Behavior of the Life-Threatening Butte Fire: August 27–29, 1985*

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On August 29, 1985, 73 firefighters were forced into safety zones, where they took refuge in their fire shelters for 1 to 2 hours while a very severe crown fire burned over them. The incident took place on the Butte Fire on the Salmon National Forest in Idaho. Five firefighters were hospitalized overnight for heat exhaustion, smoke inhalation, and dehydration; the others escaped uninjured. Investigators estimated that without the protection of the escape zones and the fire shelters, at least 60 of the 73 firefighters would have died. Thanks to preparation of safety zones, the effectiveness of the fire shelters, and the sensible behavior of the firefighters themselves, disaster was averted.

Behavior of the Butte Fire, particularly its explosive movement on the afternoon of August 29, is of vital interest to fire behavior specialists, individual firefighters, and leaders who make tactical decisions based on fire behavior projections. That an already large and intense fire could rapidly escalate to even higher intensity—some have called it a firestorm—and move fast enough to overrun 73 firefighters warrants review by anyone concerned with fire management.

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Seventy-three firefighters were forced into safety zones; without escape zones and fire shelters, at least 60 of the 73 firefighters would likely have died.

Immediately after the shelter incident, a review team was dispatched to the Butte Fire to document the meteorological conditions and fire behavior that contributed to the life-threatening run up Wallace Creek. Results of the analysis were distributed to all wildland fire management agencies early the following week. The review team was composed of Dennis Martin and Hank Walters, Forest Service Intermountain Region; Clyde O'Dell, National Weather Service; Dick Rothermel, Intermountain Fire Sciences Laboratory; and Bob Mutch, Forest Service Northern Region. The purpose of this article is to augment and expand the results of the initial review through additional interviews with those who had been on the fireline and an analysis of photographs taken during and after the fire run. Art Jukkala and Ted Putnam of the Missoula Equipment Development Center have also prepared a report on the performance of the fire shelter based on many interviews with those who used it on the Butte Fire (see Jukkala and Putnam 1986).

A separate review of the Butte Fire and adjacent fires in the Salmon River (termed the Long Tom Complex), conducted by the Forest Service Intermountain Region in October 1985, examined such topics as strategy, tactics, and other issues. The results of this review are on file in the Forest Service regional office in Ogden, UT.

Fire Environment

Severe drought characterized weather in the Butte Fire area throughout the summer of 1985, contributing to critically low fuel moisture levels. The fire weather station at nearby Indianola along the Salmon River measured only 0.31 inch (0.79 cm) of precipitation in June and 0.23 inch (0.58 cm) in July. Although more than half an inch (2.5 cm) of precipitation fell on two different days in early August, some of this as snow, only 0.12 inch (0.30 cm) fell between August 13 and August 31. At a remote automatic weather station near the fire, 1,000-hour fuel moisture readings from the National Fire Danger Rating System were rated at 8 percent prior to the run up Wallace Creek.

The weather on the Butte Fire from Monday, August 26, though Friday, August 30, was not unusual considering the location. Elevation at Base Camp was 7,400 feet (2,300 m); elevations on the fire ranged from 6,400 feet (2,000 m) near the confluence of Wallace and Owl Creeks to 8,200 feet (2,500 m) near the two safety zones. Typical late afternoon maximum temperature reached 70 to 78 °F (21–26 °C),

with minimum relative humidity in the 12 to 21 percent range at Sourdough Base Camp. The windiest period each day occurred between 1400 and 1500 mountain daylight time. The velocity was generally between 10 and 12 miles per hour (16–19 km/h), with stronger gusts. Inversions occurred each day, breaking between 1130 and 1330. Weather on the day of the blowup, August 29, was not unusual, either. In the afternoon the temperature reached the mid-70's (23–25 °C), and minimum relative humidity was in the upper teens. At base camp, low-level winds were out of the south at 8 to 12 miles per hour (12–19 km) in the afternoon, with occasional gusts to 17 to 20 miles per hour (27–32 km/h). District personnel reported that fuel loadings ranged from 80 to 100 tons per acre in spruce–fir stands in drainage bottoms, to 25 to 40 tons per acre in higher elevation lodgepole pine–fir stands. Fuel models 8 and 10 characterized most of the Wallace Creek drainage.

One unusual feature of the area threatened by fire was the topography. The upper slopes did not converge into sharp peaks as is commonly the case in the Rocky Mountains, but tended to be domelike, with continuous crown cover. Wallace Creek itself was a well-defined north–south drainage that became progressively steeper at its headwaters near the two shelter sites.

General Fire Behavior

The Butte Fire was started by lightning on July 20, 1985. This fire was part of the Long Tom Fire Complex in the Salmon River drainage, which included the Corn Lake, Bear, Fountain, Goat Lake, and Ebenezer Fires. The Butte Fire was first contained on August 5 at just over 20,000 acres (8,100 ha). Strong winds fanned smoldering fuels and spread fire across control lines on August 24 and 25. Fire activity peaked on August 27, 28, and 29, as the fire made runs of 1,000, 2,000, and 3,500 acres (400, 800, and 1,400 ha) respectively. About 3,000 of the 3,500-acre (1,200 of 1,400-ha) growth on August 29 reportedly occurred in about 90 minutes.

> At least three large whirlwinds passed over that were strong enough to knock people off balance.
>
> *—Firefighter Steve Karkanen, describing the fire from a safety zone*

It was during this run up Wallace Creek that the 73 firefighters deployed their fire shelters. Simultaneously, another run of lesser severity occurred in Owl Creek, the drainage east of Wallace Creek. Both columns were characterized by dense black smoke. By midafternoon the Wallace Creek column had reached 15,000 to 17,000 feet (4,600–5,200 m) above terrain and had a firm cumulus cap. Another area of intense fire activity took place on the western flank where the fire spread northward but was apparently pulled into the main fire in Wallace Creek.

Events of August 29

On August 29 wind velocities were not especially high. In the early afternoon, eye level winds were measured at 7 to 8 miles per hour (11–13 km/h) at the confluence of Owl Creek and Wallace Creek. At the higher elevation near the head of Wallace Creek, the local winds were stronger. Division Supervision Jim Steele estimated winds to be 10 to 15 miles per hour (16–24 km/h), with gusts to 20 miles per hour (32 km/h) across the ridges. Measurements nearby confirmed this estimate, but with gusts of 25 to 30 miles per hour (32–48 km/h).

Figure 1 shows the fire area at 0200 in the morning on August 28, the day before the big run, and its extent by 2200 in the evening. By 0200 in the morning of August 29, the fire had spread considerably further, having crossed the lower end of Wallace Creek and moved up the ridge toward Owl Creek. The burned areas in lower Wallace Creek were patchy. Of special importance on the morning of August 29 were the spot fires in the middle portion of Wallace Creek and along Owl Creek at the southeast corner of the fire.

An understanding of the fire control operations is essential to understanding many events during the 29th. Having had little success at close-in direct attack on the 26th and 27th, the overhead team had decided to use an indirect attack strategy. On the 28th and 29th, a tractor line was built along the main ridge on the north end of the fire, approximately 1.5 miles (2.4 km) north of the nearest spot fires in Wallace Creek (fig. 1). Fortunately, the line construction included several safety zones 300 to 400 feet (90–120 m) in diameter at approximately 1/4-mile (0.4-km) intervals. The plan for the 29th was to conduct a burnout operation in the late afternoon when humidity was expected to rise. An aerial drip torch would be used for center firing in the upper end of Wallace Creek. Crews were to be dispersed along the line to burn out from the line after a convection column was developed.

Each time they were hit by a new wave of fire, the firefighters moved, crawling along the ground inside their shelters searching for cooler areas of the safety zone.

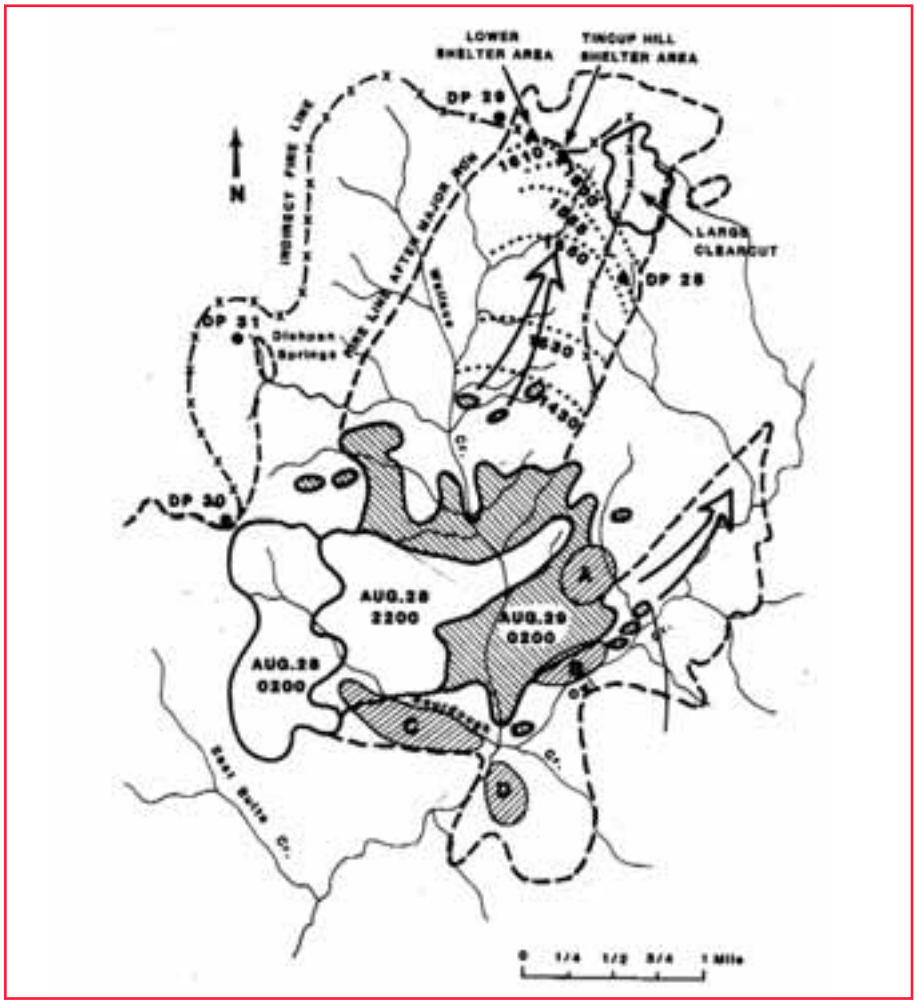

Figure 1—*Arrows depict major fire runs on the Butte Fire during the afternoon of August 29, 1985. The 73 firefighters deployed fire shelters at the lower shelter area and Tin Cup Hill shelter area. Areas A, B, C, and D indicate where the helitorch burnout operation was conducted that afternoon.*

During the morning of August 29, spot fires near the confluence of Wallace and Owl Creeks threatened valuable timber and seemed to have the potential to outflank the control line to the east. Thus, it was decided to use the helitorch early in the day to burn out and stabilize the line in this area. Initial attempts began just to the north of Owl Creek (marked A on fig. 1) about 1200. The area did not burn very well, and ignition attempts were repeated. Bill Williams, the operations chief, reported that this fire was ineffective at developing a significant fire column necessary for improving the fireline.

While attempts to burn out line near Owl Creek were in progress, the fire was developing strength in lower Wallace Creek. Three reports substantiate the development of fire in Wallace Creek. Bill Williams reported a large convection column east of Dishpan Springs. Dave Broberg, division supervisor in Owl Creek, reported two strong columns developing, one near drop point 30 at the upper end of Sourdough Creek and the other east of Dishpan Springs. Gary Orr, the division supervisor on the west side at drop point 30, saw the fire east of him throwing fire brands into Wallace Creek. Orr reported that the fire in this area was becoming active around 1100.

The spots along Owl Creek also became active and developed a strong convection column by 1300 (fig. 2). Smoke from these spots and from the helitorch fire was moving to the north. It appeared to some that these columns were being pulled to the north by the larger column developing to the northwest. With the aid of indrafts to these columns, the helitorch was used to burn out hand line and dozer line in areas C and D near the confluence of Sourdough and Owl Creek.

Meanwhile, Gary Orr at drop point 30 reported lots of fire in lower Wallace Creek. Considerable red coloration could be seen in the smoke columns, and at 1300 or 1400 the fire was intensifying and moving up Wallace Creek. The helitorch continued burning out the line in area C. Later, at approximately 1500, area D was burned according to Bill Williams and Dave Broberg. Photographs looking north taken from a helicopter just to the south of the convergence of Sourdough, Wallace, and Owl Creeks (fig. 2) show the smoke columns building at about 1515. From this vantage point, the strongest column was from the burnout operation and spots in Owl Creek. All of the smoke was moving northward up Wallace Creek. The

firing operation at the south end of the fire was completed successfully about 1550, and the fire was contained along the southern line just as it was reaching full strength in upper Wallace Creek.

Wallace Creek Run

About 1515, Jim Steele, at the northeast end of the fire, who later went into his shelter at Tin Cup Hill, reported that he was walking on the trail above the large clearcut and could see fire coming up over a ridge to the south. He reported that at that time he could not see fire in Wallace Creek because of intervening smoke and trees. The fire he saw to the south was probably coming out of Owl Creek.

Bill Williams reported that about this same time a large, strong convection column was standing over the fire. This column was within the main northern dozer line, and Bill still hoped to use indrafts from the column to complete the planned burnout in upper Wallace Creek. Because a very severe crown fire started moving to the north up Wallace Creek on a western exposure (the east side of Wallace Creek) though extremely heavy fuels, the helitorch was never used in this area as originally planned.

Gene Benedict, the incident commander, was returning to the fire by helicopter between 1500 and 1515 and reported that "while viewing this fire I had three other convection columns in view: Goat Creek on the Salmon National Forest, Hand Meadows on the Payette National Forest (a new start), and a fire on the Nezperce near Cotter Bar. All fires were extremely active with apparent strong convective activity and substantial rates of spread, except for

After 40 minutes in their shelters, they came out, but dense smoke forced them back in again for another 30 minutes; air entering the shelters was remarkably free of smoke.

Figure 2—*Convection column development near the confluence of Sourdough, Wallace, and Owl Creeks at about 1515 mountain daylight time on August 29. These columns originated from spot fires and helitorch operations.*

Goat Creek, which was topographically confined."

After landing, Gene received reports that the fire in Sourdough Creek had moved into Wallace Creek and had started firestorm.* Initial reports said it covered about 2 miles (3 km) in 15 minutes. (This later proved to be an overestimation.) Right after the major run, a second run started on the west side near drop point 30, apparently outside the dozer line. Initially, it spread rapidly to the north, but then veered to the east, probably due to indrafts from the larger column in Wallace Creek. This secondary run threatened firefighters along the line on the west side, who were evacuated by pickup truck and helicopter. Although this rescue was overshadowed by the fire shelter deployment, it was nevertheless an intensive effort accomplished safely.

Neal Davis, air attack supervisor, flew by helicopter around the fire just after 1400 and again at 1515. He provided estimates of the fire location in Wallace Creek before the fire developed the extreme behavior reported later. On his next flight, at 1550, Neal saw the firefighters in the safety zones preparing to go into their shelters.

Firefighter Steve Karkanen, working between drop point 28 and the large clearcut at the head of Wallace Creek, recorded the movement of the crown fire as it progressed up Wallace Creek. Steve

* Although referred to as a firestorm, it should more properly be called a conflagration, which is a severe spreading fire. The term "firestorm" is normally used to describe a severe stationary fire or burnout of an area within a conflagration.

Viewed from the air, ahead of the fire, the flames were estimated to be two to three times the tree height.

took color photographs of the fire, recording his location, the direction he was shooting, and the estimated time and location of the fire front. His notes were especially helpful in reconstructing the fire movement. His notes at 1600 describe the nature of the fire as it passed around the large clearcut:

> *Experiencing intense heat and high winds from all directions. At least three large whirlwinds passed over that were strong enough to knock people off balance. The area became too smoky and dusty to take photos. The smoke column completely enveloped everyone, and it was impossible to see the fire. Visibility was reduced to zero several seconds at a time, the air was very hot, and the area was showered with burning embers. Personnel within the clearcut did not take to their shelters, a dozer was used to build fireline around the vehicles, and the pumper crew worked on small spot fires in flashy fuels.*

Personnel at the lower shelter area reported that the fire reached them at 1610. Jim Steele reports that the firefighters on Tin Cup Hill went into their shelters approximately 10 to 12 minutes before those in the lower area did. This would have put them in their shelters at just about 1600, or a couple of minutes before. Steele further reports that the fire approached them at about 1545 out of a draw to the southeast. While Steele was preparing to get into his shelter, he talked by radio to Strike Team Leader Ron Yacomella at the lower shelter area approximately 1,000 feet (300 m) away. Ron asked if he should start his backfire at this time, which he did. His crew burned out approximately 200 feet (60 m) in front of the lower shelter zone before the fire hit at 1610. Their backfire started easily. At first strong indrafts pulled the fire and smoke toward the fire front, but later the smoke blew back over the crew.

The Nature of the Fire

From observations by Neal Davis, Steve Karkanen, Jim Steele, and Ron Yacomella, we have reconstructed the probable location and time of the fire front as it moved up Wallace Creek and overran the crews (fig. 1). The rate of spread during the run is derived by scaling the distances from the map at each timeline.

It appears that up until about 1530, although crowning and developing strong convection columns, the fire behavior was similar to the behavior observed on the two preceding days (table 1). The spread rate was low, about 1/3 mile per hour (0.5 km/h). After 1530 the fire spread much faster, with an average rate of about 2 miles per hour (3.2 km/h) and a maximum of about 3-1/2 miles per hour (5.6 km/h). This period was described as a firestorm by observers. The fire had to travel slightly over 1 mile (1.6 km) in half an hour to reach the safety zone. In order for the firefighters to reach the large clearcut from the lower safety zone, they would have had to begin the evacuation by 1530.

As with any fire, this one must have moved by surges, with some periods of little or no spread. The reconstructed spread rates are too coarse to show the surges and appear to be slower than the impression received by observers on the ground.

Jim Steele reported that on Tin Cup Hill, firefighters in their shelters were hit by three waves of fire, the first one from the southeast. The second one burned up the north side and then burned back towards them at about the same

Table 1—*Behavior of Wallace Creek fire run on the afternoon of August 29, 1985.*

Time period	*Elapsed time*	*Distance*	*Rate of spread*	
1430–1530	60 min	0.32 mi	0.32 mi/h	26 ch/h
1530–1550	20 min	0.48 mi	1.45 mi/h	116 ch/h
1550–1555	5 min	0.29 mi	3.48 mi/h	278 ch/h
1555–1600	5 min	0.14 mi	1.68 mi/h	134 ch/h
1600–1610	10 min	0.15 mi	0.90 mi/h	72 ch/h

time as the people in the lower safety zone were going into their shelters. The third wave hit from the southwest. Each time they were hit by a new wave of fire, the firefighters moved, crawling along the ground inside their shelters searching for cooler areas of the safety zone. At one time they moved away from the dozer piles of slash that had been made during the clearing of the safety zone. After 40 minutes in their shelters, they came out, but dense smoke forced them back in again for another 30 minutes. The air entering the shelters around the lower edges was apparently remarkably free of smoke.

The fire that overran the crews was very large and very intense. Figure 3 shows the nature of the fire as it passed over the shelters and indicates the size of the column in comparison to the trees. In the original color slide, the convection column shows red coloration for hundreds of feet above the trees. The fire at this time was almost certainly an independent crown fire (Van Wagner 1977).

Viewed from the front, the fire appeared as a wall of flame 200 to 300 feet (60–90 m) high. Viewed from the air, ahead of the fire, the flames were estimated to be two to three times the tree height. The fire front was advancing as a typical standing flame with the base of the fire in the trees. The flames in the front were not seen to be rotating or turbulent. The smoke was rising sufficiently so that the flame could be seen clearly. The column rose nearly vertically, then tilted toward the north. The rear of the column was a turbulent, swirling mass impressive in its extreme behavior. After the run, aerial inspection of upper Wallace Creek revealed a large, intensely burned area in which all crown needles and smaller surface fuels were essentially gone. There was, however, no evidence from the air, or on the ground near the shelter sites, of firestorm activity such as that seen on the Sundance Fire in the Idaho Panhandle in 1967. Trees were not laid down in patterns that would indicate large firewhirl activity. Some firewhirls had been observed during the fire, but trees were not knocked down, uprooted, or broken off as they were in the Pack River Valley as a result of the Sundance Fire.

After the run, aerial inspection of upper Wallace Creek revealed a large, intensely burned area in which all crown needles and smaller surface fuels were essentially gone.

Figure 3—*A view of the fire as it reached upper Wallace Creek and overran the fire crews. The crews deployed their fire shelters in safety zones similar to those seen in the foreground. This photo was taken from a helicopter looking toward the east.*

Inside the Fire Shelters

That all the firefighters in the escape zones survived without serious injury borders on the miraculous. Nevertheless, the approach and passage of the fire was a terrifying ordeal. Many, in fact, doubted that they would live though it. The trauma of the event was reflected in interviews with the survivors.

Witnesses, all of them experienced firefighters, said that this was no ordinary crown fire. To some it was a standing wall of flame that reached 200 feet (61 m) above the treetops. Others described it as a huge, rolling ball of fire with a bright orange glow. Some witnesses reported large balls of exploding gasses in the flame front.

Passage of the flame front was accompanied by a roaring sound, like that of a jet airplane or a train. One firefighter found this the most frightening part of the ordeal: "The noise builds up until you can't hear yourself think and then the ground begins to shake." He estimated that the shaking and roaring lasted 10 minutes. Over the roar of the fire he could hear the shouts of nearby firefighters screaming for reassurance, followed by shouts of encour-

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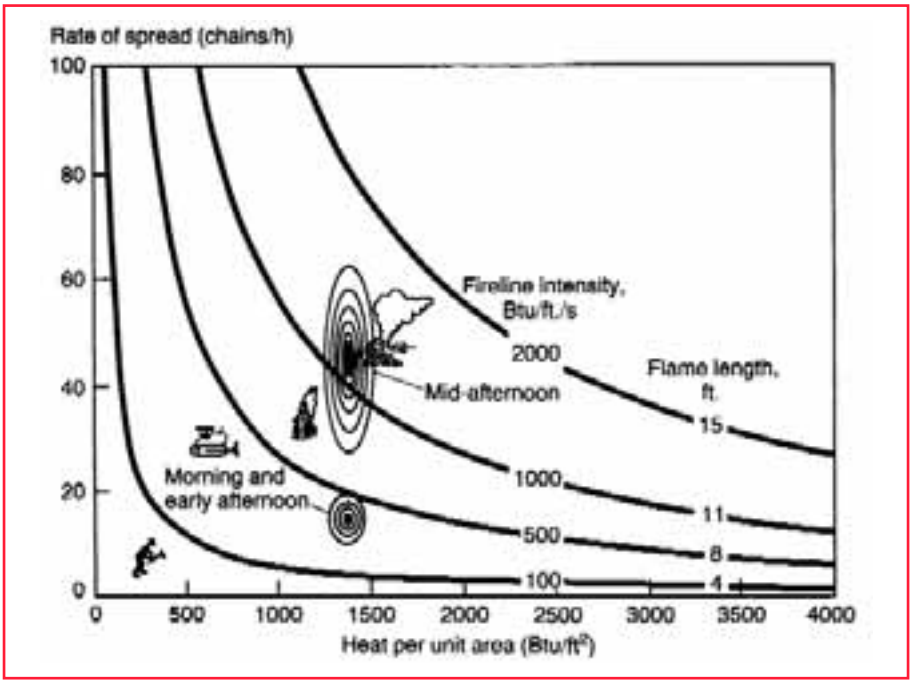

Figure 4—*Fire characteristics on the Butte Fire.*

agement from other firefighters. Strong, fire-induced turbulence made it difficult to deploy shelters and keep them down. One witness reported a feeling of weightlessness, of being lifted off the ground. Another reported the shelter being slammed down against his legs. Within the safety zones, everyone moved as far as possible from the flame fronts by crawling along under the shelter.

Within the shelters, firefighters experienced extreme heat for as much as 10 minutes. Shelters were so hot that they could only be handled with gloves. Light entering the shelter though pinholes changed from dark red at peak intensity, to orange, to white, as the fire passed over. One survivor said that at one point the ground looked as though it had been painted a bright orange. Firefighters learned to evaluate the color of the light as an indication of the fire's intensity in order to judge when it was safe to come out of their shelters.

After leaving the shelters, some firefighters showed symptoms of carbon monoxide poisoning: vomiting, disorientation, difficulty in breathing. Emergency medical technicians administered oxygen to several individuals; five were evacuated to a hospital for treatment and observation. All fully recovered. Among those interviewed, the consensus was that without the shelters none would have survived. A fire fighter with 20 years experience summed it up as follows: "The most frightening, scariest experience I've ever had. The fire was over us, around us, everywhere. I was in Vietnam for a year, but this beats it all."

Factors Contributing to Fire Behavior

Fire activity in the preceding days contributed to the ease with which the fire in Wallace Creek began.

Fire behavior on the afternoon of Thursday, August 29, was a repeat, albeit a much more severe repeat, of the fire behavior of the preceding two days. Each day took out more acreage and consequently left a larger holdover fire for the following day. On the morning of the 29th, the north edge of the fire was uncontained. Fuels were burned in patches, leaving large amounts of scorched fuel and trees within the fire area. The continuous fuels and lack of topographic barriers allowed the fire to move up the slopes of Wallace Creek with only moderate winds. The topography contributed substantially to the fire behavior and difficulty of control. The slopes from the valley bottoms were steep, contributing to rapid upslope runs; the ridge tops were rounded and covered with continuous fuels. Hence, there were no definite fire barriers such as steep rocky slopes, sharp ridges, or scrubby subalpine fuels.

Examination of weather records failed to reveal any factors that would have contributed to the large-scale convective activity observed on August 29. The extremely dry spring and summer probably contributed to the rapid spread of the fire and difficulty in controlling it. As on other fires in the northern Rocky Mountains at that time, tree crowns were extremely easy to ignite. Certainly the dry fuels on the ground also contributed, although the major fire runs at this elevation (6,000 to 8,000 feet [1,800–2,400 m]) carried predominantly though the crowns.

Fire Behavior Analysis

Postfire analysis of the potential fire behavior in surface fuels was made with the BEHAVE fire prediction system (Andrews 1986) and displayed on the fire characteristics

chart (fig. 4). Fuel model 10 was used. The values for fuel moistures ranged between 3 and 7 percent. The light winds of the morning and early afternoon would have produced fireline intensities of 250 to 500 Btu/ft.sec, making the fire difficult to control. The stronger midafternoon winds would have produced fireline intensities in the surface fuels of 600 to 1,500 Btu/ft.sec, virtually assuring an uncontrollable crown fire. The range of the conditions is shown by the ellipses on the fire characteristics chart (fig. 4). The inputs to BEHAVE and the outputs produced are shown in table 2.

The calculated rate of spread in the surface fuels was 11 to 19 chains per hour (726–1,254 feet per hour [221–382 m/h]) in the morning and early after noon. The higher windspeeds in midafternoon would have pushed the rate up to 28 to 57 chains per hour (1,848–2,762 feet per hour [563–842 m/h]). We do not have methods for calculating crown fire rate of spread, but it has been found that crown fire spread can be 2 to 4 times faster than the rate of spread calculated for fuel model 10 in fuels exposed to the wind and as much as 8 times faster if the fire is going up steep slopes (Rothermel 1985). If we compare the calculated rate of spread in the surface fuels with the crown fire values given in table 2, we find that for the period 1430 to 1530 the crown fire was 1.4 to 2.3 times faster than the surface fire. In late afternoon, from 1530 to 1610, the crown fire was 2.6 to 5.3 times faster. These values fall within the suggested range mentioned above.

There is a great deal of uncertainty in this type of calculation, indicating a strong need for research on crown fire behavior and better guidelines for predicting the onset and spread of crown fires and potential blowup situations.

Conclusions

The type of fire run observed in upper Wallace Creek on August 29 was not unusual for fires in lodgepole pine during the 1985 fire season throughout the northern Rocky Mountains. The high-intensity fire runs were the result of drought-induced, extremely low fuel moistures in all size classes and the speed of the transition from surface fires to torching, spotting, and crowning fires. Because large areas were burning unchecked by either fireline or natural barriers and a southerly gradient wind had reinforced upslope and upcanyon afternoon winds in Wallace Creek, the direction of fire spread and crown fire development before 1530 were not a surprise. The distance the fire spread, from 1530 to 1600, and its severity, were, however, unexpected. The large area of holdover fire adjacent to continuous timber with heavy surface fuels proved to be a juxtaposition capable of generating an

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Table 2a—*Data used in BEHAVE to assess fire behavior in surface fuels on the Butte Fire.*

Element	*Data*
Fuel model	10
Fuel moisture:	
1-hr	3 to 7%
10-hr	6%
100-hr	9%
Live woody	75%
Midflame windspeed:	
Early afternoon (sheltered)	4 to 6 mi/h
Midafternoon (exposed)	10 to 15 mi/h
Percent slope	45%
Wind direction	Directly uphill

Table 2b—*BEHAVE outputs.*

Time	*Rate of spread*	*Heat per unit area*	*Fireline intensity*	*Flame length*
Early afternoon	11–19 ch/h	1286–1487 Btu/ft^2	251–523 Btu/ft.sec	5.7–8 ft
Midafternoon	28–57 ch/h	1286–1487 Btu/ft^2	664–1563 Btu/ft.sec	8.9–13.3 ft

That all the firefighters in the escape zones survived without serious injury borders on the miraculous.

incredible amount of energy in a short time.

Although crown fires are often associated with strong winds, in this case winds of only 10 to 15 miles per hour (16–26 km/h), with some stronger gusts, were sufficiently strong to channel the flow up the canyon and produce the exceptionally intense crown fire that overran the crews. The question arose as to whether the burnout operation with the helitorch on the south side of the fire directly accelerated the high-intensity run up Wallace Creek. Interviews combined with a careful inspection of burning patterns on a 1/24,000 aerial photo mosaic did not reveal any fire behavior process whereby the helitorch burnout could have accelerated the run up Wallace Creek. The photo mosaic showed a patchy pattern of burned and unburned areas between the helitorch burning at the confluence of Wallace and Owl Creeks and upper Wallace Creek. The burnout operation, however, probably contributed to the shelter incident by preoccupying the attention of some key overhead personnel for so much of the afternoon of August 29. The "eyes in the sky" reconnaissance that had been routinely available on previous days was not available during the critical time on August 29.

Early reports on the Butte Fire estimated that the fire traveled 2 miles (3.2 km) up Wallace Creek in 15 minutes, or a spread rate of 8 miles per hour (13 km/h). This estimate now appears to be considerably higher than the actual rate of spread. Reconstruction of the fire front location at various times indicated that the average spread rate was closer to 2 miles per hour (3.2 km/h) with a maximum of about 3-1/2 miles per hour (5.6 km/h).

The safety zones that were bulldozed into the tractor line at the head of Wallace Creek made it possible for 73 firefighters to safely and effectively use their fire shelters and survive one of the more violent fire runs observed in the northern Rockies in 1985. But, as one crew foreman observed after the incident, "the best safety zone is one where a fire shelter is not needed." This conclusion deserves special emphasis whenever the Butte Fire is discussed.

If an indirect attack strategy is selected, then a fail-safe warning system must be in place to absolutely clear the line of personnel well in advance of a high intensity run.

Preventing Future Incidents

What measures can be taken to prevent such a life-threatening event from recurring in the future? If an indirect attack strategy is selected, then a fail-safe warning system must be in place to absolutely clear the line of personnel well in advance of a high intensity run. Another approach in conifer forests is to select a direct attack strategy, build a line along the flanks of the fire from a well-secured anchor point, and attack the head of the fire only when fuels, weather, and topographic conditions allow firefighters to work safely.

Whatever the strategy selected, the fundamental principles of fire behavior and fire suppression should always guide decisions that affect the health and welfare of the firefighter. Despite the remarkable progress made in fire management in the past quarter of a century—better understanding of fire behavior, better trained and equipped fire crews, more flexibility in attack strategy—conditions like those experienced in the northern Rockies in the summer of 1985 call for extreme vigilance in all aspects of fire suppression. And the safety of the individual firefighter is always the top priority.

References

Andrews, P.L. 1986. BEHAVE: Fire behavior prediction and fuel modeling system—BURN subsystem. Part I. Gen. Tech. Rep. INT–194. Ogden, UT: USDA Forest Service, Intermountain Research Station.

Jukkala, A.; Putnam, T. 1986. Forest fire shelters save lives. Fire Management Notes. 47(2): 3–5.

Rothermel, R.C. 1985. How to predict the spread and intensity of forest and range fires. Gen. Tech. Rep. INT–143. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station.

Van Wagner, C.E. 1977. Conditions for the start and spread of crown fire. Canadian Journal of Forest Research. 7: 23–24.