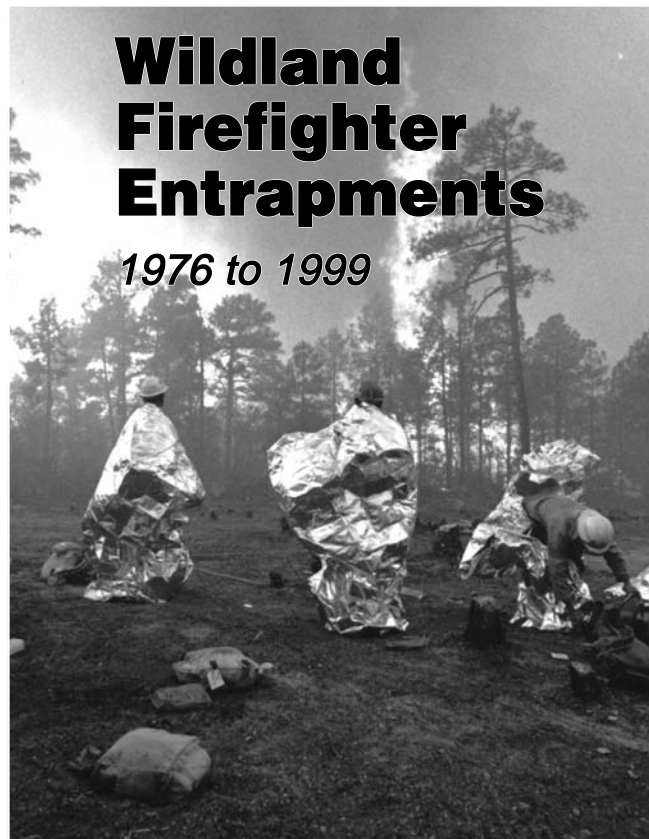


United States
Department of
Agriculture

Forest Service

**Technology &
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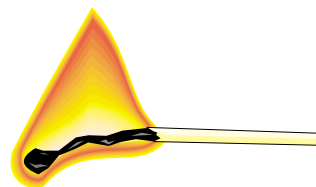
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**USDA Forest Service
Technology & Development Program
Missoula, Montana**

TE02P16—Technical Services, Fire & Aviation

October 2000



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—Photos by Mark Erickson, Silver City, NM.

Introduction

United States wildland firefighters are facing increasing risks from continued fuels buildup, trees dying because of insects or disease, and more complex fire-fighting environments. Decades of fire suppression, and disease and insect outbreaks have added to the fuels and increased the potential for extreme fire behavior. Increasing wildland/urban interface concerns and more multijurisdictional incidents have also added to the risk firefighters traditionally face. Although equipment and technology have added better tools for more effective firefighting, too many firefighters are becoming victims of fire entrapments. Entrapments are the leading cause of wildland firefighter fatalities. With an average of over 70 fire entrapments occurring each year, the factors affecting entrapments need to be identified and understood.

This study of wildland firefighter entrapments was initiated under the auspices of the National Wildfire Coordinating Group and coordinated by the Missoula Technology and Development Center. The goal was to identify the causal factors underlying fire-behavior-related incidents that have threatened firefighters' lives. Most of the entrapment records were compiled by Karen Peck. A data base was developed to determine common factors and trends. The study was restricted to incidents from 1976 to 1999 to identify trends over the past quarter century. Administrative changes, such as the requirement of fire shelters on the fireline, the implementation of the National Fire Danger Rating System, and additional safety guidelines and procedures have been instituted since 1976. These changes have had a significant impact on how firefighters perceive and account for risks in their working environment. The study included entrapments involving Federal, State, and rural firefighters.

The National Wildfire Coordinating Group defines an entrapment as:

➔A situation where personnel are unexpectedly caught in a fire behavior-related position where planned escape routes or safety zones are absent, inadequate, or have been compromised. An entrapment may or may not include deployment of a fire shelter for its intended purpose. These situations may or may not result in injury. They include "near misses." ➔

The term *entrapments* includes not only entrapments, but also shelter deployments and burnover fatalities. Previous accident studies have shown that many near misses could easily have involved fatalities if luck had not been on the victims' side. Safety professionals commonly use the "incident triangle" to illustrate the possible scope of the safety problems in an organization. The incident triangle (Figure 1) illustrates transitions between accident severity (low to high), level of visibility (low to high), frequency of occurrence

(high to low), and degree of reporting (low to high). Based on the 240 entrapment incidents that were recorded since 1976, statistics suggest that 2,330 near misses occurred. The same statistics suggest that over 23,000 unsafe acts or conditions may have occurred since 1976. To reduce the frequency of near misses, entrapments, and fatalities, we must reduce the occurrences of unsafe acts.

Information about entrapments was recorded in 16 fields:

- Incident name.
- Date.
- Year.
- Number of fatalities.
- Number of entrapments.
- Number of fire shelter deployments.
- Number of burnover related injuries.
- National Wildfire Coordinating Group geographic area.
- Responsible agency.
- Employing agency.
- Resource type.
- Qualified (true or false).
- Incident type.
- Fuel model.
- Wildland/urban interface fire (true or false).
- Weather information available (true or false).

These variables were cross-referenced and analyzed for general trends and occurrences. Some variables were not included in this paper because information was incomplete.

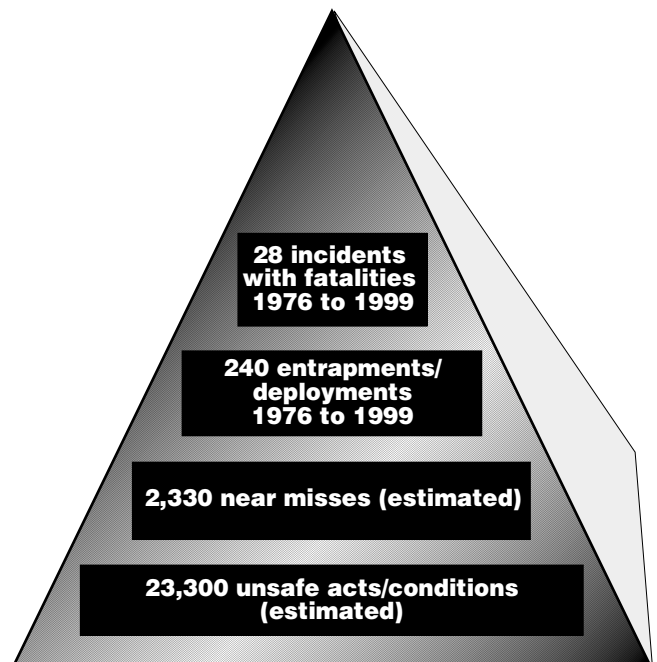


Figure 1—The incident triangle shows that many unsafe acts lead to the entrapments that cause fatalities.

Introduction



Each section of this document includes significant findings and graphs. The report's primary focus is on the number of incidents, not on the number of people involved.

The investigative reports studied included varying amounts of detail. Some reports were summaries, while others were very detailed. No incidents were reinvestigated. Some followup calls were made to try to account for missing data or uncertainties.

This report includes entrapments and shelter deployments that were determined to be critical to the safety of the firefighters. Precautionary deployments were not included. The distinction between precautionary deployments and those that were critical to the safety of the firefighters was not always clear.

General Summary

Since 1976, 1,692 firefighter entrapments have been reported during 240 incidents (Figure 2), an average of 70 entrapments a year. Some wildfires had more than one incident, such as the Marble Cone Fire (California, 1977), Lake Mountain (Idaho, 1985), 49'er (California, 1988), Altamont (California, 1988), Canyon Creek (Montana, 1988), Eagle (California, 1989), Hour Glass (Colorado, 1994), IL Complex (Nevada, 1994), Logan (California, 1996), and Cleveland (Washington, 1998). Figure 2 also illustrates shelter deployments throughout the period (1,050 or an average of 43 per year). Burnovers with fatalities averaged four a year, for a total of 105 burnovers. The largest entrapment occurred on the 1988 Butte Fire in Idaho when 118

firefighters were threatened. The incident with the most fire shelters deployed was on the 1988 Canyon Creek Fire in Montana (Elk Creek Zone, 107 shelters deployed). The most fatalities (14) occurred on the 1994 South Canyon Fire in Colorado.

Figure 3 compares entrapments, shelter deployments, and fatalities by NWCG geographic region. This comparison is by numbers of personnel. The Eastern Basin Region includes the 1985 Butte and Lake Mountain (Idaho) incidents, accounting for the high number of entrapments and shelter deployments.

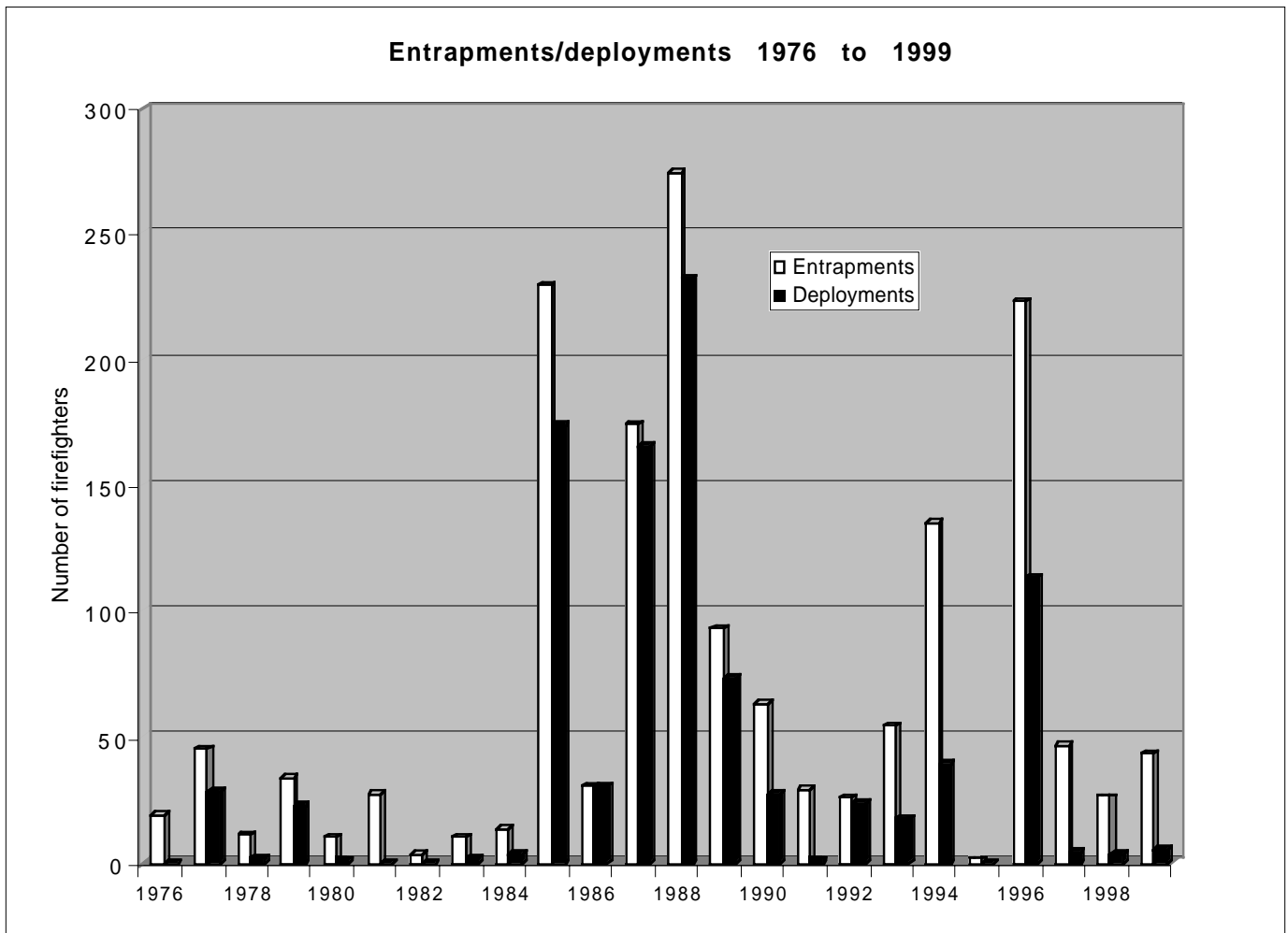


Figure 2—Comparison by year, from 1976 to 1999, of the number of wildland fire personnel entrapped and fire shelters deployed.

General Summary

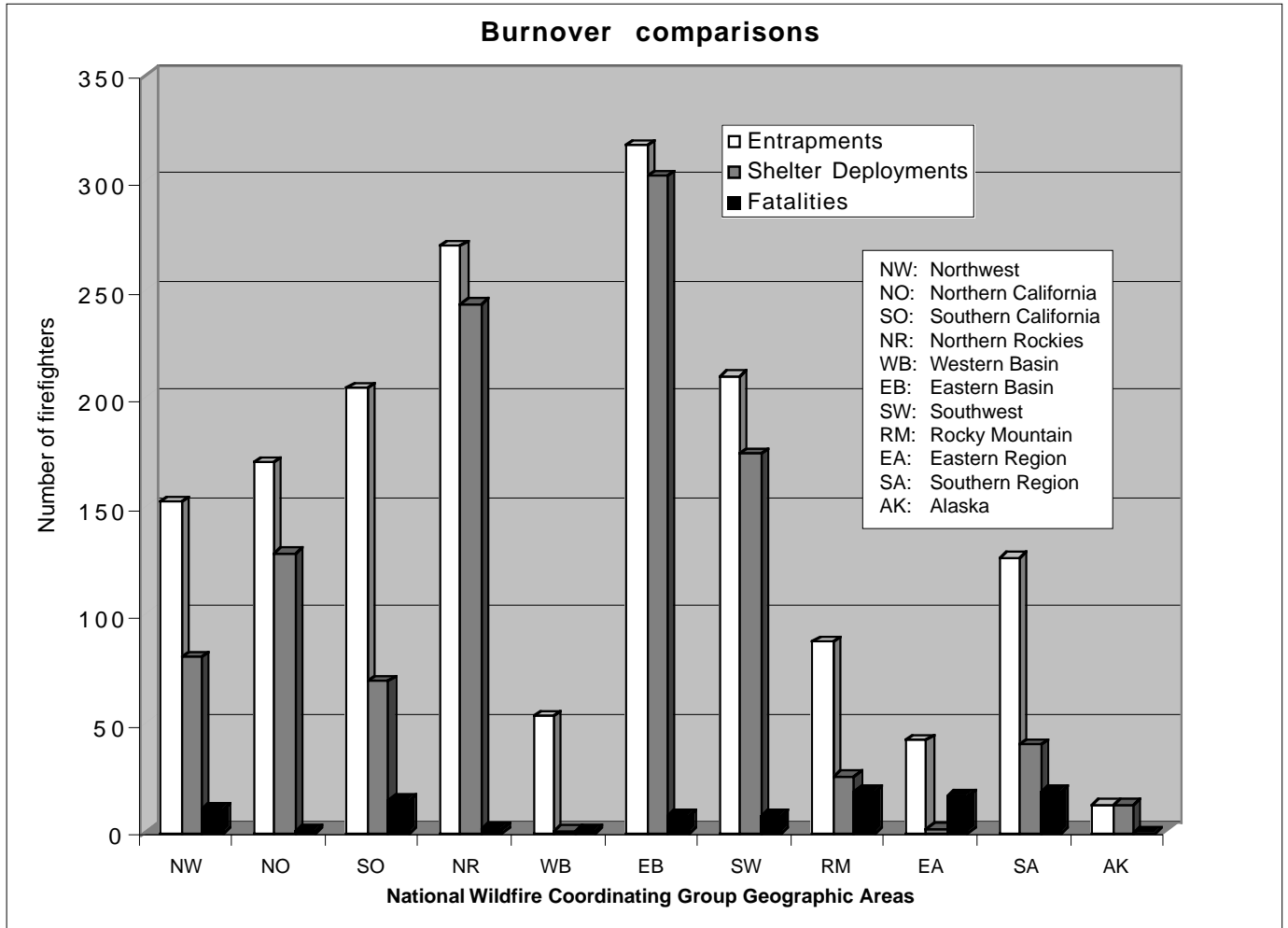


Figure 3—Entrapments, shelter deployments, and burnover fatalities by each National Wildfire Coordinating Group geographic area.

Entrapments

Of the fires with entrapments, 51 were Type 1 or 2, 31 were Type 3, and 47 were Type 4 or 5 (Figure 4). The most complex incidents, typically involving the largest acreages, are Type 1. The least complex incidents are Type 5. Eleven entrapment incidents occurred during prescribed burns. Four of those incidents had fatalities. Nearly a third (67) of all entrapments occurred on fires at the wildland/urban interface.

Figure 5 illustrates the types of equipment and crews involved in entrapment situations. Forty burnovers (19 at the wildland/urban interface) involved engines, 22 involved dozers, and 31 involved tractor/plow units. Of the organized crews that were entrapped, Type 1 crews were involved in 13 incidents (25 percent) and Type 2 crews were involved in 52 incidents (75 percent). Of the organized crews available annually, about 14 percent are Type 1 and the rest (including inmate crews) are Type 2.

Figure 6 shows agencies with overall jurisdiction in areas where the entrapment incidents occurred. The Forest Service had overall jurisdiction in 70 entrapment incidents, States (except California) had overall jurisdiction in 55 incidents, the California Department of Forestry had overall jurisdiction in 37 incidents, and the Bureau of Land Management had overall jurisdiction in 18 incidents. The Forest Service was the primary employer of persons entrapped during 54 incidents, the States were the primary employers of persons entrapped during 38 incidents, and the California Department of Forestry was the primary employer of persons entrapped during 29 incidents.

No significant trend was noted by examining fuel types. Fuel types corresponded with the geographic area and occurred in all 13 Fire Behavior Prediction System fuel models. Weather information was not readily available.

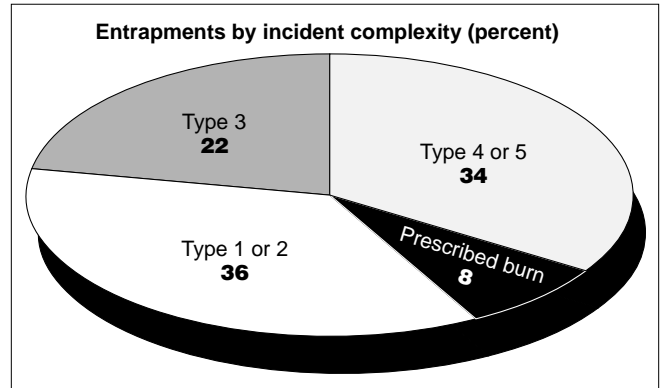


Figure 4—Percentages of entrapments by type of incident complexity.

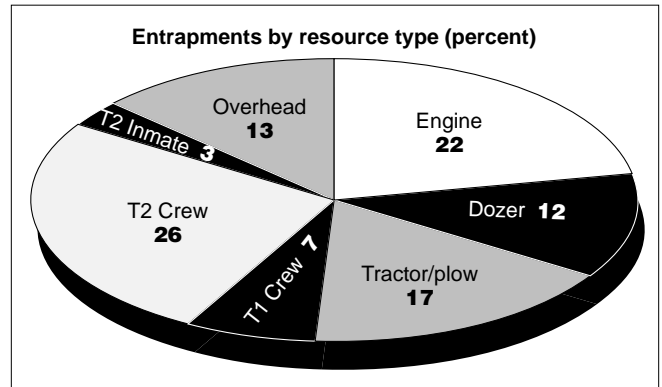


Figure 5—Percentages of entrapments by resource type.

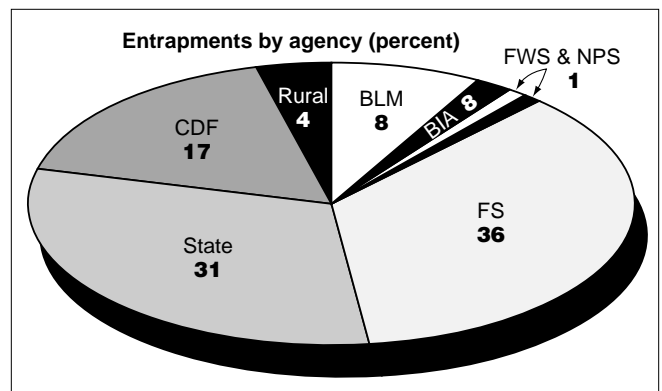


Figure 6—Percentages of entrapments by responsible agency.

Fire Shelter Deployments

One thousand and fifty firefighters deployed fire shelters in 109 incidents during the study period. Figure 7 shows the percentages of incidents by incident complexity. A majority (70 percent) of the shelter deployment incidents occurred on fires managed by incident management teams (incident Types 1, 2, or 3). Initial attack accounted for 23 percent of the reported deployments. The remainder were prescribed burns. Several incidents were identified in which two people shared one shelter and survived (Boyd

1985, Florida; Madison Gulch 1988, Montana; Early Bird 1988, Montana; Wampee Bay 1988, Florida; Clover 1988, Wyoming; Sheep Mt. 1990, Oregon). Figure 8 illustrates the type of firefighting resources involved in the incidents. Over half (54 percent) of the shelter deployments involved fire crews. Another 28 percent involved engines, dozers, or tractor/plows. Single resources, such as overhead, accounted for the remaining numbers.

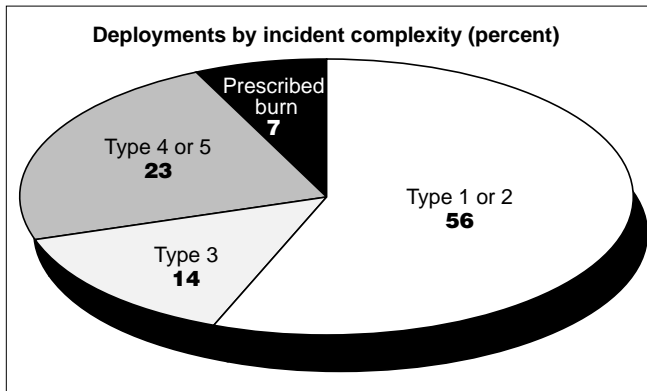


Figure 7—Type of incident complexity for fire shelter deployments.

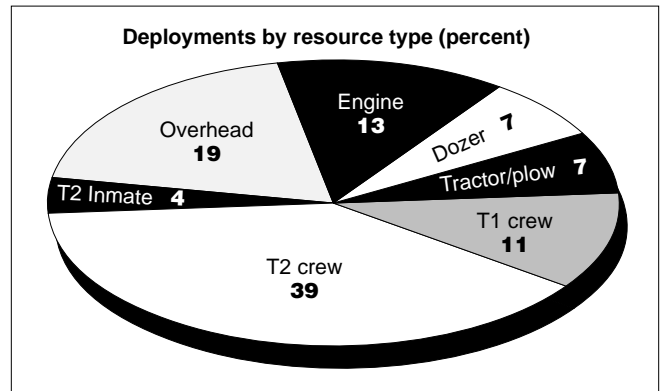


Figure 8—Resources involved in fire shelter deployments.

Fatalities

During the study period, fatalities occurred during 28 incidents. A total of 105 fatalities were reported, about four per year. Figure 9 shows the percent of fatalities by the complexity of the incident. Twelve incidents (43 percent) occurred on Type 1, 2, or 3 fires. Twelve incidents (43 percent) occurred during initial attack. Four incidents (14 percent) occurred during prescribed fires. Figure 10 shows the number of fatalities by resource type. Engines, dozers, and tractor/plows were involved in 14 incidents with

fatalities (56 percent). Type 1 crews were involved in two incidents (7 percent) with fatalities: the Battlement and South Canyon fires. Type 2 crews were involved in six incidents (24 percent) with fatalities.

Proportionately, Type 1 crews were involved in twice as many burnovers as Type 2 crews. Type 1 crews may be exposed to more situations that could lead to entrapments than Type 2 crews.

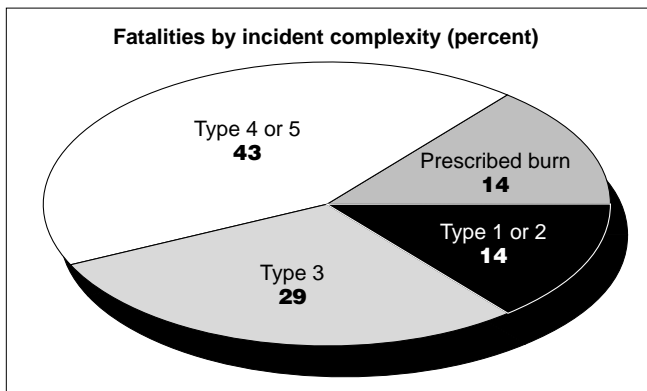


Figure 9—Incident complexity in firefighter fatality burnovers.

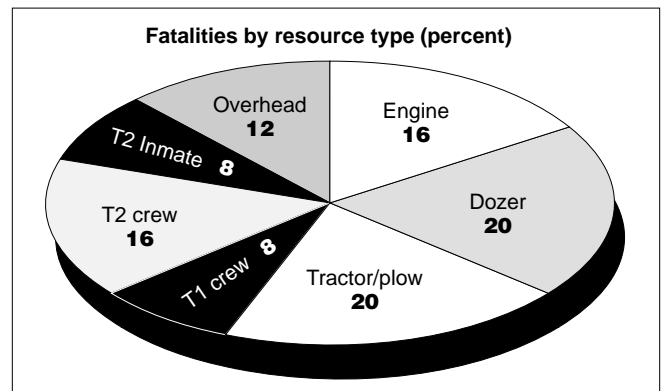


Figure 10—Fatalities by resource type.

Conclusions

Selected variables were highlighted to show a general picture of firefighter entrapments, shelter deployments, and burnover fatalities. Any agency, organization, or person fighting fire can experience a burnover. Burnovers can also occur at any time of year and with any resource on any scale of incident. In other words, anyone fighting a wildland fire can become a victim of an entrapment (Figure 11). There has always been a risk, no matter what you do, whom you work for, or where you are located. Complacency may be the most difficult factor to overcome. Becoming aware of the hazard of entrapment is a key step in reducing the risk.

Certain factors were common themes in the entrapments, shelter deployments, and burnover fatalities. They include: fire behavior, communications, escape routes and safety zones, and qualifications.



⇒ The fire behavior on many incidents could have been predicted given the environmental conditions. The current fire danger, the fuel conditions, and predicted weather were not taken fully into account on the majority of burnover incidents.

⇒ Communications at both the strategic and tactical levels were inadequate on 38 percent of all entrapment incidents.

Strategic communications included general area fire situation briefings, fire behavior information, and line assignment briefings. Tactical briefings such as morning briefings, line resource intercommunications, and feedback throughout the operational period were cited consistently as factors that caused entrapments. Another factor was lack of lookouts who could provide critical information about the ongoing fire situation.

⇒ Identifying and using escape routes and safety zones was an additional factor cited in entrapment investigations. Firefighters failed to consider a safe, effective way out when conditions deteriorated. Although every entrapment incident can be cited as a failure to properly use escape routes to safety zones, in many occasions these critical contingency measures had not been accounted for.

⇒ In 16 percent of the incidents firefighting resources were minimally qualified for their positions or did not meet qualifications for their position.

Resources that could be categorized as mechanical (dozers, engines, tractor/plows) accounted for 50 percent of the entrapments and 56 percent of the fatalities but only 28 percent of the shelter deployments. This raises the question why there were so many entrapments and fatalities involving mechanical resources but so few deployments.



Figure 11—Anyone fighting a wildland fire can become a victim of an entrapment.

Recommendations

The large number of entrapments and shelter deployments after the 1994 South Canyon Fire brings up many questions. What have managers done to decrease the exposure to risk from burnovers? What measures have supervisors and firefighters incorporated into their training and operations to increase safety awareness? What have firefighters done to increase their awareness of hazards? What have managers done to conduct fire operations so that information flows freely, contingencies are accounted for, and regular risk assessments are an ongoing part of the job? What more can be done?

⇒ While more than half the entrapments and fatalities involved engines, dozers, and tractor/plows, fire shelters were deployed in only 28 percent of the incidents. Are we using these resources in ways that expose them to greater risk? Additional tactical training and fire shelters that were more readily accessible, such as on chest packs, could provide operators a wider margin of safety. Research into engine survivability, vehicle construction materials, and the use of safe, effective tactics were recognized as critical needs. The number of interface fires and incidents involving engines points out the need to provide better training and more survivable enclosures for firefighters. In addition, the number of entrapments and lack of corresponding shelter deployments may indicate the need to better train equipment operators in tactics, use of Personal Protective Equipment (PPE), and quicker access to fire shelters.

⇒ Fire shelter improvements should include the development of a better product and training in the timely, proper use of shelters. Fire shelters have been proven to save lives. Practicing with the fire shelter is critical for fast deployments. Continual training is required to identify areas best suited for survivable deployments and to polish the techniques needed to deploy a fire shelter “on the run.”

⇒ The basics of hazard identification and entrapment avoidance must be learned and reinforced throughout a firefighter’s career. Safety must become a way of “doing business.” These concepts are inherent in the orders, guidelines, and safety training established for wildland firefighting. Management and supervisors must ensure that personnel are trained and retrained as often as necessary to perform required tasks effectively and safely. Management must provide all the tools necessary for personnel to mitigate the inherent risks. Firefighters themselves have a responsibility to be continually aware of the fire conditions they may encounter. Adherence to the standards and guidelines must be inherent in the firefighter’s approach to fighting fires. Firefighters must be trained and supported to evaluate safety, strategy, and tactics on each fire. Management and line personnel must actively learn from the successes and failures of their missions as well as the near misses and tragic outcomes of others.

⇒ Fireline safety is the responsibility of all fire personnel from top-level decision makers down to firefighters. Safety should be as inherent in the organizational culture as the “can-do” attitude.

The risks firefighters face need to be continually assessed at every level of the fire organization. Wildland firefighting will always be a risky occupation. However, the hazards associated with the fire environment can be assessed and accounted for. By communicating the hazards and evaluating the risks inherent in each task, the number of life-threatening entrapments can be reduced. All wildland firefighters have to commit themselves to being a valuable part of the best possible firefighting organization, committed to excellence in training, firefighting, and safety. Professional wildland firefighters must know their job, the hazards of each task, and the safest, most effective means to accomplish their objective.

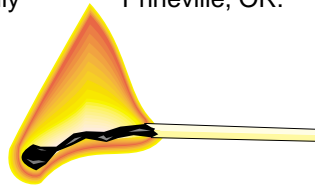
About the Authors



Steve Munson is the Fire Operations Supervisor on the Red River Ranger District of the Nez Perce National Forest in Elk City, ID. He has worked in fire management for over 20 years. He is qualified as a Division Group Supervisor, Fire Behavior Analyst, Type 3 Incident Commander, Type 1 Burn Boss, Type 2 Prescribed Fire Manager, Class C Faller, and Fireline Blaster. He completed a master's degree in forestry with an emphasis in forest fire science at the University of Montana during 1999.

Dick Mangan has been Fire and Aviation Program Leader at MTDC since 1989. His major responsibilities include developing equipment for wildland firefighters, primarily

personal protective equipment and equipment for smoke-jumpers. Dick serves on the National Wildfire Coordinating Group Fire Equipment and Safety and Health Working Teams, and is chair of the National Fire Protection Association's technical committee for wildland fire personal protective equipment. He is red-card qualified as an Operations Section Chief 1, Planning Section Chief 2, and Safety Officer 2. Dick has a bachelor of science degree in forestry from Humboldt State University and more than 20 years experience on Ranger Districts and National Forests in Oregon and Washington. His last assignment before coming to MTDC was as Fire Staff Officer for the Ochoco National Forest in Prineville, OR.



Library Card

Munson, Steve; Mangan, Dick. 2000. Wildland firefighter entrapments: 1976 to 1999. Tech. Rep. 0051-2853-MTDC. Missoula, MT. 10 p.

Summarizes United States wildland firefighter entrapments, fire shelter deployments, and burnover fatalities from 1976 to 1999. During the period, 105 firefighters died in 28 entrapments. Firefighters were entrapped 240 times during the period. Entrapments are summarized based on incident complexity (Type 1, most complex, to Type 5, least complex), resource type (engines, dozers, tractor/plows, and crews), agency jurisdiction, and geographic area. Fire shelter deployments and fatality burnovers were analyzed by incident complexity and resource type. Failure to pay proper attention to fire behavior, communications, safety zones and escape routes, and firefighting qualifications were identified as common factors in many entrapments.

Keywords: burnovers, entrapments, fire fighters, fire fighting, firefighting, fire shelter deployments, safety, safety at work.

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