# The Topanga Fire: A Dramatic Response to Topography, Fuels, and Critical Fire Weather Conditions

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## Introduction

For the firefighting community, dealing with extreme wildland fire behavior is very challenging. To complicate matters, there are a number of key variables that can contribute to extreme fire behavior with rapid fire growth. In order to assist in predicting fire behavior, the fire behavior triangle was created (**Figure 1**). The fire behavior triangle consists of three sides: **Topography** (slope, aspect, etc.), **Fuels** (type, moisture, loading, etc.) and **Weather** (temperature, relative humidity, wind, etc.). When all three sides of the triangle are present, extreme fire behavior with rapid fire growth is highly likely (USDA 2007).

From September 28$^{th}$ to October 6$^{th}$, 2005, the Topanga Fire affected eastern Ventura County and western Los Angeles County. This fire, which started around 2:00 PM PDT on Wednesday the 28$^{th}$, eventually burned over 24,000 acres of land. Most of this, around 20,000 acres, was consumed in only a 28 hour period from the 28$^{th}$ to the 29$^{th}$ of September (**Figure 2**). The purpose of this paper is to show how all three variables of the Fire Behavior Triangle**—*topography, fuels, and weather*—**combine to produce the rapid spread of the Topanga Fire on 28-29 September, and to discuss tools available to the fire weather forecaster that can assist in predicting extreme fire behavior, including tools available at the time of the fire.

## Topography

**Figure 3** shows the region affected by the Topanga Fire. This area includes the valleys of eastern Ventura County and extreme western Los Angeles County. The dominant topographic features in this area are north to south and northeast to southwest oriented ridgelines and canyons. Elevations in this area range between 500 and 2000 feet, which produce slopes between 20% and 40%. Complex terrain of this nature is fairly common in Southern California.

Due to the steepness of its topography, this area is very susceptible to extreme fire behavior. The steep slopes promote significant preheating of fuels which can lead to rapid upslope fire spread. In addition, the steep slopes make it difficult for firefighters to suppress any fires with ground resources. Significantly, the orientation of the canyons in the region closely parallels the usual direction of the strongest offshore wind events. Therefore, the terrain also has a high potential for dangerous, wind-driven fires.

## Fuels

The vegetation in the fire area was typical of much of Southern California foothill and mountain areas. **Figure 4** shows a map of the various vegetation types that are common to the region. These include widespread areas of California chaparral (fuel model 4) and annual grasses (fuel models 1 and 3). Since the previous winter season (2004-2005) was the second wettest on record, the vegetation in the area, especially annual grasses, was abundant with an average grass length of 36 inches. The availability of such fuels was very important to the spread of the fire. The abundance of grasses, especially when combined with normally volatile chaparral, would allow any wildfire in the region to grow at an incredible rate, much faster than the usual forest fire.

In addition to the quantity of fuels, the lack of precipitation across Southern California the previous summer through early fall resulted in very dry conditions with live fuel moistures falling to near 60% by late September. This compares to the 25 year average of 70% for live fuel moistures in late September for Southern California. This further enhanced the fire threat. **Figure 5** shows the Observed Fire Danger Class for Southern California as of the 29th of September. These graphics from the Wildland Fire Assessment System (WFAS), which are maintained by the National Interagency Fire Council (NIFC), indicate that environmental conditions across Southern California were favorable for rapid fire development and growth. These graphics show that the fire danger was high or very high while 100 Hour Fuel Moistures were only 6-10%.

## Weather

During 28-29 September, Southern California experienced a weak to moderate Santa Ana wind event. Santa Ana wind events are typical weather phenomena across Southern California during the late summer and fall, generating gusty northeast winds, hot temperatures and low relative humidity. As seen in **Figure 6**, Santa Ana wind events develop when high pressure aloft builds over the West Coast and strong surface high pressure builds across the Great Basin area (Idaho, Nevada and Utah). A strong surface pressure gradient develops between the Great Basin and the Southern California coast. With this offshore pressure gradient, air is funneled through the north to northeast orientated passes and canyons across Southern California, producing gusty winds that blow towards the ocean. The orientation of the high pressure aloft contributes to the strength of the Santa Ana by providing northeast winds at low and mid levels of the atmosphere. As the winds aloft mix down, they reinforce the surface winds.

As the Santa Ana winds blow towards the ocean, compressional warming occurs when the air moves downslope on the west side of the mountains. This compressional warming can easily produce high temperatures in the 90s to low 100s across the valleys and even coastal areas. In addition, the air dries out very quickly due to the downslope effect. It is very common during Santa Ana wind events to see relative humidity values in the teens to single digits for long durations.

## Red Flag Criteria for the Topanga Fire Location

**Table 1** shows the red flag criteria for the region where the Topanga Fire occurred. These criteria are coordinated with the fire community on a routine basis to ensure their continued relevance.

| RED FLAG CRITERIA FOR VENTURA AND LOS ANGELES COUNTIES |
|---|
| 1. Relative humidity 15% or less combined with sustained winds 25 mph or greater, or frequent gusts to 35 mph for a duration of 6 hours or greater. |
| 2. Relative humidity of 10% or less for a period of 10 hours or longer. |
| 3. Widespread dry lightning. |

**TABLE 1.**

Note that, besides the weather elements, there are also a duration criteria that have to be exceeded before red flag conditions are met. Further, the criteria assume dry fuels and high to extreme fire danger ratings.

## The Forecast Challenge

Accurately forecasting red flag criteria for the region presents several challenges for the forecaster. The first challenge is to determine the location and strength of the gusty winds. The second is to determine if, where, and when relative humidity levels will fall to critical levels. Finally, there is the all-important determination of timing. Do the strong winds occur simultaneous with the critically low humidities? And, finally, are red flag duration thresholds met or exceeded?

Synoptic-scale models, such as the GFS, give the forecaster a general idea about the potential for a Santa Ana but less precise information pertaining to the actual wind speeds that can be expected as well as the location and timing of the strongest winds. This limitation is due to the resolution of the synoptic models, generally 40 to 80 km, which is not detailed enough to capture the terrain effects across Southern California. In order to get a better idea about the actual wind speed, the forecaster must rely on mesoscale models which have a resolution of 12 km or greater.

With high resolution models, wind speed and direction forecasts are typically more precise, since terrain influences have a more significant impact in model computations. However, this is no guarantee of accuracy. For example, while the WRF-NAM runs at 12 km resolution, this model has proven in practice to be less reliable when compared to the previous Meso-Eta model when it comes to accurately forecasting fire weather conditions. Since its implementation, forecasters at WFO Los Angeles/Oxnard have noted that the WRF-NAM has over-forecast many Santa Ana wind events and subsequent Red Flag events when compared to previous forecaster experience with the Meso-Eta model.

For this particular event, the MM5 model from CANSAC (California and Nevada Smoke and Air Committee, **www.cefa.dri.edu/COFF/cofframe.php**) provided very useful and accurate wind speed forecasts for the event. The MM5 model from CANSAC generates forecasts at a horizontal resolution of 4 km. **Figures 7 through 9** show the 10 meter wind fields from the 1200 UTC model run on 28 September. The approximate fire perimeter is outlined in white. In general, the MM5 model forecasted sustained northeast winds between 20 and 30 MPH across the fire area.

With respect to relative humidity, the CANSAC MM5 model forecast somewhat higher relative humidity than was eventually observed. For the sake of brevity, the relative humidity fields are not included in this paper. However, the CANSAC MM5 model forecasted relative humidity levels ranging from 20 to 30 percent across the fire zone; whereas, observations from surrounding stations indicated that the relative humidity was actually in the 12 to 22 percent range. Overall the CANSAC MM5 model predicted windy and dry conditions, but not to the level of Red Flag criteria.

While the overall weather and fuel conditions during this period resulted in a heightened concern, the fire weather forecaster did not feel that the critical red flag criteria would be exceeded for the durations specified. This view was further supported by national guidance. **Figure 10** shows the National Fire Weather Outlook from NOAA's Storm Prediction Center (SPC). This product, which depicts areas of critical fire weather conditions, did not indicate any critical fire weather conditions across Southern California. Therefore, in coordination with the local fire community, the decision was made not to issue Fire Weather Watches or Red Flag Warnings on the 28$^{th}$ of September

**Figure 3** shows the location of weather observations stations immediately surrounding the fire. Specifically, the Cheeseboro RAWS is located at 1650 ft elevation on the south flank of the fire; the Simi Valley RAWS is at 914 ft elevation on the northwest side of the fire; and the Thousand Oaks RAWS is at 795 ft to the west of the fire. Observations from these sites are contained in **Table 2**.

**Table 2** amply demonstrates the difficulty in forecasting fire weather criteria. Note that, while individual elements exceeded their corresponding red flag thresholds, never did all the criteria exceed their red flag thresholds for the same location, at the same time, for the duration required. Therefore, while criteria were incredibly close—and perhaps a red flag warning should have been issued based on adjustments of the thresholds due to fuel conditions—the existing red flag criteria were never met for the Topanga Fire.

## Conclusions

From early afternoon on 28 September to the evening of 29 September, the Topanga Fire burned 19,428 acres (**Figure 2**). The combination of rugged terrain, abundant dry fuels and favorable weather conditions (low relative humidity and gusty Santa Ana winds) allowed the fire to grow from a small brush fire to a significant wildland fire that threatened multi-million dollar homes and property in the urban-wildland fire interface, despite the lack of Red Flag conditions. For the fire weather forecaster, it is important to keep the fire behavior triangle in mind and identify situations where all three sides of the triangle occur simultaneously in order to provide the customers the best fire weather service.

To assist in identifying critical situations, the fire weather forecaster can use many sources of data. As mentioned earlier, there are several NWP models available to predict critical fire weather patterns such as Santa Ana events. The Storm Prediction Center in Norman, Oklahoma now produces daily fire weather outlooks for the entire country that highlight areas of critical fire weather conditions (**Figure 10**). From the National Interagency Fire Center, the Wildland Fire Assessment System (WFAS) provides numerous graphics such as Fire Danger and Dead Fuel Moisture (**Figure 5**). These products provide the fire weather forecaster with more detailed information about fuel conditions and their effect on fire conditions which would not otherwise be readily available.

A final tool available to the fire weather forecaster is coordination. For this particular event, the forecasters at WFO Los Angeles/Oxnard maintained good communication with Los Angeles County Fire, the Angeles National Forest, and the Southern California Geographic Area Coordination Center in Riverside, CA. Through various coordination calls with these users, the fire weather forecaster was able to acquire valuable information about fuel conditions and solicit user concerns. In return, the fire weather forecaster relayed the latest forecast information to the users, stressing the potential for significant, but not critical, fire weather conditions. Although all agencies involved were in agreement that Red Flag conditions would not occur, the coordination between agencies heightened the awareness of all three sides of the Fire Behavior Triangle and the potential for fire growth and development.

## Acknowledgements

I would like to thank Mark Jackson (MIC) and Dave Gomberg (Senior Forecaster) of WFO Los Angeles/Oxnard for their review of this paper. Also I would like to thank Jayme Laber (Service Hydrologist) of WFO Los Angeles/Oxnard for his assistance with developing the fuel model graphic. Finally, I would like to thank Julide Koracin at CANSAC for assistance in acquiring the MM5 graphics.

## References

Los Angeles Fire Department Bureau of Training and Risk Management, cited 2006: Topanga Fire After Action Report [Available online at http://lafdtraining.org/ttg/wp-content/topanga_narrative.pdf]

USDA Forest Service, cited 2007: The Science of Fire [Available online at http://na.fs.fed.us/fire_poster/science_of _fire.htm]

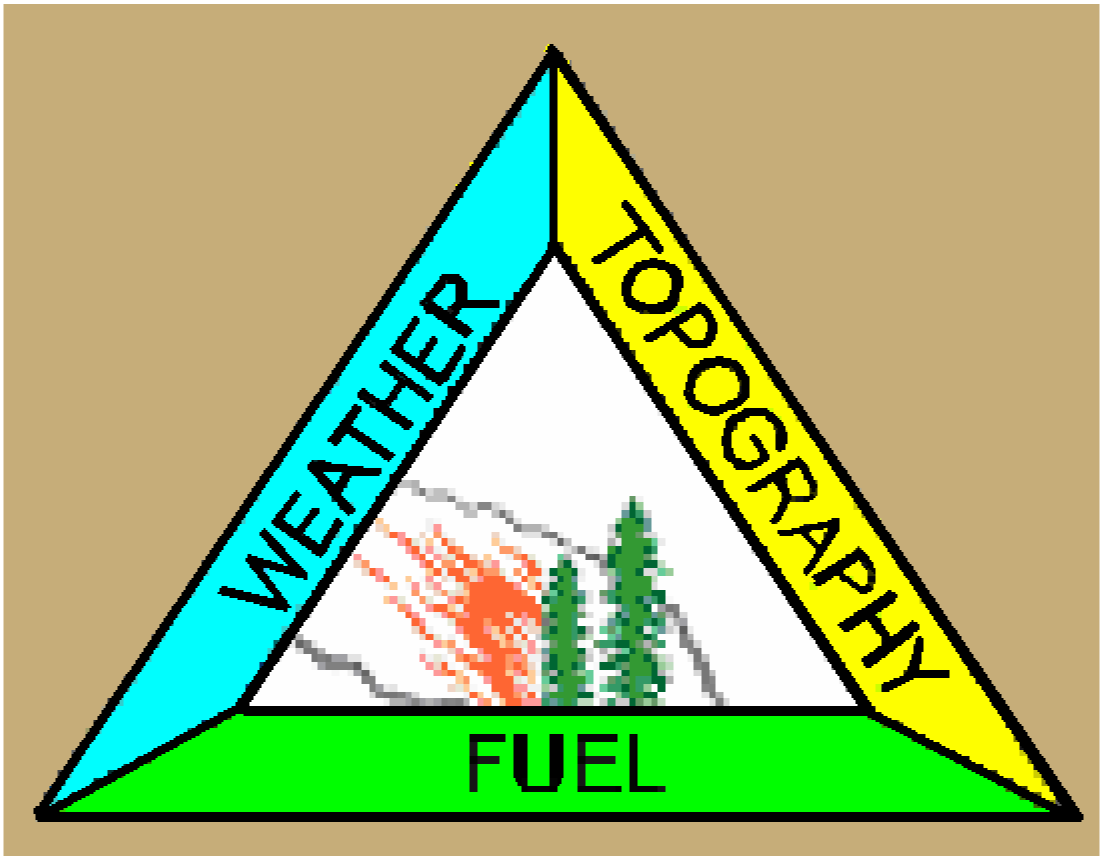
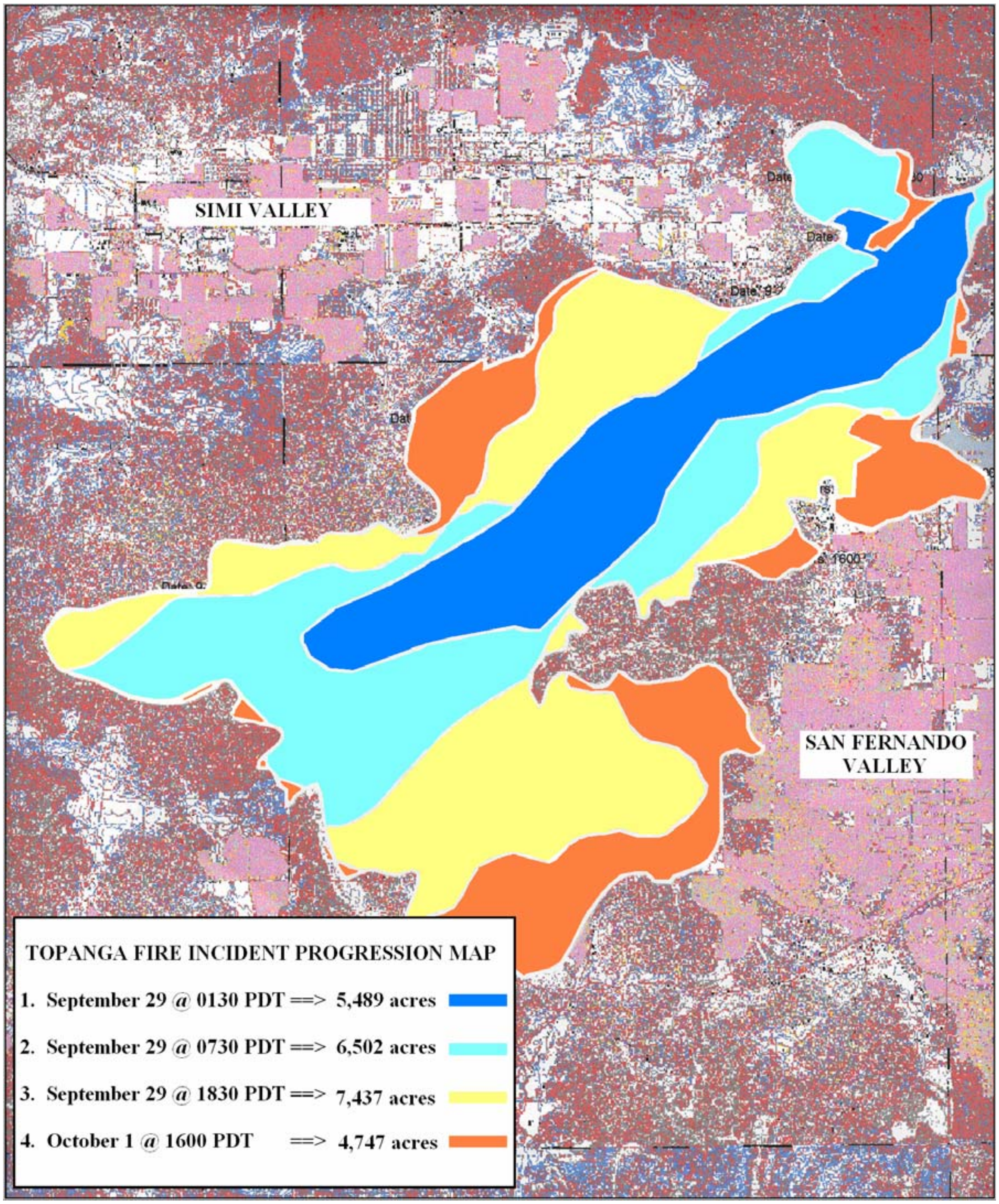



**Figure 1.**

**The Fire Behavior Triangle**




# Figure 2.

## Topanga Burn Area Fire Progression Map

**(Courtesy Los Angeles County Fire Department)**

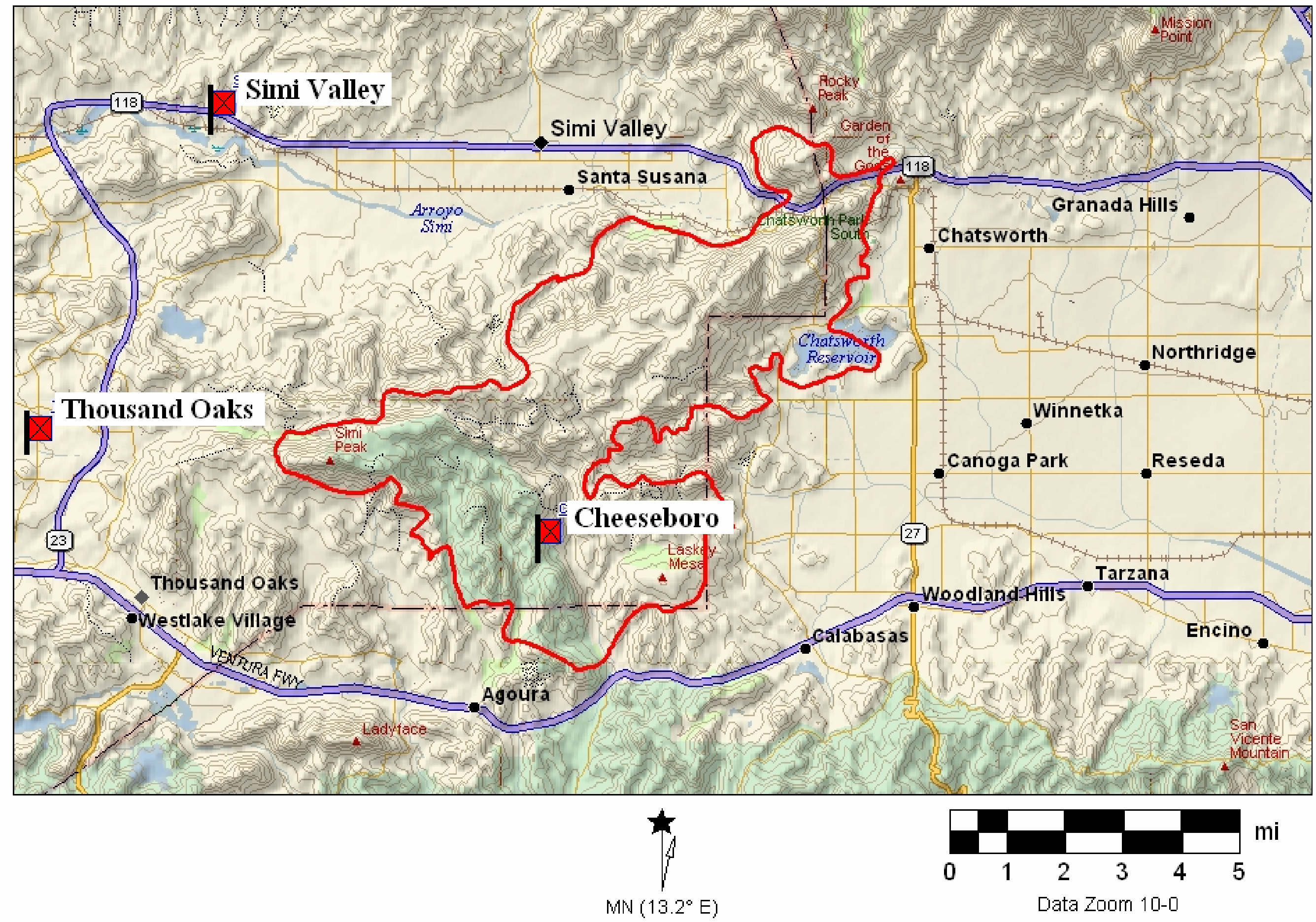



**Figure 3.**

**Topanga Fire Perimeter Map**
**[Red flags show locations of nearest RAWS stations.]**

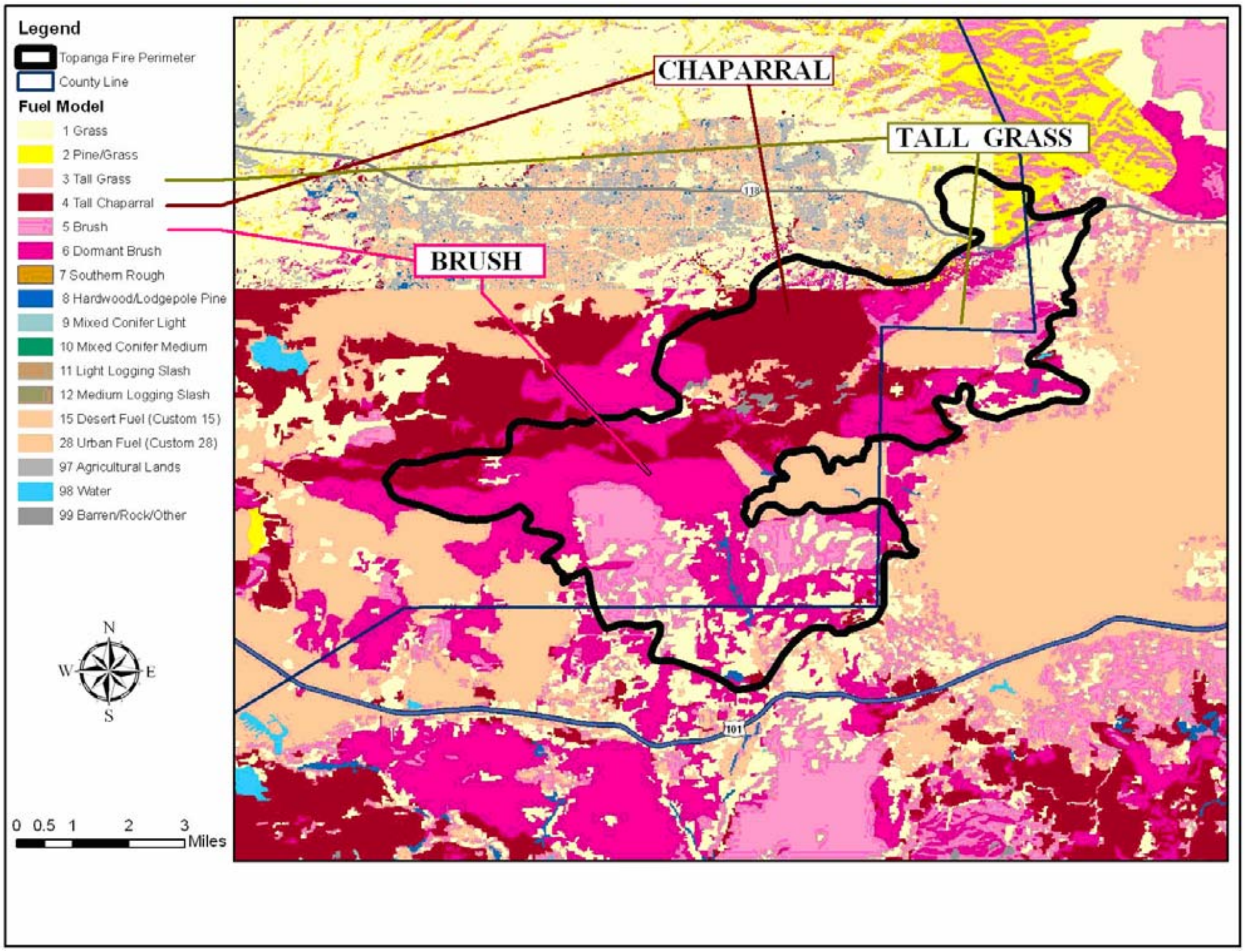
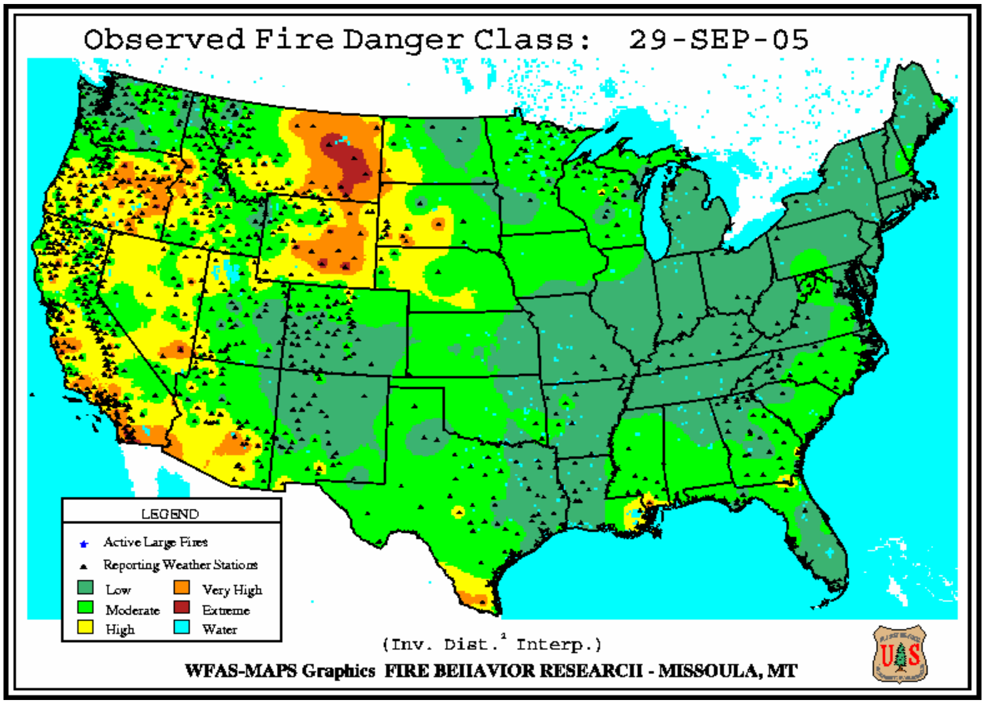



**Figure 4.**

**Fuel Model Map of the Topanga Burn Area**



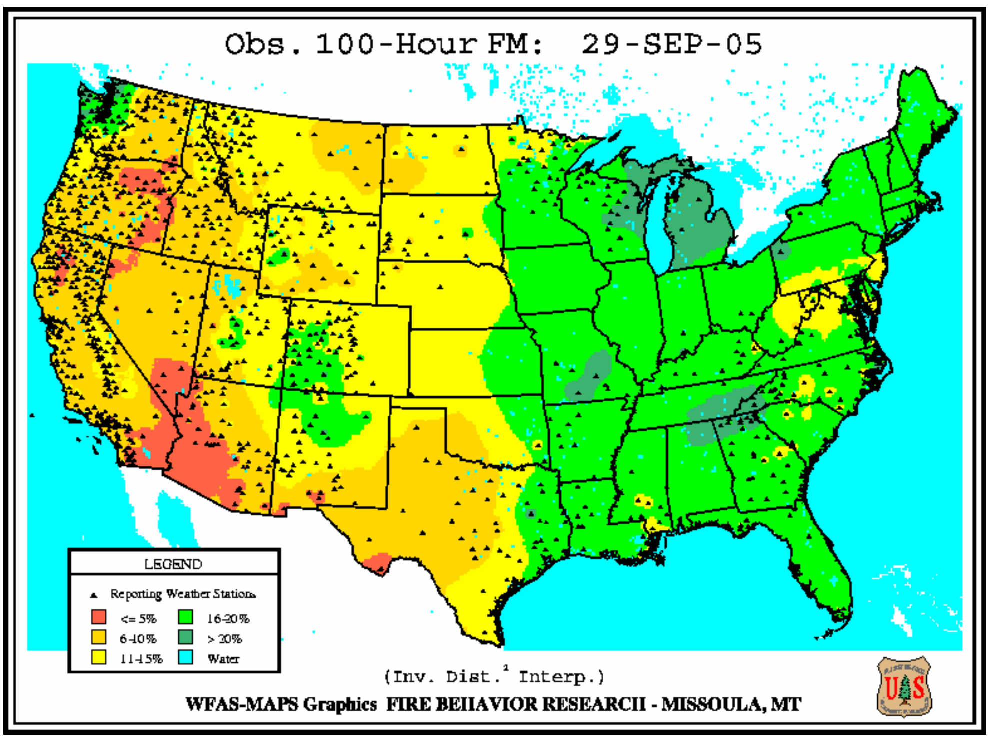




**Figure 5.**

**Fire Danger Class and 100 Hour Fuel Moisture from NIFC [Valid for September 29th 2005]**

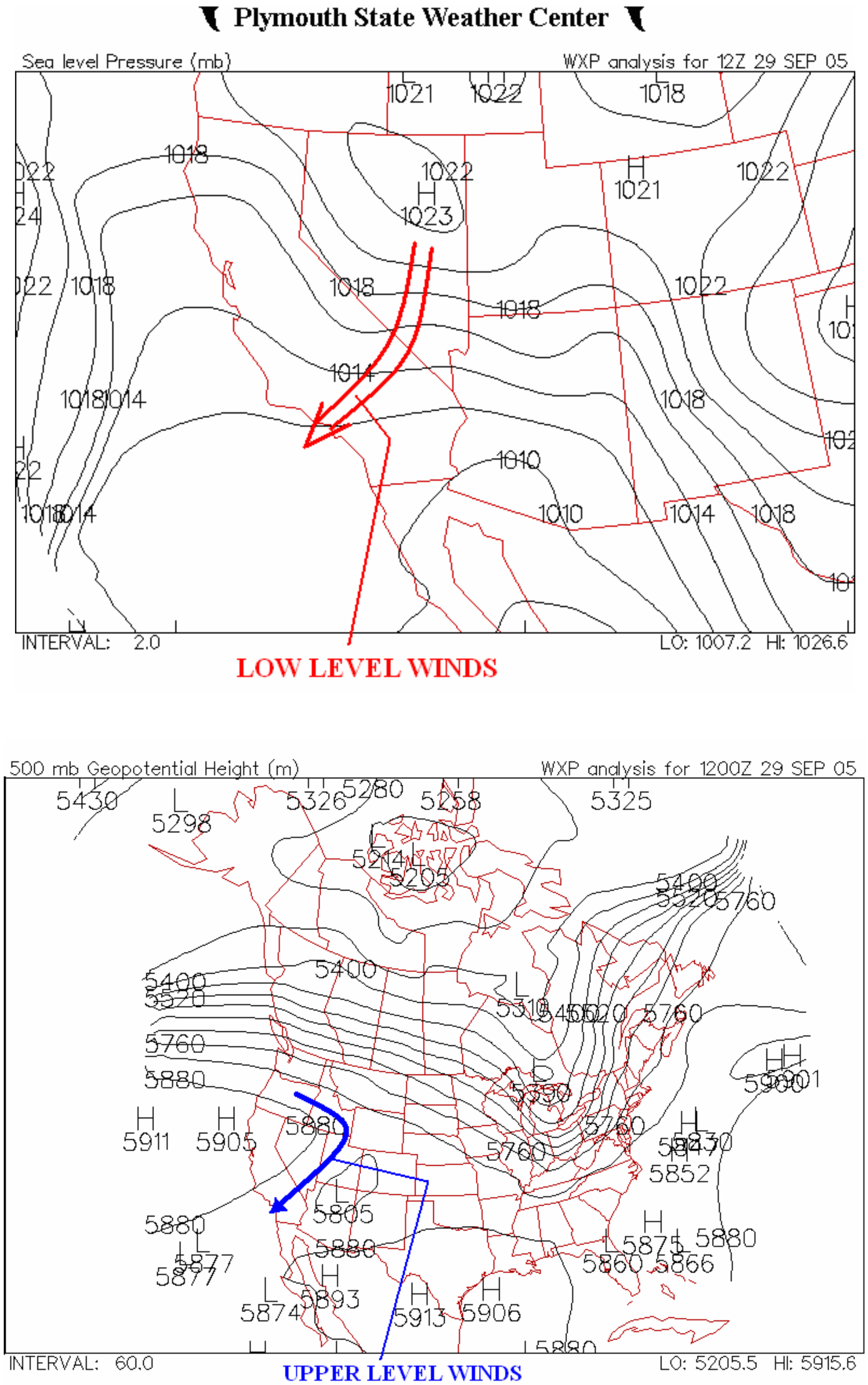



**Figure 6.**

**Surface Chart (Upper) and 500 MB Heights (Lower)**
**[1200 UTC, 29 September]**

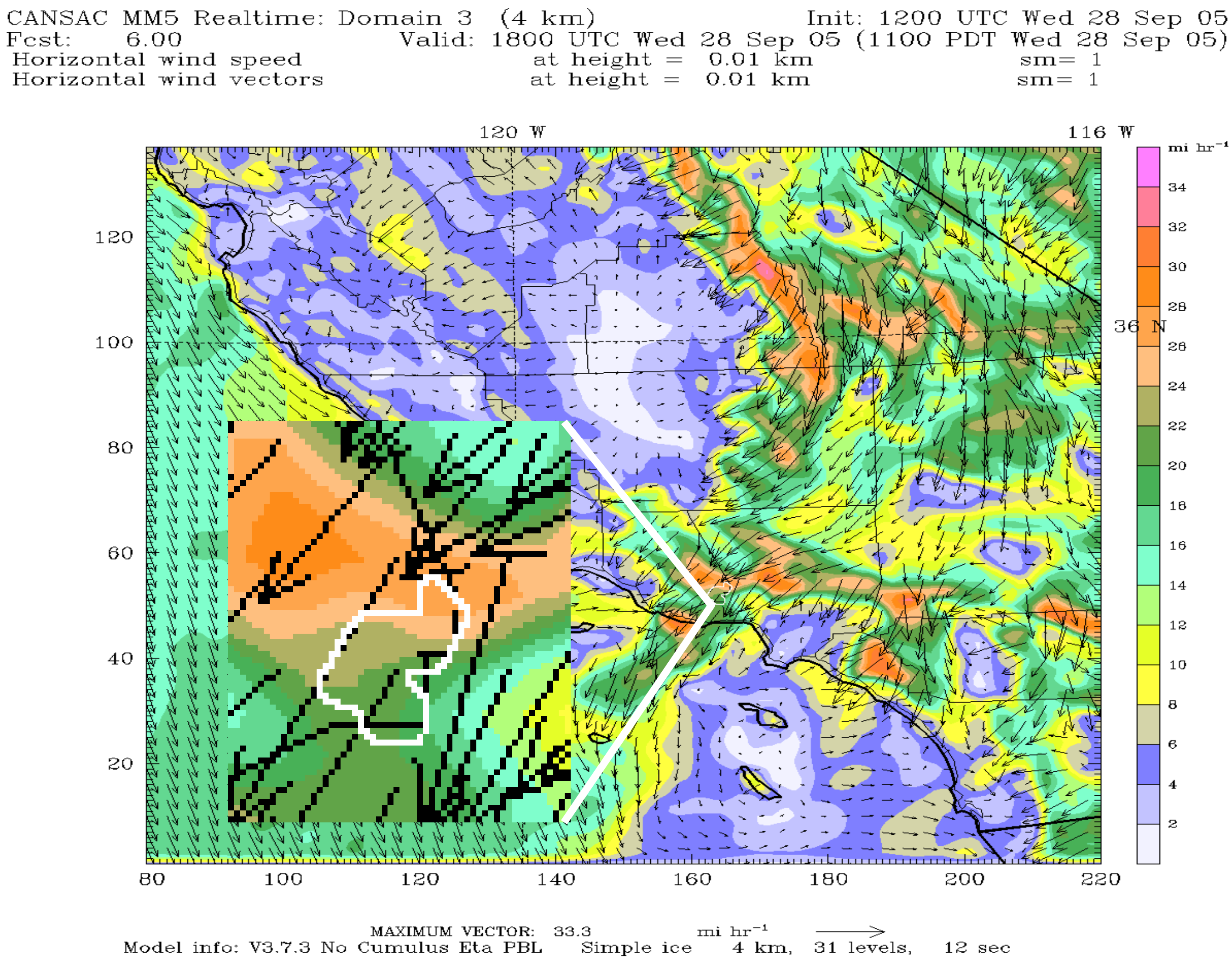



**Figure 7.**

**CANSAC MM5 10 Meter Wind Forecast Valid 1800 UTC on 28 September**

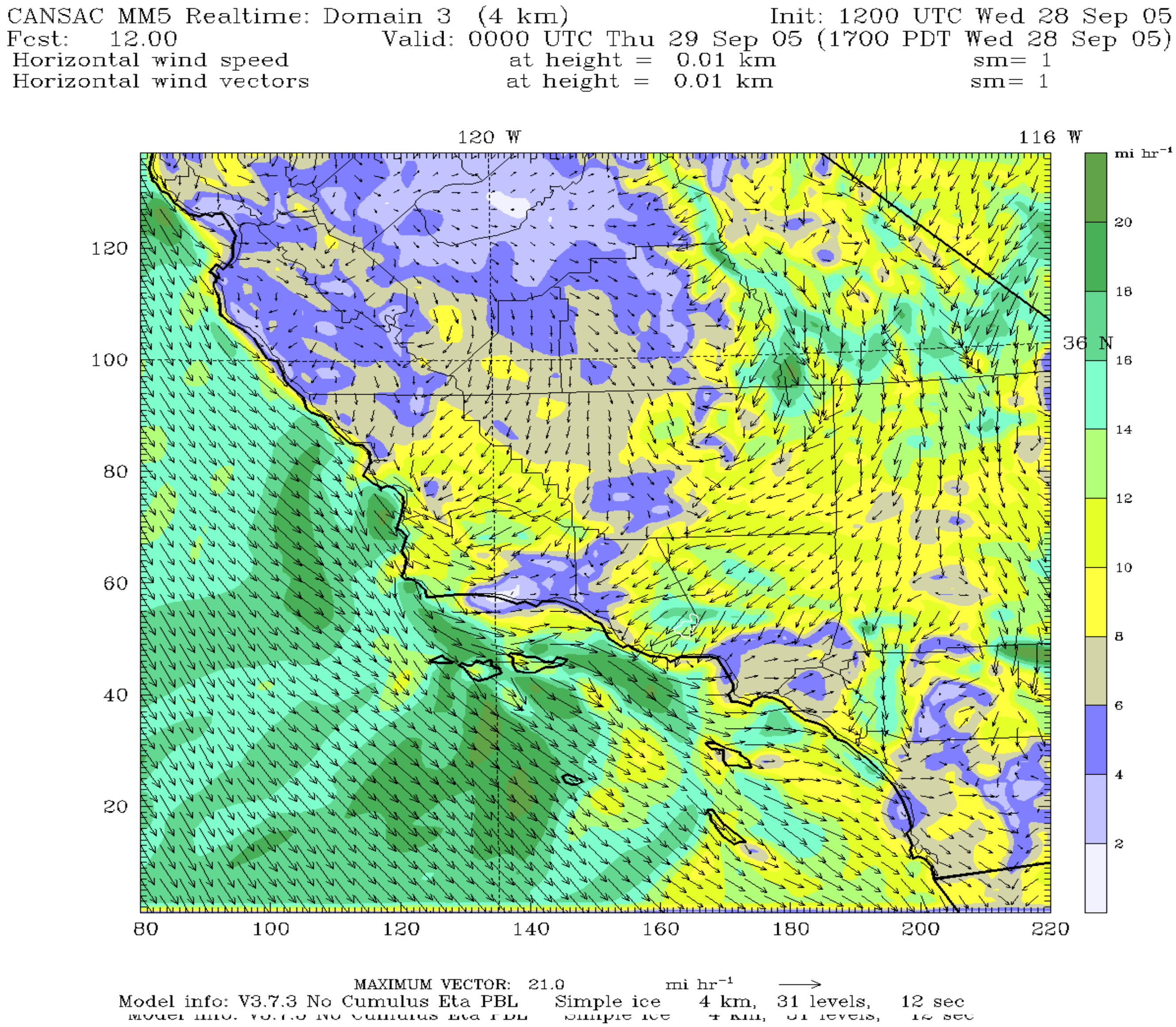



**Figure 8.**

**CANSAC MM5 10 Meter Wind**
**Forecast Valid 0000 UTC on 29 September**

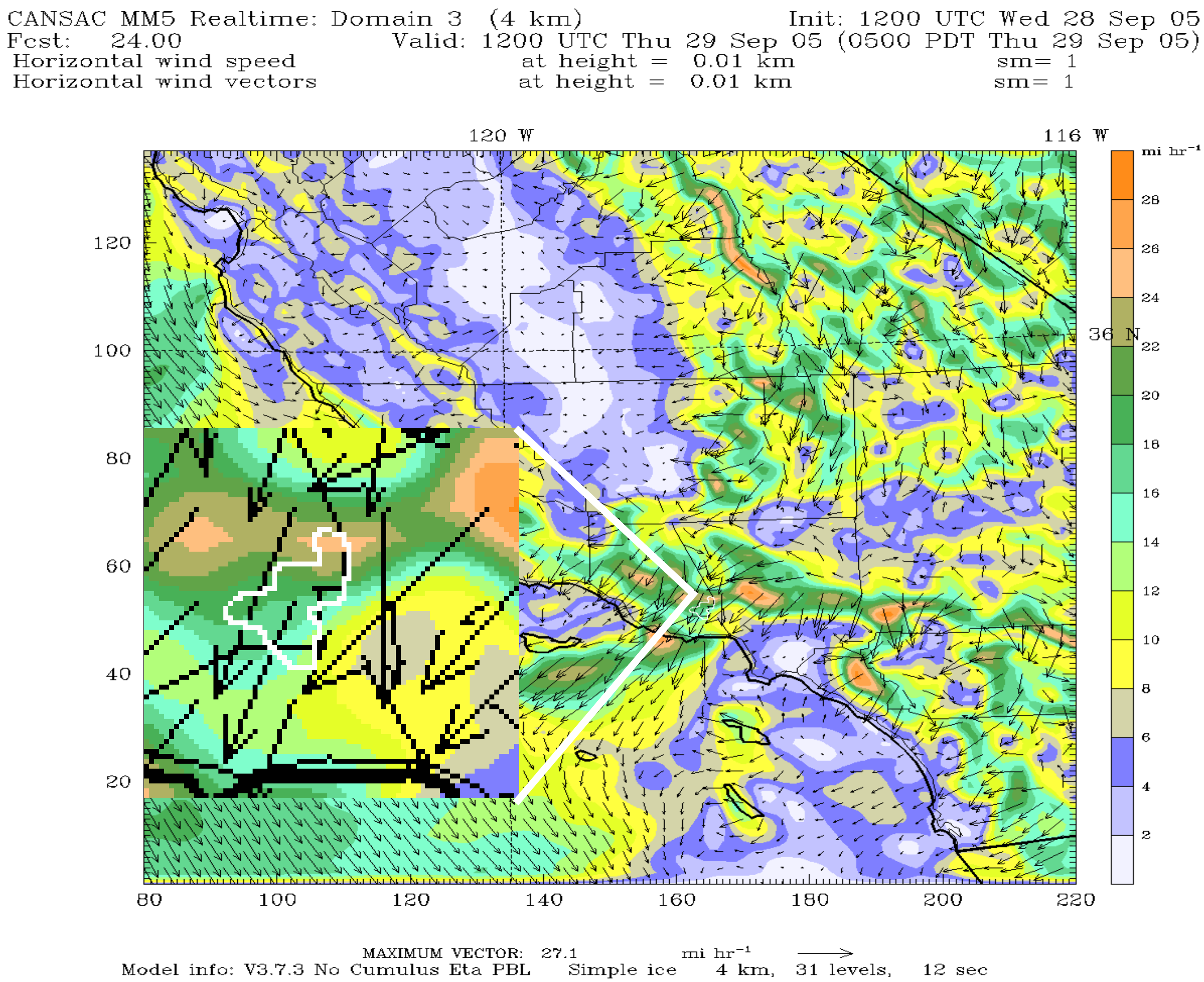
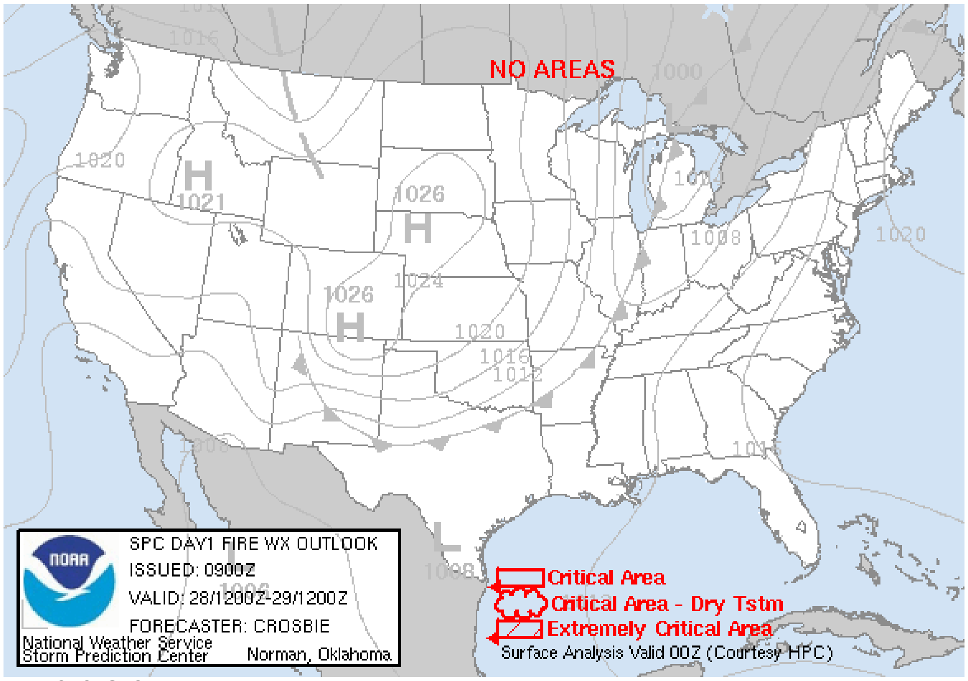



**Figure 9.**

**CANSAC MM5 10 Meter Wind Forecast Valid 1200 UTC on 29 September**

**Storm Prediction Center**
**Day 1 and Day 2 Fire Weather Outlooks**




ZCZC SPCFWDDY1 ALL
FNUS21 KWNS 280852

DAY 1 FIRE WEATHER OUTLOOK
NWS STORM PREDICTION CENTER NORMAN OK
0352 AM CDT WED SEP 28 2005

VALID 281200Z - 291200Z

...NO CRITICAL AREAS...

...SYNOPSIS...
A STRONG UPPER TROUGH WILL MOVE SEWD ACROSS THE CENTRAL CONUS TODAY. AN ASSOCIATED COLD FRONT WILL PUSH RAPIDLY SOUTH THROUGH THE CENTRAL/SRN PLAINS AND MIDWEST...EXTENDING FROM THE ERN GREAT LAKES TO SOUTH TX BY 29/12Z. BEHIND THE FRONT...SUSTAINED WINDS FROM 20-30 MPH WITH GUSTS OVER 40 MPH WILL BE POSSIBLE FOR 6+ HRS. COMBINED WITH MIN RH READINGS AROUND 30 PERCENT OVER PORTIONS OF NRN OK/KS...A THREAT FOR WIND DRIVEN FIRES WILL OCCUR IN THIS AREA. HOWEVER LACK OF DROUGHT AND CLIMATOLOGY WILL PRECLUDE A CRITICAL FIRE WEATHER THREAT.

MEANWHILE AN UPPER LOW WILL MOVE LITTLE OVER THE FOUR CORNERS. THE COMBINATION OF LIFT WITH THE UPPER LOW AND MONSOONAL MOISTURE WILL LEAD TO SCATTERED THUNDERSTORMS OVER MUCH OF THE SRN ROCKIES. FARTHER WEST...UPPER RIDGING WILL OCCUR OVER THE WEST COAST. ABOVE NORMAL TEMPERATURES AND LOW RH READINGS WILL RESULT OVER MUCH OF THE NRN ROCKIES/INTERIOR PAC NW SWD INTO CA/GREAT BASIN. LACK OF SUSTAINED WINDS ABOVE 10 MPH WILL PRECLUDE ANY CRITICAL FIRE WEATHER THREAT.

..CROSBIE.. 09/28/2005

## Figure 10.

## Fire Weather Outlook (Valid 281200 UTC to 291200 UTC)

| | Cheeseboro Wind ~ RH | Simi Valley Wind ~ RH | Thousand Oaks Wind ~ RH | CANSAC Forecast (estimated sustained) |
|---|---|---|---|---|
| **15Z/28** | NE 29G47 ~ 26 | W 6G15 ~ 22 | N 11G20 ~ 21 | |
| **16Z/28** | NE 33G58 ~ 24 | NE 10G19 ~ 20 | N 14G25 ~ 20 | |
| **17Z/28** | NE 30G58 ~ 23 | NNE 11G27 ~ 18 | SSW 15G29 ~ 18 | |
| **18Z/28** | NE 32G51 ~ 22 | N 13G32 ~ 16 | N 16G31 ~ 15 | NE 20-30 |
| **19Z/28** | NE 26G50 ~ 21 | NE 14G31 ~ 15 | N 15G35 ~ 14 | |
| **20Z/28** | NE 28G50 ~ 19 | NW 14G31 ~ 13 | N 17G33 ~ 13 | |
| **21Z/28** | NE 24G50 ~ 19 | NE 16G27 ~ 12 | NE 15G31 ~ 12 | |
| **22Z/28** | ENE 20G46 ~ 17 | NNE 13G28 ~ 12 | NE 16G30 ~ 12 | |
| **23Z/28** | ENE 23G39 ~ 17 | NE 11G29 ~ 12 | NE 11G27 ~ 12 | |
| **00Z/29** | ENE 19G38 ~ 16 | NE 12G23 ~ 11 | NE 11G22 ~ 11 | NE 12-16 |
| **01Z/29** | NE 14G28 ~ 16 | NE 6G22 ~ 10 | ENE 8G22 ~ 10 | |
| **02Z/29** | NE 13G28 ~ 17 | NE 6G19 ~ 11 | E 4G15 ~ 11 | |
| **03Z/29** | ENE 17G30 ~ 17 | **missing** | **missing** | |
| **04Z/29** | E 19G30 ~ 17 | ENE 5G13 ~ 13 | ESE 1G5 ~ 29 | |
| **05Z/29** | ENE 21G31 ~ 17 | E 3G11 ~ 14 | ESE 3G5 ~ 23 | |
| **06Z/29** | ENE 15G25 ~ 17 | S 3G7 ~ 15 | ESE 5G9 ~ 18 | |
| **07Z/29** | ENE 18G23 ~ 17 | NE 6G14 ~ 15 | E 5G9 ~ 17 | |
| **08Z/29** | ENE 17G24 ~ 17 | NW 3G14 ~ 15 | ESE 4G8 ~ 17 | |
| **09Z/29** | ENE 14G20 ~ 17 | SE 4G12 ~ 14 | ESE 6G8 ~ 19 | |
| **10Z/29** | ENE 17G25 ~ 17 | SE 3G8 ~ 17 | ESE 6G9 ~ 21 | |
| **11Z/29** | ENE 15G25 ~ 16 | SE 5G10 ~ 17 | ESE 4G9 ~ 27 | |
| **12Z/29** | ENE 14G24 ~ 17 | NE 5G9 ~ 15 | E 2G6 ~ 31 | NE 14-26 |

## TABLE 2.

This table shows the hourly wind and relative humidity observations for RAWS sites in the vicinity of the Topanga Fire from 1500 UTC 28 September to 1200 UTC 29 September. Individual weather elements that exceed red flag thresholds are shown in **red.** The fourth column contains forecast sustained winds from the CANSAC model, for comparison purposes.