

## Part 1: Fire Weather, Meteorology, and Climate

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The Hayman Fire in June 2002 was heavily influenced by antecedent regional weather conditions, culminating in a series of daily weather events that aligned to produce widely varying fire behavior. This review of weather conditions associated with the Hayman Fire consists of two parts:

- A brief overview of prior conditions as described by a regional climate review and assessment of the state of the fuels as described by the National Fire Danger Rating System.
- A more detailed daily discussion of the synoptic-scale and local meteorological conditions affecting the fire.

### Data Sources

Data are presented from a wide variety of sources in formats generally available from public, nonsubscription Internet sites. Because this review was not instigated until several months after the fire, many real-time Internet sites were not available for presenting “as of June 2002” conditions unless they had on-line archives. The weather discussion generally proceeds from a regional climate-based summary to a more site-specific narrative.

Climate information for the region is based on data from the National Weather Service Cooperative Climate Network whose data are usually organized by State climate divisions. Individual station data for three stations near the Hayman Fire are examined in more detail for the 2002 water year (October 2001 to October 2002) prior to the fire. These data were obtained primarily from Internet resources at the Colorado Climate Center (<http://climate.atmos.colostate.edu>), the National Oceanic and Atmospheric Administration’s (NOAA) Climate Prediction Center (<http://www.cpc.ncep.noaa.gov>), and the National Drought Mitigation Center (<http://www.drought.unl.edu>).

Archived weather maps (upper air and surface charts) from San Francisco State University, the National Climate Center, and the Storm Prediction Center were obtained for identifying and illustrating synoptic scale weather patterns. Atmospheric soundings are routinely taken via radiosonde (weather balloons) at 00Z and 12Z at several hundred sites around the world. These time notations refer to Greenwich Mean Time (GMT or UTC) which is 6 hours earlier than Mountain Daylight Time (MDT). For example 00Z (June 1) corresponds to 6 p.m. MDT on May 31, and 12Z (June 1) corresponds to 6 a.m. MDT on June 1. We illustrate 500 millibar (mb) maps, which are maps

that depict the height, temperature, and wind velocity at a constant pressure surface. The 500 mb map corresponds to heights around 19,000 feet (5,820 m) above ground level. Archived upper air soundings were obtained from the University of Wyoming (Laramie), for Denver, 56 miles (90 km) north of the fire, and for Grand Junction, 250 miles (402 km) southwest of the fire. The soundings were used to compute Lower Atmospheric Stability Index (Haines 1998) and to estimate vertical wind speed profiles over the fire area.

The Lower Atmospheric Stability Index (LASI), more commonly known as the Haines Index, was developed by USDA Forest Service meteorologist Donald Haines to quantify (via index) the lapse rate (stability) and dryness (dew point depression) of lower levels of the atmosphere, and correlate the index with days of large fire growth, particularly in the absence of significant surface winds. An index value of 2 or 3 (a moist stable lower atmosphere) indicates low potential for large fire growth, and 5 or 6 (dry unstable) indicates moderate or high potential. Since 1988 there have been several studies focused on exploring and documenting relationships between the Haines Index and fire growth (for example, Werth and Ochoa 1990). More recently there have been efforts at developing the climatology of Haines Index values throughout the United States in more detail than Haines did in his original research. Werth and Werth (1998) performed a study of the frequency of Haines Index values based on the high elevation layers in the Western United States using data from 1990 to 1995 and reported Denver had Haines Index values of 5 and 6 (moderate and high) 44 percent of the days in June.

Atmospheric conditions related to blow-up fires were described by Byram (1954). He characterized vertical wind speed profiles that he deemed “potential trouble makers” and addressed the concept of a “tug-of-war” between the power of the wind and the power of the fire. Essentially this work suggested that when wind decreases with height above a fire, the power of the fire has more opportunity to influence the behavior and direction of fire growth, and given dry and abundant fuels, a fire may rapidly transition to extreme behavior and erratic in direction and rate of spread. Fires where surface winds predominate may exhibit extreme behavior but tend to be more consistent in their direction and rate of spread. In general, in a well-mixed atmosphere wind speed increases with height; this “trouble maker” wind profile has come to be known as an “inverse wind profile.”

On a more intimate scale, hourly weather observations from three active Remote Automatic Weather Stations (RAWS) near the fire are available. The Cheesman RAWS is located just west of the Cheesman Reservoir, the Lake George RAWS is at the Lake George Work Center about 5 miles (8 km) southeast of

the fire origin, and the Bailey RAWS is near the town of Bailey, about 20 miles (32 km) northwest of the fire's northern perimeter. The RAWS stations are part of a national fire weather network that supports the weather requirements of the National Fire Danger Rating System (Deeming and others 1977) and are commonly referred to as NFDRS stations. The data from the weather station at the USDA Forest Service Manitou Experimental Forest are also available for analysis, although its sensor configuration and observation format is not consistent with that of the national fire weather network. Near the waning stages of the fire, three specialized Fire Remote Automatic Weather Stations (FRAWS) were positioned near the fire; those data are also summarized. Hourly data from the RAWS and FRAWS stations were obtained from the Western Region Climate Center. Data from the Manitou station were provided by Wayne Shepperd (Rocky Mountain Research Station, USDA Forest Service). Table 1 documents the station metadata to the best of our knowledge, and their locations are depicted in figure 2. Appendix A contains the hourly listing of weather observations from Cheesman, Lake George, and Manitou and also the daily upper air information used for computing the Haines Index from Denver soundings.

## Regional Conditions

Colorado had been experiencing variable short-term drought conditions over the preceding 5 years. According

to Meteorologist Mike Baker (Summer 2002 Outlook for the Colorado Front Range, NOAA/NWS Boulder, CO, June 15, 2002):

The current drought began to unfold in Colorado during the summer of 1998, at approximately the same time the phenomenon known as La Niña began forming in the eastern Pacific Ocean. This cold phase ENSO (El Niño-Southern Oscillation) event, characterized by below normal sea surface temperatures and above normal atmospheric pressures in the central and eastern Pacific Ocean, varied from moderate and strong intensity as it continued uninterrupted through the spring of 2001. This was of extraordinarily long duration for a La Niña as the average life span for these events is only about nine months! The hiatus from La Niña was short-lived as by the end of the summer that year a weak La Niña reformed and continued intermittently through May of 2002. The link between La Niña and drought in Colorado appears unmistakable. During the last 40 years, five La Niña events of at least moderate intensity occurred, and during each of these events, drought conditions of at least severe intensity developed within the borders of Colorado. The strength and especially long duration of the latest La Niña event may also have been instrumental in producing the extreme drought conditions observed across Colorado today.

The Climate Prediction Center produces a wide array of climate analysis and assessment products for regional application using state climate divisions for displaying regional conditions. The Hayman Fire burned in four Counties (Park, Douglas, Jefferson, and Teller) of Colorado's Platte River drainage climate division (fig. 3). The winter of 2001 and 2002 saw a marked worsening of drought conditions as expressed by several regional scale analyses. One widely used index to quantify the severity of drought conditions is

**Table 1**—Weather station metadata used in Hayman Fire report.

Name	NWS number	Type <sup>1</sup>	Latitude	Longitude	Elevation ft (m)	Position	Data begin
Lake George 8 SW	054742-4	Coop	38°55' N	105°29' W	8,510 (2,594)	Valley	1948
Lake George NFDRS	053002	RAWS	38°58' N	105°21' W	8,050 (2,454)	Valley	1964
Cheesman	051528-4	Coop	39° 13' N	105° 17' W	6,890 (2,100)	Valley	1948
Cheesman NFDRS	053102	RAWS	39° 11' N	105° 16' W	7,473 (2,278)	Ridge	1987
Bailey	050454-4	Coop	39° 24' N	105° 29' W	7,740 (2,359)	Valley	1948
Bailey NFDRS	052001	RAWS	39° 23' N	105° 20' W	8,000 (2,438)	Ridge	1970
Fire Raws 12		FRAWS	39°04' N	105°05' W	7,990 (2,435)	Bench	Jun 18
Fire Raws 13		FRAWS	39°16' N	105°34' W	11,300 (3,444)	Ridge	Jun 21
Fire Raws 6		FRAWS	39°15' N	105°20' W	8,200 (2,499)	Ridge	Jun 21
Manitou		Exp	39.127 N	105.116 W	8,174 (2,491)	Valley	Jan 01
Denver	72469	UA	39.75 N	104.87 W	5,362 (1,634)	Valley	
Grand Junction	72476	UA	39.11 N	108.53 W	4,868 (1,484)	Valley	

<sup>1</sup> Station type notes: Coop: National Weather Service cooperative network generally measures precipitation totals and temperature ranges on a daily basis. RAWS/NFDRS: Standard fire weather stations measure 10-minute averages of temperature, humidity, wind, and solar radiation hourly. Rain is accumulated hourly. Maximum wind gusts are recorded for each hour. The wind sensor is 20-feet (~6 m) above ground. FRAWS: Portable incident weather stations measure 10-minute averages of temperature, humidity, and solar radiation hourly. Rain is accumulated hourly. Maximum wind gusts are recorded for each hour. The wind sensor is 6 feet (~2 m) above ground and is a 2-minute average. Exp: Station at Manitou Experimental Forest has hourly averaged temperature, wind, and humidity. UA: Upper air station where radiosondes are launched at least twice daily at 00Z and 12Z (6 p.m. and 6 a.m. MDT)

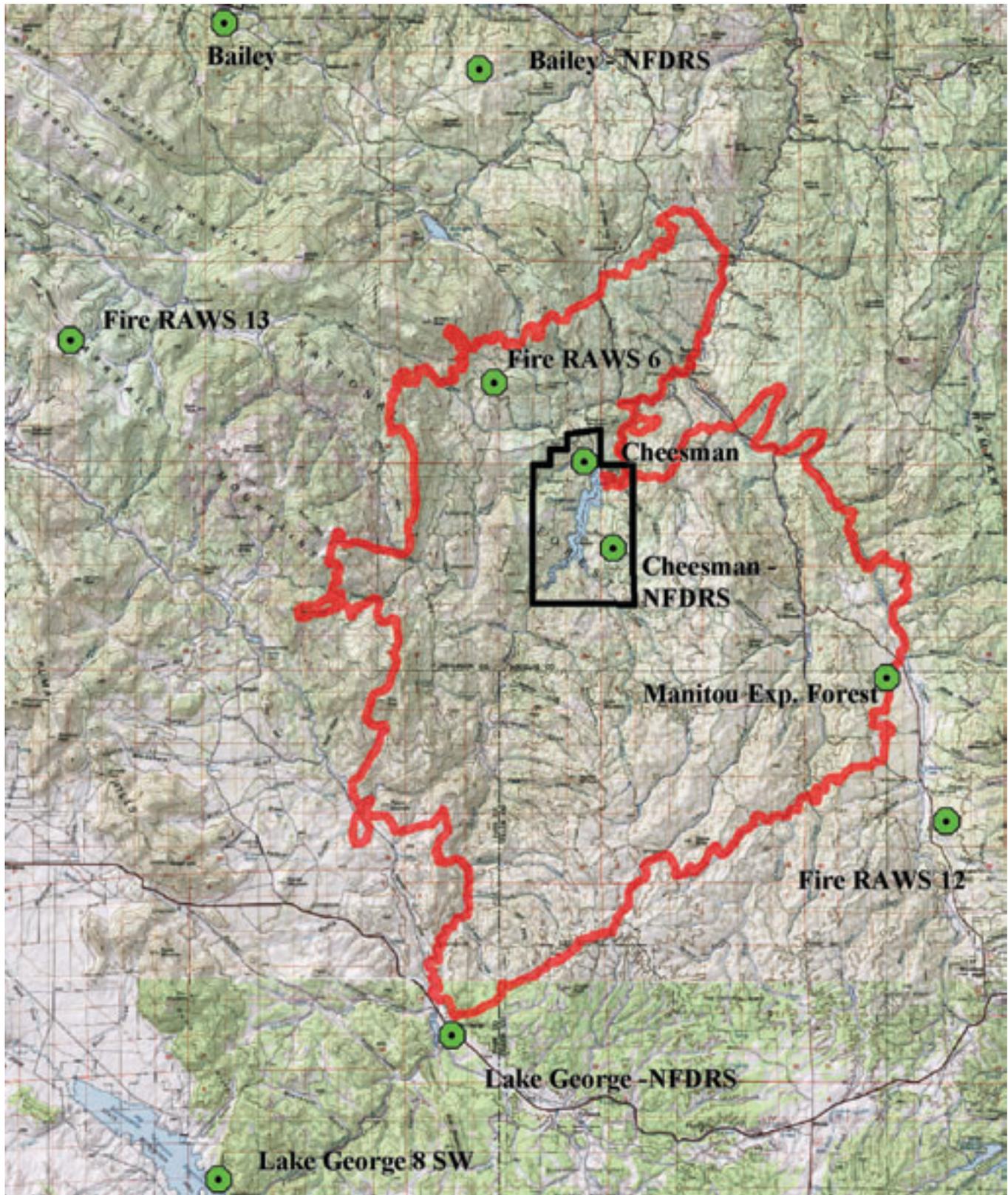
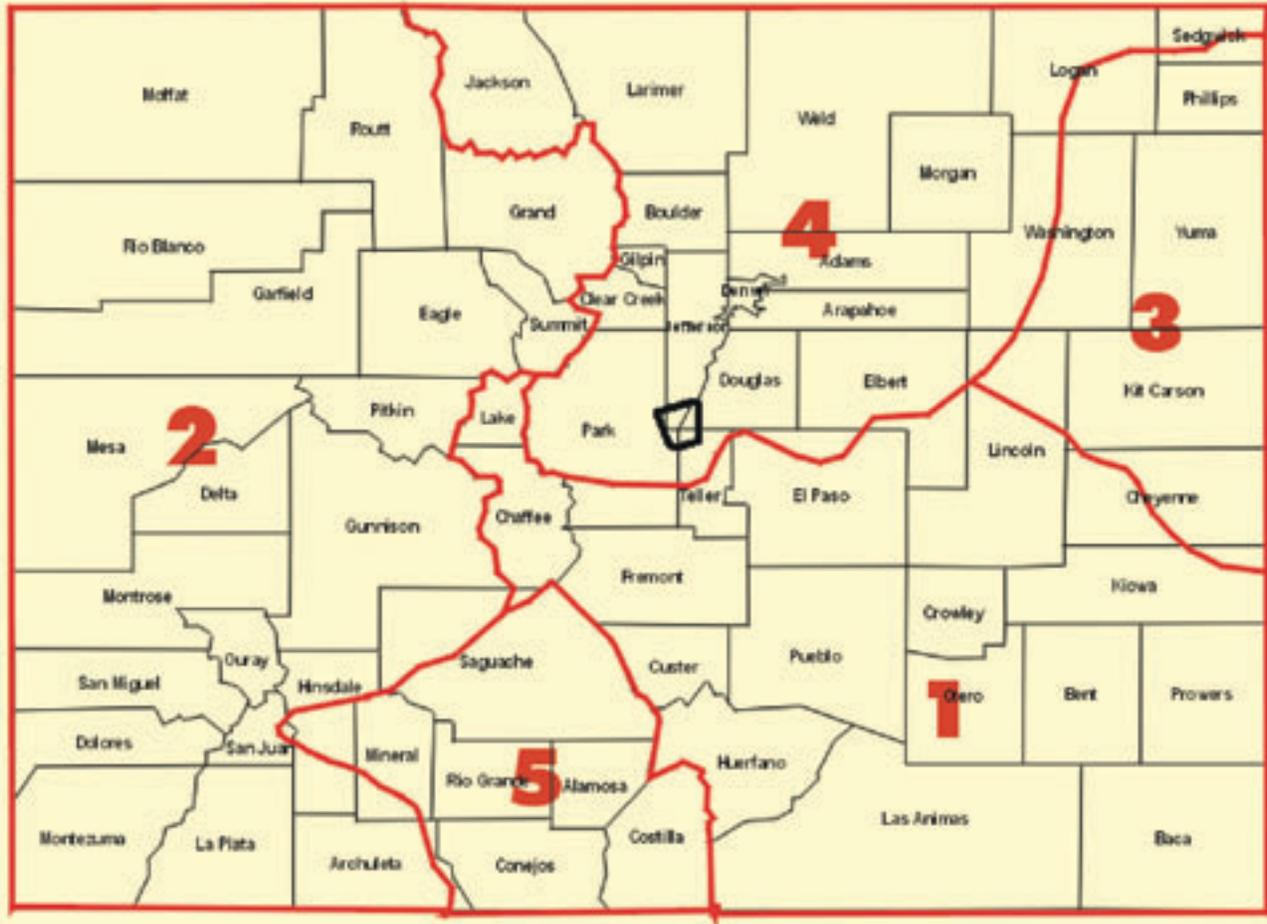


Figure 2—Location of weather stations in the Hayman Fire vicinity.

# Climate Prediction Center



## Colorado



**Figure 3**— Approximate location of Hayman Fire within Colorado Climate Division 4. The Hayman Fire burned in four Colorado Counties: Park, Teller, Douglas, and Jefferson.

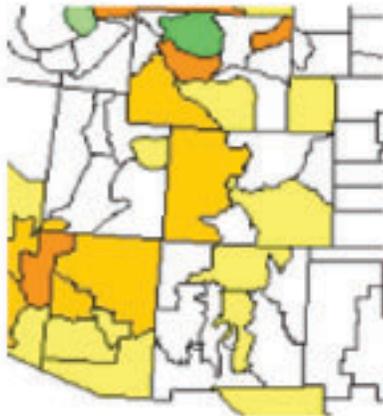
the Palmer Drought Severity Index (Palmer 1965). Based on temperatures and precipitation, the Palmer Drought Severity Index (PDSI) uses a supply and demand model to estimate soil moisture as compared to climatological averages. It is a longer term index that is compiled weekly and reflects the evolution and decay of wet and dry spells.

Figure 4 illustrates the progression of the weekly PDSI for the first week in March, April, May, and June

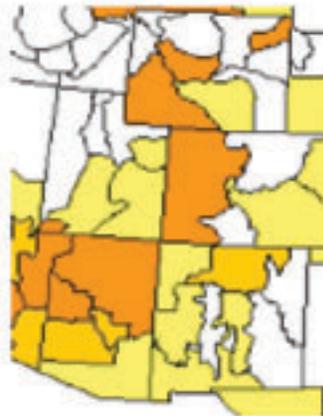
2002. By the first week of June all of Colorado was experiencing severe to extreme drought. The Platte River drainage was classified as being in severe drought but was surrounded by areas classified as extreme. Figure 5 depicts the Colorado snow pack as of May 1, 2002 showing almost the entire region at less than 50 percent of normal snow pack. Figure 6 illustrates snow water content data from the SNOTEL network for the South Platte Drainage. The 2001 and 2002 winter

**Progression of Drought Severity Index  
(Long Term Palmer)  
March 9 to June 8, 2002**

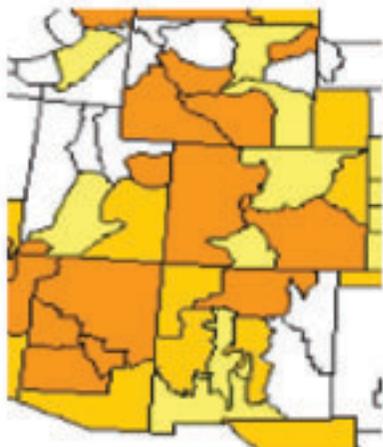
**Week Ending March 9, 2002**



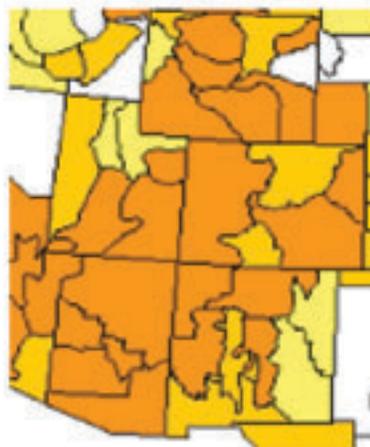
**Week Ending April 6, 2002**



**Week Ending May 4, 2002**



**Week Ending June 8, 2002**



**Source: Climate Prediction Center, NOAA**

- 4.0 or less (Extreme Drought)
- 3.0 to -3.9 (Severe Drought)
- 2.0 to -2.9 (Moderate Drought)
- 1.9 to +1.9 (Near Normal)

**Figure 4**—Regional composition of Long Term Palmer Drought Index (PDI) for spring of 2002.

# Mountain Snow Water Equivalent

as of May 1, 2002 (in relation to the average for this date)

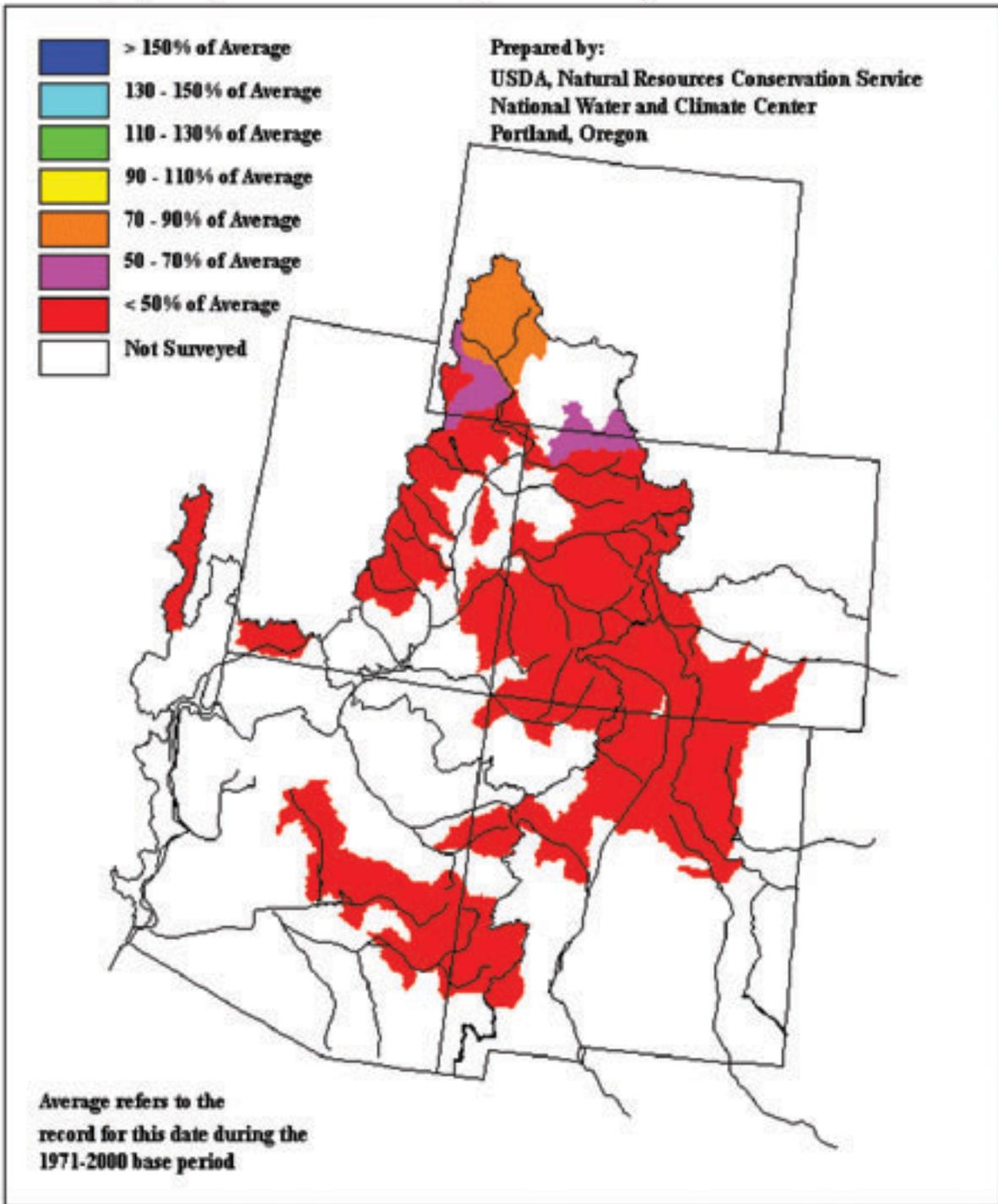
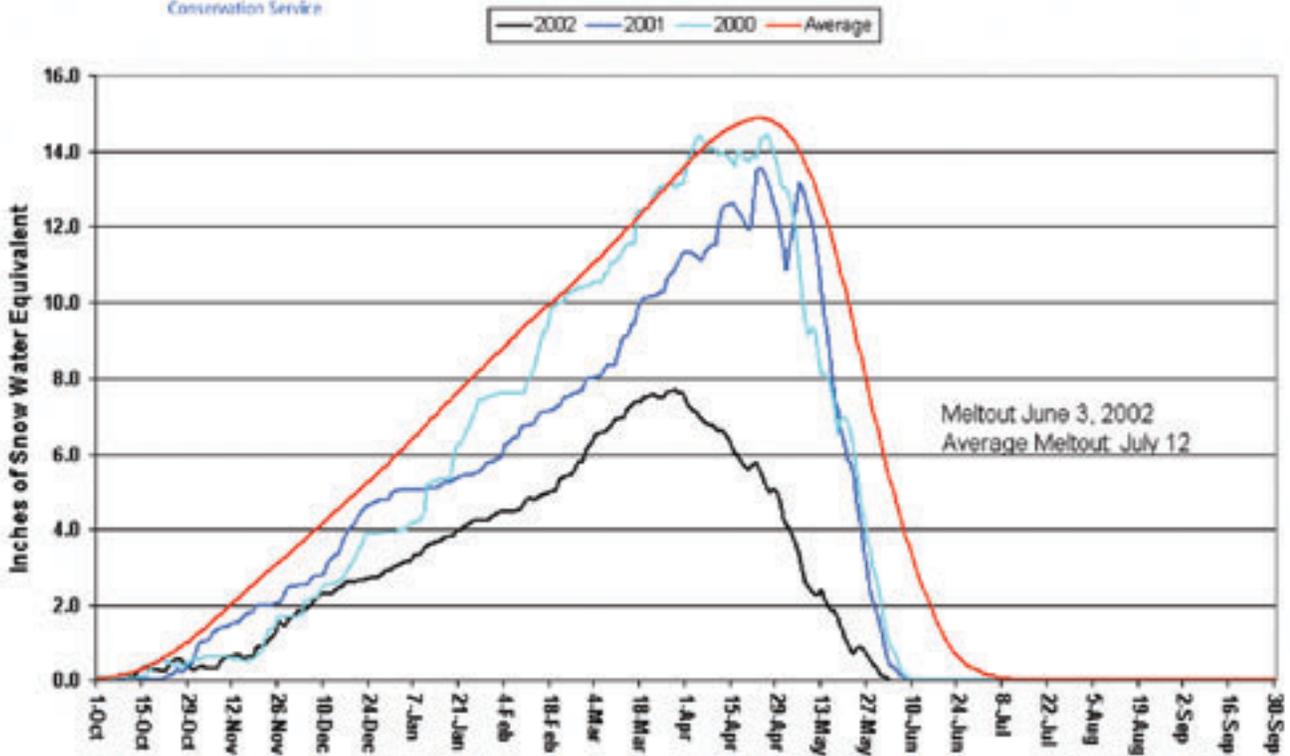


Figure 5—Regional Mountain Snow Water Equivalent as of May 1, 2002. (Source: USDA, NRCS, Portland, OR)

## South Platte Basin Snowpack

Based on provisional SNOTEL data.



**Figure 6**—Water year snow water equivalent for the South Platte Basin for 2000-2002 as compared to long-term (1971-2000) average. (Source: USDA, Natural Resource Conservation Services)

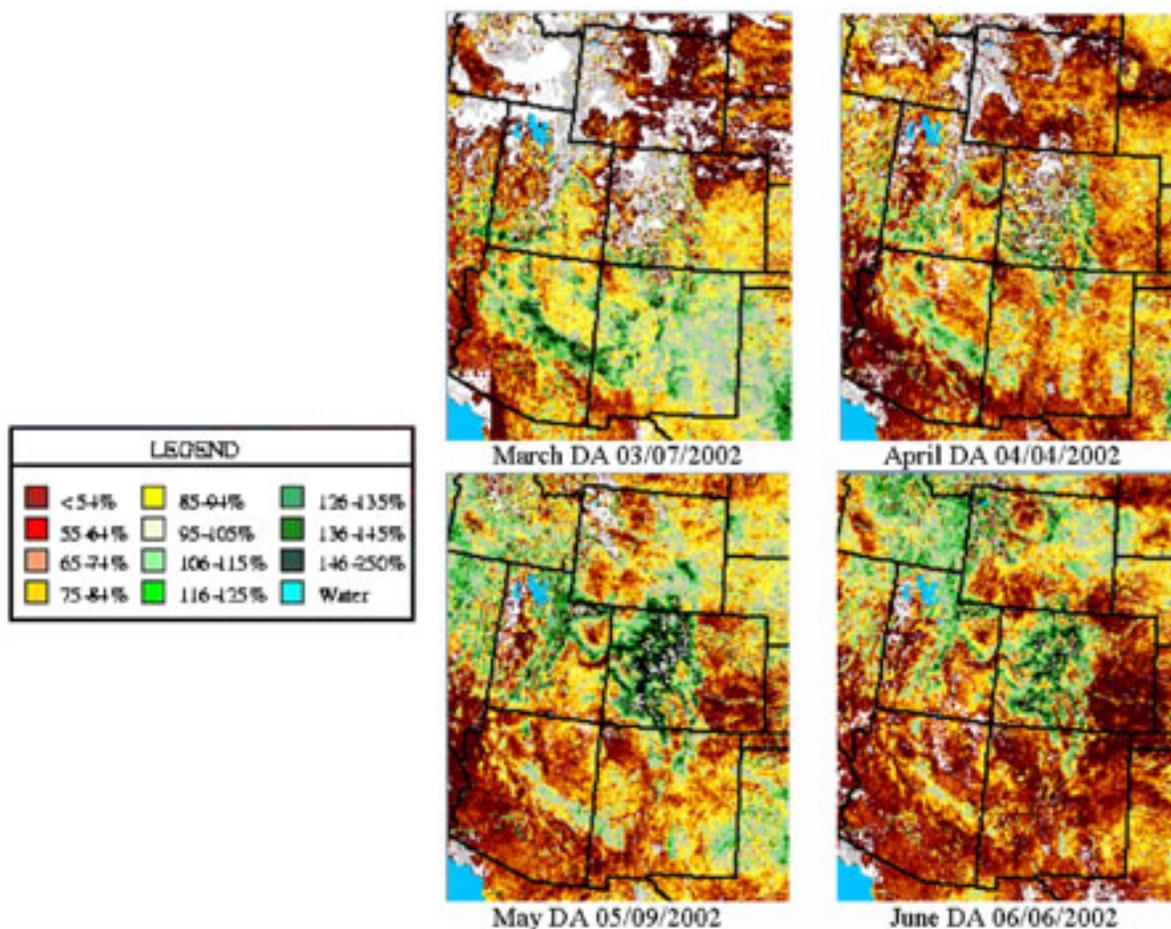
precipitation deficit (black line) is clearly shown with basin area melt-out occurring almost 6 weeks sooner than normal.

Each of these regional assessments of drought, snowpack, and snow water content clearly indicates the extent of dryness in central Colorado during the winter and spring of 2002.

Weekly composites of vegetation condition or greenness are created by the Earth Resources Observation Systems (EROS) Data Center in Sioux Falls, SD, using daily afternoon observations from the Advanced Very High Resolution Radiometer (AVHRR) on board the National Oceanic and Atmospheric Administration's (NOAA) polar orbiting weather satellites. A vegetation index, the Normalized Difference Vegetation Index (NDVI) (Goward and others 1990; Tucker and Choudhury 1987) is calculated from reflected red and near-infrared light at a spatial resolution of 0.7 miles (1.1 km), relating to the amount of actively photosynthesizing biomass and illustrating vegetation response

to drought. The weekly NDVI composite images can be used to monitor the timing and extent of green-up and curing at a landscape scale (Burgan and Hartford 1993). The NDVI history extends from 1989, offering a historical context for making comparisons. The NDVI images and a calculated Departure from Average image have been shown to relate to wildfire activity (Burgan and others 1996; Bartlette and Burgan 1998). Live vegetation's contribution to fire potential has been estimated by monitoring vegetation change through the year and also by comparing the current condition to average or droughty years for geographic area long range assessments (Zimmerman and others 2000).

The progression of Departure from Average images from early March, April, May, and June (fig. 7) shows increasing effects of drought on vegetation in the Intermountain Southwest. In the images, areas of white and light gray indicate clouds and snow. Areas that are green indicate vegetation that is more green



**Figure 7**—Water year percent of average accumulated precipitation at Lake George, Cheesman, and Bailey. Data begin in 1948 at all locations. (Source: Colorado Climate Center)

than average for the time of year. Mountainous areas appear more green than average because they were snow-free at an earlier date than normal. Most of the area displays yellow to brown colors indicating vegetation that ranged from somewhat less green than average to much less green than average for that time of year. By June, even the mountainous areas are showing the effects of continued dry weather.

Figure 8 compares the NDVI image for the first week of June 2002 with images from that period of the previous two recent significant fire years 1996 and 2000, further illustrating that the 2002 drought effect on vegetation of Colorado was most severe.

### Local Conditions

Individual climate monitoring locations provide more detail of prior conditions near the fire area. There are two climate stations near the fire perimeter and one inside the perimeter (fig. 2). The locations outside are

Bailey, about 12.5 miles (20.1 km) northwest of the northern perimeter and 25 miles (40 km) north-northwest of the origin, and Lake George, within several miles of the point of origin. Within the fire perimeter is the Cheesman station near the Cheesman Reservoir, which provides domestic water for the Denver area. These stations have recorded daily precipitation and maximum/minimum temperature since 1948. Figure 9 illustrates the accumulated percent of average precipitation for these stations for the 2002 water year. By the end of May a slight south to north gradient of increased moisture was apparent with Lake George at 26 percent of normal, Cheesman at 37 percent, and Bailey at 60 percent of normal accumulated moisture.

The National Fire Danger Rating System (Deeming and others 1977) is a weather and climate system that describes how antecedent and current weather conditions affect moisture, and thus fire potential, of wildland fuels. The National Fire Danger Rating System (NFDRS) integrates the cumulative effects of fire

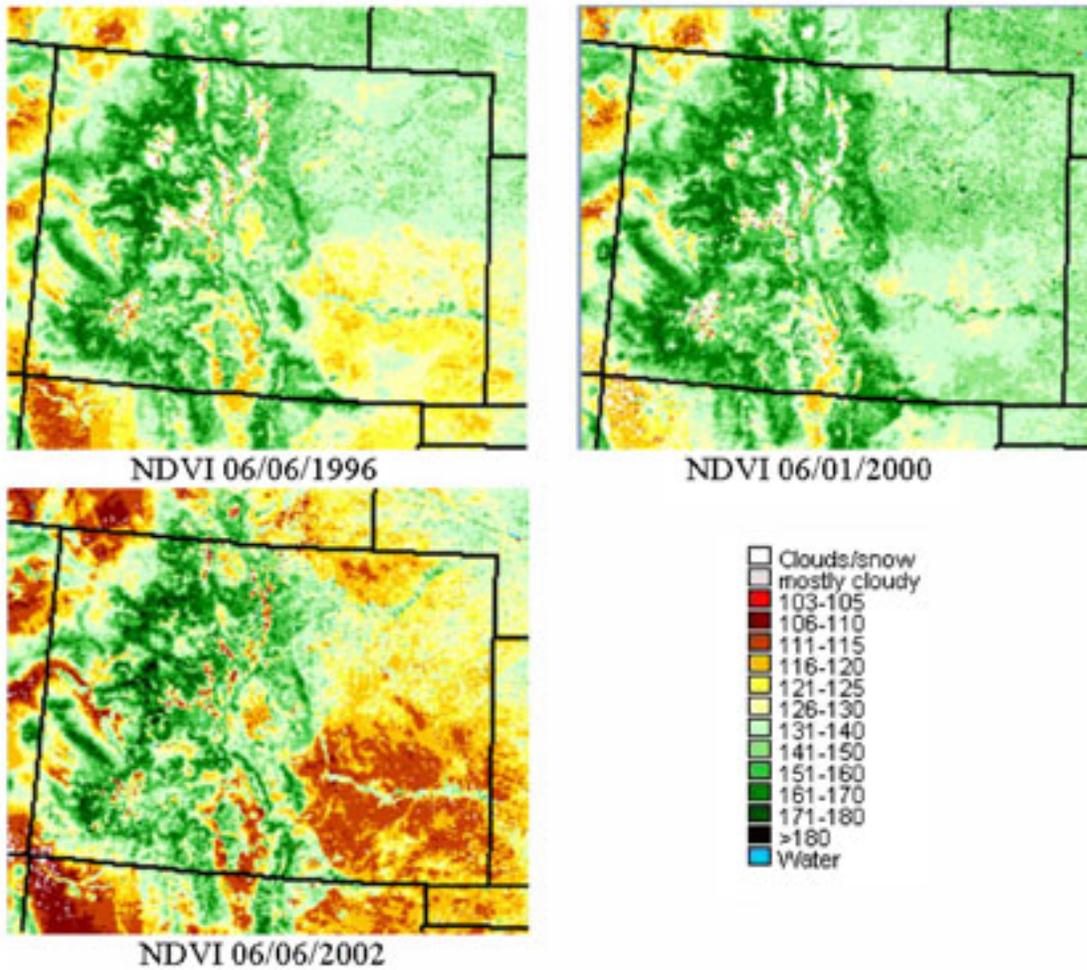


Figure 8—NFDRS comparison of 2002 versus average and two other fire years.

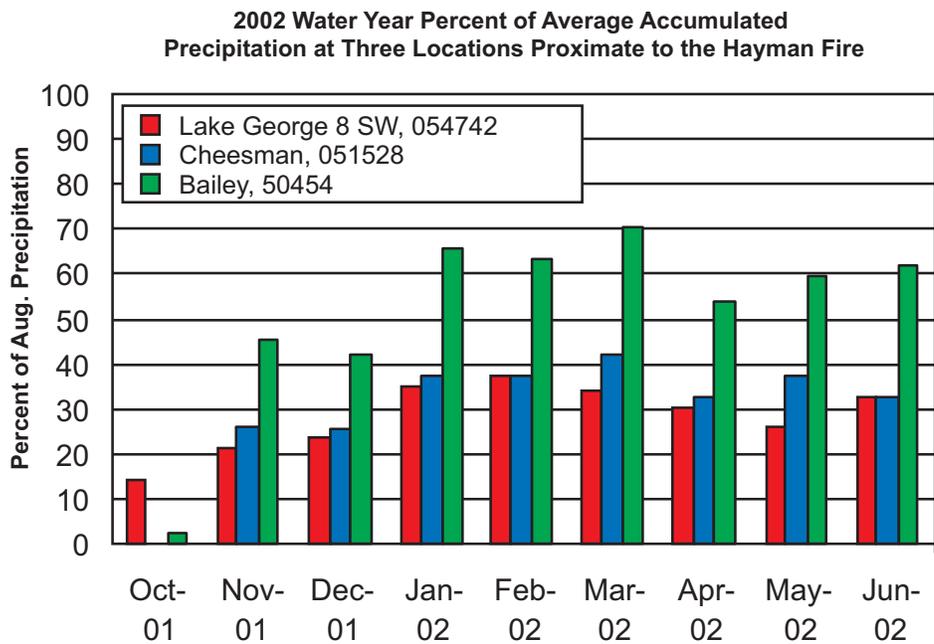


Figure 9—Progression of departure from average greenness.

weather observations into indices or components that reflect an area's fire potential. The NFDRS is based on a network of some 1,200 wildland fire weather stations that report to a central processing and archiving site. The fire weather observation is more complete than the cooperative climate observation. It includes hourly observations of temperature, relative humidity, wind speed and direction, rainfall, near-ground fuel temperature, and solar radiation. State and Federal land management agencies in Colorado operate about 70 fire weather stations during the fire season. Near the Hayman Fire, three fire weather stations were operational during the spring of 2002 (fig 2). Three additional portable "Fire-RAWS" were placed at strategic locations on the fire on June 19, 21, and 22. The models in the NFDRS process daily fire weather observations to estimate the moisture content of both dead and live fuels. Of the three stations, Lake George and Cheesman have the best climate records; Bailey has an inconsistent historical record and is not appropriate for climate comparisons.

FireFamily Plus (Bradshaw and McCormick 2000) is software for computing and analyzing NFDRS indexes from archived daily weather observations. It was used to contrast 2002 to previous fire seasons with large fires in the area near the Hayman Fire. The Buffalo Creek Fire in May 1996 and the High Meadow Fire in June 2000 both burned in excess of 10,000 acres (4,000 ha). Prior to the Hayman Fire, Buffalo Creek and High Meadow were the largest fires and the only ones exceeding 1,000 acres (400 ha) in the area since 1970.

Figure 10 illustrates the extent of the dryness of the fuels as compared to long-term averages and recent large fires of 1996 and 2000. The Cheesman station graph compares NFDRS model values of 1000-hour fuel moisture for 2002 to the 14-year history (1987 through 2000). The 1000-hour fuel moisture represents the moisture content of dead logs on the forest floor from 3 to 6 inches (7.6 to 15.2 cm) in diameter, and also the forest litter and duff several inches below the forest floor. 1000-hour fuel moisture is computed from daily observations of maximum and minimum temperature and relative humidity, and hours (not amount) of precipitation for the previous 7 days.

The Lake George graph in figure 10 contrasts NFDRS modeled woody fuel moisture for 2002 to the 30-year normal (1971 to 2000). Woody fuel moisture is a measure of the woody fuels in shrubs; it is not a model of tree moisture. The NFDRS woody fuel moisture model is based on the 1000-hour fuel moisture. Annotated on these graphs (in red) are representative values from field locations in the Hayman Fire area based on a fuel moisture monitoring program at the South Park Ranger District.

The fuel moisture trends are really quite remarkable. At Cheesman, the 1000-hour fuel moisture is at record low values during the entire month of April and most of May and June. The model value near 6 percent in early May is approaching the theoretical lower limit of the 1000-hour fuel moisture. In contrast 1996 and 2000 fuel moisture values were within normal ranges until late May. The woody fuel moisture at Lake George is even more revealing in its integration of the antecedent weather. During 2002, the NFDRS modeled woody shrub moisture content never approached that of green vegetation. Even the comparison years of 1996 and 2000 had enough moisture to allow the live fuels to reach about 100 percent, which was still below the normal rise to between 120 and 130 percent by early May.

Each piece of this analysis shows a different perspective on the integrated process of assessing the fuel moisture in the Hayman Fire area. In total, they make a compelling argument that the fuel moisture conditions in the spring of 2002 in central Colorado were among the driest seen in at least 30 years; perhaps much longer. And, unlike other years where near-normal spring conditions gave way to short-term drying and largely wind-driven fires of short duration, the fuel moisture conditions for the Hayman Fire were set up in April and May.

## Weather During the Fire

The two major fire activity periods, June 8 to 10 and 17 to 19, were both associated with the prefrontal air of associated surface cold fronts and moderate upper level troughs that brought increasing winds, and warmer temperatures as well as subsidence (slow downward motion of air over a large area) conditions. The prefrontal air was warm and exceptionally dry. There were significant surface winds during the fire activity on June 8 and 9. The period June 17 through 19 also saw the passage of the short wave ridge prior to the trough that enhanced subsidence conditions.

Both periods were associated with high Haines Indexes at Denver. The Haines Index was 5 or 6 (moderate and high) on 63 percent of the days in June 2002 compared to the June "normal" of 44 percent described by Werth and Werth (1998). The stability term of the Haines Index was 3 on 68 percent of the soundings in June 2002, and the moisture term was 2 for 27 percent of the soundings and 3 for 38 percent of the soundings. The implication of this is that lower atmospheric moisture fluctuated more than the stability did in terms of Haines Index.

Both periods had estimated vertical wind speed profiles (based on the Denver sounding) that were favorable to large column development. The first growth period had a well-defined low-level wind maximum

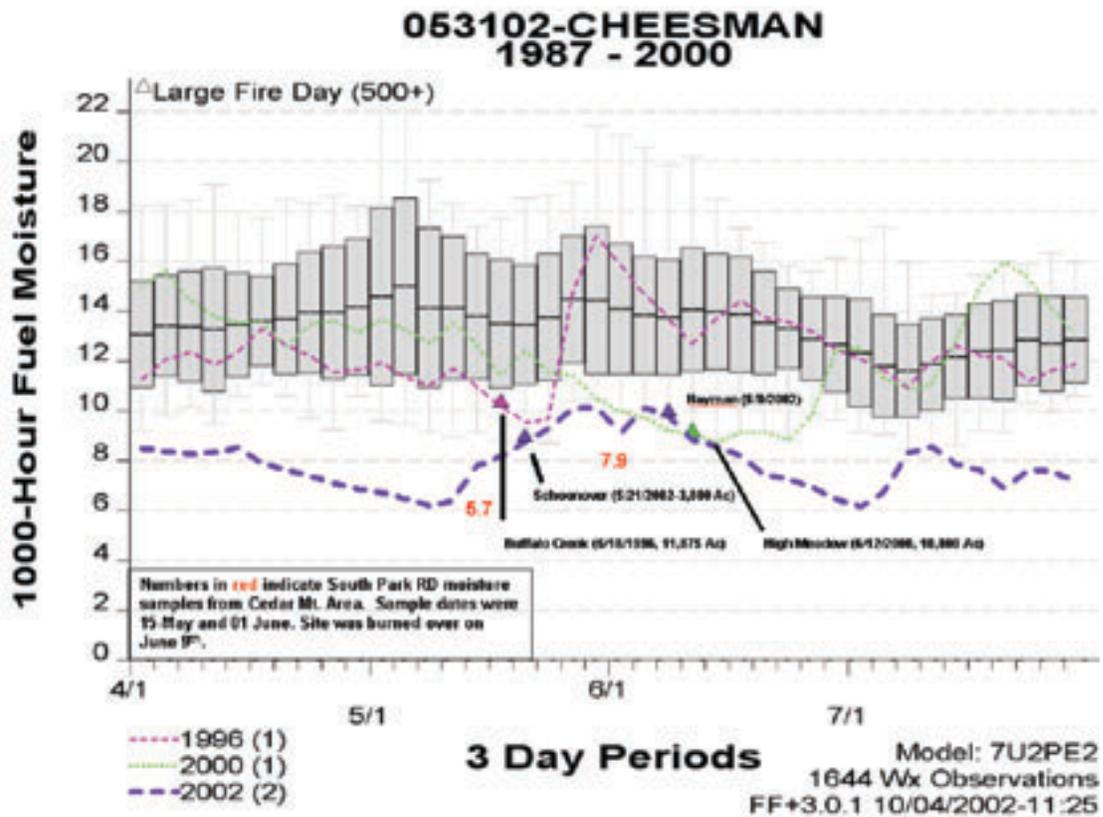
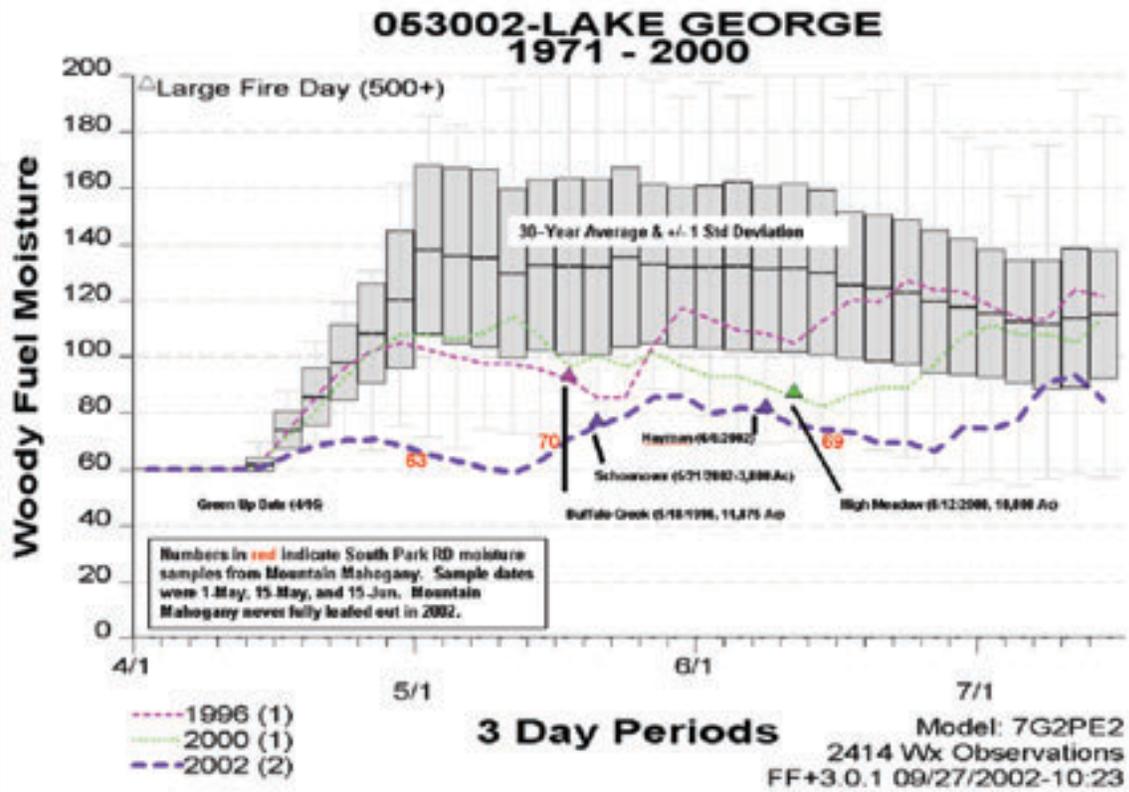


Figure 10—NDVI comparison for three severe fire years.

with wind speeds exceeding 30 mph (48 km/hr) around 1,500 feet (457 m) above the fire area that decreased to 15 mph (24 km/hr) around 4,500 feet (1,372 m) above the fire area. The second period of significant fire growth also had an inverse wind profile, but of much lower speeds and without a pronounced low-level wind maximum.

Also notable was that these events coincided with strong anticyclonic shear in the mid-level winds. Anticyclonic shear is often associated with subsidence that brings air to the surface from mid-levels of the atmosphere. This air often originates with dew points near or below 0 °F (-18 °C) and often results in single digit surface humidity as the air warms during its descent.

The high fire activity periods ended with the passage of the fronts and associated upslope winds that increased relative humidity above critical levels (12 to 15 percent). The arrival of the first monsoonal surge of the summer on June 21 started the process of increasing shower activity. A second, stronger surge on July 6 brought significant rainfall throughout the fire area allowing containment of the Hayman Fire.

## Daily Weather

We break the discussion on daily weather into five 1-week periods beginning on June 1 and ending on July 7. Meteograms (time series graph of weather parameters) for the hourly fire weather observations are shown for each week.

**June 1 to June 7:** A low pressure trough was generally in place over the Western United States (fig 11). On June 1 and 2, eastern Colorado was east of the trough. On June 1 and 2, south winds and low relative humidity preceded the passage of a weak surface front on June 3. Surface winds out of the east and northeast on June 3 resulted in upslope flow with surface dew point temperatures rising from near 0 °F (-18 °C) on the afternoon of June 2 to near 50 °F (10 °C) on the morning of June 4. On June 4 all three weather stations received rainfall with about 0.85 inch (21.6 mm) at the northern location of Bailey, 0.12 inch (3.1 mm) at Cheesman, and only 0.04 inch (1 mm) at the more southern Lake George site near the fire’s origin. This rain had virtually no lasting effect on the parched surface fuels, and

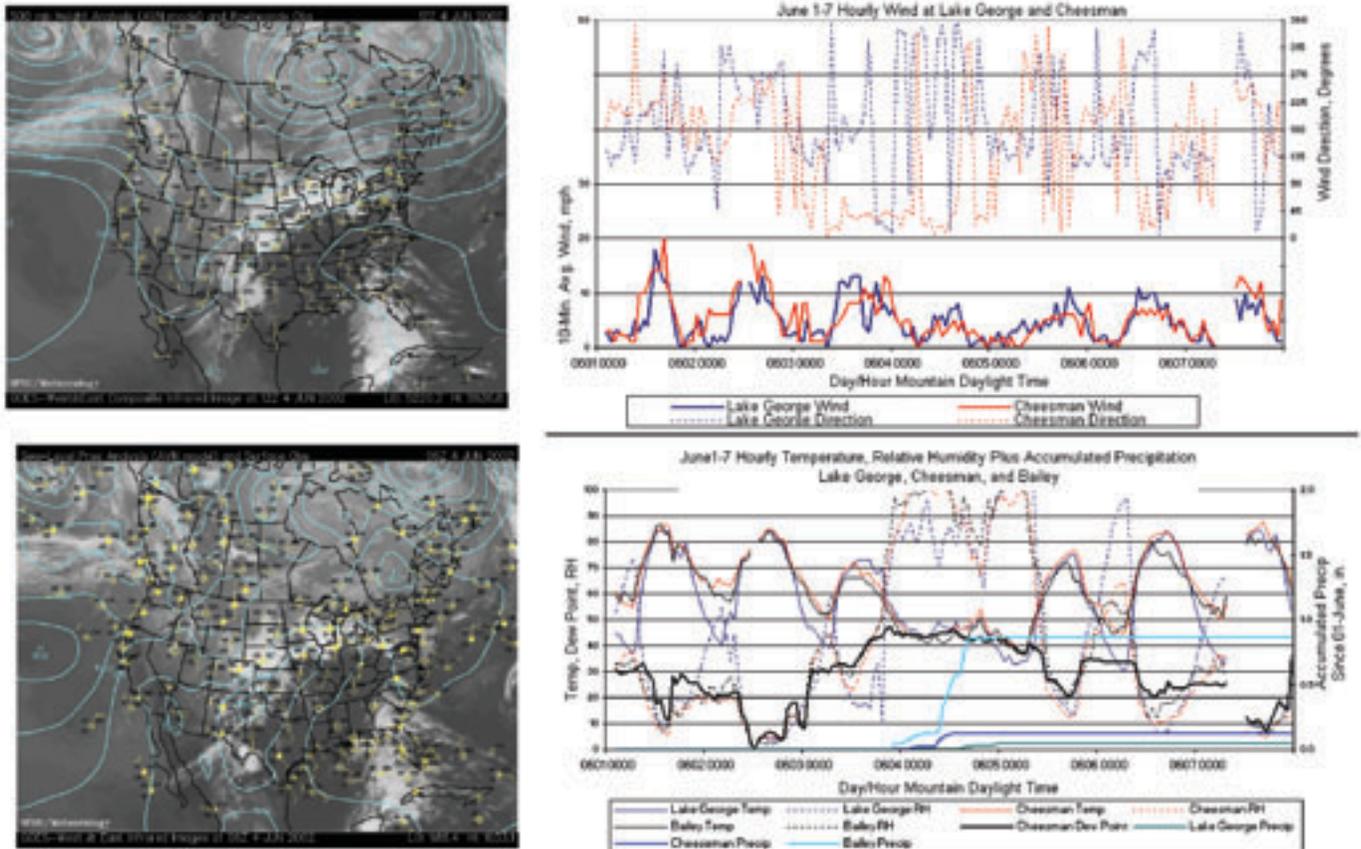
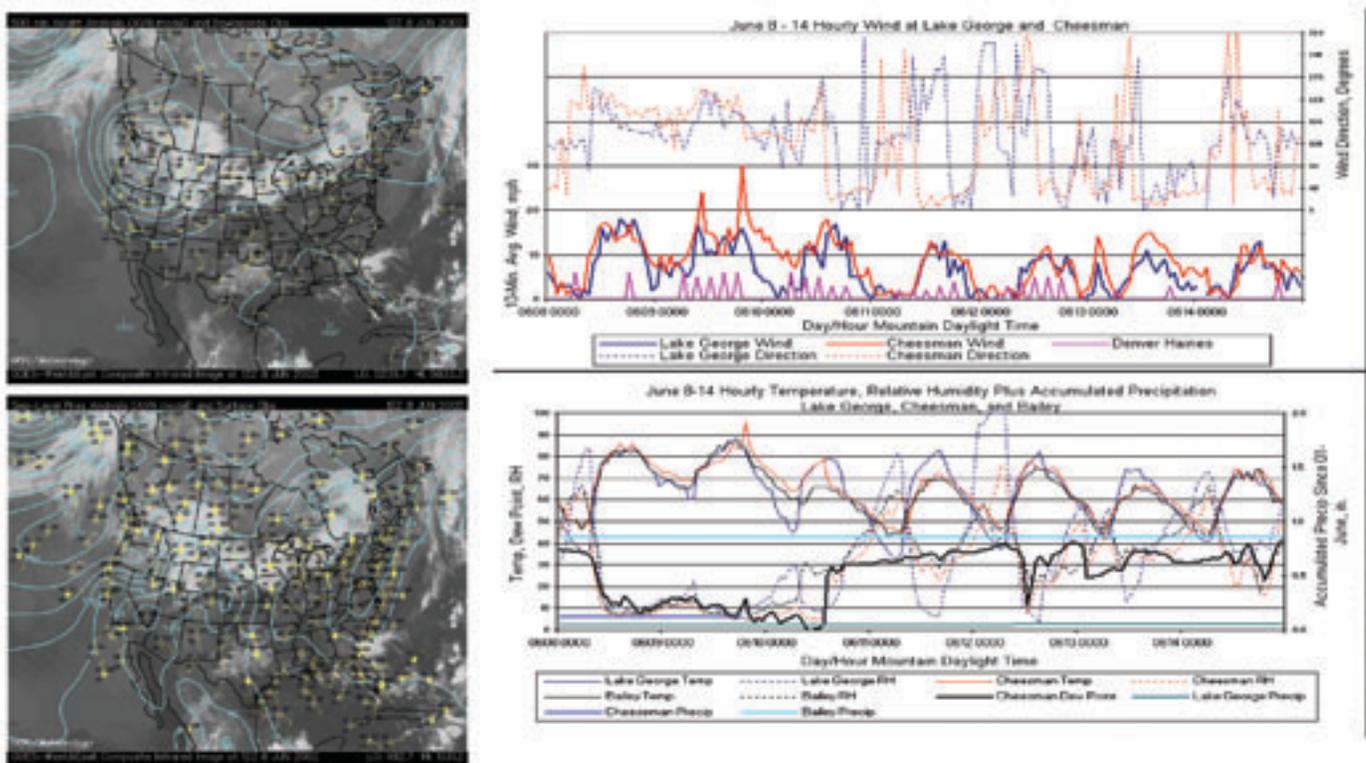


Figure 11—Upper air and surface chart for June 4 (12Z), and meteogram for week of June 1-7.

because the live fuels were essentially dormant, there was little beneficial effect on them either.

**June 7 to 14:** A cut-off low centered over southern British Columbia on June 7 dug south to southwestern Idaho by June 9 (fig. 12). It then moved northeasterly to southeastern Manitoba by June 12. Upper air (500 mb) winds over the Hayman Fire during that period were generally southwesterly exceeding 35 mph (30 kts). With the passage of the cut-off low, a weak ridge slowly filled in from the west by June 13 as the cut-off low filled and established a large trough over the Eastern United States.

**Friday, June 7**— A weak upper level ridge over the Central United States and a short wave trough entering the West Coast were the major weather features. This trough was amplifying and digging toward the southeast. A surface cold front extended from Minnesota through Nevada. South of the front conditions were dry with dew points in the 10 to 20 °F (-12 to -7 °C) range. In the fire area, afternoon winds turned southerly and relative humidity dropped into the single digits (table 2).



**Figure 12**—Upper air and surface chart for June 8 (12Z) and eteogram for week of June 8-14.

**Table 2**—Significant fire weather observation summary for Friday, June 7, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	88 (31)	5	36	10-12 (16-19)	S,SW	30 (48)	SW	
Lake George	85 (29)	7	66	7-10 (11-16)	W	32 (52)	NW	
Bailey	81 (27)	7	38	6-7 (10-11)	SW	23 (37)	W	
Manitou	83 (28)	10	70	9-10 (15-16)	SW			
Denver Haines Index		AM	6-High	PM	6-High			

**Saturday, June 8** — The upper level trough over northeastern Oregon amplified and closed off, and the upper level ridge over the east held its place causing increasing southwesterly winds over Colorado. The lower atmosphere was warm and dry; the morning and evening Haines Index at Denver was 6. The surface front intensified, running from a low over central Montana to western Wyoming, and northern Utah and central Nevada. Conditions ahead of the front were dry with dew points near 10 °F (-12 °C) and gusty westerly winds. Prefrontal winds in the fire area became southerly around 10 a.m. on Saturday as the front approached from the north. Winds remained above 15 mph (24 km/hr) all day with gusts exceeding 30 mph (48 km/hr) (table 3). Near midnight the winds subsided to below 10 mph (16 km/hr), but the relative humidity was only 14, 10, and 11 percent at Lake George, Cheesman, and Bailey, respectively.

**Sunday, June 9** — The closed upper level low moved over Idaho with a broad low pressure system over the Great Basin. Upper level flow over the Rockies was strong from the southwest. Strong anticyclonic shear associated with the onset of a band of stronger upstream winds (a jet streak) was evident over central

Colorado. Winds at 500mb were 109 mph (95 kts) at Salt Lake City, UT, 52 mph (45 kts) at Grand Junction, CO, and 23 mph (20 kts) at Denver. The forward, anticyclonic-shear sides of jet streaks are associated with subsidence that can transport extremely dry air aloft toward the surface. This subsidence condition started on the afternoon of June 8 and continued through midday on June 10. A strong surface cold front ran from a low in central South Dakota through northern Colorado, central Utah, and southern Nevada. Strong southwest surface winds were blowing from the Great Basin to Colorado. The lower atmosphere was warm and dry; temperatures at 500 mb over Colorado were a warm 21 °F (-6 °C). Steady southerly winds during the night of June 8 and morning of June 9 inhibited radiational cooling and kept the surface exposed to warm dry air in the lower levels of the atmosphere. Minimum overnight temperatures only reached 69 °F (21 °C) at Cheesman (the warmest overnight low temperature of the month) and 60 °F (16 °C) at Lake George. With dew points in the teens, overnight (Sunday morning) humidity only recovered to 22 percent at Lake George and 12 percent at the ridge-top Cheesman location (table 4). At midnight on

**Table 3**—Significant fire weather observation summary for Saturday, June 8, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	86 (30)	6	63	14-17 (23-27)	SW	30-37 (48-60)	SW	
Lake George	84 (29)	8	83	14-18 (23-29)	S,SW	32-36 (52-58)	S,SW	
Bailey	84 (29)	8	83	14-18 (23-39)	S,SW	32-36 (52-58)	S,SW	
Manitou	83 (28)	10	92	10-12 (16-19)	S,SW			
Denver Haines Index		AM	6-High	PM	6-High			

**Table 4**—Significant fire weather observation summary for Sunday, June 9, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	85* (29)	5*	12	15-20 (24-32)	S-SW	30-45* (48-72)	S-> SW, SE	N/A*
Lake George	87 (31)	7	22	10-15 (16-24)	S-SW	28-38 (45-61)	S-> SW, SE	
Bailey	88 (31)	5	15	8-11 (13-18)	SW	20-25 (32-40)	SW	
Manitou	86 (30)	8	33	10-15 (16-24)	S-SW			
Denver Haines Index		AM	6-High	PM	6-High			

\* The 18:53 observation at Cheesman had a temperature spike to 96 degrees F (36 °C) with a wind gust to 84 mph (135 km/hr) as the fire burned around the weather station. The temperature at 17:53 was 84 °F (29 °C) and at 19:53 was 85 °F (29 °C). Both these readings are fire induced. The fire damaged the solar radiation sensor and most likely the precipitation gauge (there was 0.01 in (0.3 mm) recorded on the gauge at the 18:53 observation; no more until the station was rehabilitated on June 27). There are two periods on June 17 and 18 where the relative humidity sensor is suspect but overall the Cheesman station appeared to be operating sufficiently to use wind, temperature and humidity.

June 9 the relative humidity at Cheesman was 6 percent and had been 12 percent or less for 38 straight hours, and from 9 a.m. until midnight wind gusts exceeded 30 mph (48 km/hr) for 11 of the 16 hours. Figure 13 displays hourly weather at Cheesman from the evening of June 7 prior to the ignition on June 8, through June 11.

On Sunday, Denver launched radiosondes for upper air soundings at 12 15 18, 21, and 00Z (6 a.m., 9 a.m., noon, 3 p.m., and 6 p.m.) The Haines Index was 6, 5, 5, 6, and 6 at those times. Windspeed profiles above the fire area were estimated from the soundings at Denver using a base fire area altitude of 8,500 feet (2,591 m). Figure 14 illustrates the estimated windspeed profiles above the fire area at four times. From 9 to 11 a.m. wind gusts were 41, 50, and 37 miles per hour (66, 81, and 60 km/hr), which are consistent with the low-level jet identified at the 12Z and 15Z soundings in fig 14.

**Monday, June 10** — The closed upper level low moved over Montana with strong flow over most of the Rockies with some veering of wind direction. Anticyclonic shear was still located over central Colorado. At

the surface the low had moved over northern South Dakota with a cold front from the low to northwestern Kansas and northeastern Colorado. The cold front was moving down the Front Range. Highs were in the 100s °F (38 °C) south of the front with 90s °F (32 °C) elsewhere. Conditions south of the front were dry, and gusty southwesterly winds were evident west of the Front Range.

The front in northeastern Colorado began affecting the northern locations near Bailey by 8 a.m. when winds shifted to the northeast, causing upslope conditions rising dew point and relative humidity. Winds shifted to the northeast at Manitou and Cheesman between 1 and 2 p.m., and humidity rose steadily all afternoon. At Lake George winds finally turned north by about 1700 hours, and relative humidity rose from the teens to the 30s (table 5). The evening Haines Index dropped to a 3 as a result of the moistened lower atmosphere (the 700 mb dew point depression dropped from 75 to 46 °F [24 to 8 °C] during the day). There was some light precipitation in the fire zone but no measurable rain was recorded at the fire weather stations.

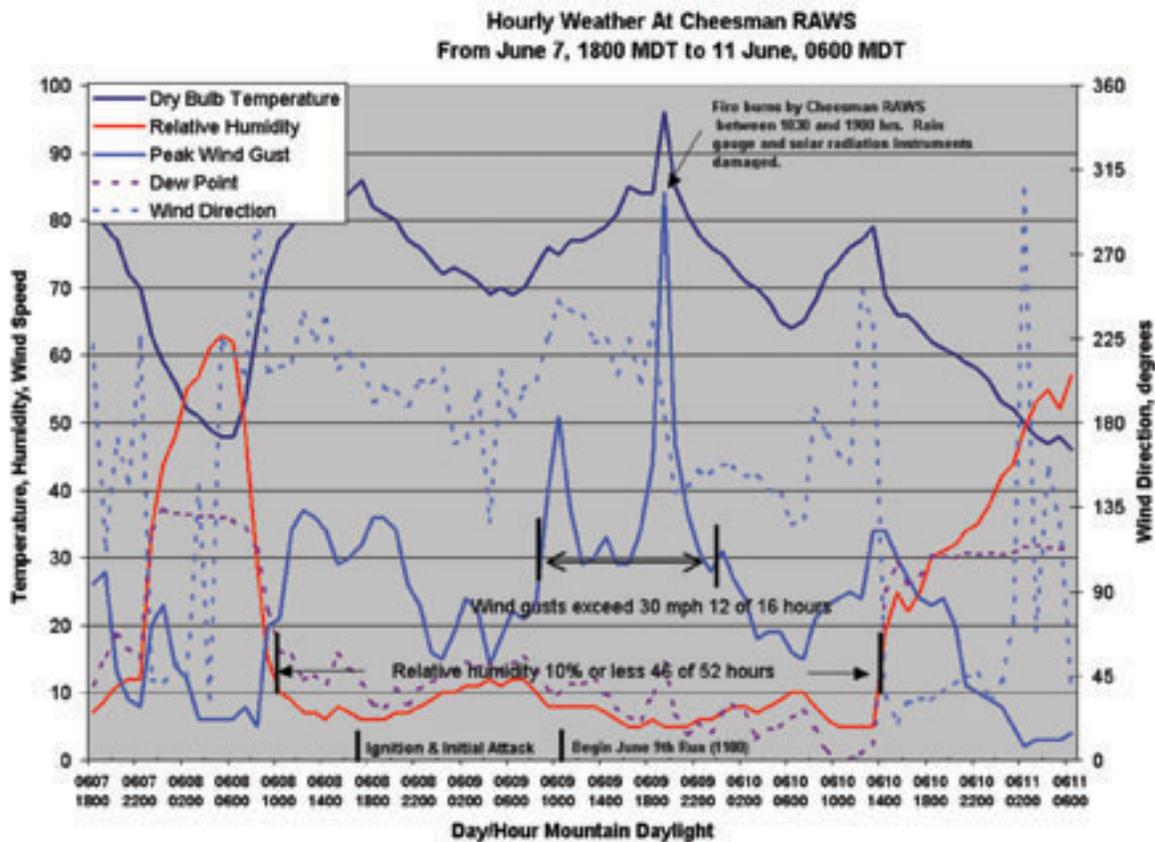
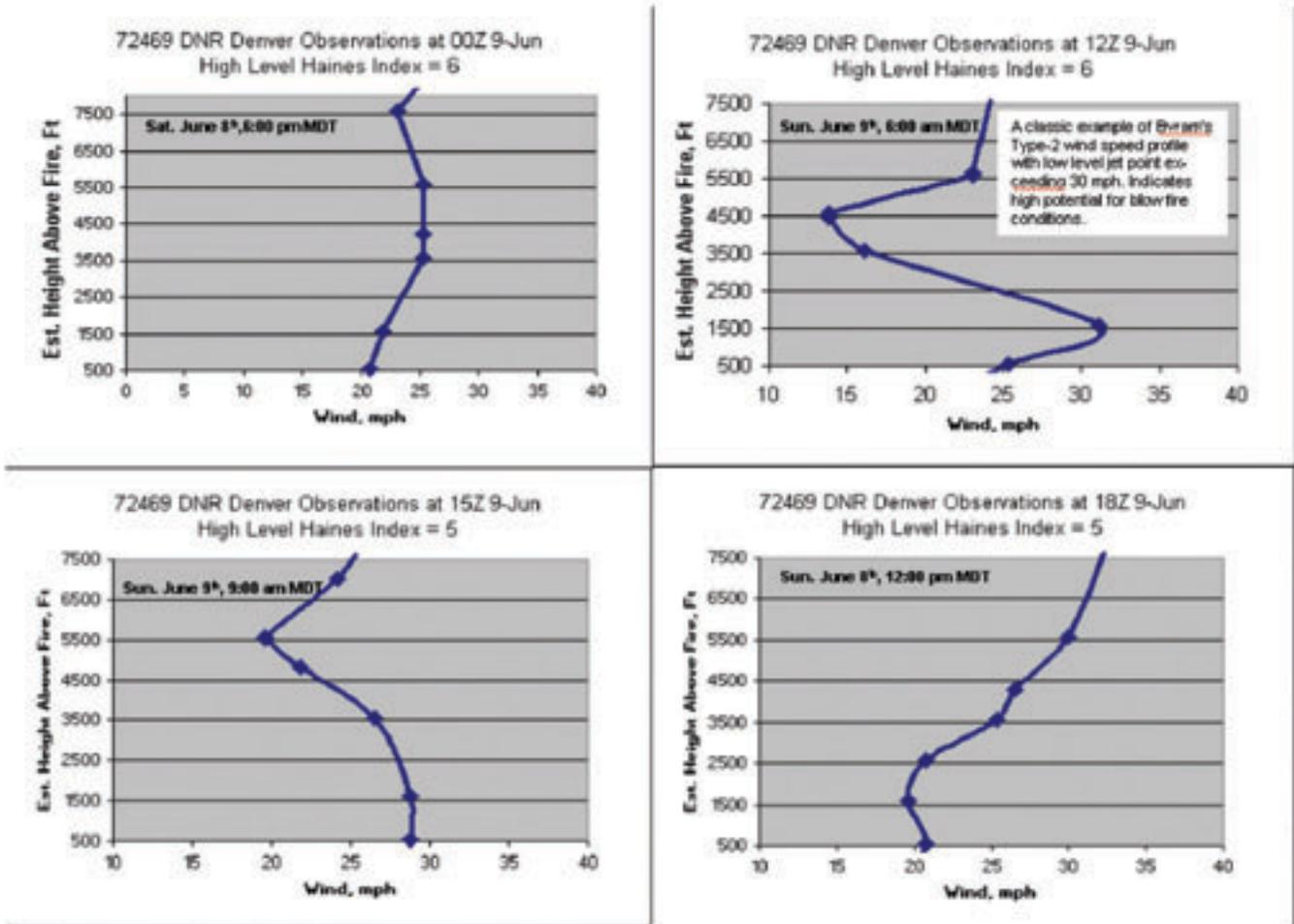


Figure 13—Hourly weather at Cheesman during initial attack and fire run on June 9.

**Estimated Vertical Wind Speed Profiles Above Hayman Fire Area Based On Denver Soundings For June 9th**



**Figure 14**—Estimated wind speed profiles at elevations above the fire area based on four soundings from Denver. 12Z 9 Jun and 15Z 9 Jun soundings illustrate low-level jets that are conducive to large column development.

**Table 5**—Significant fire weather observation summary for Monday, June 10, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	79 (26)	5	38	10-14 (16-23)	SE->NE	20-24 (32-39)	NE,W	
Lake George	79 (26)	8	43	7-17 (11-27)	SW,W,N	24-32 (39-52)	S->N	
Bailey	71* (22)	11*	46	5-8 (8-13)	SW->NE	25,10-15 (40, 16-24)	W-> SE	
Manitou	76 (24)	11	72	6-11 (10-18)	S->N			
Denver Haines Index		AM	5-Mod	PM	3-Low			

\* Bailey's minimum Max Temp/Min RH occurred at 0100 on the 10<sup>th</sup>. By 10 am winds had switched from NW to NE and humidity was up to 29 percent and continued to rise throughout the day.

**Tuesday, June 11** — The upper level low continued to move eastward over northeast Montana and cooler air moved in aloft over Colorado. The surface low moved into Minnesota with a front extending from the low to Kansas to southeastern Colorado and north-central Colorado. Cooler conditions were experienced. A few rain showers occurred north of the front. The frontal convergence zone was over the fire. Winds aloft were southwest. Surface winds were light and southeasterly in the morning and humidity was high. The cooler air mass kept temperatures lower and humidity higher all day. Lake George may have been near the frontal boundary as a brief wind shift mid-morning from the southeast to southwest allowed the temperature to reach 83 °F (28 °C) (relative humidity was 6 percent) for a few hours (table 6). Manitou recorded a light shower at midnight; no other stations recorded rainfall.

**Wednesday, June 12** — The upper level low moved into southeastern Saskatchewan as it moved over the long wave ridge. Winds over the Rockies aloft began to weaken. Temperatures over Colorado at 500 mb were 18 °F (-8 °C). Other upper level features were a ridge in western Texas that had retrograded from the Southeastern United States and a ridge off the West Coast. A surface high was moving southward over Montana. A surface low formed in New Mexico. This generated upslope flow over all of Colorado. Morning dew points at the fire weather stations rose to the 40s °F (4 °C), and there was good overnight humidity recovery at all

locations. The upslope flow generated scattered showers in northeastern Colorado; in the fire zone Lake George and Manitou saw showers in the early morning. By 11 a.m. at Lake George and noon at Cheesman, there was a brief period of southwest wind that dropped relative humidity to single digits (table 7). This lasted 1 hour at Cheesman and 4 hours at Lake George where the relative humidity was 4 percent at 3 p.m. By 4 p.m. the wind turned northeast again, and the dew point rose to 37 °F (3 °C).

**Thursday, June 13** — The upper level low moved east-southeast into Minnesota and deepened, and an upper level ridge moved over West Coast. A closed high at 500 mb was located over northern Mexico. Flow over the Rockies was west-northwest around the closed high and air at 500 mb cooled. At the surface, a clockwise circulation around a surface high pressure moving southeast out of eastern Montana created upslope (north, northeast) flow over Colorado. All locations were 10 °F (5 °C) cooler with good overnight humidity recovery at all locations. Some showers formed in southeastern Colorado (table 8).

**Friday, June 14** — The upper level low moved into southern Wisconsin and deepened. The upper level ridge on the West Coast moved onto an Idaho-Four Corners-northwestern New Mexico axis. The upper level flow was now northwesterly over Colorado. Temperatures aloft remained at 14 °F (-10 °C). The surface front pushed well south from central Alabama to Louisiana, southern Texas, and northern Mexico. A

**Table 6**—Significant fire weather observation summary for Tuesday, June 11, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	72 (22)	23	61	9-11 (15-18)	N,NE	20-25 (32-40)	N,NE	
Lake George	83 (28)	6	81	8-13 (13-21)	SE,W,N	21-32 (34-52)	N,NW	
Bailey	70 (21)	29	64	4-6 (6-10)	NW-> NE	14-17 (23-27)	E-SE	
Manitou	72 (22)	28	91	5-7 (8-11)	N,SE			.03 (.8)
Denver Haines Index		AM	2-V. L.	PM	4-Low			

**Table 7**—Significant fire weather observation summary for Wednesday, June 12, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	78 (26)	8	76	8-12 (13-19)	NE	15-25 (24-40)	SW-> NE	
Lake George	82 (28)	4	76	6-10 (10-16)	NW,N	15-31 (24-50)	NW.N	.01 (2.5)
Bailey	75 (24)	22	58	7-9 (11-15)	NE	17-21 (27-34)	E	
Manitou	75 (24)	10	99	7-10 (11-16)	SW->SE			.04 (1.0)
Denver Haines Index		AM	3-Low	PM	5-Mod			

**Table 8**—Significant fire weather observation summary for Thursday, June 13, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	67 (19)	28	49	12-15 (19-24)	N,NE	24-28 (39-45)	N,NE	
Lake George	74 (23)	13	59	7-11 (11-18)	N,NE	18-23 (29-37)	N	
Bailey	65 (18)	30	49	5-8 (8-13)	NE	13-17 (21-27)	E,NE	
Manitou	67 (19)	34	96	6-8 (10-13)	NE			
Denver Haines Index		AM	2-V. L.	PM	3-V. L.			

surface high over northeastern Colorado and Nebraska was still producing upslope flow with light winds. A few showers occurred in southeastern and central Colorado. Cumulus formed on the southern half of the Front Range, thunderstorms were evident over the fire zone by 2 p.m. Radar estimates of precipitation in the fire area were 0.10 inch (2.5 mm), but no rain was recorded at the fire weather stations (table 9). The lower atmosphere was moist and Haines Indexes were low.

**June 15 to June 21:** The period started off with a deep trough over the eastern Great Lakes, a cut-off low off the Washington-Oregon coast, and a weak ridge over the Great Basin (fig. 15). The western low moved eastward enhancing an upper level ridge over the Central Rockies with northwest flow on June 16. By June 18 the ridge had moved east with an axis from Minnesota to New Mexico. The trough moved quickly across northern Idaho, Montana, and North Dakota again creating southwest flow over the Central Rockies on June 19. By June 20 another weak trough formed along the West Coast, but this time it was much farther south and was able to entrain some subtropical moisture as it deepened over southern California and Baja.

**Saturday, June 15** — An upper level ridge was the main feature over the Rockies extending from southeastern British Columbia to Idaho and northern Baja.

Winds aloft weakened to northwest at 23 mph (20 kts). Temperatures warmed to 16 °F (-9 °C) at 500 mb. The upper level low was now over Lake Huron. Another upper level low was over the Pacific 500 miles (805 km) west of Portland, Oregon. A weak surface low formed over Utah, and the Plains high pressure had moved over Oklahoma and weakened. This kept an easterly, upslope component to the wind most of the day. A few showers occurred in southeastern Colorado, and a thunderstorm formed west of the fire causing some local gusts around noon. Under the ridge, western Colorado was dry with dew points in the 5 to 20 °F (-15 to -7 °C) range. Significant local weather events for June 15 are listed in table 10.

**Sunday, June 16** — An upper level trough from Great Lakes to Louisiana and a ridge from British Columbia to Idaho-Utah-Baja kept flow over the Rockies from the northwest and increased winds to 46 mph (40 kts). Temperatures over central Colorado cooled at 500 mb to 14 °F (-10 °C). A thermal low over Utah with a surface high over northwestern Kansas kept moist flow over Colorado. Rain was common in the southeast gradient flow all over Colorado. Dew points were in the 40s and 50's °F (4 to 10 °C) over the entire State during the morning hours, promoting good overnight humidity recovery. Cumulus formed on the mountains with thunderstorms over the fire area by 5 p.m. Radar estimated rain amounts were 0.1 inch (2.5 mm) scattered near the fire. However, no rain

**Table 9**—Significant fire weather observation summary for Friday, June 14, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	74 (23)	16	61	8-12 (13-19)	N,NE	20-29 (32-47)	NE,S	
Lake George	73 (23)	35	73	6-13 (10-21)	SE	20-28 (32-45)	SE,S	
Bailey	73 (23)	17	67	5-8 (8-13)	NE	15-18 (24-29)	NE	
Manitou	71 (22)	30	95	8-10 (13-16)	SE			
Denver Haines Index		AM	2-V.L.	PM	4-Low			

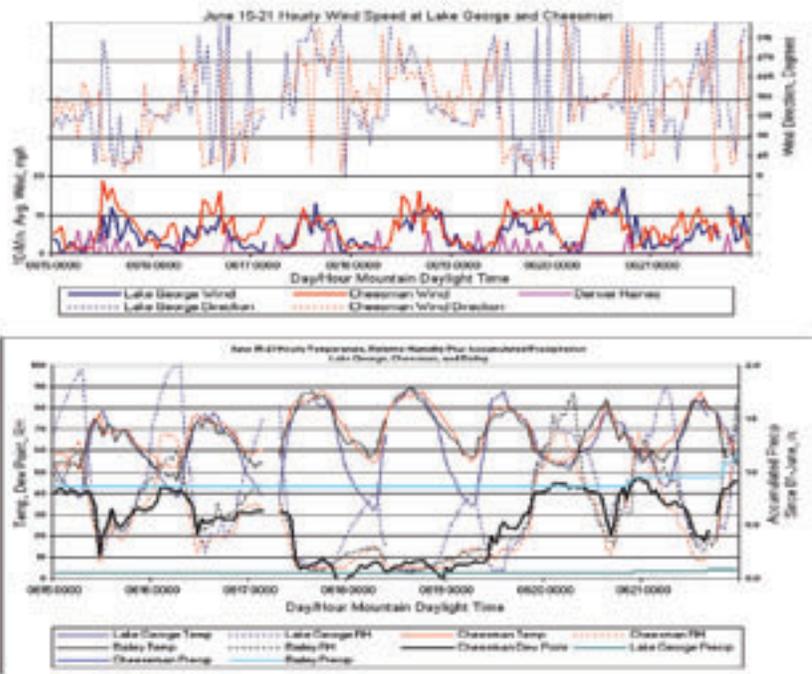
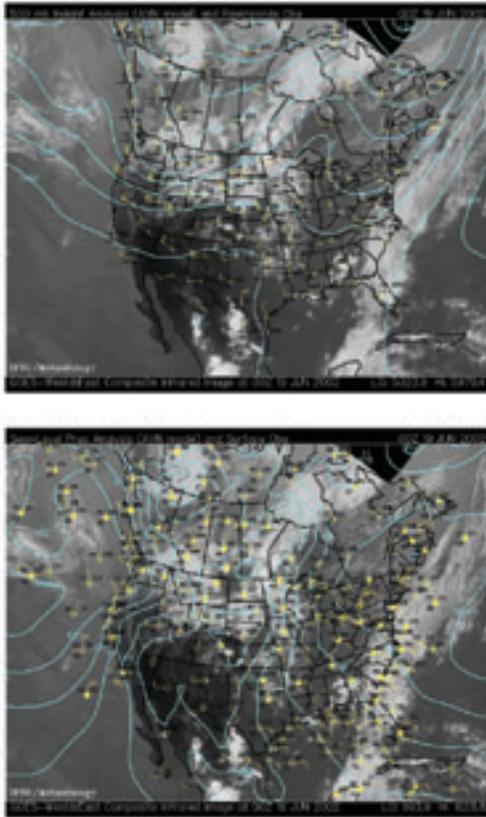


Figure 15—Upper air and surface chart for June 19 (00Z) and meteogram for week of June 15-21.

Table 10—Significant fire weather observation summary for Saturday, June 15, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	77* (25)	8*	64	11-19 (18-31)	NE	20-30 (32-48)	N,NE	
Lake George	79 (26)	11	98	9-12 (15-19)	NW,NE	26-31 (42-50)	NW, NE	
Bailey	75 (24)	20	59	3-5 (5-8)	NE	15-19 (24-31)	N	
Manitou	75 (24)	16	98	8-12 (13-19)	N			
Denver Haines Index		AM	6- High	PM	4-Low			

\* At 10:53 Cheesman recorded one hour of 77 degrees F (25 °C) and 8 percent humidity following 3 hours of light southeast winds. By 11:53 the wind had become northeast, temperature dropped to 67 °F (19 °C) and humidity rose to 17 percent and generally increased all day under a northeast wind.

was recorded at the four fire locations. Surface winds were light with easterly components (table 11).

**Monday, June 17** — The upper level ridge shifted eastward over the Northern Rockies with the axis from eastern Montana-Wyoming-Utah-Baja. Winds aloft shifted to more westerly at 23 to 35 mph (20 to 30 kts). An eastward moving upper level low over British Columbia supported a surface low in southern Saskatchewan. A surface trough in the lee of the Rockies produced southeast flow on the plains and

southwesterly flow over western Colorado. A few showers and thunderstorms formed in extreme eastern Colorado. In the fire area, morning winds were southwest at the surface and west-southwest aloft. Cumulus formed over the fire in the mid-afternoon, but no rain resulted. Temperatures rose to the mid 80s °F (upper 20's °C) and dew points dropped from morning values in the 30s °F (0 °C) to single digits by early afternoon as subsidence conditions from the ridge began influencing the area (table 12). Relative humid-

**Table 11**—Significant fire weather observation summary for Sunday, June 16, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	77 (25)	12	68	10-16 (16-26)	NE	21-28 (34-45)	NE	
Lake George	78 (26)	12	100	7-10 (11-16)	NW,NE	18-21 (29-34)	NW	
Bailey	75 (24)	23	60	6-8 (10-13)	NE	13-21 (21-34)	NE	
Manitou	73 (23)	23	98	8-10 (13-16)	NNE			
Denver Haines Index		AM	4-Low	PM	5-Mod			

**Table 12**—Significant fire weather observation summary for Monday, June 17, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	88 (31)	5*	35	8-10 (13-16)	SW-> NW	27-29 (44-47)	SW, NW	
Lake George	85 (29)	5*	81	10-13 (16-21)	W->NW	26-57 (42-92)	W, NW	
Bailey	88 (31)	*4	44	4-6 (6-10)	W->NW	21-24 (34-39)	SW	
Manitou	81 (27)	9	91	6-8 (10-13)	S,SW,SE			
Denver Haines Index		AM	5-Mod	PM	6-High			

At 10:53 Cheesman relative humidity dropped from 14 to 6 percent, then 5 percent at 11:53 where it remained until midnight. Lake George was below 10 percent from 10:53 to 21:53 (11 hours), Baily from 10:53 to 22:53. Manitou was below 10 percent for 3 hours.

ity dropped to single digits by noon as surface winds became west to northwest. The evening Haines Index at Denver of 6 reflected the drying and warming of the lower atmosphere.

**Tuesday, June 18** — The upper level low was now over northwestern Washington. The ridge continued to move eastward, rapidly passing over Colorado early with an axis from Minnesota-Nebraska-New Mexico. This short wave ridge brought increased anticyclonic flow with warmer and drier air over the Central Rockies. The relative humidity at 700mb (approximately 10,000 feet [3,048 m]) was 11 percent at Grand Junction and 14 percent at Denver. The anticyclonic flow generated subsidence conditions. By evening the

Denver relative humidity had dropped to 11 percent at 700 mb and 7 percent at the surface. The surface trough in the lee of the Rockies deepened and formed a surface low over Nebraska. A dryline formed from the surface low in Nebraska to New Mexico, and a cold front extended from southern Manitoba to northern Montana. The location of the Nebraska low northeast of Colorado continued producing westerly flow over central and eastern Colorado. The winds were not excessively strong. Winds aloft were west-southwest at 17 mph (27 km/hr), but the air was warm and dry. There was poor overnight humidity recovery at all locations, and both the morning and evening Haines Index values at Denver were 6 (high) (table 13).

**Table 13**—Significant fire weather observation summary for Tuesday, June 18, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	88 (31)	5*	15	14-16 (23-26)	SW	27-32 (44-52)		
Lake George	89 (32)	4*	40	10-12 (16-19)	SW,SE	28-37 (45-52)	SW, SE	
Bailey	90 (32)	3*	14	5-7 (8-11)	S,SW	19-43 (31-69)	SE,S, SW,N	
Manitou	80 (27)	7	52	3-6 (5-10)	S			
Denver Haines Index		AM	6-High	PM	6-High			

After poor overnight recovery humidities again fell to single digits by mid-morning and remained below 10 percent until the early hours of the morning of the 19<sup>th</sup>.

**Wednesday, June 19** – The upper level trough moved to an axis from north-central Montana-northwest Wyoming-Utah. Winds were southwesterly over the Rockies with speeds to 23 mph (20 kts) over Colorado. The 500 mb temperatures warmed to 19 °F (-7 °C). The upper level ridge axis extended from Mexico-Oklahoma-Michigan. A surface cold front developed from a surface low in southern South Dakota and pushed into western Nebraska-northern Colorado-southern Nevada. A strong dryline ran from the surface low southward into extreme western Texas. This kept the fire area in the dry, prefrontal air until the front affected the fire area during the day. Winds in the fire area strengthened and became gusty with the passage of the front, but humidities rose as dew points returned to values in the 20s and 30s °F (-7 to 0 °C) from north to south over the course of the day (table 14). By evening, thunderstorms formed over the fire zone with several locations receiving moisture around midnight.

**Thursday, June 20** — A strong upper level trough moved to Minnesota leaving a weaker residual trough along the West Coast. Temperatures aloft remained at

19 °F (-7 °C) at 500 mb. The short wave pushed a surface front through Colorado with a frontal position extending from a low in Manitoba to Minnesota-Iowa-northern Kansas-northern New Mexico. This combined with a surface high in eastern Montana to establish a southeast gradient with weak upslope flow over Colorado. Rain was common in the northeastern, northwestern, and southeastern parts of Colorado. Overnight humidity recovery was good at all locations (table 15). Thunderstorms formed to the west and moved over the fire late in the afternoon. Winds aloft were west-southwest. Surface winds were generally south-southwest during the afternoon.

**Friday, June 21** — The weak trough along the West Coast amplified in place bringing southerly flow over most of the Rockies. The monsoon flow that had been bottled up in Mexico for the previous several weeks surged northward. An upper level high developed over the plains with a center over Illinois. The desert thermal low increased in size and was centered over Nevada. Another weak low was centered over northern Colorado. A warm front extended eastward from this low to southeastern South Dakota-Iowa-Illinois.

**Table 14**—Significant fire weather observation summary for Wednesday, June 19, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	81 (27)	7*	50*	10-12 (16-19)	S->NE	23-33 (38-53)	NE	
Lake George	88 (31)	4	59	7-11 (11-18)	NE,E	21-24 (34-39)	NW, NE,E	
Bailey	79 (26)	9*	54	6-8 (10-13)	NE	14-18 (23-29)	NE	
Manitou	79 (26)	12	97	8-10 (13-16)	NNE			.30 (7.6)
FRWS-12**	81 (27)	11	91	6-8 (10-13)	SE,E	16-21 (26-34)	SE	.15 (3.8)
Denver Haines Index		AM	6-High	PM	4-Low			

\* Minimum humidity values at Cheesman and Bailey were recorded at 00:53 and generally increased thru the day. The more southern stations (Manitou, Lake George) did not see the effect of the front until mid or late afternoon.

\*\* FRWS-12 started transmitting at 1600 on June 18<sup>th</sup>.

**Table 15**—Significant fire weather observation summary for Thursday, June 20, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	82 (28)	11	69	12-14 (19-23)	S,SW	24-34 (39-55)	SE-> NW	
Lake George	78 (26)	29	70	10-17 (16-27)	S	20-30 (32-48)	S,SW,NE	.01 (.25)
Bailey	84 (29)	15	87	5-7 (8-11)	VRB*	18-25 (29-40)	NE, SW	.09 (2.3)
Manitou	77 (25)	31	99	10-14 (16-23)	S			
FRWS-12	75 (24)	36	93	5-12 (8-19)	SW	18-21 (29-34)	SW-> SE	
FRWS-13**	62 (17)	32	81	7-8 (11-13)	SW	20-24 (32-39)	SW	.17 (4.3)
Denver Haines Index		AM	3-V.L.	PM	5-Mod			

\* Wind direction at Bailey was variable all day.

\*\* FRWS-13 began transmitting at 1500 June 20<sup>th</sup>.

In the fire area it was clear early, but a moisture swath became evident by afternoon. Winds aloft were southwest with upslope surface winds from the southeast. Thunderstorms formed over the mountains and moved over the fire by 3 p.m. Rainfall was recorded at all fire weather stations (table 16).

**June 22 to June 30:** The trough passed through the area, and by June 26 a broad ridge was centered over the Central Rockies with light flow throughout the

Western United States (fig. 16). This set up a period of rather benign weather with light winds, better overnight humidity recovery, and low to moderate Haines Indexes. By June 30, the ridge had moved east over the Great Lakes, and westerly flow aloft again dominated the northern tier of the Western United States.

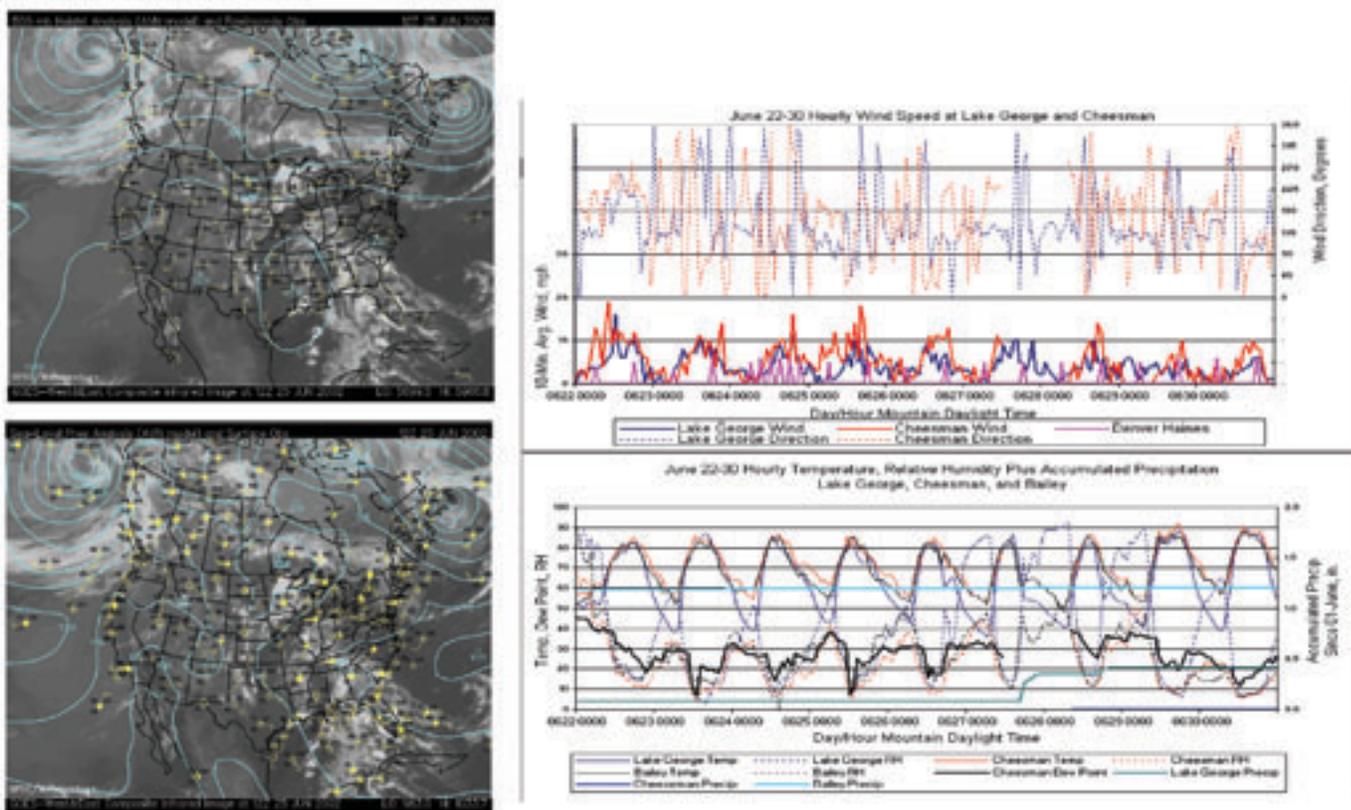
**Saturday, June 22** — A weak upper level trough from Nevada to Utah brought southerly flow to most of the Rockies including Colorado. Temperatures cooled

**Table 16**—Significant fire weather observation summary for Friday, June 21, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	88 (31)	8	64	5-12 (8-19)	SW->NE	18-20 (29-32)	SW	
Lake George	84 (29)	15	76	6-12 (10-19)	S	28-41 (45-66)	VRB*	.02 (.50)
Bailey	84 (29)	15	76	6-12 (10-19)	S	28-41 (45-66)	VRB	.23 (5.8)
Manitou	82 (28)	14	94	5-9 (8-15)	SE			.05 (1.3)
FRWS-12	85 (29)	11	66	3-7 (5-11)	S,SW	10-16 (16-26)	SW	.07 (1.8)
FRWS-13	66 (19)	20	90	6-9 (10-15)	SW	15-17 (24-27)	S,SW	.16 (4.1)
FRWS-6**								.05 (1.3)
Denver Haines Index		AM	5-Mod	PM	5-Mod			

\* Wind gusts were from thunderstorms and directions were variable.

\*\*FRWS-6 began transmitting at 1900 on June 21<sup>st</sup>.



**Figure 16**—Upper air and surface chart for June 25 (12Z) and meteogram for week of June 22-30.

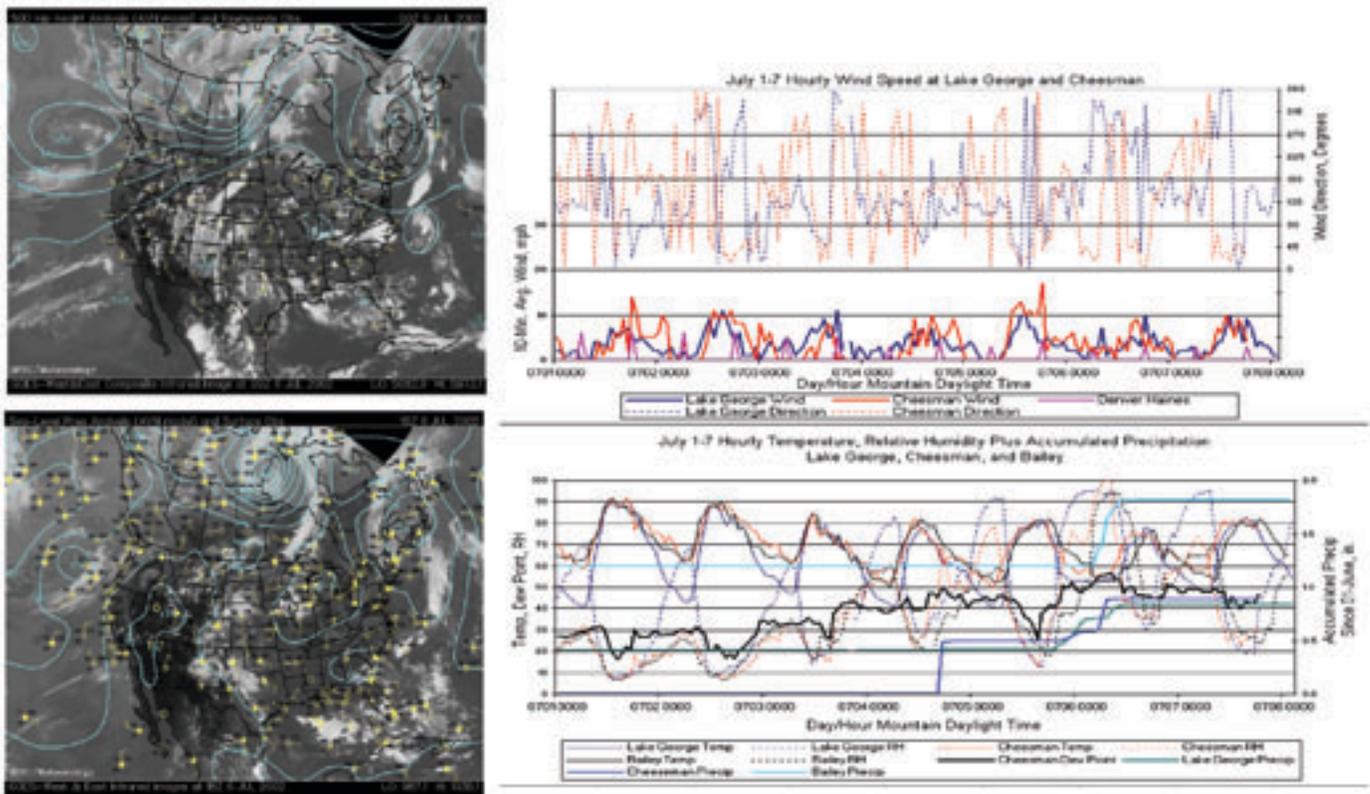
a bit to 16 °F (-9 °C) over Colorado. The upper level ridge was far to the east in Iowa. A surface low was located in western South Dakota with a trough extending southward to northeastern New Mexico. Another surface low was in northern Utah. Gradient flow over Colorado was southerly at all levels with widespread showers. A monsoonal cloud band was over the State in the morning with cumulus forming over the fire area near noon. Winds at the surface were southwest, but this was a moist flow with relative humidity generally reaching the teens (table 17). Scattered

showers were evident, but none of the fire weather stations recorded precipitation. The low and moderate Haines Indexes reflect the increased moisture in the lower atmosphere.

**July 1 to July 7:** The beginning of the period saw a broad band of westerly winds over Washington and the Northern Rockies with weak high pressure trying to establish over the Four Corners region (fig. 17). At the end of the period a second monsoonal flow was established. Cheesman recorded 0.50 inch (12.7 mm) of rain on July 4, and widespread precipitation covered the fire area on July 5 and 6.

**Table 17**—Significant fire weather observation summary for Saturday, June 22, 2002.

Station	Temp max °F (°C)	RH min %	RH max %	Wind avg. mph (km/hr)	Wind direct.	Wind gusts mph (km/hr)	Gust direct.	Rain in. (mm)
Cheesman	95 (35)	11	68	10-13 (16-21)	SW	25-32 (40-52)	SW	
Lake George	83 (28)	16	89	6-10 (10-16)	SW	20-29 (32-47)	SW	
Bailey	83 (28)	14	90	7-8 (11-13)	SW	16-21 (26-34)	SW	
Manitou	80 (27)	18	92	8-10 (13-16)	SW		SW	
FRWS-12	83 (28)	15	90	8-9 (13-15)	SW	18-23 (29-37)	SW	
FRWS-13	63 (17)	26	92	10-15 (16-24)	SW	30-38 (48-61)	SW	
FRWS-6	81 (27)	20	83	6-8 (10-13)	SW	17-21 (27-34)	SW	
Denver Haines Index		AM	4-Low	PM		5-Mod		



**Figure 17**—Upper air and surface chart for July 6 and meteogram for week of July 1-7.