

Appendixes

Appendix 1 — Weather

Prior Conditions

Persistent high pressure resulted in low snowpacks and deficient precipitation throughout the western United States during the winter and spring of 1994. As a result, western Colorado was in extreme drought as shown on the July 9 Palmer Drought Index map (Chart W-1).

Listed below is the precipitation in inches compared to normal at Glenwood Springs between October 1993 and June 1994.

Inches	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Actual	2.00	.67	.39	.25	1.23	.38	1.55	.39	.77
Normal	1.57	1.21	1.46	1.60	1.45	1.47	1.73	1.49	1.22
Dep.*	.43	-.54	-1.07	-1.35	-.22	-1.09	-.18	-1.10	-.45

*departure from normal

Glenwood Springs has had below normal precipitation for 8 months in a row. Since October 1993, only 58 percent of normal precipitation has fallen.

In addition to having below normal rainfall, May and June were much warmer than normal. Grand Junction recorded its second hottest June on record, averaging 5.4 degrees above normal.

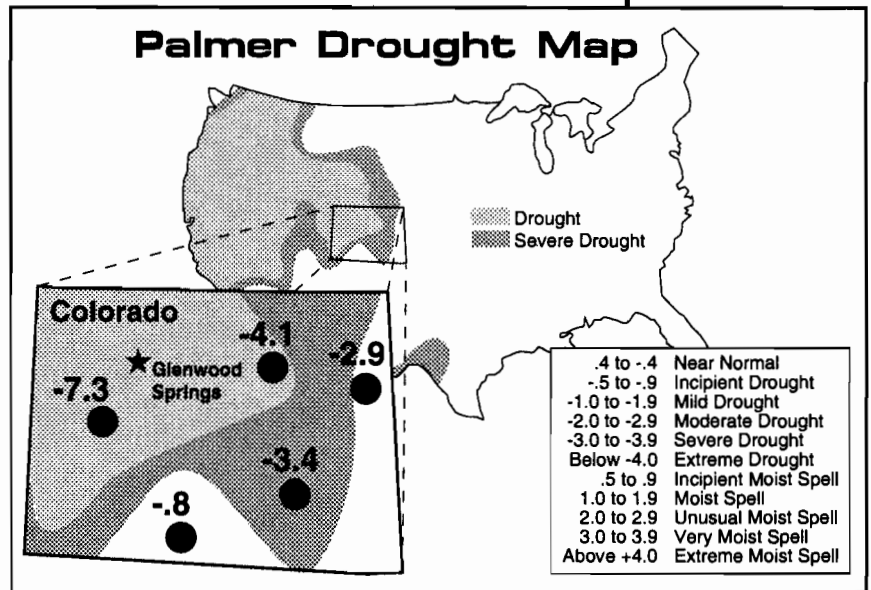


Chart W-1: Palmer Drought Map, July 6, 1994

Hot, dry weather continued into July. The South Canyon fire ignited on July 2 when dry lightning storms moved through western Colorado.

Tuesday July 5, 1994

On July 5 weak high pressure aloft and a hot, dry airmass covered western Colorado. The upper winds, measured over Grand Junction, were light southwesterly through 14,000 feet, and then increased to 30 miles per hour (mph) at 16,000 ft. Strong surface heating destabilized the lower levels of the atmosphere during the afternoon, but the air remained too dry

South Canyon Fire

for thunderstorms to develop. The BLM Automatic Lightning Detection System (ALDS) detected no lightning strikes on the West Slope.

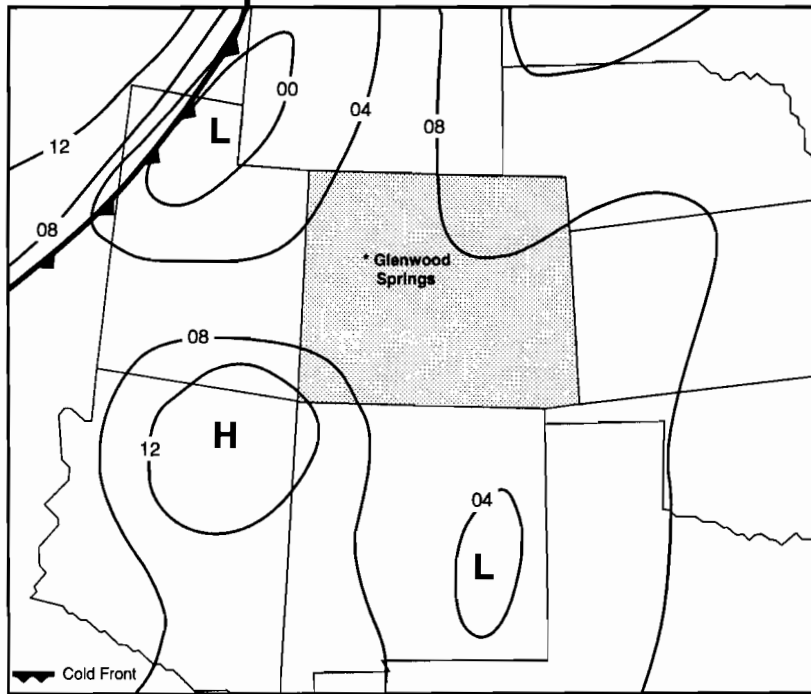


Chart W-2: 1800 MDT Surface Weather Map July 5, 1994

During the morning, a strong cold front developed in western Idaho. This front was associated with an unseasonably cold upper level low pressure system, centered over northern Oregon. At 1800 hours, the cold front had moved into eastern Idaho and extended southwestward into central Nevada (Chart W-2). The upper level low was now centered near Boise, Idaho (Chart W-3). Hot, dry and windy weather covered southern Wyoming and all of Utah ahead of the front. Much cooler temperatures and scattered showers spread across Idaho behind the cold front. A band of strong winds, 30 to 40 mph at 10,000 feet blew over western Utah and Nevada.

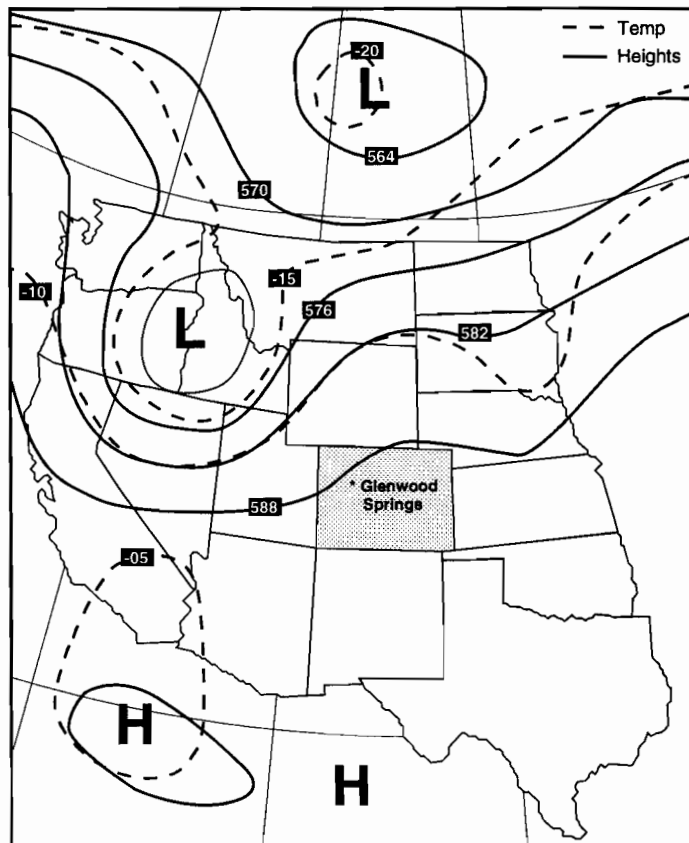


Chart W-3: 500MB Analysis Heights/Temp 1800 MDT Tuesday, July 5, 1994

No weather observations were recorded at the fire, but the nearby Rifle RAWS (Remote Automatic Weather Station) at about the same elevation recorded a high temperature of 91 degrees and a minimum relative humidity of 10 percent (Table W-1). Winds blew light and variably most of the day but became southerly 10 to 15 mph with gusts up to 20 mph during the evening. These evening winds signaled the approaching cold front.

In anticipation of strong cold front winds Wednesday afternoon, July 6, a red flag warning was issued for northwest Colorado at 1920 hours (Exhibits W-1 and W-2).

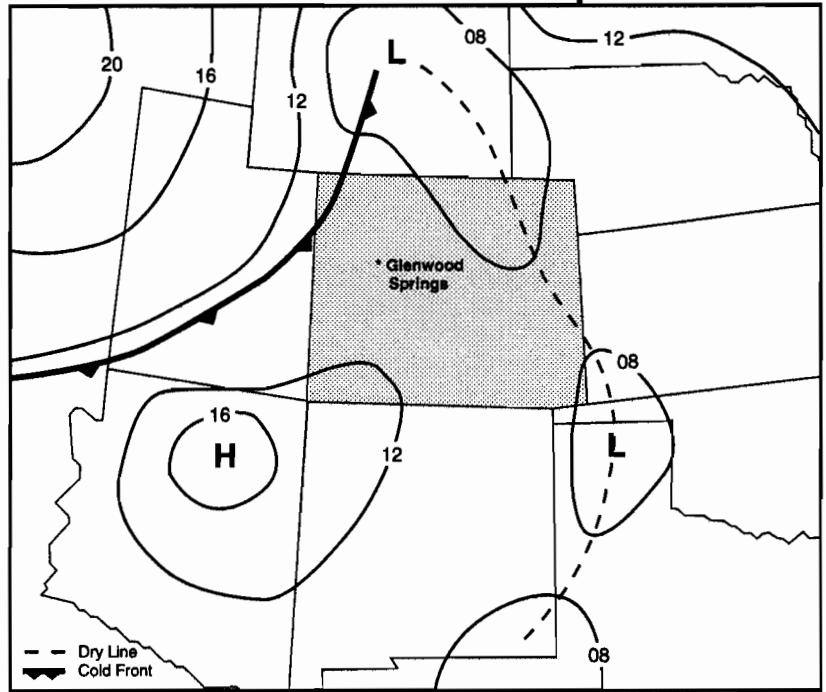


Chart W-4: 0600 MDT Surface Weather Map July 6, 1994

Wednesday July 6, 1994

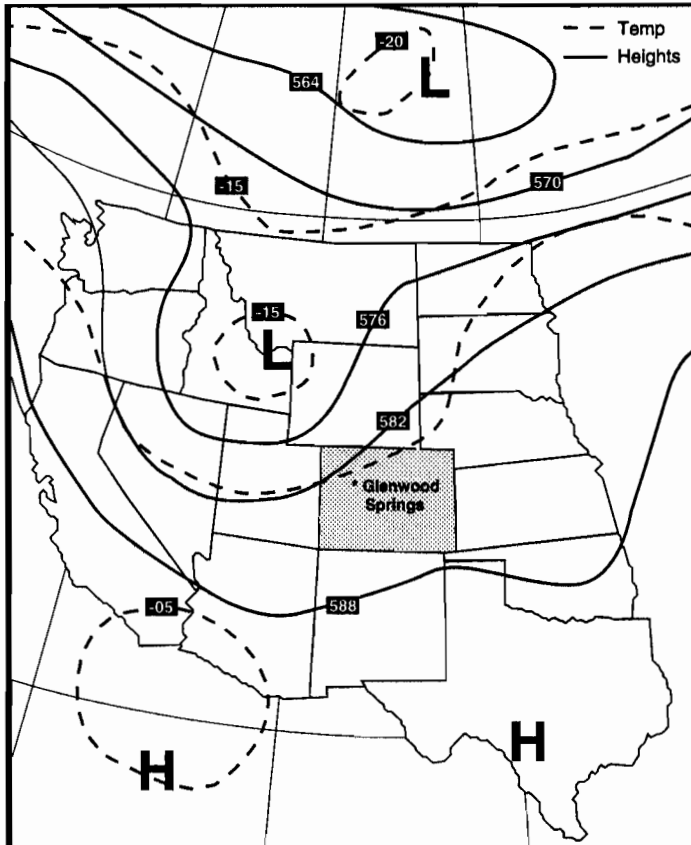


Chart W-5: 500MB Analysis Heights/Temp 0600 MDT Wednesday, July 6, 1994

At daybreak on Wednesday, the cold front extended across central Wyoming, northwest Colorado (near Dinosaur National Monument), and southwest Utah (Chart W-4). The associated upper level low pressure system was centered a little west of Yellowstone National Park with a trough extending southward into northern Utah (Chart W-5).

South Canyon Fire

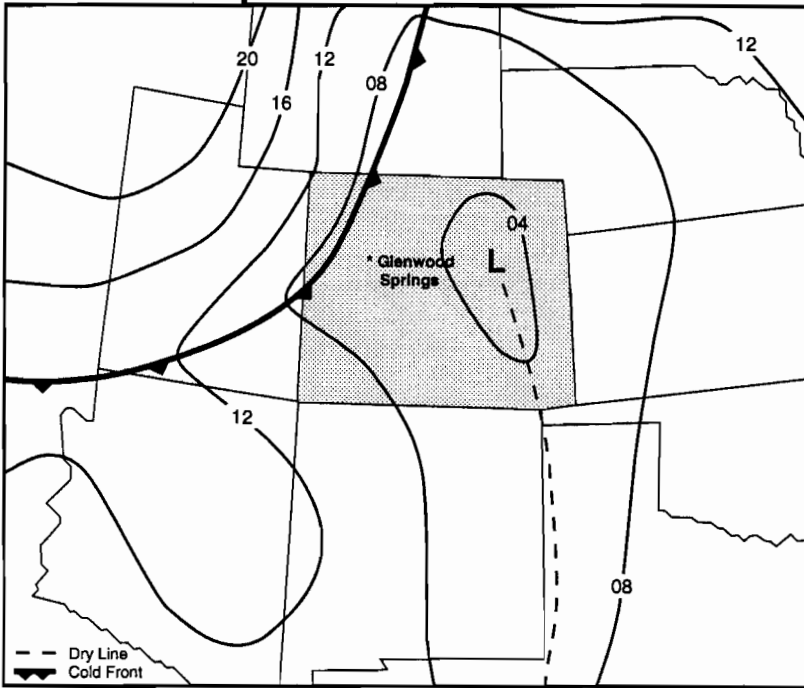


Chart W-6: 1200 MDT Surface Weather Map
July 6, 1994

The cold front continued to move south and east during the morning, reaching Grand Junction at 1300 hours (Chart W-6). As the cold front passed, winds over Grand Junction grew strong and gusty, increasing from 10-15 mph to 25-35 mph (Table W-2). The cold front advanced up Grand Valley passing Rifle RAWS at about 1400 hours. Winds increased to 25-30 mph with gusts exceeding 40 mph (Table W-1). No weather observations were taken on the South Canyon fire, but interviews revealed that the cold front crossed the fire site around 1520 hours. Wind intensity significantly increased and became very strong by 1600 hours. Estimated winds on the fire, according to the Rifle RAWS (modified for terrain),

varied from 20-35 mph in the canyon on the west side of the fire to 45 mph on the ridgetop. Wind gusts, exceeding 50 mph, were likely in the chimneys and saddles near the ridgetop. The cold front rapidly moved east into the Denver area at around 1800 hours (Chart W-7). Winds on the fire remained very strong until 2000 hours and then began to diminish.

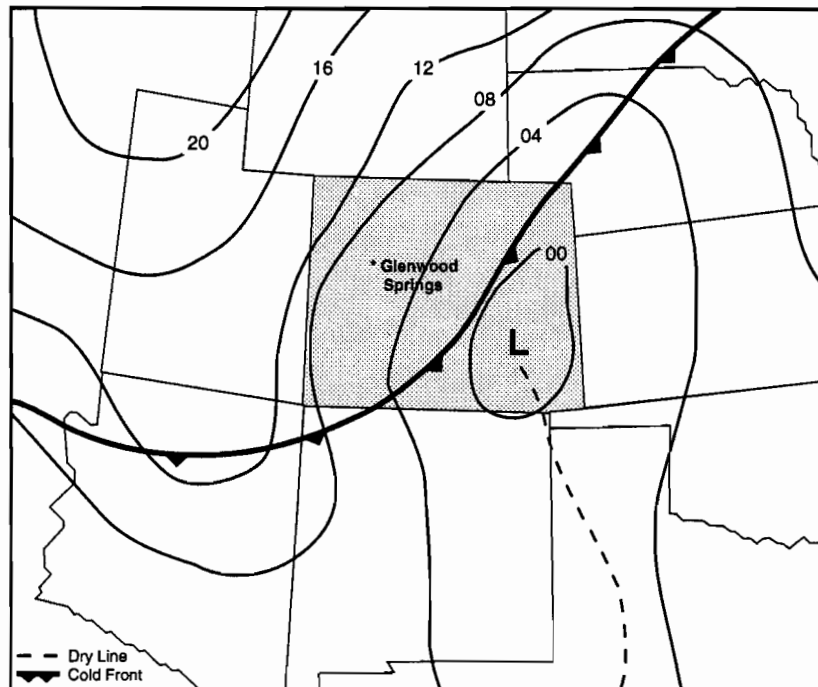


Chart W-7: 1800 MDT Surface Weather Map
July 6, 1994

South Canyon Fire

The upper level low moved across northwest Wyoming during the day and by evening was centered near Sheridan. A trough extended from the low across southwest Wyoming and eastern Utah (Chart W-8). The band of strong winds aloft traversed northern Utah and northwest Colorado.

An unstable airmass developed over western Colorado, but limited moisture allowed only towering cumulus clouds to form over the fire site (Chart W-9). A few lightning strikes were detected by the BLM's Lightning Detection System (ALDS) well south and east of the site. At the time of the blowup, the cumulus clouds had moved to the east, and skies were clearing from the west. Clearing skies and the strong winds were visual indicators that a cold front had crossed the site.

Temperatures dropped a few degrees from Tuesday's readings, but relative humidities remained extremely low. The Rifle RAWS reported a high temperature of 84 degrees and a minimum relative humidity of 8 percent.

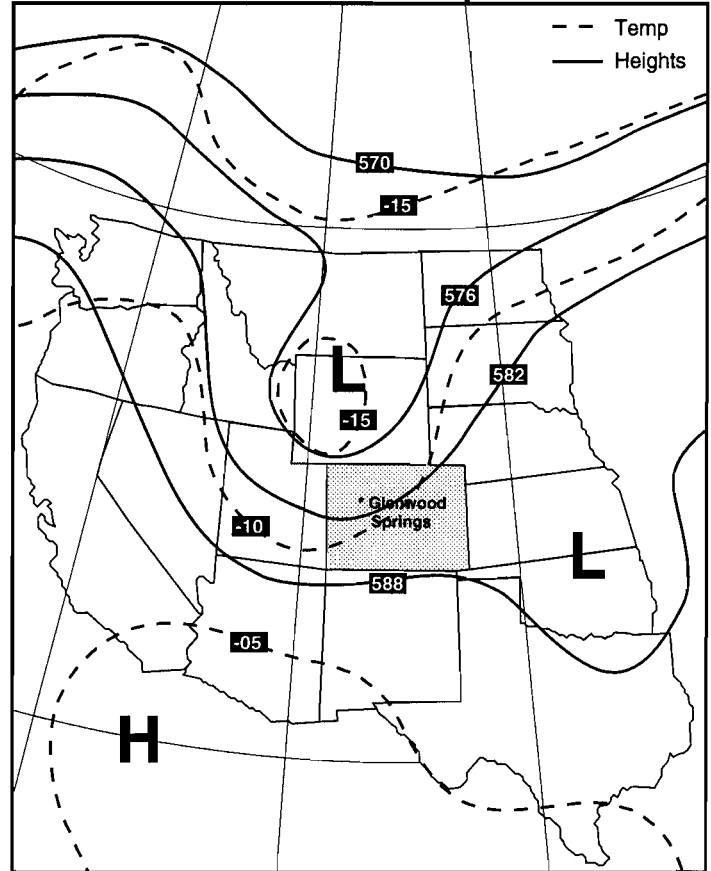
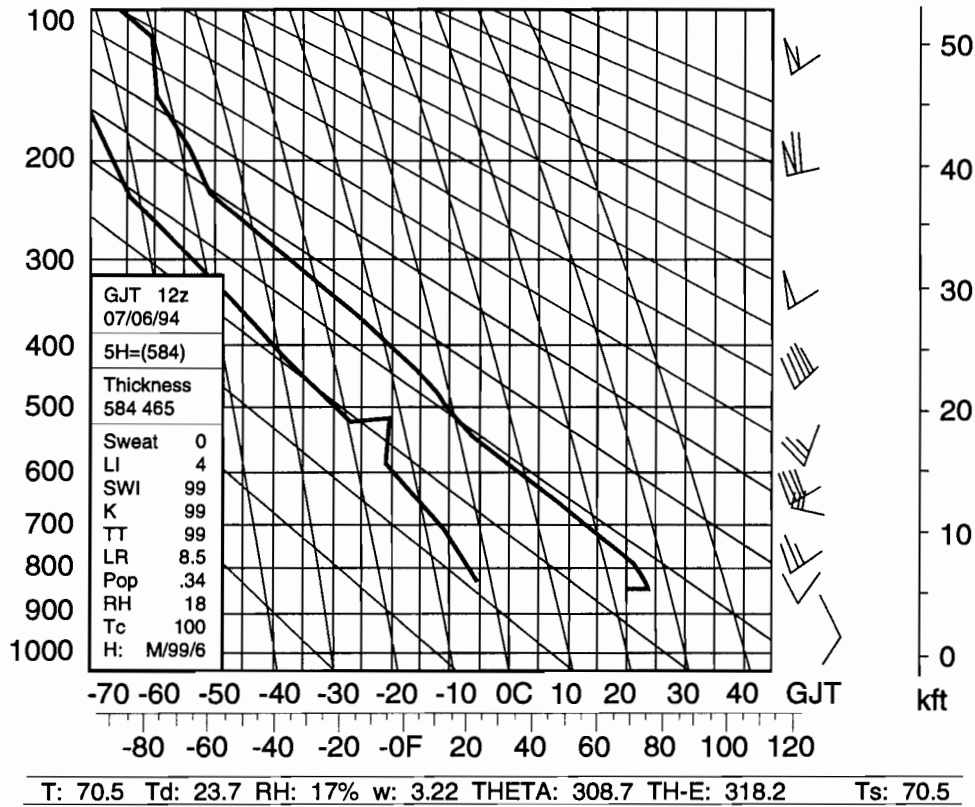


Chart W-8: 500 MB Analysis Heights/
Temp 1800 MDT Wednesday, July 6,
1994

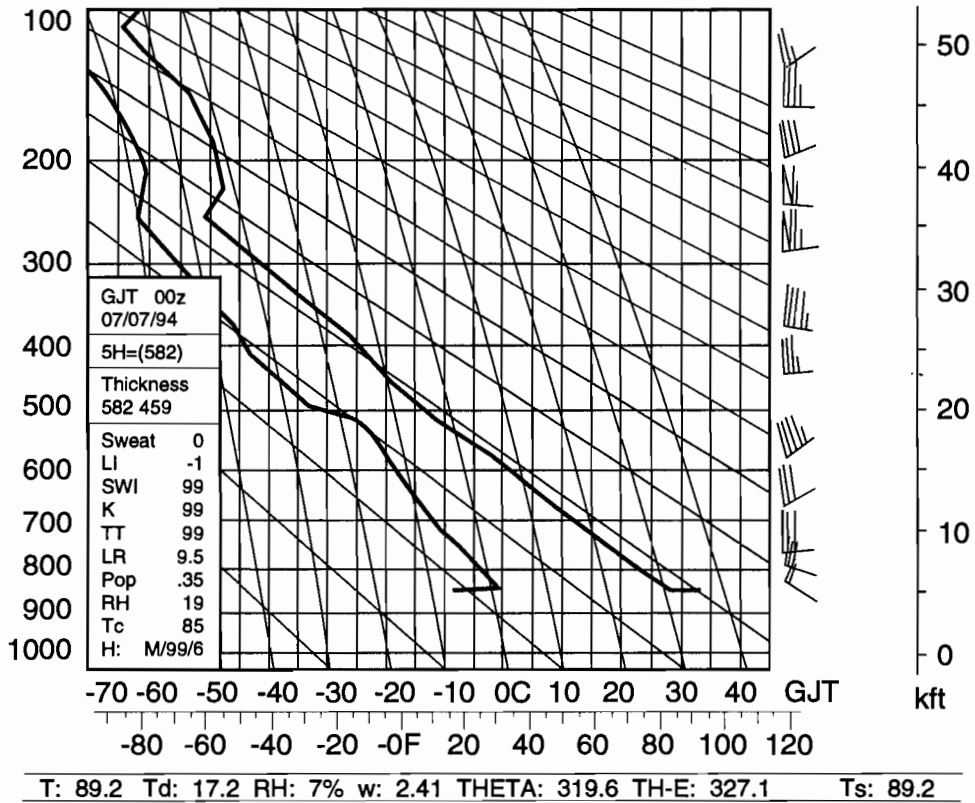
Haines Index

As a tool to measure the contribution of atmospheric stability to the growth potential of existing wildfires, the Haines Index (Haines 1988) combines two key atmospheric factors known to significantly influence the growth of wildfires: moisture and stability. Low moisture (relative humidity) adds to the combustive energy of wildfires by lowering the moisture content of fine dead fuels. Unstable air promotes vertical motion in the convective column. The Haines Index at the South Canyon fire was determined by using the upper air sounding at Grand Junction. The high-elevation Haines Index was calculated to be 6 on both July 5 and 6. On the basis of atmospheric conditions over the fire, a Haines Index value of 6 correlates to a high potential for large fire growth. The combination of strong cold-front winds and a 6 Haines Index contributed to the blowup on the afternoon of July 6.

6:00 A.M. Grand Junction Upper Air Sounding



6:00 P.M. Grand Junction Upper Air Sounding



Area Weather Outlook 1920, Tuesday, July 5

This weather outlook applies to northwestern Colorado ... including fire weather zones 201 ... 202 ... 205 ... 206 ... and zone 207 west of Aspen.

... The cold front will arrive earlier about 8 hours sooner than expected ...

*** Red Flag Warning Wednesday ***

Weather Discussion: A cold front over southeast Idaho will move into the Dinosaur N.P. area about 0900 Wednesday ... and then through Craig before 1100. The front should reach Grand Junction about 1400-1500 ... then move through Paonia and Montrose about the same time ... around 1700. This is more than 8 hours faster than previously forecast.

Craig District: Increasing clouds late tonight. Mostly cloudy Wednesday morning and afternoon with scattered showers and thunderstorms. The chance of rain: 40 percent. Southwest winds 15-30 mph, shifting to northwest 15-25 mph between 0900 and 1100. Wind gusts of 30-40 mph with frontal passage. High temps: 72-80. Low RH: 20-28%.

Grand Junction District: Increasing high clouds in the morning, with southwest winds of 10-20 mph by 1100. Winds increasing to 15-30 mph by 1300. About 1500, surface winds will shift to the northwest at 15-25 mph. Wind gusts of 30-35 mph with frontal passage. Skies will become mostly cloudy in the afternoon with a 30% chance of showers and thunderstorms in the late afternoon. High temps: 80-87. Low RH: 15-25%.

Montrose District: Increasing high clouds in the morning. By 1100 expect southwest winds of 10-20 mph. Surface winds will increase to 15-30 mph by 1400, then shift to the northwest at 15-25 mph about 1700. Wind gusts of 30-35 mph possible with frontal passage. Becoming mostly cloudy late in the afternoon, with a 20 percent chance of showers and thunderstorms. High temps: 80-87. Low RH: 15-25%.

Exhibit W-1

Rifle, Colorado RAWS Weather Data Elevation 6120 Feet

Tuesday, July 5, 1994					
Hour (MDT)	Temp (deg)	Relative Humidity (%)	Wind Direction (deg)	Wind Speed (mph)	Gusts (mph)
0	76	9	239	10	20
1	69	20	346	13	19
2	68	27	333	10	18
3	66	31	324	8	17
4	64	34	327	8	14
5	60	37	352	4	12
6	58	40	127	2	8
7	57	39	240	2	5
8	61	38	327	2	3
9	64	30	97	4	8
10	69	27	82	4	8
11	73	26	354	3	10
12	79	22	27	4	7
13	82	17	346	5	11
14	84	18	335	5	10
15	86	16	130	5	13
16	85	15	237	3	18
17	91	12	229	5	24
18	90	11	197	12	22
19	90	10	221	10	19
20	86	10	192	13	20
21	83	11	199	10	17
22	80	11	201	13	17
23	79	11	194	15	22

Wednesday, July 6, 1994					
Hour (MDT)	Temp (deg)	Relative Humidity (%)	Wind Direction (deg)	Wind Speed (mph)	Gusts (mph)
0	79	11	195	15	25
1	74	12	25	4	21
2	74	13	253	6	15
3	66	19	108	4	7
4	65	20	136	6	12
5	60	27	297	5	8
6	60	29	1	3	8
7	58	31	349	3	7
8	61	28	334	4	8
9	71	22	26	2	6
10	74	22	335	2	5
11	77	18	316	7	12
12	79	14	276	17	29
13	81	14	287	16	35
14	84	13	***	21	40
15	84	12	276	20	41
16	83	10	254	29	45
17	83	8	268	24	44
18	83	8	272	20	42
19	78	12	323	14	37
20	74	14	334	19	35
21	69	18	332	13	40
22	62	24	334	9	25
23	59	25	357	5	20

Table W-1

Grand Junction, Colorado Weather Data Elevation 4843 Feet

Tuesday, July 5, 1994					
Hour (MDT)	Temp (deg)	Relative Humidity (%)	Wind Direction (deg)	Wind Speed (mph)	Gusts (mph)
0	75	9	80	9	
1	76	8	80	10	
2	75	11	50	6	
3	71	14	280	10	
4	72	26	40	12	
5	68	29	150	7	
6	68	31	70	7	
7	67	32	330	6	
8	70	35	140	6	
9	74	29	130	8	
10	78	22	130	9	
11	82	20	190	7	
12	86	14	90	7	
13	90	12	180	5	
14	91	11	200	6	
15	93	11	280	6	
16	94	10	240	8	
17	95	10	210	10	
18	94	9	180	15	
19	94	8	190	15	
20	91	8	200	13	
21	84	10	180	10	
22	80	12	130	9	
23	79	12	120	12	

Wednesday, July 6, 1994					
Hour (MDT)	Temp (deg)	Relative Humidity (%)	Wind Direction (deg)	Wind Speed (mph)	Gusts (mph)
0	77	12	100	10	
1	77	12	50	8	
2	76	13	160	12	
3	74	15	120	15	
4	71	17	60	8	
5	69	19	120	13	
6	69	19	100	13	
7	69	20	140	10	
8	74	18	140	10	
9	79	17	190	9	
10	82	13	270	9	
11	82	14	320	16	
12	87	13	340	10	
13	88	12	300	22	29
14	89	10	300	20	32
15	89	9	280	18	35
16	89	9	270	25	32
17	89	7	300	18	35
18	88	8	280	21	33
19	86	9	330	21	32
20	82	11	320	29	
21	76	13	320	25	
22	73	15	320	17	
23	68	18	320	16	

Table W-2

Red Flag Forecasts

Red flag forecasts are issued by the National Weather Service to inform fire management agencies of the possibility or onset of critical weather and fuel conditions that could lead to extensive wildfire occurrence. Red flag conditions normally require the combination of HIGH to EXTREME fire danger (as determined by the National Fire Danger Rating System) and critical weather conditions (as determined by the Fire Weather Meteorologist). The Denver Fire Weather Office uses the following weather conditions to issue red flag forecasts:

1. A significant increase in wind speeds, i.e. sustained winds of 20 mph with stronger gusts.
2. A dry thunderstorm outbreak, a LAL (Lightning Activity Level) of 6.
3. A significant decrease in relative humidity.
4. A significant increase in temperature.
5. The first episode of thunderstorms after a hot, dry period.
6. A Haines Index of 6.
7. Any combination of weather and fuel moisture conditions that in the judgment of the Fire Weather Meteorologist would cause extensive wildfire occurrence.

Since many combinations of weather conditions and fire danger can lead to red flag conditions, no truly objective criteria can be set to determine exactly when a red flag event should be forecast. When red flag conditions are forecast, either a red flag watch or a red flag warning is issued by the Fire Weather Meteorologist.

A red flag watch is issued to advise land management agencies of the possible development of red flag conditions in the near future. A watch is issued when the meteorologist is reasonably confident that a red flag event will occur within the next 12 to 72 hours.

A red flag warning is issued when the meteorologist is aware of ongoing red flag conditions, or when there is high confidence that red flag conditions will occur within the next 24 hours.

Between June 1 and July 6 of 1994, The Denver Fire Weather Office issued 10 red flag warnings for the Grand Junction BLM District. Red flag warnings were issued for June 13, 15, 18, 26, and 28, and were in effect from July 2-6. The red flag warning for July 6 was unique in that it was issued for strong winds associated with a cold front. All other red flag warnings were for a combination of dry lightning and low relative humidity.

Appendix 2 — Fire Behavior

Analysis of fire behavior on the South Canyon incident is focused on the following questions.

1. Could the fire behavior on the afternoon of July 6, 1994, have been predicted from known information and forecasts available either on the afternoon of July 5 or the morning of July 6?
2. What changes in fire behavior, if any, could have been surmised on July 6 from fire danger indices, drought indices, or other general ratings of fire danger?
3. What fire behavior was observed on the fire?
4. What was the calculated fire behavior?

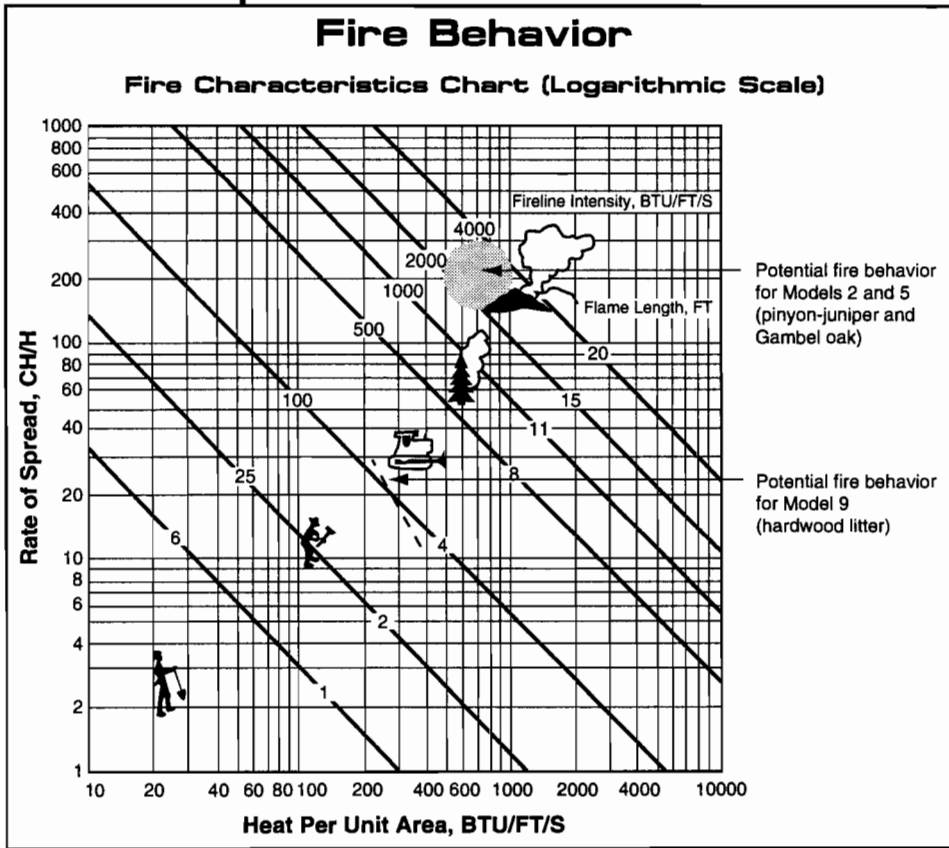
Potential Fire Behavior

In previous investigations the category Predicted Fire Behavior was used to describe predictions made by fire behavior specialists. Investigators have sought to contrast predicted to observed fire behavior and to determine whether miscalculation was a causal factor. In the case of the South Canyon fire, no predictions of fire behavior were made before the tragedy. The category Potential Fire Behavior is used here to determine whether the fire behavior prediction systems could have been used to predict the fire behavior observed on the afternoon of July 6.

Fire behavior was predicted using information and tools available on July 5, 1994. The inputs were derived from the fire weather forecast issued at 1930 hours on July 5 for July 6 and the National Fire Danger Rating System (NFDRS) outputs for July 5. The forecast is found in Appendix 1, Weather. The fire behavior was predicted using the BEHAVE system, a software program developed by Patricia Andrews and Carolyn Chase of the Missoula Fire Lab. Similar results could also be derived using the nomograms, charts in the Fireline Handbook or by the using the HP71B calculator.

Inputs & Data Sources for Potential Fire Behavior Calculations		
Fuel Models:	5	Model 5 is used to model fire behavior in low live brush. It is a conservative model for the Gambel oak fuel type.
	2	Model 2 is used to model fire behavior in pinyon-juniper with a grassy understory.
1-Hr FM	2-5	1 hour fuel moistures were calculated using the forecast temperature and relative humidity for the time when the cold front was expected to pass based on the forecast for July 6 issued on the afternoon of July 5 at 1930. Fuel moistures were calculated both for clear and cloudy conditions to develop a range.
10-Hr FM	3	Value from Rifle RAWS Station
Live Woody FM	59	Value from Rifle RAWS Station
MFWS	12	Value from forecast for July 6 for time of frontal passage. The 20 foot winds were reduced assuming that the fuels are partially sheltered.

Table FB-1



The inputs and data sources for the potential fire behavior calculations are listed in Table FB-1. The calculated rates of spread (ROS) during the passage of the cold front on July 6 were 129-146 chains per hour (1.5 to 2 miles per hour) in live brush. The calculated flame lengths (FL) in live brush were 14-15 feet at the same time. The calculated ROS for the pinyon-juniper fuel type were 241-317 chains per hour (3 to 4 mph), with flame lengths of 16-19 feet. The characteristics of potential fires based on these

Figure FB-1

Fire Behavior Interpretation Chart		
Flame Length (Feet)	Fireline Intensity (Btu/ft/sec)	Interpretations
<4	<100	Fires can generally be attached at the head or flanks by persons using handtools. Handline should hold the fire.
4-8	100-500	Fires are too intense for direct attack at the head by persons using handtools. Handline cannot be relied on to hold fire. Equipment such as dozers, pumpers, and retardant aircraft can be effective.
8-11	500-1,000	Fires may present serious control problems — torching out, crowning, and spotting. Control efforts at the fire head will probably be ineffective.
>11	>1,000	Crowning, spotting, and major fire runs are probable.

Table FB-2

calculations are shown in Figure FB-1. The predicted ROS and FL are in a range where crowning, spotting, and major fire runs are probable. The fire behavior interpretation chart (Table FB-2) shows that fire control options were limited on July 6. Predictions for the Grand Junction District are shaded in the table. The predicted range of fire behavior is viewed as resistant to any direct means of fire control, and a handline is not an effective control method.

The calculations for hardwood litter (Gambel oak litter layer) show that flame lengths would have been 3-5 feet when the cold front passed. These intensities would be sufficient to move the fire from the surface litter into the crowns of brush. This is displayed in Figure FB-1.

Calculations of probability of ignition reveal that the chance that an ember would cause a spot fire were 90 to 100 percent under conditions forecast for the time of the frontal passage on July 6. The Ignition Component (the chance that an ember will ignite a spot fire and the spot fire will spread) from the NFDRS forecast for July 6 issued on the afternoon of July 5 was 100 percent for the Rifle Remote Automatic Weather Station (RAWS). The forecast 1-hour timelag fuel and 10-hour fuel moistures and the forecast relative humidity suggest severe fire behavior potential on July 6 (Table FB-3). Predictions for the Grand Junction District are shaded in the table.

Severe Fire Behavior Potential Related to Relative Humidity and Fuel Moisture Content			
R.H. (%)	1-Hour F.M. %	10-Hour F.M. %	Relative ease of chance ignition and spotting, general burning conditions.
>60	>20	>15	Very little ignition; some spotting may occur with winds above 9 mph.
45-60	15-19	12-15	Low ignition hazard — campfires become dangerous; glowing brands cause ignition when relative humidity is <50 percent.
30-45	11-14	10-12	Medium ignitability — matches become dangerous; occasional crowning, spotting caused by gusty winds; moderate burning conditions.
15-30	5-7	5-7	Quick ignition, rapid buildup, extensive crowning; any increase in wind causes increased spotting, crowning, loss of control; fire moves up bark of trees igniting aerial fuels; long distance spotting in pine stands; dangerous burning conditions.
<15	<5	>5	All sources of ignition dangerous; aggressive burning, spot fires occur often and spread rapidly, extreme fire behavior probable; critical burning conditions.

In summary, information and materials in the Western Slope Fire Coordination Center, BLM Grand Junction District Office, and Glenwood Springs Area Office could have been used to predict extreme fire spread, high intensities, crowning in oak brush, and spot fires at the time of the frontal passage on July 6.

Table FB-3

Fire Danger Indices

The Grand Junction area has seven fire weather stations where fire weather is collected for input to the Weather Information Management System (WIMS). WIMS uses the National Fire Danger Rating System (NFDRS) to calculate the NFDRS indices. The National Weather Service also inputs trend data that allows users to view the forecast NFDRS indices for the next day.

The NFDRS indices are used to rate the relative level of fire danger when compared to the long-term record for a weather station. The adjective classes for fire danger (low, moderate, high, very high, and extreme) are based on the burning index. The forecast for every station in the Grand Junction area for July 6 was for extreme fire danger. Table FB-4 shows the values for Burning Index and Ignition Component forecast for July 4, 5, and 6 for the Rifle and the Pine Ridge RAWS. The Rifle RAWS is the station closest to the South Canyon fire. The Pine Ridge RAWS is the station most

South Canyon Fire

Forecast Indices					
Forecast for Date	Fuel Model	Burning Index		Ignition Component	
		Rifle NFDERS Station	Pine Ridge NFDERS Station	Rifle NFDERS Station	Pine Ridge NFDERS Station
July 4	H	51	36	53	49
	T	70	68	48	46
	F	37	111	51	65
	A		41		40
July 5	H	32	35	36	58
	T	42	66	30	52
	F	24	111	36	78
	A		43		47
July 6	H	146	53	100	NA
	T	107	114	100	NA
	F	51	119	100	NA
	A		243		90

Table FB-4

often used for general fire danger in the Grand Junction District. The forecast values were available on the previous afternoon to assist in planning and setting fire management priorities for the next day. Complete data for all stations is on file.

Legend

- F = Mature closed chamise stands and oak brush fields of AZ, UT and CO
- T = Sagebrush - grass types of Great Basin and Intermountain west
- H = Healthy stand of short needled conifers
- A = Western grasslands vegetated by annual grassland and herbs

Interpretation of the burning index is made by comparing the forecast value or the observed value with the high and low percent (80th and 95th percentile) from the historical record for the stations. The high and low percent values for the Rifle and Pine Ridge fire stations are shown in Table FB-5. The burning index for July 5,

1994, for the two stations was below the high percentage threshold (95th) for both stations for all fuel models except one. The forecast burning index for July 6 was well above the high percentage threshold for both stations for every fuel model due to the predicted winds. The marked difference in values (percentage change between the 2 days) suggests a corresponding increase in fire behavior between that observed on July 5 and that forecast for July 6.

Threshold Values for Burning Index (1977-1991)			
Location	Fuel Model	Low 80th %	High 95th %
Rifle NFDERS Station	F	43	97
	T	56	89
	H	31	44
Pine Ridge NFDERS Station	H	31	41
	T	55	81
	F	44	97
	A	36	47

Table FB-5

Trends In Fire Danger Indices

The Firefamily program can be used to analyze long term trends in fire danger indices. Two of the fire weather stations in the Grand Junction area, Walker and Colorado National Monument, have been established for more than 20 years. Five other stations have been in place for 5 years. Colorado National Monument was selected for analysis of long-term trends. It should be noted that the graphs of these indices are compiled from a database that has not been edited. A thorough and accurate display of the information would require checking and editing the database, a time consuming process that was not completed by the investigators. However, the analysis gives a good idea of the level of fire danger at the time of the South Canyon fire as compared to the average for the previous 20 years and to 1976, another serious fire season in the record.

Tables FB-6 and FB-7 display the trends in BI (burning index) and ERC (energy release component) for the station. Missing data in the yearly records is graphed as 0 for the July entries.

The burning index in early July was above the 95th percentile for the station. The year 1994 defines the maximum values in 20 years for most days in early July.

The energy release component in early July 1994 was above the 95th percentile for the station.

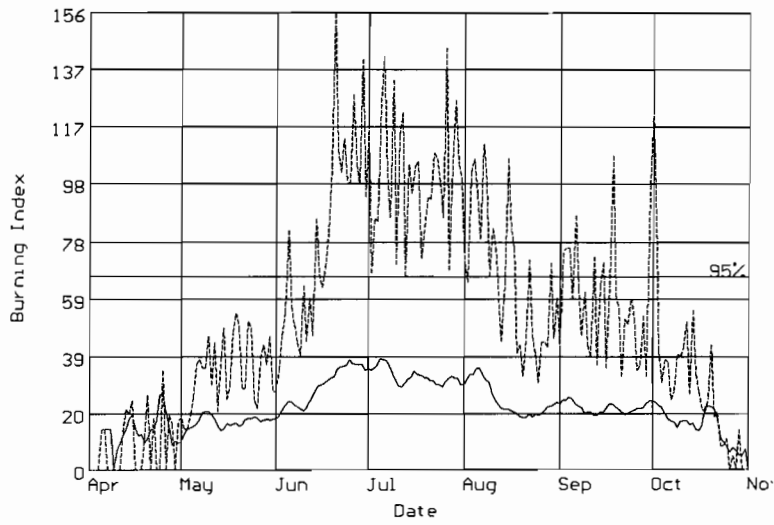
The ERC and BI for the station were above average values for June starting when the weather observations were initiated in 1994. Beginning in late June the values were well above the average for that time of year and approaching the maximum values recorded since 1973. This information paints a graphic picture of the severity of the fire season.

Actual Fire Behavior

Descriptions of the actual fire behavior are a combination of eyewitness descriptions and calculations using the BEHAVE FIRE1 system. Throughout the narrative calculated and observed values are differentiated.

The fire behavior on the afternoon of July 6 is referred to in the body of the report as a blowup. A blowup is defined as a sudden increase in fire-line intensity sufficient to preclude immediate control or to upset existing suppression plans, often accompanied by violent convection. The fire behavior on the South Canyon fire was estimated using the fire spread model. Although rates of spread and intensities were high, the observed behavior did not violate the assumptions of the spread model.

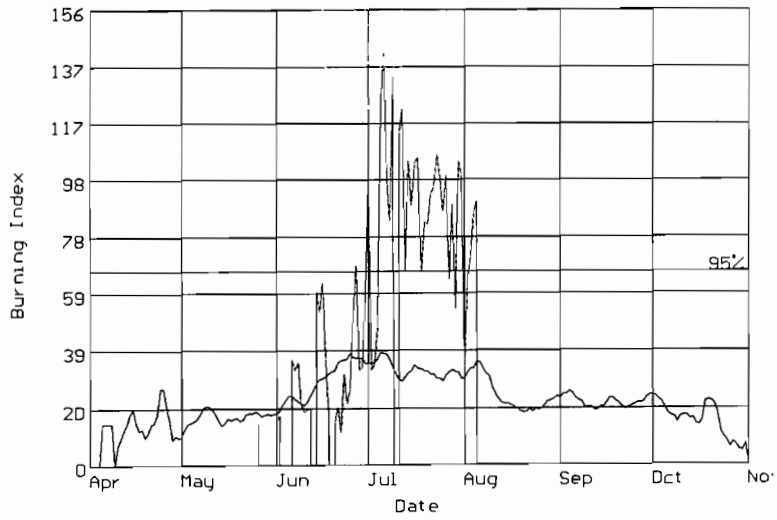
Season Plot - COLORADO



Average _____

Maximum -----

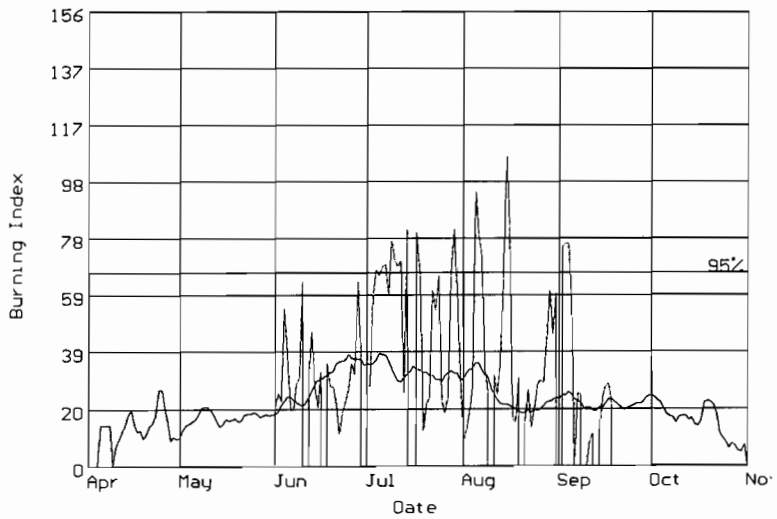
Season Plot - COLORADO



Average _____

Year 1994 -----

Season Plot - COLORADO



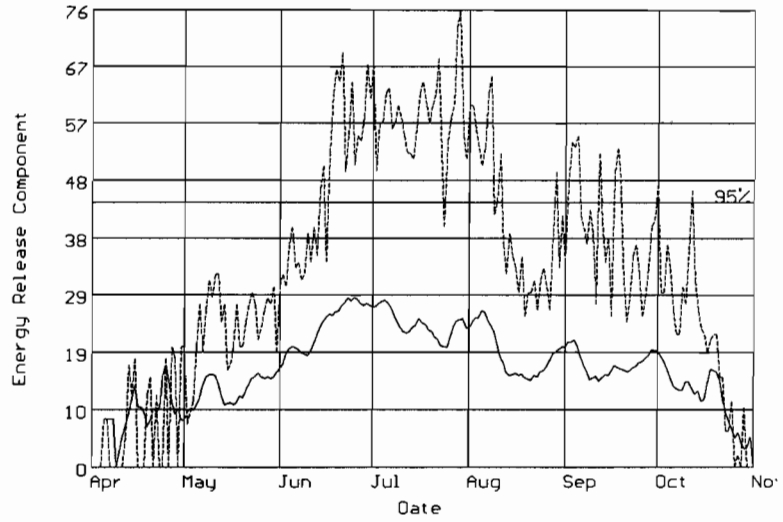
Average _____

Year 1976 -----

Table 6: Burning Index Model F 1973-1994

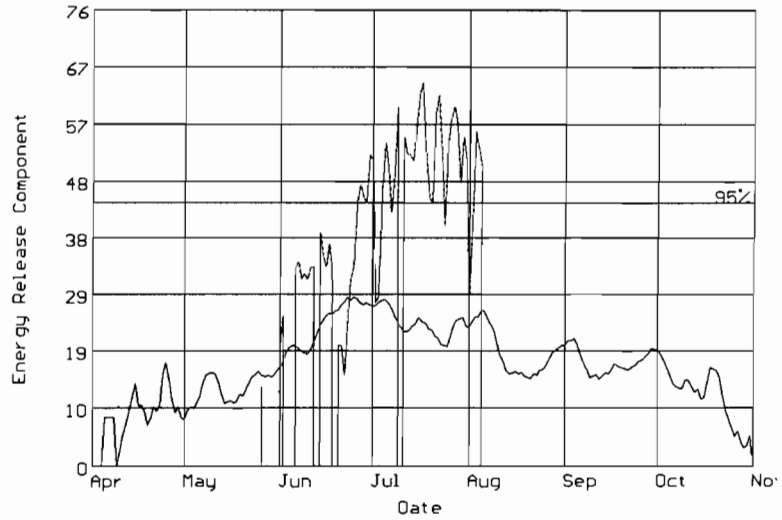
_____ Average
 - - - - - Maximum

Season Plot - COLORADO



_____ Average
 - - - - - Year 1994

Season Plot - COLORADO



_____ Average
 - - - - - Year 1976

Season Plot - COLORADO

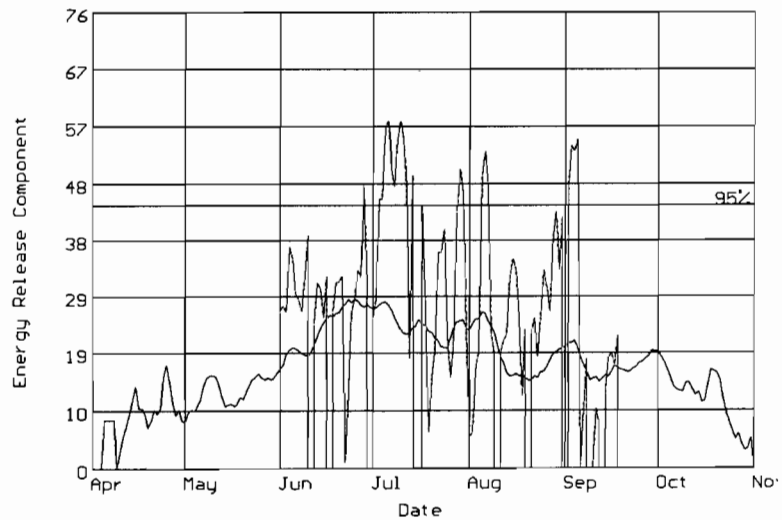
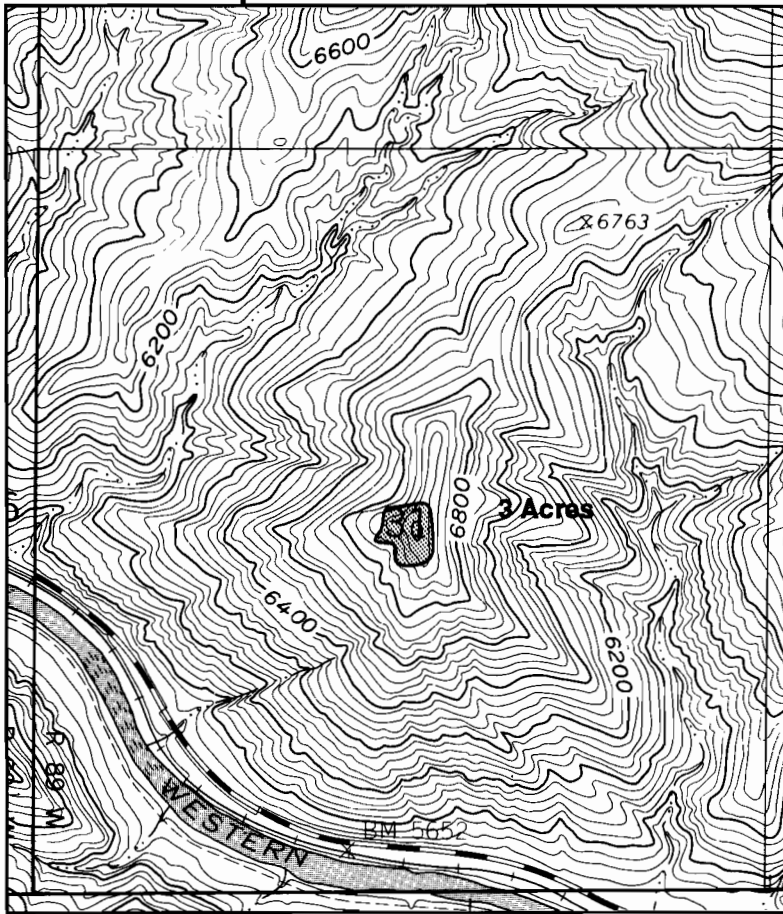


Table 7: Energy Release Component Model F 1973-1994



July 3 and 4

The fire was ignited by lightning on the afternoon of July 2. The fuel type was sparse pinyon-juniper with an understory of cured bunchgrasses and annual grasses. The terrain in the area of the ignition was steep and rocky. Since the fire was ignited near the high point of the ridge, most of the behavior over the next 48 hours consisted of backing with occasional short runs up the slope. Residents and observers reported occasional torching of trees (pinyon and juniper). The fire covered 3 acres by 1200 hours on July 4 and grew to 11 acres by 2200 hours (Figures FB-2 and FB-3).

July 5

The fire flanked along the west side of the ridge toward the northwest and grew to 29 acres by 0800 hours

Figure FB-2: 1200 July 4

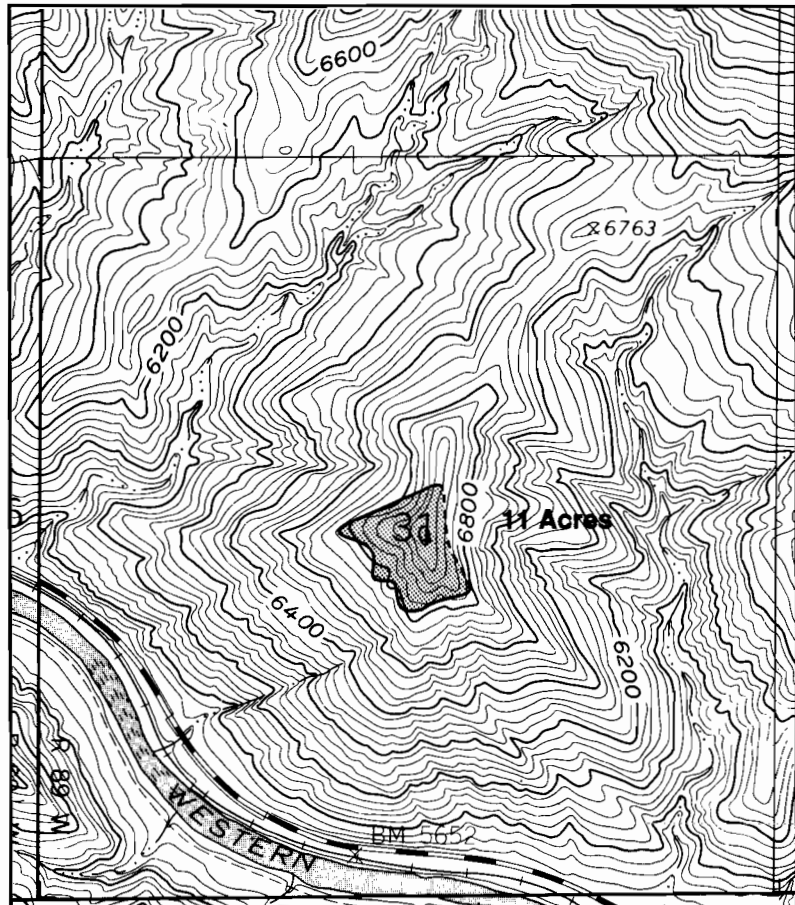


Figure FB-3: 2200 July 4

on July 5 (Figure FB-4). It continued to back and make short runs in the pinyon-juniper vegetation type. By 2000 hours it had grown to 50 acres (Figure FB-5) and had burned into the large patch of Gambel oak (*Quercus gambelii*) shown on the fuels map (Figure FB-6). The brush was dense and ranged from 6 to 12 feet high. A mat of leaves and litter approximately 2 to 3 inches deep covered the ground under the shrubs.

July 6

The fire remained active throughout the night. RAWs data shows little or no relative humidity recovery. The fire had flanked 1,000 feet by the time fireline construction began at 1000 hours that morning. The fire in the litter under the Gambel oak was moving laterally at a rate of about 70 feet per hour and backing down the slope at a similar rate.

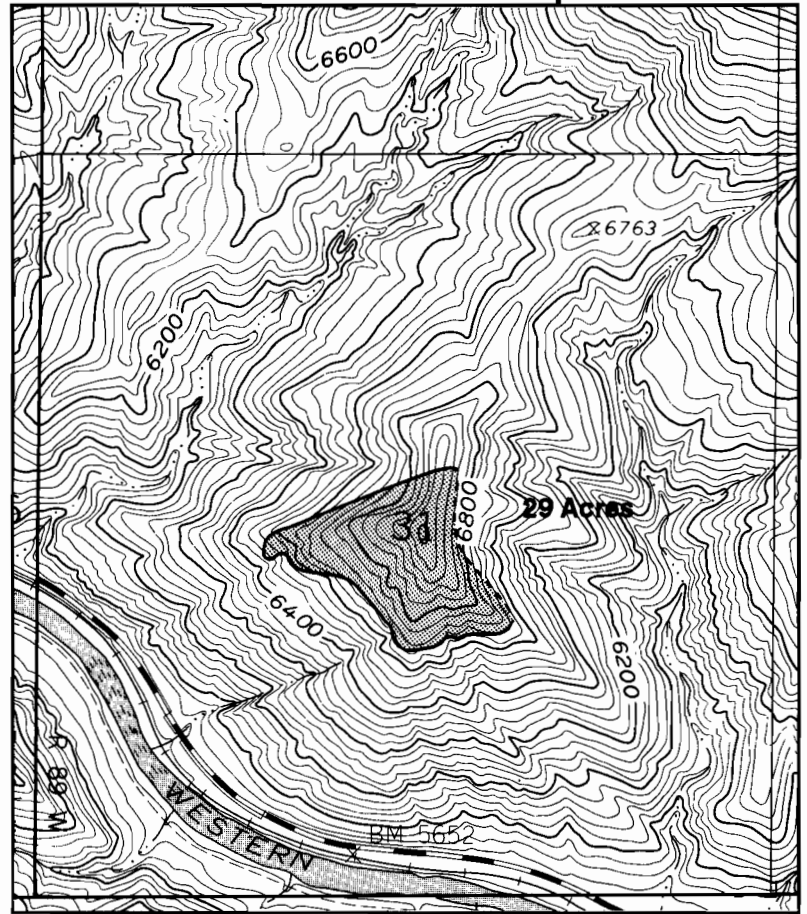


Figure FB-4: 0800 July 5

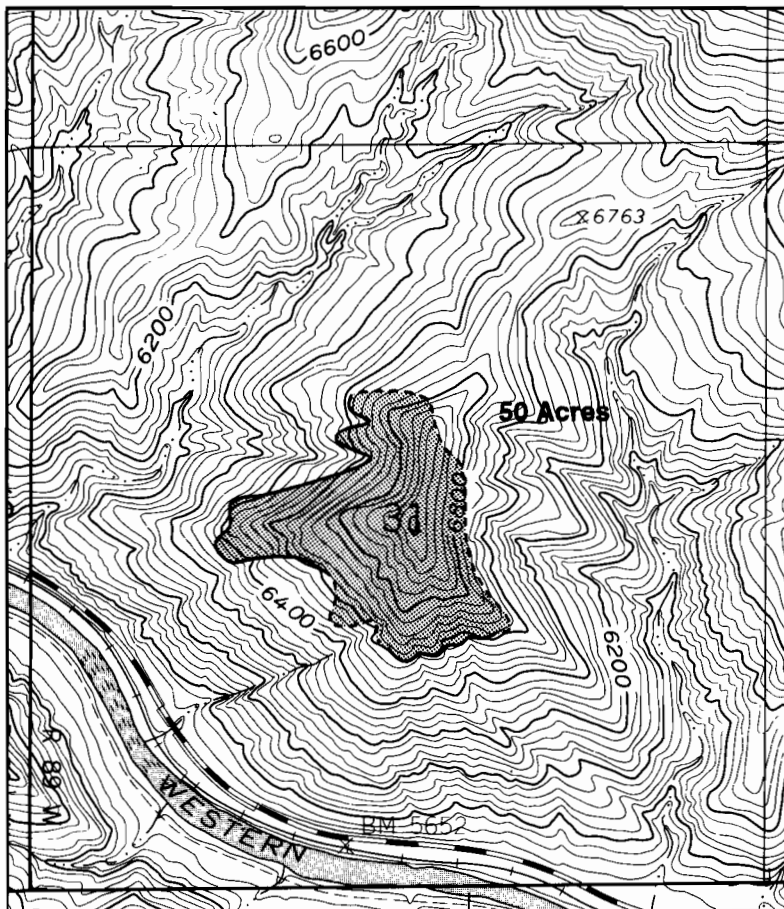


Figure FB-5: 2000 July 5

South Canyon Fire

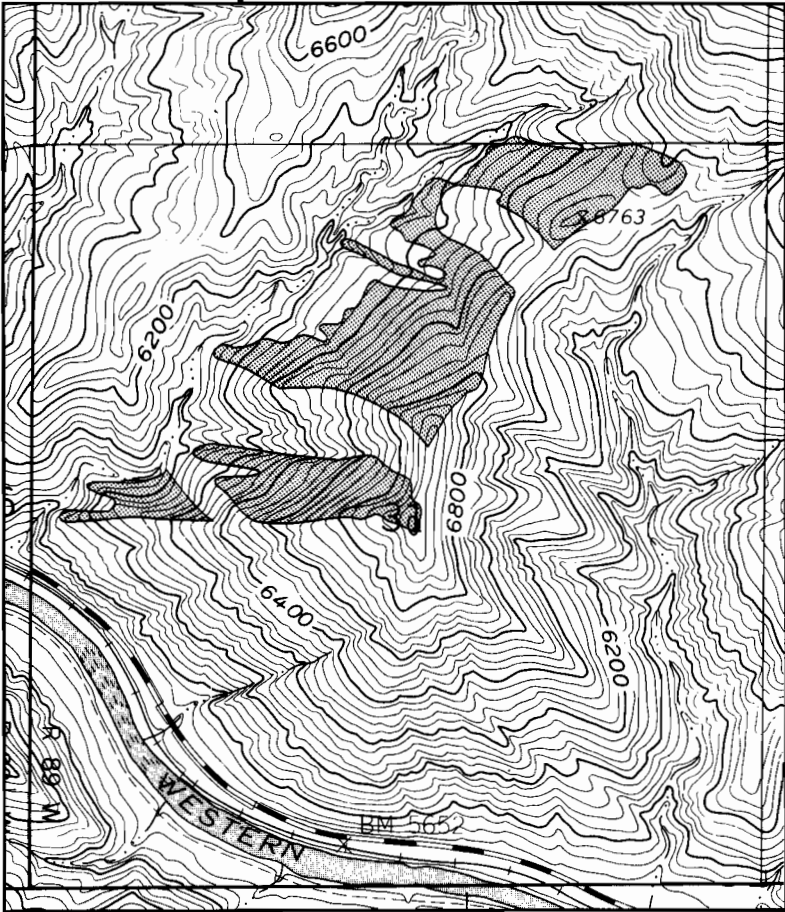


Figure FB-6: Gambel Oak Distribution Map

Observed flame lengths were 6 to 8 inches long. Few observations of the progress of the fire downslope to the south of the lunch spot are available, but the fire was mapped at 0900 hours on a reconnaissance flight, showing it to be on the slope above the west drainage.

As the morning progressed, the fire gradually became more active. By midmorning it covered 127 acres (Figure FB-7). Crews working on the ridgeline conducted a small underburn of patches of Gambel oak litter next to the fireline in the late morning. As winds picked up, the fuels dried. As the morning got warmer, there were several small slopovers along the ridgeline. A small reburn originating downslope from the intersection of the west fireline and the ridgeline also ignited a spot fire on the ridge.

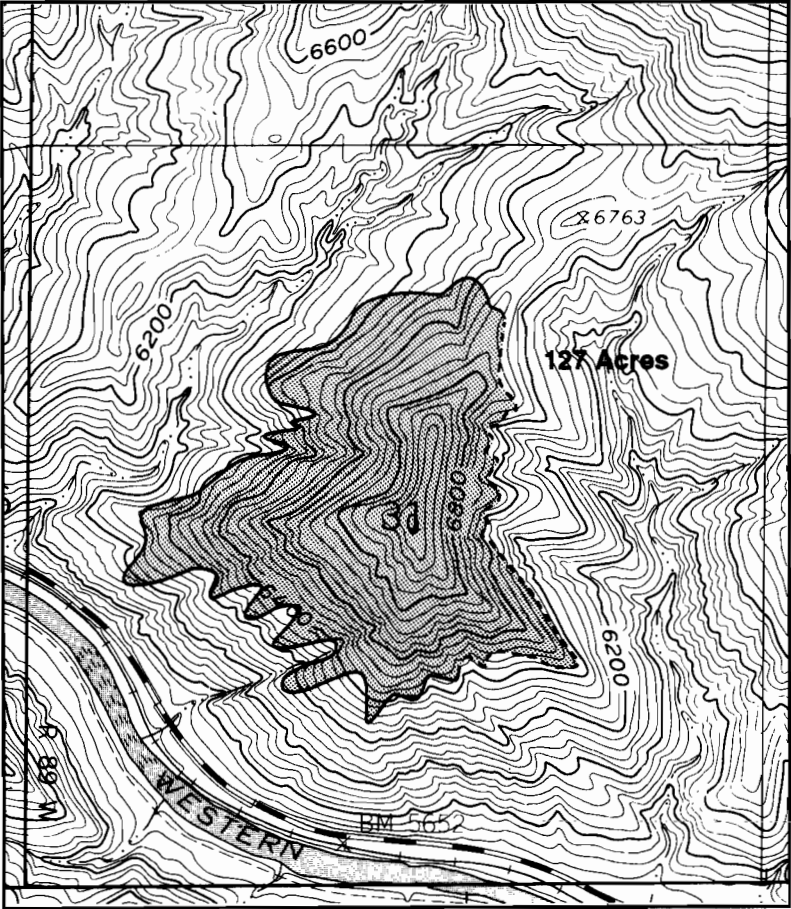


Figure FB-7: July 6

South Canyon Fire

Observers at the heliport along the Colorado River and in the local community recorded the fire behavior on the sides of the fire away from most of the line construction. The fire was active all along the perimeter in the pinyon-juniper fuel type. It continued to back down the slope and make short runs with occasional torching of trees. Starting at 1543 hours, the fire made several runs in the burn south of the lunch spot. Three smoke-jumpers observed the reburn of underburned pinyon-juniper and Douglas-fir forest (Photo 4 on page 12 of the Incident Overview). They described 100-foot flames in this flareup within the previous burn.

At 1600 hours as the winds reached their highest velocity, the fire reached the bottom of the west drainage, which it crossed at Point A (Figures FB-8 and FB-9 and Photo FB-1). The fire ignited the opposite side of the drainage and moved rapidly to the top of the opposite ridge. The fire moved up the west side of the drainage pushed by 30 mile per hour winds (Points B and C). The fire took an estimated 10 to 12 minutes to progress up the canyon to Point D (Tables FB-8 and FB-9). Taken from the opposite ridge, Photo 8 (page 16 in the Incident Overview) shows the head of the fire on the east side of the drainage at Point D. The head of the fire is not clear in the photo in the printed document but is visible in enlargements on file.

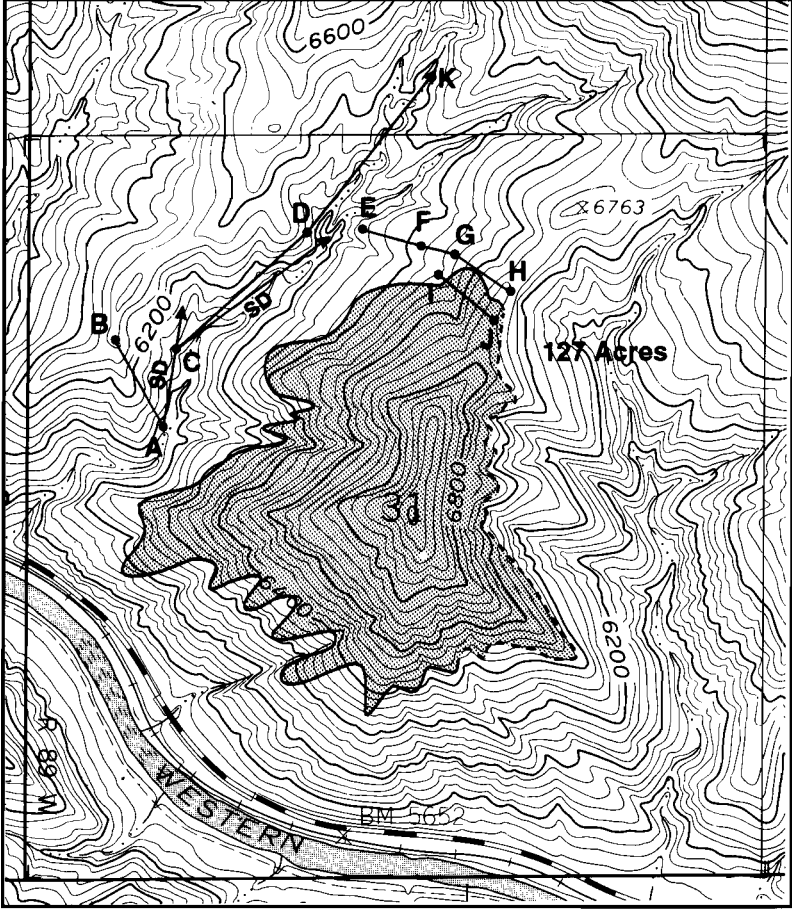


Figure FB-8: Fire Behavior Calculations

South Canyon Fire

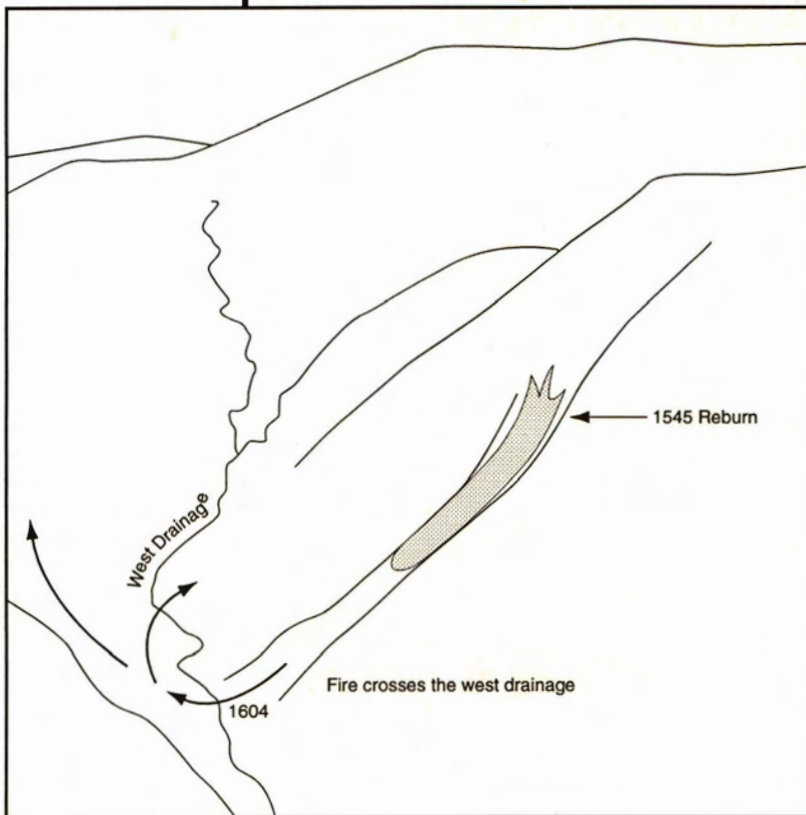


Figure FB-9

physical evidence on the site and the fire behavior puts the time closer to 2 minutes. Tables FB-8 and FB-9 show the calculated rates of spread and

The fire was observed to spot to the east side of the drainage at Point E below the crew that was walking out the fireline to the ridge. The observer was in a location 210 feet below the ridgeline. The spot fire moved from sparse pinyon-juniper and Gambel oak with a grassy understory to dense Gambel oak on a slope that steepened to 50 percent. Racing up the slope, the fire was influenced by stronger winds of 45 miles per hour. The spot fire took an estimated 2 minutes to reach the ridgeline.

During the run its calculated rate of spread accelerated from 246 to 856 chains per hour (3.1 to 10.7 mph). An eyewitness estimates that it took 30 seconds for the spot fire to move to the ridgeline, but the physical evidence on the site and the fire behavior puts the time closer to 2 minutes. Tables FB-8 and FB-9 show the calculated rates of spread and flame lengths between fire behavior projection points on the map and the calculated times between key points on the fire. The firefighters on the line were overtaken by the fire from below and to the north of them. This is demonstrated in Photo 8 (page 16 of the Incident Overview) and also by the burn pattern.

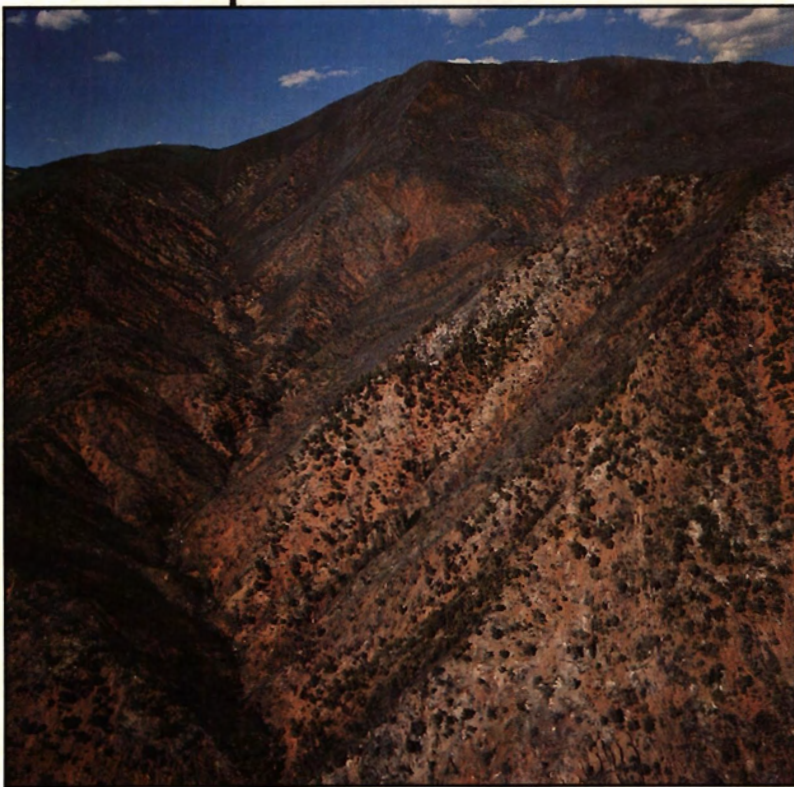


Photo FB-1

The fire continued to move up the west drainage. Calculated spread rates indicate that approximately 7 minutes elapsed from when the spot fire was observed to when the two helitack crew members were overtaken by fire at the head of the drainage at Point K.

South Canyon Fire

Once the fire moved inside the fireline to the underburned Gambel oak, rates of spread were approximately double those calculated for the green Gambel oak outside the fireline. These rates of spread may have been as high as 1,480 chains per hour (18.5 mph). As the fire moved higher on the slope, it was influenced by higher winds (Figure FB-10). Contributing to this maximum rate of spread were a 45 mph wind, steep slopes, and fuel moistures of 60 percent in the brush that had been dried by the surface fire.

Calculated Times Between Points on the Map		
Points	Description	Approx. Time
A to C	The fire crosses the main drainage and spreads up the slope to the opposite ridge.	4 min, 19 sec
C to D	The fire spreads up the drainage on the west side and is visible in photo 8 at point D.	6 min, 24 sec
E to F	The fire spots to the east side of the drainage and spreads uphill through the open brush on the lower slope.	108 sec
F to G	The fire enters the dense Gambel oak on the lower slope and spreads to the steep slope.	20 sec
G to H	The fire burns through the dense Gambel oak and spreads to the ridgeline, overtaking 12 firefighters.	31 sec
D to K	The fire moves from the point visible in photo 8 to point K where it overtakes two helitack crewmembers.	7 min, 12 sec

Table FB-8

Calculated Rates of Spread and Flame Lengths				
LOCATIONS	RATE OF SPREAD			FLAME LENGTH
	Chains/ Hour	Miles/ Hour	Feet/ Minute	Feet
East Side				
Upslope to Ridge	127	1.6	140	12
Upcanyon to Observed Point in photo 8.	177	2.2	195	15
Spot Fire				
Pinyon-Juniper 30% Slope	246	3.1	271	17
Gambel Oak 30% Slope	591	7.4	650	54
Gambel Oak 50% Slope	856	10.7	941	64
Underburned Oak 50% Slope	1480	18.5	1628	86.3

Table FB-9

South Canyon Fire

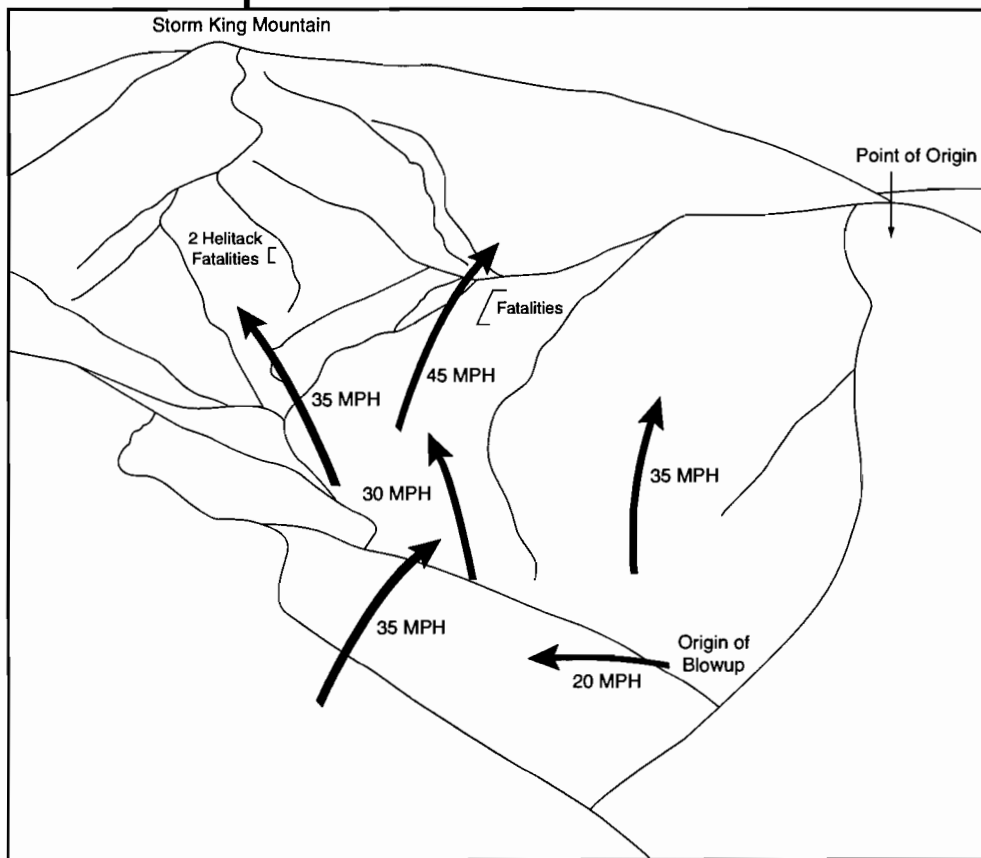


Figure FB-10

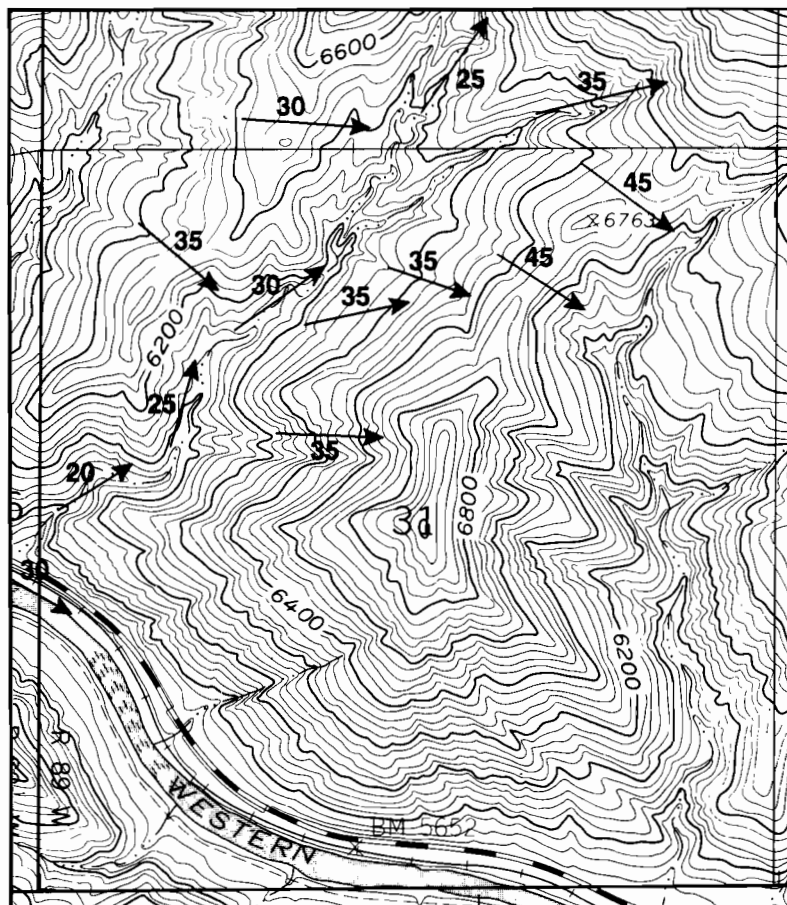


Figure FB-11

All fire behavior projections were made using the vectors, wind vectors, and fuel mapping shown in Figures FB-6, FB-8, and FB-11. Worksheets and calculations are on file.

Fuel Moisture

The live fuel moisture in shrubs is not sampled on a routine basis in the Grand Junction area. Samples of live fuels, however, were collected at two sites on July 12, 1994. Samples could not be taken on the South Canyon fire because all the fuels were consumed.

Samples of underburned brush were taken at a similar elevation and aspect on the next ridge to the west on the fire (Photo FB-2). The moisture content was 59 percent.

Samples of green Gambel oak were taken on a similar aspect and elevation east of the fire area along Transfer Trail. The moisture content was 125 percent. This is lower than the values recorded in green Gambel Oak at the time of the Battlement Creek Fire in 1976.

Fuel Mapping And Models

Mapping

The relative distribution of the major fuel types in the fire area were determined using aerial photo interpretation and ground truthing. They are shown on the fuel type drawing in the Incident Overview and the fuel type map (Figure FB-6). Photo FB-3 shows the fuels on both sides of the fireline at a location on the west flank of the fire near the bottom of the line. Photo 8 (page 16 of the Incident Overview) shows the Gambel oak fuels on the inside of the line near the fatality site. Both photos reveal that the aerial fuels were intact and continuous both inside and outside the fireline along the west flank.



Photo FB-2

Fuel Models

Model 2

Model 2 was selected to describe the pinyon-juniper vegetation found on most of the south- and east-facing aspects in the fire area. Model 2 was selected because the main carrier of fire in these areas is grass that is partially shaded by the trees and shrubs. This vegetation type is quite open in the fire area. A few areas of very sparse tree-sized Gambel oak with a grass understory are also categorized as Model 2.



Photo FB-3

Model 4

The Gambel oak on the South Canyon fire ranged from 6 to 12 feet in height. It was very dense and continuous. It was not affected by frost the previous spring and appeared to be green and growing. It did not contain much dead material. The age of the brush is unknown since no previous fires have been recorded for the site. Model 4 was selected to describe the Gambel oak fuel type because it was found to best match the fire behavior observed in Gambel oak on the South Canyon fire. It is the model used in the Battlement Creek fire report (1976) and is also used to describe some areas of very dense pinyon-juniper with canopy closure.

Appendix 3 — Entrapment Response And Analysis

At the time this appendix was written, autopsy reports and coroner photos needed for a complete analysis had not yet been released. In addition, witnesses who could add new information for the entrapment response had not been interviewed but may be contacted later. Until all reasonably available information has been considered, this analysis is incomplete.

Jumper Deployments (No Fatalities)

Crew Movement

When the Jumper in Charge gave the order to go back up to the Helispot 1, eight of the nine smokejumpers proceeded up the ridgeline. As conditions worsened, they left three saws, gas, and some tools in small openings but kept their packs with them. When one jumper's legs began to cramp up, he and another smokejumper deployed their shelters and got under them in a small opening on the ridgeline. The other jumpers continued up another 100 yards to a larger opening, and all six deployed their shelters. This site is on the ridgeline about 100 yards below Helispot 1.

The ninth smokejumper was well below the other eight and on a spur ridge towards the South. He worked his way back to the main ridge to the large opening designated the "lunch spot." He did not deploy a fire shelter and stayed in this area throughout the entrapment.

The ridge along which all nine smokejumpers stopped has many grassy areas scattered among sparse pinion-juniper stands. The larger grassy openings on benches along the ridgeline are good deployment sites.

Site Analysis

Radiant heat fluxes from fire runs to the south were .5 cal/cm²/sec or lower. Temperatures would be 300-800° F. These conditions are usually not life threatening even without a fire shelter, but radiant heat burns would be likely. Shelters in this area prevented radiant burns and would considerably reduce smoke inhalation.

Only one shelter in this area was examined, and it showed no heat damage. Two of five PVC plastic bags were partially melted, and three had no damage, showing only spotty burning of ground fuels in the immediate area.

Lower down at the "lunch site" the single jumper did not receive burns or significant smoke inhalation. The grass in this opening did not burn.

Summary

With the exception of the smokejumper at the lunch site, all firefighters at this location took actions that maximized their safety, comfort, and survival. All entrapment sites were well chosen and were the best spots in the immediate vicinity. These jumpers remained in their locations for about 1 to 2 hours, then proceeded to the main entrapment site to check for survivors.

Escape From The Ridgeline

Crew Movement

Those who escaped the fire were mainly BLM/Forest Service firefighters, Prineville Hotshots, and smokejumpers working on top of the ridge. These crews were removing fuels, digging fireline, and catching spot fires on the ridgeline. At the time of the blowup there was some indecision about the best escape route to take. After attempts to move up to Helispot 1 were cut off by the fire, all three crews decided to drop off the ridgeline into the east drainage but chose different routes down. The route out the east drainage was not a pre-established escape route.

Site Analysis

The heat fluxes on ridgetops would have been up to 1 cal/cm²/sec and below with temperatures below 1200° F. A shelter dropped on top showed no damage, but packs and tools burned on the ground were likely ignited by ground fires after the flame front subsided. Wider spots on the ridgetops are generally safe deployment sites in the absence of heavy ground fuels. Fire shelters are usually deployed safely on the lee side of ridges from the flame front with movement back towards the center of the ridge if the other side ignites.

Spot fires were observed higher up the east drainage, so it was a gamble whether a spot fire would ignite below the escaping crews. The crews moved quickly down to the highway, arriving there before this canyon burnt out. Smoke and visibility were not problems in the canyon, and the downhill route allowed rapid egress. Most these firefighters had fire shelters and were prepared to deploy them should a fire come up from below.

Summary

Under very adverse conditions these people made the decision to head down the east drainage. Recognizing that the entire canyon had the potential to burn out, they rapidly moved down canyon. They also had injured people, and this was the quickest way to get them out for aid. They had a backup plan to find alternate deployment sites if necessary. Considering the number of people and the rapid descent, this was a well executed escape.

Entrapment Along The West Flank (12 Fatalities)

Crew Movement

When the Jumper in Charge gave the order to escape, he headed north along the west flank and met up with the Prineville crew and the smokejumpers. This crew was likely digging line at the time. From their estimated location they moved about 1,425 feet to where they were trapped, carrying all their tools and equipment as they moved towards the saddle at the top of the fireline. It is estimated that they walked 1,108 feet and ran the last 317 feet.

Afternoon temperatures were in the low 80s and possibly cooler under the Gambel oak. There was no mention of smoke hindering breathing or visibility. Before arriving at this fire, members of all crews would have been acclimatized to both heat and altitude. Heat and altitude thus were not significant factors. The dense Gambel oak would have hindered rapid movement, so the only escape option was back along the fireline. With limited visibility, the firefighters may have relied mainly on hearing to track the fire progress across the canyon below them. As they started out, their main challenge was to pace themselves to get to this saddle as quickly as possible. It is estimated that they walked for about 5 minutes, moving 1,108 feet.

The fire, which had crossed to the adjacent hillside, kept pace with the crew's retreat. When the fire spotted back onto the slope below them and started uphill towards the saddle, its rate of spread increased. The crew started running toward the saddle, and within a minute two smokejumpers stopped to deploy their fire shelters. Nearby, two firefighters observing the crew running toward them and two firefighters coming up behind the smokejumpers continued to run up to the top of the ridge, 212 feet further up the hill.

Three of the firefighters barely reached the top of the ridge before the fire and received radiant heat burns before cresting the ridge. A fourth firefighter was caught 121 feet from the top. Below, the two smokejumpers fully deployed their fire shelters, but the remaining firefighters did not have time to get under their shelters before the fire caught them. All crew members were still carrying tools and packs when they stopped to deploy shelters.

Site Analysis

A clear temperature gradient exists from the bottom of this entrapment site to the top of the ridge. Six people were found in a group 270 feet from the top, five people were found in a group 212 feet from the top, and a single person was found 121 feet from the top.

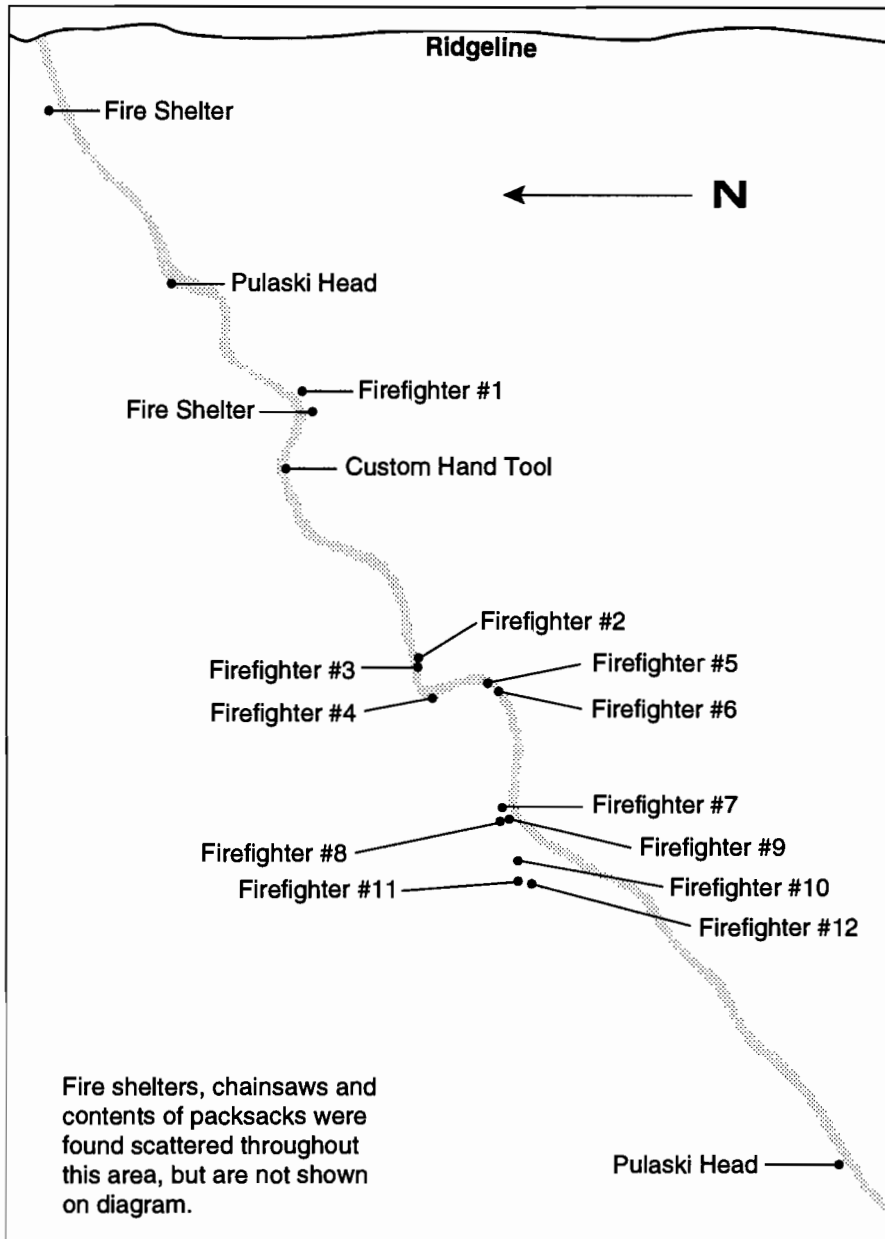
South Canyon Fire

For the bottom group of six, estimated heat fluxes were 2 cal/cm²/sec, and temperatures were in the 1600-2000° F range. This site was not survivable

even in a fire shelter. Except for fire shelters, all items dropped on the ground were completely consumed.

In the middle group two people were able to get under their fire shelters, and the three others did not have time to get their shelters fully opened. Estimated heat fluxes were about 1 cal/cm²/sec, and temperatures were in the 900-1600° F range. At this level some tools and items dropped were only melted or partially consumed. Fire shelters have worked successfully in these conditions in other instances. Fire shelter failure was likely due to an interaction between the heat, which would cause delamination between the foil and glass cloth, and extreme turbulence which would cause the foil to start cracking and then tear off in pieces. In addition, shelters were deployed perpendicular to the direction of the flame front rather than the recommended orientation of feet toward the flame front. This shelter orientation increased the effect of the turbulence and the chance for flames to enter the shelters. Flames under the shelter can cause disintegration within seconds.

Fatality Site



- | | | |
|----------------------------|--------------------------|-------------------|
| 1. Scott Blecha | 5. Doug Dunbar | 9. Jon Kelso |
| 2. James Thrash — Deployed | 6. Roger Roth — Deployed | 10. Rob Johnson |
| 3. Kathi Beck | 7. Tami Bickett | 11. Don Mackey |
| 4. Terri Hagen | 8. Levi Brinkley | 12. Bonnie Holtby |

One person's shelter blew off from the foot end, turning inside out and exposing the occupant to increased heat. Packs within the shelter contained fusees, which when touching the side of a shelter would easily ignite and could have melted the glass webbing hold-down straps. Alternatively, the occupant may have moved his feet up away from the fusees, thereby releasing the shelter bottom. Also the fusees may have ignited after the shelter blew off or after the shelter disintegrated from the heat and turbulence of the flame front.

The other firefighter under a shelter also encountered complications. Evidence suggests that the person to his left lifted the edge of the shelter off the ground and may have been partially under the shelter. The occupant rolled over onto the right side of the shelter, lifting the left edge off the ground. Since the flame front was passing from left to right, flames are likely to have entered the shelter. Alternatively, shelter failure starting on the left side may have caused the occupant to roll over to the right side.

In both cases, shelters coming off the ground would destroy the shelters, voiding the occupants' main protection. It is not clear if conditions at this level reflect marginal shelter operational conditions or if human error contributed to the failure of the shelters.

The evidence from burn patterns indicates that the flame front came across the fireline at an angle toward Helispot 1. The six people at the bottom of the site were caught fully in the flame front, with the people in the middle more on the upper edge. After the main flame front passed, the wind changed to straight uphill to the saddle. This crossing pattern gave the people who ran out the top extra time to escape before the fire turned back toward them.

At the top, site conditions were well within the fire shelters' design. Heat fluxes were below 1 cal/cm²/sec, and temperatures were below 1200° F. with ground temperatures in the 300-600° F range. Polyethylene canteens were partially melted, indicating that this site is survivable in fire shelters.

Since this crew walked part of the way out, an analysis was made based on the assumption that they ran all the way out. Another analysis assumed that they dropped all their packs and tools and could move quicker exerting the same amount of energy. Both analyses reveal that the firefighters would have reached the top of the ridge before the fire if they had perceived the threat from the start.

Summary

There was a clear temperature and heat flux gradient from the bottom of the site to the top. Survivability increased the further up the hill people went. Actions such as running and dropping packs and equipment would have resulted in greater survival chances further up the hill or over the top.

Helitack Crew (Two Fatalities)

Crew Movement

When the crews were given the word to initiate escape actions, two helitack crew members choose to run north along the ridgeline. The survivors yelled for the two helitack crew members to follow them, but the two helitack yelled back that the others should follow them. As these two headed north along the ridgeline, they passed through areas with high shelter survival rates. At some point they left the ridgetop and headed northwest into a narrow chute with minimal survival chances. Possibly brush and smoke obscured the chute. From the ridge the land looks smooth and there is a large rock outcrop on the other side of the chute, which was their likely goal. A game trail contours from the ridgeline over to the chute below the rock outcrop and was their likely route. The fire caught them in the draw below the rock outcrop. Both people carried their tools, packs and flight helmets into this site.

Site Analysis

Heat flux here is estimated at 1-2 cal/cm²/sec with temperatures in the 1200-1800° F range. Items dropped on the ground were completely consumed at the lower end of this site with some partially consumed items near the top (40 feet away). Some dissipation of heat is apparent due to less charring on the trees further up the chute near the rock outcrop.

Both victims started to deploy shelters but were overcome by heat and smoke before they got the shelters fully opened. Although shelters normally work well in rock piles, the funnel effect for heat and smoke in this location made the shelters unsurvivable. Helitack firefighters Richard Tyler and Robert Browning perished at this site, with Tyler a little higher in the chute than Browning.

Summary

It is not clear why the two helitack firefighters did not join the others going down the east drainage unless they felt it was ready to burn out. Since they left the relative safety of the ridge, they either did not recognize the good deployment spots or felt the rock outcrop offered more safety. If so, they only needed another minute to get there and possibly would have made it if they had run without tools and packs. In addition, smoke from the fire below probably interfered with visibility and breathing and slowed their progress.

Appendix 4 — South Canyon Fire

Chronology

June 14

The Grand Junction District Management Team discusses the high fire danger and decides that, because of severe fire conditions and limited fire-fighting resources, all fires will be initial attacked and put out as soon as possible.

July 2

Grand Junction District has 22 new fire starts and six carryover fires, two of which are Type II. At about 1800 hours Mrs. Temple of the Glenwood Springs area observes a lightning strike that hits a tree on the ridge east of her house. Shortly thereafter she sees smoke but no flames on the ridge.

July 3

Grand Junction District is in moderate to very high fire danger conditions and planning level 4 (on a scale of 1-5). Lightning storms over the past 2 days have started more than 40 fires. The District has developed a priority list for initial attack. Winds have hampered the use of aircraft. Initial attack resources are taxed, and more lightning is scheduled for tomorrow with a red flag warning.

- 1100 hours Garfield County Sheriff reports the South Canyon fire to Grand Junction District Dispatch. The initial report considers the fire to be on private land. Reporting the fire to be two trees torching and to have a high spread potential, the Garfield County Volunteer Fire Department asks if it can get air support. The District Fire Management Officer replies that the district is fully committed but that air attack assistance will be requested if action is needed. Dispatch asks if the Sheriff will approve air support (according to an agreement for private lands).
- 1410 hours The Sheriff's Office reports to District Dispatch that the fire covers a half acre and is very active and that the Sheriff approves the use of aircraft.
- 1412 hours Dispatch radios District Fire Control Officer Winslow Robertson, asking him to respond. He is enroute from Rifle.
- 1416 hours Dispatch calls Western Slope Fire Coordination Center and requests one load of jumpers (J49), an air tanker (T140), and

South Canyon Fire

a lead plane (64) to South Canyon fire (and other fires reported in the area).

- 1414 hours Clay Fowler, BLM Engine (E611) foreman, meets with the Garfield County Sheriff along Interstate 70. He completes the initial sizeup for BLM and reports that only the burning canopies of two trees are visible and the fire has a low potential for spread. He recommends that the fire be observed because of steep slopes, inaccessibility, low rate of spread, and presence of other priority fires in the area. The fire is confirmed to be on BLM-administered land. Winslow Robertson arrives later at the scene and concurs with Fowler's assessment.
- 1438 hours Aircraft Jumper 49, Lead Plane 64, and Tanker 14 are off the ground to the South Canyon fire.
- 1508 hours Air Attack (Lead 64) reports that fire is 1 to 1.5 acres, is burning on the ridgetop, is spreading downslope slowly, that no structures are in danger, and that continuous fuels are in all directions. Dispatch requests that Lead 64 attack other fires in the area.

Winslow Robertson arrives back in Grand Junction to assess fire activity and plan for July 4. He calls Western Slope Fire Coordination Center and requests more resources for the South Canyon fire. He also calls the Craig District to have Grand Junction District resources released from the Copper Spur fire.

July 4

Five new fires start on July 4, two of which are 100 acres or larger. Thirty-one existing fires remain uncontrolled. Local initial attack is spread thin. Radio communication is inadequate for the fire load and is a safety concern. Fire danger is very high to extreme with more lightning forecast for July 5. A red flag warning has been issued.

The District Fire Management Officer and the Western Slope Fire Coordination Center Manager discuss the need for more firefighting resources on the South Canyon fire. More resources are ordered.

Butch Blanco and Brad Haugh are released from the Copper Spur fire and go directly to the South Canyon fire.

- 1450 hours A resident reports that fire activity has increased and needs attention. White River National Forest relays that an engine from the Sopris Ranger District (Shroeder) is enroute.

- 1630 hours Butch Blanco and crew (Bureau of Land Management) and Sam Shroeder and crew (USDA Forest Service) arrive at the scene to initial attack fire but decide to delay initial attack until morning because of terrain, imminent darkness, safety concerns, and equipment needs. Blanco and crew return to their office to rehabilitate their tools from past fires and prepare for the South Canyon fire.
- 2100 hours Dispatch receives a call from a concerned homeowner who says that fire is moving aggressively downhill. Dispatch requests a report from the Garfield County Sheriff's Office. Garfield County reports little change in fire activity.
- 2109 hours The White River National Forest aerial observer flies over the fire and reports that it is burning in all directions on steep and inaccessible terrain to the northeast on the ridge. The terrain is too steep for crews, and there are few if any escape routes. He suggests bucket drops.
- 2320 hours Dale Shanholzer (White River National Forest) calls Grand Junction District Dispatch and says that Shroeder, on another fire, wants him to relay to BLM Dispatch that he is not available and that they need to find resources to help Blanco on the South Canyon fire. Shroeder has ordered two crews for the Mamm Creek fire and would send firefighters to the South Canyon fire if he does not need them all. Dispatch relays this message to Blanco.

July 5

Very high to extreme fire danger with a red flag warning.

- 0405 hours Blanco calls Dispatch and requests that Engine 651, Jim Byers and Mike Hayes be assigned to the South Canyon fire.
- 0630 hours Blanco (Incident Commander), Brad Haugh, Janie Jarrett, Neil Shunk, Michelle Ryerson, Loren Paulson, and Brian Rush walk into the fire from the east drainage. They cut a helispot (Helispot 1) on the ridge above the fire and begin direct line construction flanking the fire down the hill westward from helispot.
- 0819 hours Blanco calls Dispatch to confirm that Engine 651, Byers and Hayes, will be assigned to the fire. He also requests a crew and helicopter. A discussion of resources results in a decision to use smokejumpers.

South Canyon Fire

- 0832 hours Grand Junction Dispatch orders one load of eight jumpers with a requested delivery time of 1200 hours.
- 1420 hours Blanco orders one retardant drop.
- 1500 hours The air tanker drops retardant along the fireline built down the hill to the west from Helispot 1.
- 1716 hours Blanco receives the second air tanker drop on the flank over the highway. The pilot discusses the location of the drop with Blanco and the problem of rolling rocks on Interstate 70. The pilot says he cannot safely meet Blanco's needs and recommends a helicopter with bucket as much more efficient.
- 1730 hours Taking a route down the west side, the BLM crew leaves the fire because all of their chainsaws are broken. On the way out, Blanco discusses with the crew the hazards of building a fireline downhill.
- 1745 hours Smokejumpers Mackey, Doehring, Woods, Rhoades, Soto, Archuleta, Shelton, and Erickson arrive. The Spotter describes the fire as 30 acres, on extremely steep terrain, and burning downhill in all directions. The fire has potential to spread the next day if it gets into the bottom of drainages. Light winds are reported. A smokejumper reports that the winds are erratic and that jumpers are scattered over the flank of Storm King Mountain.
- 1944 hours Jumper in Charge Mackey calls Blanco on the radio and reports that fire has crossed the handline to the west and is burning actively.
- 2000 hours The smokejumpers start building a fireline down the east side of the fire from Helispot 1.
- 2230 hours The BLM crew and Blanco finish preparing their gear at the BLM District Office and cache and go home for the night.
- 2310 hours Mackey orders two Type I crews.

Not all resources were documented. Blanco may have requested more resources, but the requests were not recorded on either the resource orders or in the dispatch logs. Entries in the dispatch logs are made selectively, with a subjective decision made on what entries to write down.

July 6

Thirty-six fires are burning in the Grand Junction District. The fire weather forecast for the Grand Junction area: increasing high clouds in the morning, with winds of 10-20 mph by 1100 hours, winds increasing to 15-30 mph by 1300 hours. At about 1500 hours, surface winds will shift to the northwest at 15-25 mph and would gust to 30-35 mph with passage of the cold front. RED FLAG WARNING.

- 0030 hours Smokejumpers stop building fireline on the east side and return to Helispot 1. Line construction is ineffective and dangerous because of poor footing and many rolling rocks.
- 0300 hours The fire is burning actively on the ridgeline with 10 mph winds blowing from the east. Smokejumpers decide to move their gear first thing in the morning because the fire could threaten it at the jump site.
- 0430 hours Dispatch relays to the Incident Commander via telephone a summarized version of the fire weather forecast. The report forecasts windy conditions with passage of the cold front.
- 0430 hours The BLM/Forest Service crew of 11 begins its 3.5-hour hike to the fire, taking an east drainage route that differs from the previous day's. Expecting to spend the night, the crew carries extra saws, gas, food, and water.
- 0528 hours Mackey orders a helicopter with a long line for gear removal, reports that fire grew during the night, and requests a fixed-wing aircraft with an aerial observer. He plans to finish the fireline from Helispot 1 along the ridge to the north and gather the jump gear.
- 0630 hours Prineville Interagency Hotshot Crew is assigned to fire.
- 0709 hours Mackey calls Dispatch requesting that the Prineville Hotshots be ferried into the fire by helicopter and that he have the use of the helicopter for reconnaissance.
- 0800 hours The BLM/Forest Service crew arrives at the Helispot 2 site and starts cutting the helispot. Smokejumpers and the BLM crew build a fireline from Helispot 1 to Helispot 2, burning out islands of unburned fuel along the ridge.
- 0800 hours The Prineville Hotshot Crew departs Grand Junction.
- 0830 hours The smokejumpers complete a scratchline between Helispots 1 and 2 and then go to the jump site to gather their gear.

South Canyon Fire

- 0845 hours Blanco and Mackey discuss strategy and tactics for the day. They plan to improve and widen the handline between Helispots 1 and 2. They intend that half of the Prineville Hotshots work with the jumpers building the fireline on the west, and the other half build a fireline on the east side of the fire.
- 0900 hours Some of smokejumpers and Blanco listen to the NOAA radio channel and receive the Grand Junction area weather forecast.
- 0915 hours In response to community concern, Glenwood Springs Fire Chief requests information on how many people and how much equipment are on fire. Blanco is told that he can keep the smokejumpers and is informed that a second load will soon be heading his way.
- 0930 hours Helicopter 93R arrives at fire, but only 4 hours of flight time are available because Western Slope Fire Coordination Center anticipates initial attack needs. Mackey and Blanco take a reconnaissance flight of the fire. Mackey radios smokejumpers on the ground, directing them to begin building a fireline downhill. The smokejumpers question Mackey's strategy, ask him if there are any safe areas, and say that they want to talk about the strategy when he completes his flight.
- 1027 hours The aircraft "Jumper 17" arrives over fire, and smokejumpers Hipke, Thomas, Petrelli, Longanecker, Cooper, Feliciano, Roth, and Thrash parachute out. Wind at this time is blowing at 0-5 mph.
- 1113 hours Jumper 17 leaves site.
- 1115 hours A tree torches 40 yards from the top of ridge and ignites a 5-foot wide reburn of Gambel oak. The fire runs to the top and causes a spot fire across fireline. The helicopter drops water, and the crew controls the spot.
- 1130 hours The smokejumpers start downhill, building a direct fireline from the location flagged by Mackey on the ridgeline. Longanecker is scouting the fireline. The smokejumpers are building a 6-7-foot wide line with a 16-18 inch scrape.
- 1200 hours The Prineville Interagency Hotshot Crew (IHC) arrives at helibase.

- 1230 hours Ten Prineville Hotshots arrive at Helispot 2. Mackey, Blanco, and Prineville Hotshot Superintendent Shepard discuss strategy and agree to send the first half of hotshots down to cut fireline with the jumpers on the west flank and use the second half to build fireline on the east flank. Blanco and Shepard go to Helispot 1 to discuss strategy.
- 1245 hours Nine hotshots start down hill.
- 1300 hours The fire flares up on west flank. The jumpers consider retreat but decide to proceed after an effective water drop.
- 1300 hours A cold front arrives in Grand Junction.
- 1330 hours Firefighters on the ridgeline break for lunch.
- 1400 hours Some jumpers and hotshots have lunch on the southwest corner of the fire at a designated location known as the lunch spot.
- 1430 hours After lunch Sara Doehring, Eric Hipke, and Kevin Erickson are directed to go back to help hotspot and improve the line.
- 1445 hours Mackey walks down from the ridgeline and directs Doehring and Erickson to carry the chainsaw back up the hill. Longanecker goes downhill to scout the next section of fireline off the lunch spot.
- 1500 hours The second group (10) of hotshots arrives at Helispot 2 and helps hold the fireline along the ridge. Longanecker goes down the hill to scout next section of fireline south from the lunch spot.
- 1515 hours The helibase reports that fire activity is picking up west of Helispot 1.
- 1520 hours As forecast, a cold front moves into fire area.
- 1523 hours The fire spots across the ridgetop fireline. Blanco asks Ryerson to scout the ridgeline. She is joined by Scholz (Prineville Hotshots), who reports that there are spot fires across the line. Bucket drops are called in. Blanco reports to Dispatch that winds have picked up and fire activity has increased.
- 1530 hours Crews complete widening fireline on the ridge between Helispots 1 and 2.

South Canyon Fire

1530 hours Longanecker (line scout west flank) requests two sawyers and diggers to help in the drainage. Thomas and Petrelli are sent. They observe increased fire activity. Longanecker gets a water drop.

1545 hours Fire rapidly runs up the draw within burned area toward Helispot 1 in several places above Longanecker with 100-foot flame lengths. Petrelli suggests that Longanecker get out of there.

Longanecker requests a water drop in the bottom. The helicopter is directed to the ridgeline instead. Longanecker directs Petrelli to stay in the gully until helicopter returns. Longanecker stays down hill about 200 yards from the bottom.

The firefighters improving the handline noticed the fire activity and started moving up the line towards the top of the ridge.

1600 hours The fire crosses west drainage at base of gully below Longanecker. It immediately starts to run for the ridge on west side. Petrelli calls Longanecker to tell him to get out of bottom. Winds become extremely strong.

1600 hours Ryerson radios for a second bucket drop on ridgeline. The fire blows up. Blanco directs Mackey to bring firefighters up from bottom.

1602 hours Petrelli radios Mackey and tells him that the fire has crossed the canyon and is running. Mackey asks if the fire has crossed main canyon. Petrelli says "yes" and that it's "rolling."

1604 hours Kelso calls Shepard and says that they have a spot below them. Blanco directs the hotshots on the ridge and the BLM/Forest Service firefighters to go to Helispot 1 into safety zone.

1611 hours Blanco radios Dispatch to report that he is losing the fire on the side towards the homes and needs retardant.

1620 hours Air tanker is dispatched.

Events between 1600 and 1624 hours are described separately for the four main groups involved.

1. Jumpers That Deploy Their Fire Shelters Below Helispot

Thomas and Petrelli notice that the fire is in the gully and has crossed to the other side of the main drainage. At about 1610 the jumpers meet Mackey at the lunch spot. Mackey tells them to climb the hill and they will find a good burned safety area below Helispot 1. Petrelli calls Longanecker and tells him to get out of there into the burned area. They last see Mackey as he leaves to check on Longanecker. Mackey tells the other firefighters on the ridge to go to Helispot 1. The jumpers climb the hill to seek an adequate safety zone and to distance themselves from the blowup. The smokejumpers drop their Sigg bottles and saws partway up the hill. Soto has leg cramps and falls behind. Woods stays back with Soto. Woods and Soto deploy their shelters between the upper group and the saws. Six other firefighters (Thomas, Petrelli, Cooper, Feliciano, Shelton, and Rhoades) move up just below Helispot 1 and have time to clear areas and remove their chainsaw chaps. They have difficulty deploying their fire shelters because of winds strong enough to blow their hardhats off. The smokejumpers radio Mackey between 1619 and 1621 hours to report that they are in their shelters. The six smokejumpers at the upper site move into shelters at 1624 hours. They do not remember Mackey's reply. They remain in their shelters for about 1.5 hours until Longanecker arrives at site. Longanecker waits out the fire near lunch spot and does not deploy a shelter.

2. Group on Ridgeline

Half of the Prineville Hotshots, Ryerson's squad, and the two helitack crew members (Tyler and Browning) are on the ridgetop at this time. Byers is working the farthest up the line toward Helispot 1, and the hotshots are all working the spot fire or are nearby. Fire activity is increasing, with several spot fires. Ryerson calls in water drops. At 1604 Blanco gives the order to proceed to Helispot 1. They make it to the big rock just below the burned area when they receive the message that the way up is blocked and they should turn around and go to Helispot 2. Archuleta waits just north of the point where the fireline ties into the ridge, until all the firefighters coming down from Helispot 1 pass him. He then follows them toward Helispot 2. Everyone runs to the red packs, where Blanco and Shepard direct them down the east drainage. This is the last point of contact with Tyler and Browning, who from the ridgeline yell at everyone to go up the ridge. They are told to drop down into the drainage but choose not to.

3. Group on the West Flank

The hotshots and smokejumpers are improving and holding the fireline between the lunch spot and the saddle. Doehring and Archuleta have already worked their way back up the hill with the chainsaw. Erickson arrives at the tree from the bottom and stops there with Haugh. Haugh and Erickson decide to stay until the crew is in view. Erickson can see the fire running up the opposite side of the drainage. As they are waiting, the fire

becomes very active, and crews are directed to move out of the bottom. As the crew comes into view, the fire spots across the drainage to the east side below them in the bottom of the drainage. Erickson radios Mackey between 1614 and 1618 to tell him about the spot fire below him. Erickson takes a picture as the crew comes into view and flames roar over the spur ridge behind the firefighters. He puts his camera around his neck, and Haugh grabs him to go up the hill. From the ridgeline Doehring and Archuleta can see the last two firefighters in line. Reaching the tree where Erickson and Haugh are standing, Thrash says to deploy shelters. Haugh turns and runs to the ridge, followed by Erickson. Haugh reports that the crew is walking briskly but is still in line, carrying equipment and apparently not aware of the closeness of the fire until Erickson radios Mackey that fire has spotted directly below them. Hipke says that they walked quickly when they went up the line until they got to the last steep pitch. Hipke does not deploy because of the density of the fuels. He runs around Roth and Thrash. About halfway up the last pitch he sees Erickson and Haugh telling the firefighters to drop equipment and run. The rest of the crew is 20 to 30 yards behind Hipke. Hipke is running, while trying to remove his shelter from its case. A blast of hot air knocks Hipke to the ground. He thinks the main heat passes over him. Haugh described the main fire cresting the ridge with 200- to 300-foot flame lengths 2 to 3 seconds after he bailed over the top. Hipke dives over the top of the ridge, and Haugh, Erickson, and Hipke run 200 to 300 feet and stop. Erickson and Haugh then attend to Hipke's burned hands. Doehring and Archuleta believe that 30 to 45 seconds elapse between when they take their photo and when the fire crests the ridge. Erickson believes that the spot fire moved from the bottom of the drainage to the top of the ridge in about 30 seconds.

The people that dropped off the ridge to the east take various routes down the drainage. The fire moves down to the mouth of the drainage about 30 to 40 minutes after the last person has escaped.

4. Helitack Crew

The helitack crew (Tyler and Browning) were at Helispot 2 directing helicopter operations. They are last seen going up the hill from Helispot 2. Blanco and Shepard direct them down the east drainage, but they continue up the ridge out of sight, yelling "Run the ridge." That is the last contact with them. Helicopter 93R pilot Good attempts radio contact but receives no answer. Tyler and Browning run the ridge above the jump site. The fire funnels through the saddle at the jump site and cuts off a route to the east. The slope to the northwest looks relatively flat with rock outcrops. The route appears to be the best. Being flanked by the fire, Tyler and Browning head northwest. In 150-200 yards they run into a steep 50-foot-deep rocky chute. Trying to cross the chute, they are caught by the fire in the bottom.

Winslow Robinson assumes the responsibility for managing the South Canyon Fire at about 17:00 hours on July 6. An interagency Incident Management Group manages the fire from 1900 hours until noon on July 7. At this time, Jack Lee's national Type I incident management team assumes management of the fire.