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Forest Fires!

Fatal and Near-Fatal Forest Fires The Common Denominators

by Carl C. Wilson

Fighting large forest fires often is compared to military operations. Each involves a highly structured organization with a "general" at the head, massive movements of men and equipment, tactical aerial support and long periods of combat and stress until the enemy finally is conquered. Yet, there is one major difference between military and firefighting strategy: in suppressing large fires we do not take the calculated risk of losing fire fighters. In spite of this policy, many people have lost their lives in forest fires in the United States.

The concern is with the differences and the similarities between those fires in which someone dies and those in which someone has a very narrow escape. As this article will show, the line is thinly drawn and depends on many factors, the most vital and most uncertain being that of human behavior.

A review of the U.S. Forest Service's records between 1926 and 1976 shows that 145 men died on 41 fires from fire-induced injuries. There have been no heavy losses in recent years. The largest losses on single fires occurred on the Blackwater fire in Wyoming in 1937 and on the Rattlesnake fire in California in 1953 (Table 1). In each case, 15 people died. A similar analysis made of people lost on fires in areas protected by other Federal agencies and State, county and private agencies reveals 77 fire-induced fatalities on 26 fires. The one fire responsible for the largest number of lost lives was the 1933 Griffith Park Fire in southern California, which accounted for 25 fatalities and 128 injured people (Table 2).

The data in these tables and in the two additional tables listing "near-fatal" fires (Tables 3 and 4) help demystify these related fire types. It is possible to identify some common denominators of fire behavior in both fatal and near-fatal fires. It should be stressed at the very beginning, however, that all fires differ and the change of one small factor can result in an entirely different picture. A glance through the four tables should convince any reader of the immense variability between the circumstances surrounding each fire. The tables also show that fatal and near-fatal fires often involve so-called "erratic fire behavior" and occur under seemingly innocuous conditions. Finally, we need to examine the potential for future tragedy fires and offer some suggestions and guidelines to the man who is going to be out there on the fire line tomorrow.

Common Denominators of Fatal Fires

Based on personal knowledge and information obtained from reports and reviewers, the following generalizations can be made about the fatal fires in Tables 1 and 2:

1. Most of the incidents occurred on relatively small fires or isolated sectors of larger fires.

2. Most of the fires were innocent in appearance prior to the "flare-ups" or "blow- ups". In some cases, the fatalities occurred in the mop-up stage.

3. Flare-ups occurred in deceptively light fuels.

4. Fires ran uphill in chimneys, gullies, or on steep slopes.

5. Suppression tools, such as helicopters or air tankers, can adversely modify fire behavior. (Helicopter and air tanker vortices have been known to cause flare-ups.)

In Tables 3 and 4, near-fatal fires are those close calls which involved a potential threat to life. A review of these tables shows that most of the generalizations made concerning fire behavior apply to near-fatal fires as well as to fatal fires. The hairline difference between the two groups of fires is determined by the individual's reaction to his suddenly critical situation. Escapes may be said to be due either to luck, circumstances, advance planning, a person's ability to stay cool and not panic, or a combination of these factors. Whatever the reasons, individual behavior and circumstances determine between life and death. For the individual fire fighter and crew boss, it becomes increasingly important to be able to identify those conditions under which so many close calls and fatalities occur.

Surprising Factors

Many fire fighters are surprised to learn that fatal and near-fatal incidents occur in fairly light fuels, on small fires or isolated sectors of large fires, and that behavior is relatively quiet just before the incident. The general belief is that the high-intensity crown fire in timber or heavy brush is most likely to trap and kill forest fire fighters. Yet, with rare exceptions, such as the disastrous Sundance fire (north Idaho, 1967), the Blackwater fire (Wyoming, 1937) and King's Canyon fire (western Nevada, 1967), most of the fires in this study were innocent-appearing just before the accidents.

Why, then, do these tragedies and near-fatalities occur under so-called "easy" fire behavior conditions? First, fire spread and intensity can change much more quickly in light fuels than in heavy fuels. Thus, finer fuels tend to be more responsive to changes in atmospheric conditions than heavy fuels. Second, hot, dry weather or Santa Ana (föehn-type) winds dry out the lighter fuels with the result that any change of wind, slope, or other environmental factor may lead to a drastic and unanticipated change in fire behavior. For example, in some areas in the West, downslope winds may occur normally during the afternoon or following thunderstorms. In such cases, an "unexpected wind" or "erratic fire behavior" is blamed for the disaster. In addition, there are few visual clues to warn of fire behavior changes, because dry fuels burn with little or

no smoke. Under such conditions, the obvious signs of a change, such as smoke and crackle of flames, are only noticeable once the situation already has become critical. It is, therefore, important that the fire fighter be alert and sensitive to the fire's behavior, particularly under those environmental circumstances in which a sudden change in fire behavior may occur.

Topography, like wind, has a major influence on fire behavior. A fire spreading uphill resembles a fire spreading before a strong wind. The rate of spread will usually increase as the slope increases. Not only are the flames closer to the steep slope, but also convection is more likely to carry firebrands and start spot fires. For example, other factors remaining constant, a fire burning on level ground (0 to 5%) will spread twice as fast when it reaches a 30 percent slope. The rate of spread will double again as the slope reaches 55 percent.

Topography also has another major effect on fire behavior. Box canyons, narrow canyons and gulches tend to act like the chimney of a stove. Radiation, convection and spotting speed up as if a damper were opened in a chimney.

The external signs and warnings are important, but the internal state of the fire fighter also must be considered in an examination of fatal and near-fatal fires. A glance through the "remarks" section of the fatal tables shows some very strange behavior by well-trained fire fighters. A person reading about these incidents may think, "I would never do that. . . I know what to do in such a situation. . . ." However, conditions on the line are not the same as in a classroom. There are reasons why so many well-trained fire fighters often are unaware of a dangerous situation until it is too late, and reasons why they often act foolishly and fatally once they do become aware.

Also, there may be physiological reasons for fire fighters' blindness to their potentially dangerous situation. They may be tired and their senses dulled by a long, fatiguing shift on the fire line. Or they may be fresh, but with their "sensing system" not yet tuned to the early warning signals which precede changes in wind direction, velocity, or both. Another physiological factor which is currently gaining attention is the adverse effects of carbon monoxide upon wildland fire personnel. It is a fact that relatively high concentrations (800+ ppm) in the environment can cause death within several hours. Carbon monoxide can occur in and around wildland fires in low-level amounts.[1] Carbon monoxide readings of 50 ppm were taken on a grass fire at a place where a tanker or initial attack crew usually would be operating. On a five-acre prescribed burn at the North Mountain Experimental Area, measured concentrations of 30 ppm were found about 200 feet from the fire front. Research and experience show low-level carbon monoxide poisoning can impair alertness, judgement, vision, and some psychomotor functions. The fire fighter is less likely to be capable of detecting the warning signals associated with drastic changes in fire behavior when he or she is being affected by carbon monoxide.

Carbon monoxide studies made on the Deadline fire (Sawtooth National Forest) and Outlaw fire (St. Joe National Forest) during the 1974 fire season showed that on one fire, most of the fire fighters were exposed to levels of carbon monoxide higher than those permitted by the standard proposed by the National Institute of Occupational Safety and Health (35 ppm during an 8-hour period).[2]

Since the effect of carbon monoxide is cumulative, it becomes a matter of great concern to fire fighters. They should be aware of the kinds of topography which encourage the build-up of carbon monoxide. Since carbon monoxide is heavier than air, this includes areas such as saddles, deep canyons and depressions.

Potential for Loss of Life

The potential for loss of life on forest fires because of burns or other fire-induced causes, is higher now than ever before. There are twice as many people in the United States in 1977 as there were in 1926, and many of these people live or play in the wildlands. As a result, "protection of life and property" has begun to dominate fire suppression action plans. The relative safety of "perimeter fire strategy" often must be sacrificed in favor of people and their possessions. This puts forest fire agencies and fire departments at a disadvantage since most training in the past has concentrated on perimeter strategy. Additional hazards arise as the state, city, and county fire departments confront the extraordinarily flashy grass, brush, and timber fuels in the urban-wildland border.

New fire suppression technology, including air tankers, helitack, chemical fire retardants, and other new tools and techniques have contributed indirectly to the problem by reducing the number of fires which escape initial attack. There are fewer opportunities for training assignments for young people on large fires. As a result, many do not have the chance to use fire behavior training knowledge learned in the classrooms. Moreover, some of the new firefighting tools, such as helicopters and air tankers, create vortices which can adversely affect fire behavior. An analysis of the Timberlodge fire (Sierra National Forest) showed that vortex turbulance created by an aircraft can be projected to the surface.[3] A small fire can then blow up, particularly if the wind is light and the atmosphere unstable.

In summation, there seems to be a strong justification for being pessimistic about the future. There is another side to the story too, however, one that includes some hope for the future. Firstly, there are better fire behavior courses now, and more people from all agencies are being trained. Under the auspices of the National Wildfire Coordinating Group, interagency teams are developing new fire behavior courses. Secondly, strengthened fuel management programs and the integration of fire into forest land use planning are reducing the threat to fire fighters and to the people who live and play in the forests.

New developments in the field include major improvements in aerial support for ground forces. New air tanker systems, better fire retardants, larger and faster helicopters, and the potential for "first-night control" using night-navigational systems for helicopters, all can

(Continued on page 15)

[1] Countryman, C.M. 1971. Carbon monoxide: a firefighting problem, U.S. Forest Service, Pacific Southwest Forest and Range Exp. Stn. 6 p., illus.

[2] Tietz, John G. 1975. Firefighters' exposure to carbon monoxide on the Deadline and Outlaw fires. ED&T 2424 (Smoke Inhalation Hazards), Forest Service, USDA Equip. Dev. Center, Missoula, Mont. 8 p., illus.

[3] Davis, James B., and Craig C. Chandler, 1965. Vortex turbulance—its effect on fire behavior. Fire Control Notes 25(1):4-7, illus.

TABLE 1 Common Denominators of Fire Behavior On Fatal Forest Fires

Name of Fire, National Forest And Year	Deaths By Burning	Erratic Fire Behavior	Remarks
Romero Los Padros 1971	4	Strong, "Sundowner" (Santa Ana) evening wind pushed fire downhill.	Bulldozer operator and 3 men burned as they hurried downhill to find safety.
Banning San Bernardino 1971	1	Fire ran upslope in early evening.	Member of tanker crew was laying hose downhill from road at night.
Canyon Angeles & L.A. Co.F.D. 1968	8	Santa Ana weakened, and unexpected wind pushed fire upslope in late morning.	Men tried to outrun fire uphill after flareup in brush below them.
Williams Coronado 1968	1	High temperatures, local gusty winds-cumulus clouds near fire.	Burned trying to outrun fire.
Slaughter Apache 1967	1	Fire became intense in pre-commercial thinning slash.	Fire boss tried to outrun fire and couldn't hear warning calls from crew on road.
Sundance Kootenai 1967	2	Fire blew up and made major run toward north under strong wind conditions.	Operator and man with tractor were ahead of fire and tried to hide under blade.
Bailiff San Bernardino 1967	1	Flareup at night in light fuels on steep slope.	Fire fighter fatally injured when he fell trying to escape flareup.
Loop Angeles 1966	12	Unexpected upslope wind in afternoon after Santa Ana stopped.	Fire fishhooked under crew in a chimney and part of the crew couldn't reach safety in time.
Coyote Los Padres 1964	1	Downslope wind through Romero Saddle in early afternoon.	Man panicked and ran to lower part of saddle where the temperatures and carbon monoxide concentrations were too high.
Timberlodge Sierra 1962	4	Hot,dry, unstable atmosphere and light fuels. Loaded B-17 air tankers flew low over fire.	Tornado-like action from air tanker vortices probably caused fire to blow up and trapped men.
Silver Creek Nezperce 1961	2	Fire spotted in extremely steep terrain in light fuel under gusty wind conditions near the bottom of the fire.	Crew went to a chute above spot fire, but all except two men left chute when danger was obvious. One man had asthma and had to move slowly.
Sierra Angeles 1961	1	Sudden, unexpected wind change.	Man unable to gain safety in time.
Cummings Cr. Umatilla 1960	1	Unexpected wind change in light fuel on ridge.	Man dropped behind and couldn't keep up with crew when fire flared up below them.
Dry Sequoia 1959	1	Unexpected downslope afternoon wind on east-facing slope.	Two men were returning after going downhill to get water. Fire came downhill and trapped them.
Stable San Bernardino 1959	1	Very hot and dry, unstable atmosphere.	Tried to outrun fire but apparently had heart attack.
Decker Cleveland 1959	5	Downslope afternoon wind stopped and fire came upslope in early evening.	District Ranger and four men were on state highway when fire came upslope and caught them in the open.
Gun Angeles 1959	1	Minor flareup. Fire in front country canyon and wind changed.	Man was laying hose uphill was caught by fishhook run.
Albert Ranch Angeles 1958	1	Minor flareup as wind changed at night.	Man was trapped ahead of fire.
Stewart Cleveland 1958	1	Minor flareup in chaparral under weakening Santa Ana conditions.	Out-of-region man scouting in brush ahead of fire.
Inaja Cleveland 1956	11	Upslope wind in evening when Santa Ana winds eased. Fire ran uphill.	Crew working on indirect line of canyon. Fire fishhooked under them, ran upslope and caught them before they could reach safety.
East Highlands San Bernardino 1956	1	Upslope winds in light fuels after Santa Anas tapered off at night.	Tractor operator trapped before he could reach safety.
Sagebrush Cyclone Malheur 1955	1	Fire was being mopped up in sage and grass. Down drafts from cumulus cloud caused unexpected wind.	Man was separated from crew and tried to outrun fire.
Johnson Prescott 1955	1	FDR "Extreme," and fire made run in light fuels.	Man tried to outrun fire uphill.
Tunnel No. 6 Tahoe 1954	3	Mono (dry east) winds caused flareup at night.	Men were sleeping in unburned area at edge of fire.
Rattlesnake Mendocino 1953	15	Unexpected evening downslope wind caught entire crew eating lunch on a spotfire.	Part of crew tried to outrun fire downhill.
Mann Gulch Helena 1949	13	Rapid spread in light fuels burned upslope. Hot, dry weather.	Smokejumpers jumped into unburned basin, and fire fishhooked below them. Most men failed to use area (burned area) and were caught going uphill.
Hells Canyon Payette 1949	1	Fire fanned by high winds.	Man stumbled and fell into fire.
Warm Springs Payette 1949	1	Unexpected strong winds caused flareup.	Man dropped behind crew to eat lunch and was trapped.
Walton Spur. Stanislaus 1949	1	Swirling winds in light fuels in Tuolumne River Canyon.	Tractor operator trapped above fire.
Barrett Dam Cleveland 1948	1	Winds changed at night from SW to East, and fire flared up.	Man became separated from crew.
Bryant Canyon Angeles 1947	2	Spotfire below men burned upslope trapping men in unburned fuel.	Burning rat ran out of main fire into nest. Spotfire spread uphill under men.
Hot Springs Payette 1944	1	Man found in sitting position on trail. Fire burned around him.	Suspected heart attack or other health problem.
Hauser Creek Cleveland 1943	11	Sudden wind shift under slackening Santa Ana conditions -maximum wind 8 miles/hr. SW.	Crew of Marines caught in small canyon off main Hauser Creek (72 were injured).
Williams Hill Los Padres 1943	1	Fire made a run in chamise and buckwheat.	Cat operator was building line in advance of fire. Cat threw track, and operator tried to escape fire.
Silver Plume Lincoln 1940	1	Sudden wind change and fire flared up.	Man sleeping outside fire line.
Rock Creek Humboldt (Toiyabe) 1939	5	Sagebrush and grass fire made an "unexpected run" upslope and trapped boys.	Five CCC boys from Paradise Camp were burned to death on fire near head of Rock Creek.

(Table 1 continued on next page)

Name of Fire, National Forest And Year	Deaths By Burning	Erratic Fire Behavior	Remarks
Blackwater Shoshone 1937	15	"Sudden wind" caused fire to blow up in heavy Douglas-fir re-burn. Spotfire made a run uphill toward men.	Men went in from top toward spotfire - then it flared up. Part of crew found safety on rocky point.
Welcome Lake Huron 1937	1	Early spring fire, strong, dry winds from West. Fire crowned in jack pine and red pine plantation.	CCC foreman was pulling his crew out when it started to crown. He was looking for 2 of his men and was trapped and died 100 feet from safety.
Kamus Burn Okanogan 1933	2	Fire in light fuels, and wind changed direction.	Men tried to outrun fire but failed.
Dollar Mt. Colville 1929	1	Sudden wind change in relatively light fuels.	Man tried to outrun fire uphill.
King's Canyon Toiyabe 1926	5	Unexpected downslope wind on lee side of Sierra pushed fire into second-growth forest with understory of brush.	Men had gone downhill for water and were trapped on road when wind changed.

TABLE 2

Common Denominators of Fire Behavior On Fatal Forest Fires (State, County and Local Agencies)

Name of Fire, State And Year	Deaths By Burning	Erratic Fire Behavior	Remarks
Battlement Creek Colorado 1976	3	Rapid upslope fire on a steep draw with Southwest exposure on mixed mountain shrub type.	Four men were trapped on narrow fireline on ridge and three died.
Morgan Co. Tennessee 1972	1	Small 24-acre fire. Wind gusts 20-25 mph. Fire crossed plowed line.	Plow operator trapped and suffocated on bench on upper side of fire.
Harris Ridge Idaho 1972	2	Steep, rocky terrain. Dry grass and brush and scattered trees. Thunderstorms caused "squirrely winds."	Two men on fire line. A rolling log hit the men, and they rolled into the fire and died of suffocation.
Banks Arkansas 1972	1	Medium fuels, moderate winds, very high FDR.	Man was knocked unconsious by falling tree. He was fatally burned.
Eagle Rock Virginia 1971	1	Reburn in rhododendron, steep slope.	Three men were felling snags.
None N. Carolina 1968	1	Unknown	Man, age 84, tried to beat fire with pine tops; clothes caught fire; was dead when found.
None Florida 1968	1	Heavy palmetto and wiregrass. Unexpected wind.	One-man suppression crew - tractor lodged on stump, and man couldn't escape.
None N. Carolina 1968	1	Unknown	A county ranger was suppressing fire. Died of 3rd degree burns.
None Mississippi 1967	1	Small fire, flashy fuels, gusty winds.	Man backfiring but lost backfire. Died after 3 days in hospital.
Windsor S. Carolina 1967	1	Weather dry and windy. Fire (4,000 acres) was fast-moving and erratic in pine.	Man was trapped by fast-moving head fire in dense smoke, couldn't escape.
Helker N. Carolina 1965	1	Wind speed increased. Fire in broom sedge.	Was helping on control burn. Was caught in wire fence and burned to death.
Fairview Hollow Kentucky 1965	3	Small fire (26.6 acres) near town, light wind. Fire burned in a small hollow with 40-65 degree slope. Fuels were light carpet of leaves of beech, oak, maple, basswood, and poplar.	Men ran up the hill ahead of fire but were trapped on steep slope.
Joshua Falls Virginia 1964	1	Fire burned up draw toward men.	One man apparently refused to follow leader and was killed by heat.
None Georgia 1963	1	Control burn escaped.	Man overcome by smoke and/or coronary.
Unnamed Georgia 1960	8	Ordinary. Control burn escaped.	All 8 men were shown as dying of heart attacks. (Only 3 were 70+)
None Florida 1960	1	Light fuels and unexpected wind change.	Two men on jeep. One ran to safety.
Siler City N. Carolina 1960	1	Fire in grass.	Man burned to death while attempting to put out grass fire.
Pennington Texas 1959	1	High winds in grassy fuels.	Man on road grader got in front of head of fire and was killed.
Hacienda California 1955	5	Light fuels, high temperatures, low humidity and unstable atmosphere. Fire threatening homes.	Foreman and crew were in bowl-like area when flashover occured.
Gap Creek Tennessee 1954	3	Stong winds pushed fire upslope and it crowned.	Men were trapped on slope above fire.
None N. Carolina 1953	2	Woods fire.	Woman (age 82) and child (age 11) were burned in woods fire trying to put it out.
Bonnie Blue Virginia 1953	1	Fire burned rapidly up steep slope.	Man became separated from main crew and was burned.
Glenville Dist Arkansas 1952	1	Sagebrush & grass, high winds, high FDR and fire threatening homes.	Individual fighting fire fell in path of fire (from exhaustion) and died.
Kawailoa Hawaii 1941	2	Flashy fuel and the wind changed unexpectedly.	Two men were unable to gain safety in thick staghorn fern.
Pepper Run Pennsylvania 1938	8	Fire burning in mixed-hardwood leaves on fairly steep slope. Wind shifted and crossed fireline below men. Final size 134 acres.	Squad foreman told men to run for safety. All ran up the hill and were caught by the fire.
Griffith Park California 1933	25 killed plus 128 injured	Fire burned in light chaparral near Griffith Park. Wind changed.	Men tried to run for safety, but 25 failed.

TABLE 3

Common Denominators of Fire Behavior On Near-Fatal Forest Fires

Name of Fire, National Forest And Year	Number Involved	Erratic Fire Behavior	Remarks
Meyers Fire San Bernardino 1970	Sector Boss and crews	Fire burning in steep country and dense chaparral at night and spotted across line.	Crews and cats were building line downhill when fire blew-up - they found safety in cat line.

(Table 3 contined on next page)

Name of Fire, National Forest And Year	Number Involved	Erratic Fire Behavior	Remarks
Mitchell Creek Fire Wenatchee 1970	Line boss and crews	Unexpected strong, upslope winds at midnight caused fire to jump line.	Crews were pulled out in time.
South Tommy Fire Wenatchee 1970	Crew	Fire spotted below crew and came "roaring up mountain." Weather hot, dry and windy.	Crew in unfamiliar country found refuge in burned-over rock slide for two nights.
Fourth of July Mt. Fire Wenatchee 1967	Foreman and crew	Fire in light fuels was quiet in early morning (2:00-3:00 a.m.), then humidity unexpectedly dropped and entire canyon burned out.	All men were pulled into safety zone.
Payette Forest Fire Payette 1967	6-man crew	Lodgepole pine blowdown. Gusty winds caused blow-up from cat piles.	Three men found safety in clearing, and 3 went into burn. No one hurt.
Boot Strap Fire BLM, Elko District 1964	Foreman and inmate crew	Fast-moving fire in sagebrush and grass moving on wide front.	Foreman was driving across front of fire with crew when they encountered edge of fire and drove through safely.
Magpie Fire Wallowa-Whitman (near Hells Canyon) 1963	Fire Boss and 20 men	Fire was in mop-up stage when there was a sudden increase in wind - blowing upslope. Fire burned in dense stand of grass.	Crew working downhill on steep slope in heavy, dry grass. Found safety in 30 ft. burned out strip on the ridge top.
River Bend Fire Deschutes 1962	Division Boss and Tractor Operator	Fire burning in open ponderosa pine and manzanita brush. Fire crowned in ponderosa pine.	Man ran uphill along dozer line and buried face in soil. Wind let up, and he escaped.
Fresno Co. Fire-Calif. Div. of Forestry 1962	4 men (3 received burns)	Strong winds in light fuel (grain field), 90° F temp. Wind shifted unexpectedly.	Fire outflanked 4-man pumper crew. 3 men found safety in truck cab. One man went to burnt out area.
Salmon River Fire Payette 1961	Crew Boss and Pumper Crew	Fire burning in cheatgrass then crowned in brush and timber on steep slopes of Salmon River.	Fire jumped road, but crew moved back and forth on road to avoid being burned.
Tenus Gorge Fire Wenatchee 1961	Crew	Fire in heavy cheatgrass and scattered brush in breaks of Columbia River. Spotfire started below crew.	Crew burned out a "safety area" on a knoll. In a few minutes main fire passed, but no one was injured.
Oregon Protection Agency Fire Ore. Prot. Agency 1960's	Crew Boss and 37 men	Daytime temperature was 105°, and fire was burning in scrub oak and light brush at night. Unburned fuels inside perimeter caused spots across catline.	Crew moved to safety in time - while 200 acres more burned.
Fire in Region 4 1960's	Two men	Fire had burned downhill on ground then crowned uphill toward men.	Men abandoned fireline in time to reach safety.
Cottonwood Park Fire Medicine Bow 1960's	Crew Boss and 13 men	Fire was in mop-up stage. Temperatures rose, and unexpected winds blew fire across firelines - because of unburned fuels inside.	Crew scrambled to safety as fire burned 1,200 acres more.
Brushy Gulch Fire Salmon 1960's	Sector Team and 40 men	Fire burning in logging slash in steep canyon at night with up-canyon winds.	Sector boss and 5 men found safety at heliport as fire ran uphill - rest stayed on fireline.
Satters Meadow Fire Payette 1957	Foreman and brush crew	Fire burning in spruce logging slash at 7,000 ft. elevation. Winds picked up and blew fire across line.	Foreman and crew had predetermined line of retreat to small meadow and elk wallow.
Sagebrush Cyclone Malheur 1955	One crew	Downdrafts from thunderstorm created strong winds on a sagebrush fire.	Experienced logger got separated from crew, and he tried to outrun fire uphill. Rest of crew went into burned area.
Milepost 324 Plumas 1949	One	Fire made run in sagebrush and grass.	Wind shifted briefly, and fireboss ran back through burn to safety.

TABLE 4

Common Denominators of Fire Behavior On Near-Fatal Forest Fires

Name of Fire, National Forest And Year	Number Involved	Erratic Fire Behavior	Remarks
Freezeout Oregon 1973	60-70	Fire came up slope at night into grass-covered area.	Crew pulled away from edge of canyon into safty area. Crew isolated from camp for 3 hours.
Laguna Cleveland 1970	75 men, 2 tractors and 4 tankers	Fuels were grass and brush. Wind from E-NE 40mph. Spotfire outside of line "blew up." About 40 acres exploded.	All men ran for cat line and semi-burned area. Nobody hurt, but all had singed hair and eyebrows.
Canyon Angeles 1968	3 tanker crews	Backfire operation triggered flareup of main fire in canyon below men at night. Tankers surrounded by unburned fuels.	Tanker crews retreated to burned out area near powerline and waited out the flareup.
Alaska Interior Bureau of Land Mgmt. Territory 1968	25 men	Temperatures continued high at night because sun didn't set. Flareup in peat bogs surrounded crew.	Line was abandoned and men moved into a swamp, waist-deep in water. Fire burned in grasses covering swamp, but no one was burned.
Slash Colville 1967	Scout	Reburn below saddle in 250-acre cut-block blew through saddle.	Ran downhill through fire in saddle and got second & third degree burns on face, neck and hands.
Indigo Siskiyou 1967	1	Fire in Douglas-fir reproduction and in clear-cut block. Fire crowned in reproduction and blocked line of retreat.	Scout ran down cat line between fire in cut-block and flare-up in Douglas-fir reproduction, but was not injured.
Evergreen Mountain Rogue River 1967	Crew Foreman and Crew	Firebrands from a clear-cut area rolled downhill below crew. Fire fishhooked up slope during mid-day.	Crew foreman and crew ran to the clear-cut burned area for safety and had to stay six hours.
Winter Rim Fremont 1966	Sector Boss & 50 men	Light gusty winds at night caused fire to jump line in reproduction patches.	Crew pulled out, and went to fire perimeter because of erratic behavior.
Magpie Ridge Oregon 1960's	4 men	Main fire was contained, but it blew up and headed uphill toward crew on small spot fire on slope.	Crew ran toward ridge top but one man fell and had to be carried - made safe area with 5 minutes to spare.
Woodwardia Angeles 1959	18	Fire was smouldering in canyon below helispot in light fuels.	Eighteen men dug in on lee side of helispot, and fire spotted overhead. Steep downhill situation without planned escape route.
Lakeview Fremont 1958	Sector Boss & 25 men	Fresh logging slash and pine reproduction. Wind stopped and direction changed unexpectedly.	Sector boss and crew rushed back into burned area and suffered minor burns.
Alder Creek Oregon 1955	One crew	Fireline being built in bottom of heavily-timbered canyon. Fire crossed canyon and surrounded crew.	Crew ran down canyon to edge of fire. One tractor burned up.
Horseshoe Basin Gallatin 1953	Crew Boss & 10 men	Unburned islands of subalpine fuels & small meadows. Unburned islands burned out when cumulus clouds developed over fire.	Fire was spotting all around men so they sat in pothole with water up to their necks while fire blew over.

View of disaster scene in Rattlesnake Canyon, Mendocino National Forest, California where 15 men lost their lives in 1953. Circle in left center of photograph marks the spot where crew was working before fire overran them. Photo courtesy of U.S. Forest Service

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speed up suppression and reduce threats to the fire fighters on the ground. Finally, more effective use of the National Fire Danger Rating components under pre-suppression and suppression conditions is helping to alert all concerned to potentially explosive conditions. For example, a high ignition component will indicate the high probability of spot fires. Similarly, a high burning index will tell the fire fighter that rapid fire spread can be expected in the light fuels where possibility of getting trapped is the greatest.

The final picture, therefore, includes some positive and some negative aspects. The individual fire fighter must realize that this year's fire season is bound to be the worst one ever. Modern technology, however, will help make the job of firefighting as safe as possible. But, the final responsibility rests with him and his fellow fire fighters. Once they are conscious of which situations are potentially dangerous, and once they know what to do in a blow-up or flare-up, their chances for avoiding a fatal fire increase.

Conclusions

There are four major common denominators of fire behavior on fatal and near-fatal fires. Such fires often occur:

1. On relatively small fires or deceptively quiet sectors of large fires.
2. In relatively light fuels, such as grass, herbs, and light brush.
3. When there is an unexpected shift in wind direction or in wind speed.
4. When fire responds to topographic conditions and runs uphill.

Yet, these factors should not be considered all inclusive. A sudden change of wind, and the fire may change direction, regardless of the topography.

Each set of circumstances has the potential for creating a fatal or near-fatal fire. Often, human behavior is the determining factor. The fire fighter, who "keeps his or her cool" when the wind direction changes, moves back into a burned area, will survive. The fire fighter who panics and tries to outrun a fire under similar conditions may die. The difference between a fatal and a near-fatal fire may be luck, skill, or advanced planning. But in all cases, it pays to be alert and aware of certain conditions which may signal a sudden change in fire behavior. In a few words—

Be alert. Watch out for:
Light fuels
Wind shifts
Steep slopes and chimneys

The person who is not caught unaware has the best chance for survival.

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Carl C. Wilson *joined the U.S. Forest Service in 1946. In 1956 he transferred to the Pacific Southwest Forest and Range Experiment Station of the U.S. Forest Service and, in the following year, became Chief of the Division of Forest Fire Research. He was named Assistant Director of the Experiment Station in 1962, and eleven years later transferred to the Cooperative Fire Protection Staff of State and Private Forestry where he serves as National Fire Specialist. He has done work abroad in the development of fire management programs for the Food and Agriculture Organization of the United Nations.*

Mr. Wilson is the author of more than 30 professional and technical publications of forestry and forest fire matters. In 1975, he received an Outstanding Fire Management Award from the Chief, U.S. Forest Service and President, National Association of State Foresters.