

Wildland Firefighter Burnover Fatalities on Prescribed Fires and Wildfires in the United States, 1990 to 2017

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Abstract—In the 28-year period from 1990 to 2017, there were 41 incidents in the United States where firefighter burnover fatalities occurred on wildland fires. Ninety-six fatalities and 78 injuries were reported, with an average of 1.5 incidents and 3.4 fatalities per year. The great majority (76 percent) of fatalities occurred in mountainous terrain, where the most common situation was that fire personnel became trapped while working upslope or upcanyon from the fire when the fire made a sudden upslope run. The information for my report came primarily from serious accident investigations of individual incidents. The information presented in this paper will help managers and fire personnel better understand the environmental conditions and some of the human and organizational factors that are present during fatal burnovers.

Keywords: accident, burnover, fatalities, incident

INTRODUCTION

This report is a review and analysis of wildland firefighter burnover fatalities on prescribed fires and wildfires in the United States from 1990 through 2017. The National Wildfire Coordinating Group (NWCG) Glossary of Wildland Fire Terminology (2018) defines a burnover as “an event in which a fire moves through a location or overtakes personnel or equipment where there is no opportunity to utilize escape routes and safety zones, often resulting in personal injury or equipment damage.” Information for my analysis was gleaned primarily from serious accident investigation (SAI) reports.

In the United States between 1990 and 2017, there were 41 incidents where firefighter burnover fatalities occurred on prescribed fires and wildfires, resulting in 96 fatalities and 78 injuries. During this period there was an annual average of 1.5 incidents and 3.4 fatalities. An NWCG report for the period of 1990 to 2006 indicated there were 64 total burnover fatalities with an average of 3.8 per year (Mangan 2007).

Burnover fatalities are a rare occurrence when we consider the large number of fires that are suppressed each year in the United States, but the results are catastrophic. Five incidents between 1990 and 2017 resulted in 44 fatalities: 6 in the Dude Fire (Arizona), 5 in the Esperanza Fire (California); 14 in the South Canyon Fire (Colorado), and 19 in the Yarnell Hill Fire (Arizona).

A better understanding of the commonalities during burnover entrapments is needed. Environmental conditions (e.g., fuels, weather, topography, climate), human and organizational factors, and other variables must be considered. Greater understanding of the conditions, situations, and commonalities under which entrapments occur can improve research, training, strategic and tactical decisionmaking, planning, and safety practices. All of these efforts can help reduce burnover injuries and fatalities.

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METHODS

Information for this report was obtained mainly from SAI reports, which were usually completed by agency or interagency teams, and the National Institute for Occupational Safety and Health (NIOSH). Other sources of information on historical incidents included:

- Wildland Fire Lessons Learned Center
- California Department of Forestry
- Texas State Fire Marshall
- NWCG (various reports)
- WLF Always Remember
- Information from various websites
- Historical Palmer Drought Severity Indices (PDSIs)

The SAI reports for the burnovers vary widely in scope and detail, with the document lengths running from 10 to 290 pages. There were nine incidents where no investigative report could be found; however, I was usually able to obtain some basic information.

In completing this report I used other tools, which included U.S. Geological Survey topographic maps, Google Earth, historical fire weather observation data, and FireFamily Plus software. A database was also established to gather, organize, sort, and analyze information.

FINDINGS

Locations of Burnovers

Burnover fatalities have occurred in 18 states: Arizona, California, Colorado, Idaho, Montana, New Mexico, Oregon, South Dakota, Utah, Washington, Georgia, Kentucky, Florida, Mississippi, Oklahoma, Tennessee, Texas, and Virginia.

Topography

Topography is a major factor in burnovers. Seventy-three fatalities occurred in mountainous terrain;

upslope fire runs resulted in 67 fatal burnovers, and downhill fire runs resulted in 6 fatal burnovers. In addition, 59 percent of the SAI reports state that the fire was running up a canyon or chimney. Incidents in flat to rolling terrain resulted in 11 fatalities. There were 12 fatalities that occurred where not enough information was available to determine the type of topography.

Fuels

Burnovers generally occur during extreme fire behavior (EFB) events. Extreme fire behavior can occur on any scale, great or small, in any fuel type, and at any time of the day or night. There is no time or circumstance when fire managers can safely assume EFB will not occur (Werth et al. 2011). Other studies of burnovers have shown there is no significant trend when examining fuel types (Munson and Mangan 2000).

My analysis classified vegetation present at the incident scene into fuel types (grass, shrub, and timber). Table 1 displays the number of sites where one, two, or all fuel types were present at the location of the fatal burnover or incident.

Weather

In a review of weather information from the SAI reports, an incomplete picture of onsite weather observations and weather forecast information emerged. Evaluating observed weather values such as air temperature, wind speed, wind direction, and relative humidity was not practical due to the lack of weather observations in several of the SAI reports.

I determined that evaluating weather factors was best done by using information from National Fire Danger Rating System (NFDRS) weather stations and daily fire danger rating indices. The index that was chosen for this analysis was the Energy Release Component for NFDRS fuel model G (ERCg). Fuel model G represents dense conifer stands where there

Table 1—Number of burnover sites having a given number of fuel types.

One fuel type present	Two fuel types present	Three fuel types present	Unknown	Total number of incidents
7	17	10	7	41

is a heavy accumulation of litter and downed woody material. The NFDRS weather station closest to and most representative of the incident scene was selected, and weather observation data for the time period of the entrapment were downloaded; ERCg was calculated in the FireFamily Plus software. The results of this analysis showed that the great majority (78 percent) of fatalities occurred when conditions were much drier or more extreme than normal. Table 2 shows the number and percentage of fatalities by ERCg.

Climatic Factors

The PDSI was used as an indicator of climatic conditions that occurred during the fatal burnover incidents. Historical PDSI information was obtained for every incident. An analysis of this information indicated that 84 percent of the fatal burnovers occurred when the PDSI was at the moderate, high, or extreme level.

Temporal Factors

An analysis of the month and time of day when fatal burnovers occurred was completed.

The majority (68 percent) of fatalities occurred in June, July and August, with the peak month being June (30 percent). No fatalities occurred in January and February.

Time-of-day analysis indicated that 69 percent of the fatalities occurred between 3 and 5 p.m. No fatalities occurred between 11 p.m. and 6 a.m.

Human and Organizational Factors

There are many human and organizational factors that play into a fatal burnover. Generally, the SAI reports do not provide a great deal of information on this topic.

The most common occurrence in burnovers is that fire crews were trapped while working upslope or upcanyon from the fire when the fire made a sudden upslope or upcanyon run (71 percent of fatalities). This situation was also referenced in another study (Wilson and Sorenson 1978), in which one of the four main common denominators of fire behavior in tragedy (burnover) and near-miss fires is “when fire responds to topographic conditions and runs uphill.”

Table 2—Number and percentage of total fatalities by Energy Release Component (ERCg) values.

ERCg	Number of fatalities	Percentage of fatalities
97th percentile	19	20
90th percentile	40	42
80th percentile	15	16
Low/Moderate	14	15
Unknown	8	8

Other findings of my analysis include:

- The average age of individuals involved in burnovers was 33 years old.
- Regarding qualifications of individuals, 43 percent of total fatalities occurred with our most experienced and highest qualified fire personnel (e.g., overhead personnel, Type 1 crews, helitack, and smokejumpers) (table 3). The SAI reports do not provide detailed information on the qualifications and experience of people involved in entrapments.
- In my evaluation of safety standards that may have been compromised, as measured by the Standard Firefighting Orders (Fire Orders) and the 18 Situations that Shout Watch Out (Situations), this report found that 15 serious accident reports

Table 3—Percentage of fatalities by resource type.

Resource type	Percentage of fatalities
Type 1 resource: hand crew (e.g., hotshot, helitack, smokejumper)	39
Type 2 resource: hand crew (e.g., regular, inmate)	23
Engine crews	23
Dozers and tractor plows	8
Overhead (e.g., division supervisors, burn boss, incident commander)	4
Unknown	3

(37 percent of the total incidents) addressed this matter. On burnover incidents an average of eight Situations were present and seven Fire Orders were compromised.

- State employees were involved in the largest percentage (27 percent) of burnover incidents, followed closely by individuals from Federal agencies (24 percent) (table 4).

Trends

From 1990 through 2017, looking at 10-year averages, there has been a slight decrease in the number of fatalities during burnovers, from about 3.7 to 3.6 per year. The number of incidents from 1990 to 2017 has also slightly decreased from about 1.3 to 1.1 per year. Of particular note are the following:

- From 2007 to 2017 there were 5 separate years when no fatal burnovers occurred. This is very significant because in the previous 10-year period, 1997 to 2006, there was only 1 year when no fatal burnovers occurred.
- There have been no fatal burnovers of Type 2 hand crews since 2010.
- The trend in burnover fatalities for engine crews is sharply up. From 1990 to 2003 there were 6 fatalities and from 2004 to 2017 there were 16 fatalities.

CONCLUSIONS

Every fatal burnover is unique; however, there are many commonalities in burnover incidents across the United States. Fatal burnovers generally occur on wildland fires because of extreme fire behavior (fuels, weather, topography, and climate) and a wide variety of human and organizational failures. Answers to questions on human and organizational failures are not usually found in SAI reports.

The findings of my analysis show that there has been some improvement in the last 10 years in the total number of burnover fatalities and incidents. Of concern is the significant increase in entrapments of engine crews, which is probably related to the growing number of fires being fought in the wildland-urban interface.

Table 4—Affiliation of people involved in burnovers by percentage of incidents.

Affiliation of individuals involved in burnovers	Percentage of incidents
State	27
Federal	24
Volunteer department	22
Municipal department	10
Other	10
Unknown	7

There are multiple contributing factors in any incident and often complex coincidences that cause organizations to fail. Often on a wildland fire incident there are many participants, none of whom may have complete information.

The Esperanza Fire Accident Investigation Factual Report, Riverside County, California October 26, 2006 gives a good example of how our culture can affect operations. The report states: “Contributing Factor 1. Organizational culture—The public (social and political) and firefighting communities expect and tolerate firefighters accepting a notably higher risk for structure protection on wildland fires, than when other resources/values are threatened by wildfire.”

It appears that burnovers result from a series of mistakes that may lead to a fatality or injury. An analysis of these incidents showed that an average of seven Fire Orders were not followed or were otherwise compromised. In these situations, Fire Orders seem to have been generally ignored or misunderstood.

The preponderance of burnovers in mountainous terrain is due to several factors. Weather and fire behavior can be hard to predict in the mountains, and steep slopes and narrow canyons have a major effect on fire intensities, fire spread rates, and spread direction. In addition, travel in mountainous terrain on foot can be very difficult and slow.

Extreme fire behavior can be eruptive in nature and surprise fire personnel, entrapping them. This report

has shown that fatal burnovers occur during the hottest and driest time of the day and during the months of peak fire season, with exceptions. The National Fire Danger Rating System has been shown to be a good tool for helping to predict the potential for extreme fire behavior.

In 1957 the Forest Service, Department of Agriculture commissioned a task force to recommend further action needed in both administration and research to materially reduce the chances of men being killed by burning while fighting fire (Moore et al. 1957). This task force found that there are a large number of factors common to many tragedy fires (burnovers) and developed a list of the most significant ones. These factors marked the origin of the Fire Orders and Situations.

Commonalities on fatal burnovers cannot be narrowed down to a few factors that could define when an entrapment might happen. Fire personnel need to evaluate all environmental conditions on any given incident, including fuels, weather, topography, and climate and how they all relate and interact with each other. Weather forecasts and fire danger ratings need to be closely monitored. There are many complex and interrelated factors that lead to fatal burnovers. I have concluded that the current Fire Orders and Situations are still very relevant and if followed can help prevent burnover situations.

SUMMARY

This report has shown that fatal burnovers have decreased in the last 10 years, but only slightly. I recognize that missing information from several SAI reports and the lack of investigations or reviews on nine incidents may affect the conclusions in this report, and efforts need to be made to obtain missing information. It is my hope that having a better understanding of burnovers will help reduce the number of injuries and fatalities.

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