can be used as a TRA, yard and road can be used as a safety zone.

Threatened Defensible

- Safety Zone nearby and TRA present at structure.
- Construction features/defensible space require structure defense tactics during fire front impact.
- Residents may/may not have to be evacuated.

Threatened Non-Defensible

- Lack of adequate Safety Zone nearby.
- Structure cannot be safely defended.
- Residents must be evacuated.

Although the above categories have been established to help firefighters triage structures, there will not always be a clear-cut definition of a defensible or non-defensible structure. For that reason, the following lists describes some red flag (non-defensible) signs, yellow flag (defensible or non-defensible) signs, and green flag (defensible) signs.

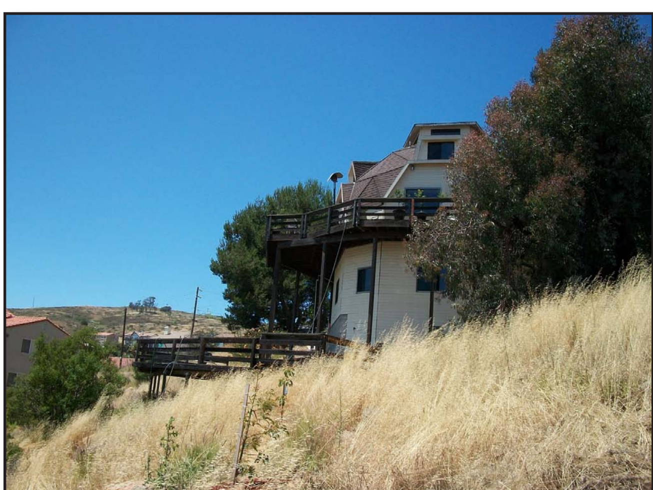
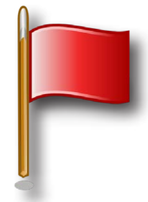


Figure 13-45 Threatened Non-Defensible: No clearing around structure, grass next to house and below wood deck, large treees close to house, house is midslope.

Red Flag Signs



The following signs mean that the structure is non-defensible and firefighters should leave immediately:

- Cannot survive here based on expected fire behavior.
- No Safety Zone or Temporary Refuge Area (TRA).
- LCES not in place.
- Safety issues cannot be mitigated.
- Structure is located in a chute, chimney, or saddle.
- Not enough time to escape to the Safety Zone.

Yellow Flag Signs – Defensible or Non-Defensible

Yellow flags can be thought of as warnings. One yellow flag may not be an excluding factor to defending a structure but several yellow flags together may be. Ultimately, it is a judgment call that must be made by the firefighters and company officers, relying heavily on their experience and training.

- Any structure on a slope with the fire approaching from below.
- A structure that requires locating your engine between the structure and the fire.
- A structure that has vegetation up against itself.
- A structure that has an LPG tank impacted with vegetation.
- A structure surrounded or enclosed by trees giving the appearance that it is in a cave or tunnel.
- A structure on a "junkyard property," or large amounts of combustible debris, sheds, tires, rubbish etc.
- Time of day and slope aspect. Afternoons on a south and west aspect slope are the most dangerous.
- Fuel type and height.
- No water source or limited water source available.
- A structure with a wood shingle roof or wood siding.

Green Flag Signs

Green flags are positive traits that indicate the structure may be safely defended.

- A structure with 100' of clearance or more.
- A structure on a ridge with the roadway or driveway on the opposite side of the approaching fire.
- A structure with obvious safety zones (large grass areas or parking lots).
- The fire is approaching from higher elevation than the structure you are

protecting with little or no wind.

- A backing fire (fire is burning against the wind towards you).
- Structure is on a slope with a north or east aspect provided there is little wind.
- A source of water is available (hydrant, private water tank, pool, domestic hose bib).

The most important factor in structure triage is the feet of clearance at the location where the flaming front will impact the crew. In some cases 10' will be adequate (backing fire), in other cases you will need 40' to 50'. In some extreme cases when the fire is wind driven and in alignment with the slope, 200' may not even be adequate.

Structure Protection Tactics

Once a structure has been triaged, the appropriate tactic must be employed. Although slightly different from tactics taught in years past, the following structure protection tactics are recognized as the CALFIRE industry standard and taken directly from the CALFIRE Structure Defense Guide 2012.

Check & Go

- Used for Threatened Non-Defensible structures
- Most appropriate action when no Safety Zone/TRA is present and fire front impact is imminent.
- Conduct rapid evaluation to check for occupants and evaluate for follow up action.
- LEAVE promptly

Figure 13-46 Prep & Go: For structures that are threatened and non-defensible, protective measeures can still be taken. Above, the debris and wood piles were moved away from the house and propane tanks.

Prep & Go

- Used for Threatened Non-Defensible structures
- Structure preparation can be safely completed prior to fire front impact, Figure 13-46.
  - Remove small combustibles near structure (wood piles, furniture, etc.)
  - Close windows and doors and leave unlocked
  - Clear around LPG tanks and shut off fuel valve
  - Remove larger vegetation if time permits
  - Turn on sprinklers
- Potential fire activity is too dangerous to remain and/or there is no Safety Zone/TRA present.
- LEAVE before escape routes are compromised.

Prep & Defend

Figure 13-47 Prep & Defend Tactic

- Used for Threatened Defensible structures
- Appropriate when a Safety Zone is nearby and TRA is present.
- Adequate time exists to prepare the structure for defense prior to fire front impact.
    - Same as prep & go above
    - Put in hose lines
    - Pre-treat structure with foam
- Escape routes must be maintained.

Fire Front Following

- Follow-up tactic after passage of the fire front.
- Involves searching for victims, perimeter control, hot spotting, and ember control.

Bump & Run

- Resources move ahead of the fire front extinguishing spot fires and defending structures.
- Extreme caution must be utilized.

Anchor & Hold

- Resources use large volume fire streams to extinguish structure fires, stop structure-to-structure ignitions, protect exposures, and control embers, Figure 13-48.

Figure 13-48 Anchor & Hold

Tactical Patrol

- Resources remain mobile and continuously monitor assigned area after fire front passage.
- Involves aggressive mop up around structures. Most structures do not burn until after the fire front has passed.

Indirect Attack

Indirect attack tactics are used to support a defensive strategy. An indirect attack is a suppression tactic used a distance away from the oncoming fire. Fuel reduction, contingency control lines, back-firing, and pre-treating unburned fuels with foam are all examples of an indirect attack. This method allows for more effective planning, ideally placed control lines in lighter fuels using natural barriers to the fire and for safer firefighter working conditions in less smoke filled and cooler areas. However, it may also allow for more burned acreage, larger hotter fires, and the possibility of wasted time constructing unused control lines.

Figure 13-49 Control lines can be created by aerial retardant drops ahead of the fire front.

Control Lines

Control lines are boundaries that contain no combustible material and are used in an attempt to control wildfires. These may be constructed by physically removing combustible material with tools or heavy equipment, or control lines may be naturally occurring.

Control lines may also be constructed through the use of long-term fire retardants, fire-fighting foams, and superabsorbent polymer gels. These retardants may be applied by both ground and aerial means, Figure 13-49. These compounds reduce the flammability of materials by either blocking the fire physically or by initiating a chemical reaction that stops the fire.

Figure 13-50 Back-Firing Operation - The pre-existing dirt road was used as the control line. Dozers widened the control line then crews set a back-fire using wind to their advantage. Brush crews were then spaced out along the control line to extinguish any spot fires that may have crossed the control line (right of road).

Back-Firing

Another method for creating control lines is back-firing. Back-firing is the process of creating a control line by using low intensity fire to remove the fuels, Figure 13-50. Drip torches or fusees (flares) are used to ignite the fuels ahead of the main fire front, taking into account the weather, topography and fuels. The resultant fires are then quickly extinguished by firefighters to create a control line.

Another back-fire tactic is to time the ignition of the fire and direct the burn in such a way that it meets the main fire front, at which point both fires run out of flammable material and are thus extinguished.

Back-firing should only be performed by trained personnel and require the approval of the IC.

Burn-Out

A burn-out can be used as both an indirect or direct attack tactic. A burn-out operation is the intentional burning of fuels inside the control line to strengthen the line. Burning-out can also be utilized to create safety zones for fire crews or increase defensible space around a structure prior to the fire front arriving. Burn-out operations may be performed without the approval of the I.C. or direct supervisor however, a notification of both is essential to avoid confusion regarding observed fire behavior on the incident.

Fire Line/Hand Line Construction

Fire lines constructed by hand are one of the oldest methods of wildland fire suppression. This method is used in areas too steep for mechanized equipment, in areas where mechanized equipment would cause severe damage to the environment, or where use of mechanized equipment would be otherwise impractical. Constructing hand lines to control the spread of wildland fires is sometimes the only technique available. The work is tiring and demanding under the best of circumstances.

Figure 13-51 Handline Construction

There are several methods used by hand crews for constructing control lines. In general, the cutting tools, chainsaws and brush hooks, are used towards the front for cutting trees and shrubs. Next are the Pulaski, McLeod, and shovels used for scraping the grasses and low vegetation down to bare earth. This control line will range in width from no less than 18" wide to 1 ½ times the adjacent fuel height. For safety reasons, firefighters shall be spaced out 10' apart on the fire line.

A well-trained hand crew can make significant and quick progress. However, it is important to keep in mind that a true hand crew will have 20 personnel and a crew boss, Figure 13-51. As city firefighters, if you are assigned to construct hand line, you must understand that it will be a slow process and you must adapt to perform as best as possible with the number of firefighters available.

Advantages To Indirect Attack

- Control lines can be located using favorable topography.
- Natural or existing barriers can be used.
- Firefighters may not have to work in smoke and heat.
- Control lines can be constructed in lighter fuels.
- There may be less danger of slop-overs.

Link 13-3 CAL-FIRE Handline Construction Manual

Disadvantages To Indirect Attack

- More area will be burned.
- Must be able to trade time and space for line to be constructed and fired.
- Firefighters may be in more danger because they are distant from the fire and have unburned fuels between them and the fire.
- There may be some dangers related to firing operations.
- Firing operations may leave unburned islands of fuel.
- May not be able to use control line already built.

Direct Attack

Direct attack tactics are used to support an offensive strategy. Direct attack is any firefighting effort applied directly to burning fuel such as wetting, smothering, or by physically separating the burning from unburned fuel, Figure 13-52. This includes the work of engine crews, hand crews, and aircraft applying water or fire retardant directly to the burning fuel.

Use the following table as a guide to determining the appropriate tactic for initiating a direct attack.

Flame Length	*Tactics*
0' - 4'	Fire may be attacked at head, flanks, or by using a hand crew
4' - 8'	Hoselines required, too big for hand crews
8' - 11'	Heavy equipment and aircraft required
11' +	Do not attempt a direct attack, consider indrect tactics

Attacking the Head of the Fire

The tactic of attacking the head of the fire is a high-risk operation that involves placing firefighters between unburned fuel and the active fire front. This tactic should only be considered when a life safety hazard exists, or when the flame lengths are less than four feet providing that all safety measures are in place (LCES, Standard Firefighting Orders, etc.).

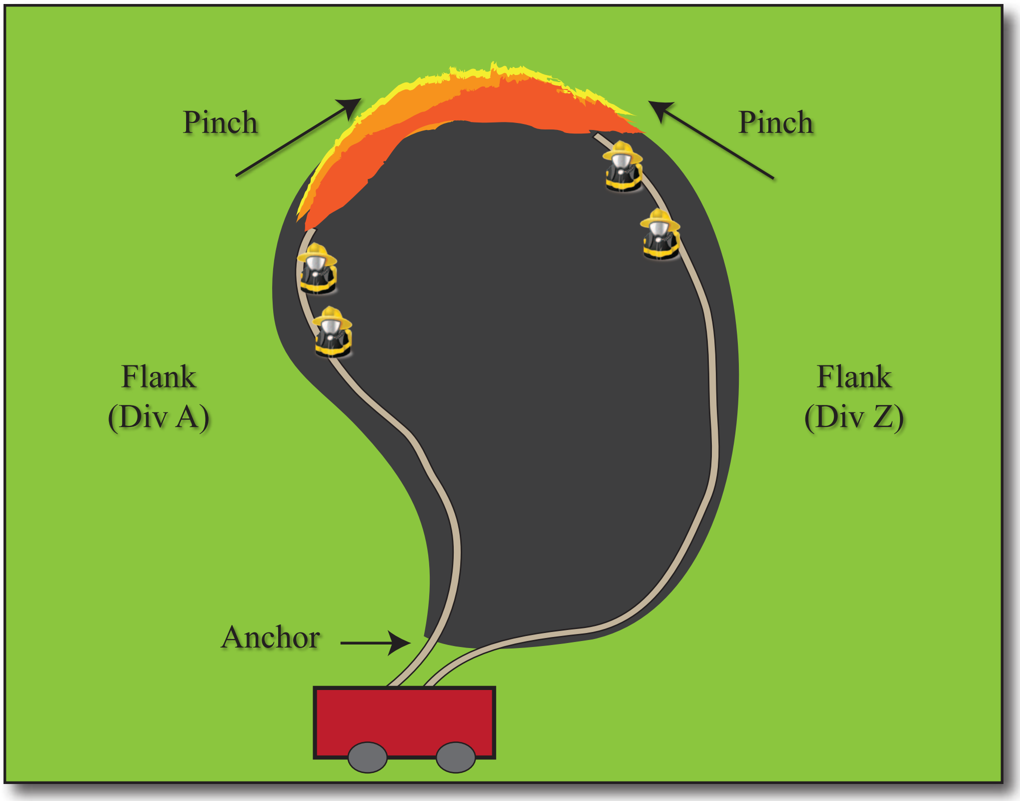
Figure 13-52 Direct Attack

Anchor / Flank / Pinch

One of the most commonly used, and safest methods of direct attack is to anchor, flank, and pinch the fire. Before any direct attack can begin, an anchor point must be established to begin fighting the fire.

Anchor

An ideal anchor point will have a safety zone or large clearing nearby, good access for incoming resources, a water supply, and good visibility of the main body of the fire. Often times the anchor point will be the point of origin of the fire. From the anchor point, engine companies can begin progressive hose lays working up the left (alpha) and right (zulu) flanks



Flank

The flanks of the fire are the sides of the fire and are identified by letters. These letters represent a "division" in the ICS system and allow for expansion should a fire grow in size. Standing at the anchor point and facing the fire, the left flank begins with "A" or "alpha" division and progresses alphabetically in a clockwise direction as the need arises. The right flank will always end with "Z" or "zulu" division and progresses backward through the alphabet as necessary, keeping a manageable span of control.

Flanking, as a tactic, means initiating a progressive hose lay up the flanks of the fire towards the fire's head. Generally, the first-in engine company should begin a progressive hose lay up the most active flank of the fire and subsequent arriving crews will attack the less active flank.

Pinch

Once the flanks of the fire have been extinguished, the two progressive hose lays on the "alpha" and "zulu" flanks shall continue until they join together. This action is referred to as "pinching" the fire and stops the forward spread and fire front.

Progressive Hose lay Construction

Progressive hose lays are the most common method used for fighting wildland fires by engine companies, Figure 13-53. Wildland hose packs have been strategically setup in order to perform a fast and coordinated hose lay. Progressive hose lays are designed so that they may start small and grow in length as the incident requires; upwards to several thousand feet in some cases.

A well constructed progressive hose lay should have the following characteristics:

Figure 13-53 Progressive hoselay working the flank of the fire.

- The hose lay should be in the cooled black or burn area, avoiding heavy smoldering fuels.
- No kinks in the hoseline. Even minor kinks in the single jacket hose will cause significant pressure reductions.
- A one inch water thief placed every 200’ in the hose lay for mop-up and rekindles.
- An extra roll of 100’ of 1” hose and nozzle placed every 200’ to 300’ along the hose lay to use as a lateral line.
- An extra roll of 100’ of 1 ½” hose placed every 200’ to 300’ along the hose lay in the black to use when a hose ruptures or burns.
- Leave enough slack, approximately 10’, in between each coupling. Because not all rolls of hose are a true 100’, this slack allows for a shorter piece of hose to replace a burst section.

For more information on the procedures for performing a progressive hose lay, refer to SDFD Drill Manual Chapter 14, Engine Company Strategy & Tactics.

Advantages To Direct Attack

- Minimal area is burned; no additional area is intentionally burned.
- Allows firefighters to work in or near the safety of the burned, or “black” area; firefighters can usually escape into the burned area.
- The uncertainties of firing operations can be reduced/eliminated.

Disadvantages To Direct Attack

- Firefighters can be hampered by heat, smoke, and flames.
- Control lines can be very long and irregular.
- Burning material can easily spread across mid-slope lines.
- May not be able to use natural or existing barriers.
- More mop-up and patrol is usually required.

Class A Foam use for Wildland Firefighting

SDFD's policy is to always use class A foam for extinguishment when fighting wildland fires. Mixing class A foam with water at a 0.3% solution will allow for deeper penetration into the fuels and make it twice as effective than water alone. When pre-treating structures with foam, a 1% foam solution using an aspiration device at the end of the nozzle, or CAFS, should be applied to the structure prior to the fire's arrival. With water availability usually at a premium during wildland firefighting, class A foam doubles your effectiveness and saves water.

Refer to SDFD Drill Manual Chapter 10, Fire Extinguishers and Foam Agents, for detailed information on class A foams and CAFS.

Mop-Up

The threat of wildfires does not cease after the flames have passed, as smoldering heavy fuels may continue to burn unnoticed for days after flaming. It is during this phase that either the burn area exterior or the complete burn area of a fire is cooled so as to not reignite another fire, Figure 13-54. Although mop-up is a dirty, tedious, and often boring assignment, its importance cannot be overstated.

Figure 13-54 Mop-Up operations

After the initial direct attack on a fire has been completed, progressive hose lays should remain in place for as long as necessary to completely cool the burned area. This may range from as short as a few hours to several days. Depending on the type of fuel burned and weather conditions present, complete mop-up of the entire burned area may be necessary. In other situations, the IC may only call for mop-up and complete cool down of burned materials 25', 50', or 100' into the black from the fireline.

Effective mop-up involves using a tool to stir up hot spots and/or deep penetration with a hose line. Firefighters should not simply "water the lawn," instead aggresively overhaul the black. Mop-up often includes cutting a fire line to strengthen the wet line and ensure containment.

Do not dismiss mop-up as an uneventful assignment, all safety measures still must remain in place and all PPE must be utilized. There are many documented cases of injuries and/or death occurring during the mop up phase because firefighters had let their guard down. From falling trees, to rolling rocks, to the re-burning in an incomplete burn area, mop-up is every bit as important as structure protection or direct attack.

Strike Team Deployment

Most often strike teams refer to wildland firefighting, but they can also be used for any emergency, mass casualty, high-rise fire, or earthquake. The following is a brief introduction to strike teams. More detailed information on strike team assignments can be found in the SDFD Wildland Refresher Manual and the FIRE SCOPE Field Operations Guide (FOG).

Link 13-4 SDFD Wildland Refresher Guide

Types of Strike Teams

A strike team is defined as five like units with a leader coming together to achieve a common goal. FIRE SCOPE sets the parameters for all types of resources and their minimum requirements. The two types of strike teams that San Diego City firefighters need to be most familiar with are type I and type III.

Type I Strike Team

A type 1 strike team consists of five type 1 triple combination engine companies. These units must be staffed with 4 firefighters and are given a four-digit designator followed by the letter "A." For example, Strike Team 6432A. Type 1 strike teams are commonly used for structure protection and direct attack tactics.

Link 13-5 FIRE SCOPE Field Operations Guide

Type 3 Strike Team

A type 3 strike team consists of five type 3 triple combination brush engine companies. These units must be staffed with 4 firefighters and are given a four-digit designator followed by the letter "C." For example, Strike Team 6432C. Type 3 strike teams are commonly used for direct and indirect attack tactics.

Strike Team Readiness

All personnel should be prepared to be deployed at a moment's notice for up to 14 days, and in some situations longer. All PPE shall be brought on the strike team regardless if it is a type 1 or 3.

Conduct & Expectations

As professional firefighters it is of the upmost importance to conduct ourselves as such on all strike team deployments. We are representatives of the San Diego Fire Department to not only the public we serve but to the wide ranging agencies we will be working with on large campaign fires. Strike teams have been sent home early and in an embarrassing manner because they did not conduct themselves professionally. The following is a brief list of strike team expectations while in base camp and on the fire line.

Base Camp Expectations

- In class B uniform while in the ICP, briefing area, dining area, or attending any other meetings.
- Keep apparatus in a state of constant readiness; fueled, supplied, ice, water, etc.
- Have the VHF portable radios cloned every day; communication plans often change from day to day.
- Be ready and able to perform your assigned duties effectively.
- Conduct yourself professionally and appropriately at all times
- Keep in constant communication with your company officer and Strike Team Leader at all times.
- Stay together as a crew as much as possible.

Fire Line Expectations

- Always wear full PPE and web gear on the fire line. This includes your hot shield (respiratory protection) when involved in actual fire suppression.
- All personnel should carry glow sticks and flagging tape.
- LCES – Always and often.
- Maintain good communication among all crewmembers and strike team leader.
- Read and review the IAP with all crewmembers and make sure everyone is clear on the objectives, weather, communications, safety hazards, and medical plan.
- An ICS-214 form should be completed at the end of each work period and given to the Strike Team Leader, or STL.
- Do not leave the fire line for any reason without notifying the STL.
- If you are assigned to Staging:
- Full PPE- No shorts, tennis shoes, or lounge chairs.
- Be ready to respond in 3 minutes or less.

Strike Team Bag Items

CLOTHING

- Pants, Class B (2 Pair)
- Shorts, Class D (2 Pair)
- Shirts, Class B w/Hardware (2 Each)
- Shirts, Class C Short Sleeve (4 Each)
- Shirts, Class C Long Sleeve (2 Each)
- Shoes, Tennis (1 Pair)
- Shoes, Shower (1 Pair)
- Socks (6 Pair)
- Undergarments, (6 Each)

PPE

- Boots, Wildland (1 Pair)
- Brush Firefighting Jacket (1 Each)
- Brush Firefighting Pants (1 Each)
- Battery, Initial Replacement for Flashlight (1 Set)
- Flashlight (1 Each)
- Ear Plugs (Meets ANSI S3.9-1974) (2 Pair)
- Canteen (2 Each)
- Glasses, Safety Goggles (Meets ANSI Z87.1) (1 Each)
- Gloves, Wildland (1 Pair)
- Helmet, Brush with Shroud (1 Each)
- Helmet Lamp (1 Each)
- Lum-Stick (Chemical Lighting Device) (2 Each)
- Signal Mirror (1 Each)
- Personal Web Gear
- Whistle (1 Each)

MISCELLANEOUS

- Sleeping Bag (1 Each)
- Bandana (2 Each)
- Chap Stick (1 Each)
- Glasses, Sun (1 Pair)
- Insect Repellent (1 Each)
- Medications, Prescription & nonprescription (Minimum 14-Day Supply)
- MRE & Snacks, high energy/ carbohydrates (Enough for 24-hours)
- Sunscreen (1 Each)
- Tissue, Small Pack (1 Each)
- Toiletry Kit (1 Each)
- Trash Bag (Rainproof Gear) (1 Each)
- Towel, Bath (1 Each)
- Toilet Paper (1 Roll)

OPTIONAL ITEMS

- Books, Paperbacks
- Camera & Film
- Compass
- Knife, Folding (SOG Tool)
- Matchbox, Waterproof
- Sleeping Pad & Pillow
- Pen, Pencil & Notepad
- Radio, AM/FM w/headphone (situational/not allowed on aircraft)
- Sewing Kit, Small
- Tape, Duct Roll (6’ rolled)
- Tent, Small 2-person (1 Each)

Wildland Fire Glossary

Parts of the Fire

Fingers of a fire
The long narrow extensions of a fire projecting from the main body

Fire perimeter
The entire outer edge or boundary of a fire, also referred to as the fire line.

Flank of a fire
The part of a fire's perimeter that is roughly parallel to the main direction of spread.

Head of a fire
The side of the fire having the fastest rate of spread.

Island
Area of unburned fuel inside the fire perimeter.

Pockets of a fire
Unburned indentations in the fire edge formed by fingers or slow burning areas.

Point of origin
The precise location where a competent ignition source came into contact with the material first ignited and sustained combustion occurred.

Rear of a fire
That portion of a fire spreading directly into the wind or down slope. That portion of a fire edge opposite the head. Slowest spreading portion of a fire edge. Also called heel of a fire.

Spot fire
Fire ignited outside the perimeter of the main fire by a firebrand.

Fire Behavior Terms

Backing fire
That portion of the fire with slower rates of fire spread and lower intensity, normally moving into the wind and/or down slope. Also called heel fire.

Clean Burn
All the fuels within the fire perimeter have been burned out leaving very little to no fuel for re-burn. Commonly occurs with a consistent size and tight arrangement of fuels.

Creeping fire
Fire burning with a low flame and spreading slowly.

Crown fire
A fire that advances from top to top of trees or shrubs more or less independent of a surface fire. Crown fires are sometimes classed as running or dependent to distinguish the degree of independence from the surface fire.

Dirty Burn
Only some of the fuels within the fire perimeter have been burned out, leaving areas of unburned fuel within the "black." Commonly occurs with a mixed fuel type and an inconsistent arrangement of fuels.

Firewhirl
Spinning vortex column of ascending hot air and gases rising from a fire and carrying aloft smoke, debris, and flame. Fire whirls range in size from less than one foot to over 500 feet in diameter. Large fire whirls have the intensity of a small tornado.

Flaming front
The zone of a moving fire where the combustion is primarily flaming. Behind this flaming zone combustion is primarily glowing or involves the burning out of larger fuels (greater than about 3 inches in diameter). Light fuels typically have a shallow flaming front, whereas heavy fuels have a deeper front.

Flare up
Any sudden acceleration in the rate of spread or intensification of the fire. Unlike blowup, a flare-up is of relativity short duration and does not change existing control plans.

Running fire
Behavior of a fire spreading rapidly with a well defined head.

Smoldering
Fire burning without flame and barely spreading.

Spotting
Behavior of a fire producing sparks or embers that are carried by the wind and which start new fires beyond the zone of direct ignition by the main fire.

Torching
The burning of the foliage of a single tree or a small group of trees, from the bottom up.

Other Useful Firefighting Terms

Anchor point
An advantageous location, usually a barrier to fire spread, from which to start constructing a fireline. The anchor point is used to minimize the chance of being flanked by the fire while the line is being constructed.

Chain
Unit of measure in land survey, equal to 66 feet (20 M) (80 chains equal 1 mile). Commonly used to report fire perimeters and other fireline distances. Popular in fire management because of its convenience in calculating acreage (example: 10 square chains equal one acre).

Contained
The status of a wildfire suppression action signifying that a control line has been completed around the fire, and any associated spot fires, which can reasonably be expected to stop the fire's spread.

Controlled
The completion of control line around a fire, any spot fires, and any interior islands to be saved. Burn out any unburned area adjacent to the fire side of the control lines. Cool down all hot spots that are immediate threats to the control line, until the lines can reasonably be expected to hold under the foreseeable conditions.

Control line
An inclusive term for all constructed or natural barriers and treated fire edges used to contain a fire.

Fire line
The part of a containment or control line that is scraped or dug to mineral soil.

Mop-up
Extinguishing or removing burning material near control lines, felling snags, and trenching logs to prevent rolling after an area has burned, to make a fire safe, or to reduce residual smoke.

Terrain Terminology

Box Canyon
A canyon that has been created by two ridgelines that sharply converges, and forces the valley to curve up in a vertical direction.

Chimney
A canyon feature that funnels hot smoke and gasses upwards. Also used as another term for a box canyon. *See box canyon above.*

Draw
A draw is also similar to a box canyon, but is typically used to describe an area where a mid-slope road has an inward turn. This can be a shallow wide canyon or a steep box canyon. A draw gets its name because fire tends to increase and build intensity in these areas, or draw in towards the canyon.

Depression
A low place in the ground having no outlet for surface drainage.

Hill
A naturally occurring mass of earth whose crest or summit is at a lower elevation than a mountain.

Mesa
A flat-topped mountain bounded on all sides by steep terrain.

Ridge
Long narrow elevation of land, often located on a mountainside.

Saddle
Ridge between two hills or summits.

Valley
Stretch of low land lying between hills or mountains and sometimes occupied by a stream.

Media & Link Index

- SDFD Wildland Refresher Manual
- FIRE SCOPE Field Operations Guide
- NWCG Incident Response Guide
- Burn Index Card Powerpoint
- San Diego Coastal Burn Index Card
- San Diego Inland Burn Index Card
- Fire Shelter Deployment Manual
- CAL FIRE Structure Defense Guide
- CAL FIRE Handline Construction Manual

NOTE - In order for the following links to work you need to log in to your targetsafety account first, then click the link

http://targetsafety.com/sdfd

References

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2. FIRESCOPE - Wildland Urban Interface (WUI) Structure Protection, May 20, 2011
3. Incident Resource Pocket Guide, NWCG, PMS 461, NFES 1077, January 2010
4. Intermediate Wildland Fire Behavior, S-290 National Wildfire Coordination Group's (NWCG)
5. Introduction to Wildland Fire Behavior, S-190 National Wildfire Coordination Group's (NWCG)
6. San Diego Wildland Refresher Manual, SDFD 2008
7. Structure Triage and Defensible Space, John P. Harris and Gary Harris, LA County Fire 2009
8. The New Generation Fire Shelter, NWCG, PMS 411, March 2003
9. Wildland Firefighting, Power Point, San Diego Fire-Rescue Department, 72nd Academy, 2009

Credits

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NOTE: If you have any additional information or content that you feel would be appropriate to contribute to this Chapter or would like to report any errors or misrepresentations, please contact the SDFD Training Division or email the Drill Manual Revision Staff at

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Revisions/Updates

Date	*Revision/Update Description*