

Fire Whirls In California...A Firefighter's Perspective

Royal Burnett March 15, 2008

Fire whirls are one of the most visual and least understood aspects of extreme fire behavior. Many a good plan has been wrecked and lots of firefighters have been burned over as a result of these events. Fire whirls used to be considered rare occurrences, but with the advent of a multiple year drought, increased communications and digital cameras, fire whirls are reported on a more routine basis.

Fire whirls happen infrequently for a brief duration. There is no recording system. The event happens in terrain that varies from flat to very broken mountains, in conditions of no wind to moderate and perhaps high winds, in fuels that vary from light to heavy, so it is nearly impossible to define the conditions under which fire whirls can appear.

We know that fire whirls can develop from energy release or from wind shear caused by the wind interacting with topographic features. Occasionally the convection column is strong enough to form an obstacle to the prevailing wind and fire whirls will develop in the lee of the column. For those reasons I define 4 separate types of fire whirls:



Fig 1. Typical thermal or energy release fire whirl

1. Thermally Driven fire whirl... The most common fire whirl we encounter as wildland firefighters is the thermally driven or energy release fire whirl. They are similar to dust devils and may rise to heights of 100 feet or more. They are usually short lived and will dissipate when the heat source is removed or they cross the fireline.



Fig 2. Energy Release fire whirl formed when a jackpot of fuel burns

. When fuels release a lot of energy in the correct atmospheric conditions, fire whirls can occur. Massive fire whirls were reported in Dresden Germany and Tokyo Japan during World War 2 when those cities were fire bombed. Piles of stacked railroad ties were used to generate fire whirls for study during Operation Firestop in 1954. This picture of a fire whirl that formed during a structure fire demonstrates that all fire whirls are not generated from wildland fuels. (fig 3) .



fig. 3 Thermal Fire Whirl forms during a structure fire

Fire whirls and dust devils seem to form more often at low windspeeds in open terrain. Its common to see dust devils and small fire whirls form on recently burned ground. The heat from the fresh burn plus the added solar heating makes for low level instability and any errant gust of wind can produce a whirl.

Fire whirls generally form when windspeeds are less than 20 mph, but the winds generated by the whirl can be of tornado strength, capable of uprooting brush and twisting trees in half.

Fire whirls and dust devils are usually formed during periods of atmospheric instability, thus they are more often seen on East facing slopes in the morning, moving to South and West facing slopes as the day progresses. High temperature lapse rates, greater than 5.5 degrees per 1,000 feet of elevation rise are often associated with fire whirl formation.

The Haines Index is a measure of atmospheric instability that is not used in much of coastal and interior California because the marine influence can skew the results. In those parts of California where the weather is influenced by the Great Basin, the Haines Index can be a valuable tool. A Haines index of 6, the highest in the system should never be ignored

2. Lee Side fire whirls...Here I differ in the current teaching in S-490 Extreme Fire Behavior. They lump these fire whirls into the class with thermally driven fire whirl. While I agree they are thermally driven I see them as a far more dangerous event. These are the fire whirls that develop on the lee (downwind) side of ridges due to wind shear. The appearance of these fire whirls may precede a significant downhill run. These are an indicator of severe burning conditions (fig 4,5). These two pictures are of fire activity on the La Brea fire on the Los Padres NF in 2007.



fig 4. La Brea Fire Los Padres NF 2007



fig. 5 La Brea fire 2007. Notice how a fire whirl develops as the head of the fire moves onto the lee side of the ridge.

3. Leading Edge fire whirls... Again I differ from the current teachings. The S-490 course names this type of fire whirl a “Wake Type” fire whirl... that implies that the whirl may be created in the wake of or after the flaming front passes...” Leading Edge” is much more descriptive of the event in my opinion. A Leading Edge fire whirl is one that develops on the leading edge or head of the fire.

This type of fire whirl is extremely dangerous and can generate tornado strength winds. Here are two pictures (fig 6,7) of a leading edge fire whirl on the Fletcher Fire in Modoc County near Goose Lake in 2007.



fig 6. Fletcher Fire, Modoc County 2007 1558 hours. A leading edge fire whirl develops in front of the head of the fire. Note the twisting smoke columns on both the spot fire and the main fire.



fig 7. Fletcher Fire, Modoc County 2007 1600 hours. The Leading Edge Fire Whirl is fully formed.

The Fletcher fire whirl was strong enough to be classified as a category 2 tornado on the Fujita Scale with winds from 113 to 157 mph. The third photo (fig 7) shows the trees twisted in half by the force of the winds.



Fig 8. trees twisted in two by the force of the fire whirl formed on the Fletcher fire

4. Convection Column vortex...In this type of fire whirl the entire convection column is rotating due to extreme energy release and wind shear.



(Fig. 9) Rotating convection column on the French Fire Shasta County 2004



Fire whirls often develop on the lee side of ridges and thusly, fire whirls are often seen in places that are associated with down slope winds and downhill fire runs such as the East slope of the Sierras. From the Diamond Mountains near Susanville South to Hallelujah Junction, in the Reno Verdi area and the Walker Pass near Carson City. This may be caused the heating in Sacramento Valley spilling over, the Sierra Wave effect or the presence of a thermal low in the Great Basin. Whatever the cause, the effect is down slope runs and fire whirls. The Eagle fire near Susanville in 1989 generated fire whirls which over ran a CDF Engine and severely injured at least one crew member.

In the Bishop/ Independence area, down slope winds and fire whirls are common. The Seven Oak Fire Complex in Inyo County in 2007 generated several fire whirls and severe fire behavior resulted in the burnover of two CDF engines and crews with multiple injuries.

The drier the fuels, the more rapid the combustion and energy release. Thusly, fire whirls are more commonly seen in desert fuel types and during times of drought. Fires in the Desert Front Country from San Bernardino County south through San Diego County have produced countless fire whirls. The dry desert air mass is constantly moving as the marine influence ebbs and flows, this results in wind shear as the air moves up and down the canyons of the front country. Yucca Valley, Whitewater Canyon, The area from Warner's Springs in the north to Campo in the south in San Diego County is a notorious fire whirl producer. In fact, I regard the entire County of San Diego County and the Cleveland NF as one of the most fire whirl prone areas in the State. The north /south alignment of the mountains, the fuels and the proximity of the desert and ocean create a set of conditions that is unique in California.



Fig. 11. Desert Front Country fire whirl

The Marine Influence and the subsequent movement of air mass has produced some spectacular and deadly fire whirl activity. The Santa Ana Mountains in Orange and Riverside Counties has a long history of fire whirl events, one being the Decker Fire on the Ortega Highway in 1959 where 6 fire fighters were fatally injured.

Fire whirls have been reported in moderate to strong Santa Ana events. These could be caused by a combination of energy release and wind shear. Los Angeles County and the Angeles NF is another area where the Marine and Desert influences constantly battle, and the constantly moving airflow over the desert type fuels can cause a fire whirl on literally any given fire at any time of the year.



Fig. 12. Fire whirl approaches a home in Southern California

The Southern half of the Los Padres NF seems to be particularly prone to fire whirl formation. The Indian fire in 2008 produced numerous fire whirrs, and the infamous Sundowner winds Santa Barbara and Ventura Counties are known fire whirl producers.

In Summary:

1. Fire whirl and dust devil formation indicate atmospheric instability.
2. The appearance of dust devils and fire whirrs can be an indicator of more severe fire behavior to come.
3. Fire whirl activity indicates cured fuels and rapid energy release, which can trigger extreme fire behavior.
4. Any fire whirl can exponentially increase the Rate of Spread.

Fire whirls should be a warning sign to all wildland firefighters that conditions are right for extreme and unpredictable fire behavior. When fire whirls appear, the experienced leader should take precautions such as posting extra lookouts, bringing crewmembers into close proximity, briefing on Safety Zones and direction of retreat. The old adage of “one foot in the burn for Safety” is never more true than when the fire whirls appear. If you’re working indirect line or structure protection and fire whirls appear, post more lookouts and consider burning out. If that’s not possible, consider disengagement.

When fire whirls are sighted, it is imperative to advise line personnel. Contact Division Supervisors and adjacent crews and advise them of whirl activity.