

United States
Department of
Agriculture

Forest Service

**Technology &
Development
Program**

5100 Fire
March 1999
9951-2808-MTDC



Wildland Fire Fatalities in the United States

1990 to 1998

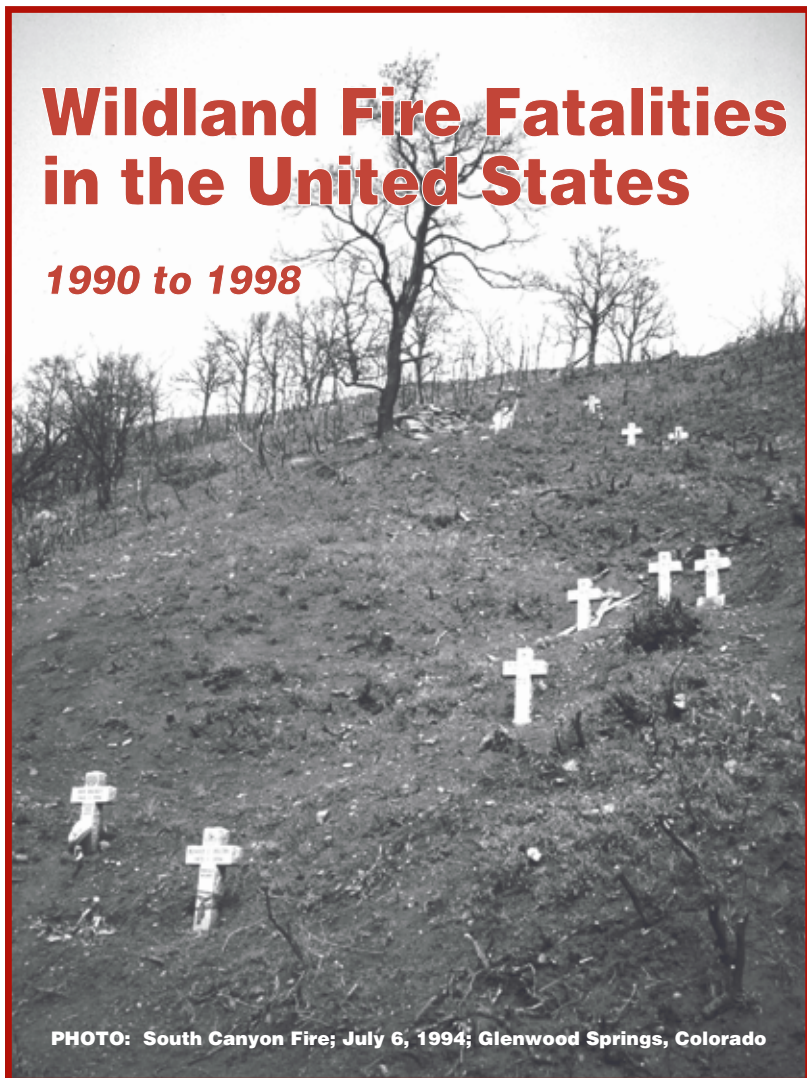


PHOTO: South Canyon Fire; July 6, 1994; Glenwood Springs, Colorado

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Missoula, Montana USA**

9E92P30—Fire Entrapment Avoidance

March 1999

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Introduction

Wildland fire operations are conducted in a high-risk environment. Individuals involved in all aspects of fire management are subject to the dangers of burnovers, vehicle and aircraft accidents, and medical emergencies. In the period between 1990 and 1998, 133 individuals died while involved in wildland fire activities (Figure 1). These deaths occurred on 94 separate events.

Each year, the National Wildfire Coordinating Group's (NWCG) Safety and Health Working Team prepares a "SafetyGram" documenting wildfire fatalities across the United States in all jurisdictions, including areas protected by Federal, State, city/county, rural, and volunteer firefighters. The SafetyGram contains specific information about each fatality (and nonfatal fire entrapments), but does not process, analyze, or interpret the data.

This paper will analyze the data presented in the SafetyGrams for the years 1990 to 1998, looking for trends and making recommendations that may be important to fire managers in their efforts to reduce future fatalities. Specific information analyzed includes: cause of death, organization, and the geographic area of the fatality.

Causes of death have been grouped into six categories:

- ❑ Heart attacks;
- ❑ Burnovers;
- ❑ Falling snags;
- ❑ Vehicles, including single- or multiple-vehicle collisions, as well as individuals struck by a moving vehicle;
- ❑ Aircraft accidents, both fixed and

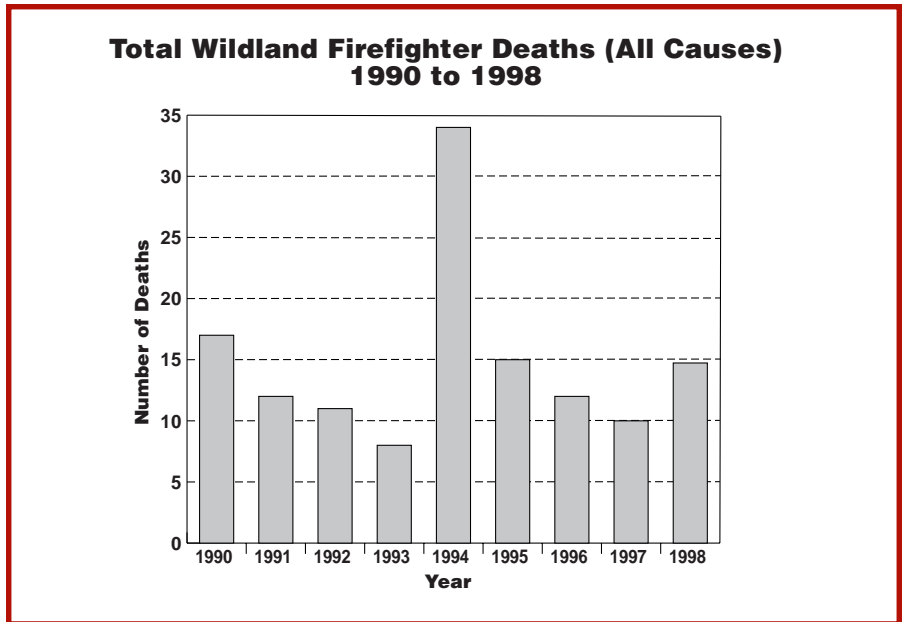



Figure 1—The annual death toll for persons who died while involved in fighting wildland fires from 1990 to 1998 (133 total deaths).

- rotary wing, as well as aircraft-related accidents on the ground;
- ❑ Miscellaneous causes, such as training, medical, suicide, drowning, and so forth.

Organizations of the individuals killed are broken into seven groups:

- ❑ Federal: USDA Forest Service, National Park Service, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, and the Bureau of Land Management;
- ❑ State forestry or fire organizations;
- ❑ City/county: Permanent employees of these jurisdictions;
- ❑ Volunteers: Members of organized departments;

- ❑ Military: Active duty, National Guard, and Army Reserve;
- ❑ Contractors: Individuals such as air tanker and helicopter pilots and crew, caterers, drivers, and organized contract fire crews;
- ❑ Private: Individuals not affiliated with other groups, but who died while fighting fires.


Two significant wildfire events had multiple fatalities during the 1990-to-1998 period: the South Canyon Fire in 1994, where 14 Federal firefighters died; and the Dude Fire in 1990 where six State employees perished. The data from these events are included in the analysis, but in some cases, those events are discussed separately for comparison with the baseline. 

Cause of Death

Individuals involved in wildland fire operations died more often in burnovers than from any other cause (Figure 2). Fifteen separate burnovers led to the deaths of 39 firefighters in 13 states. Fatalities from burnovers have occurred in each year except 1992, ranging from a high of 17 in 1994 to a low (excepting 1992) of 1 in 1997 and 1998. If the South Canyon Fire (14), and the Dude Fire (6) fatalities are removed, the total deaths from burnovers falls to 19, and the average drops to 2.1 fatalities per year. Burnovers were responsible for 29% of all fatalities in the period analyzed, even though they represented just 16% of the events causing fatalities. This demonstrates that the number of burnover fatalities is not just a function of the quality of the decisions leading to the event, but also represents the number of individuals at the scene.

Aircraft accidents are the next leading cause of fatalities among wildland fire personnel (total: 30, 23%), closely followed by heart attacks (total: 28, 21%) and vehicle accidents (total: 25, 18%).

Other causes of death on wildland fires include falling snags (total: 5, 5%), and miscellaneous (total: 5, 5%). Specific

causes in the miscellaneous category include drowning, electrocution, suicide, and training. 

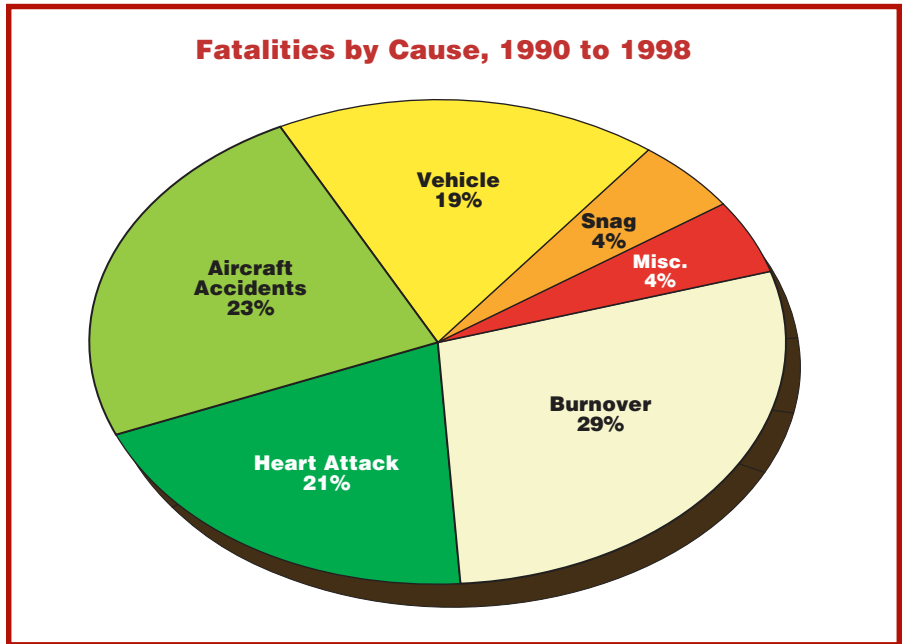


Figure 2—The causes of death for 133 persons who died while involved in fighting wildland fires from 1990 to 1998.

Organizations

Everyone involved in wildfire activities is exposed to hazards, not just on-the-ground firefighters (Figure 3).

Volunteer firefighters were the most likely to die on wildland fire operations (total: 41, 31%). The most common causes of death were heart attacks (total: 17, 12%), and vehicle accidents (total: 18, 13%). Five volunteers died from burns, and one from electrocution (Figure 4).

Thirty five Federal employees (26%) died during the period. Burnovers were the leading cause of death (16), including the 14 firefighters who died on the South Canyon Fire in 1994. The other causes of death were evenly distributed: heart attacks (5), vehicle accidents (4), miscellaneous (4), aircraft accidents (4), and falling snags (2). Removing the South Canyon Fire from the database would drop Federal fatalities to 21 (17% of 122 fatalities) (Figure 5).

Contractors working on wildland fire operations suffered 28 fatalities in the 1990 to 1998 period: 23 died in aircraft accidents (19 fixed wing and 4 rotary wing), with other fatalities occurring from falling snags, heart attacks, and vehicle accidents (Figure 6).

Eighteen State employees died on wildland fire operations from 1990 to 1998. Burnovers were the leading cause of death (10), and include the six State of Arizona employees killed in the Dude Fire. Other causes of death among State employees include heart attacks (2), aircraft accidents (2), and falling snags (2), and heat stress (2). If the six fatalities on the Dude Fire were excluded, the state's fatalities would drop to twelve, with four caused by burnovers (Figure 7).

City/county fire personnel suffered seven fatalities. Six occurred from burnovers, with five of those early in the period of this report.

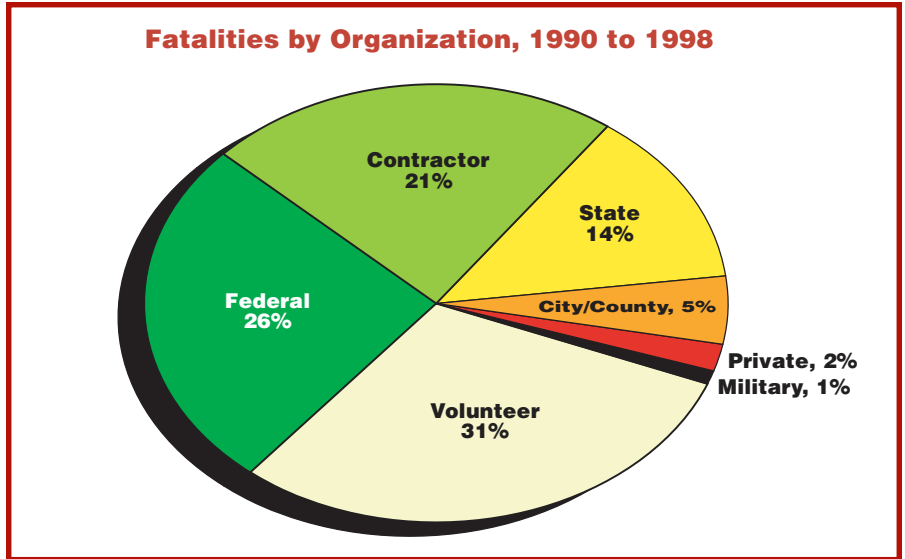


Figure 3—Fatalities grouped by the organizations of persons who died while involved in fighting wildland fires from 1990 to 1998.

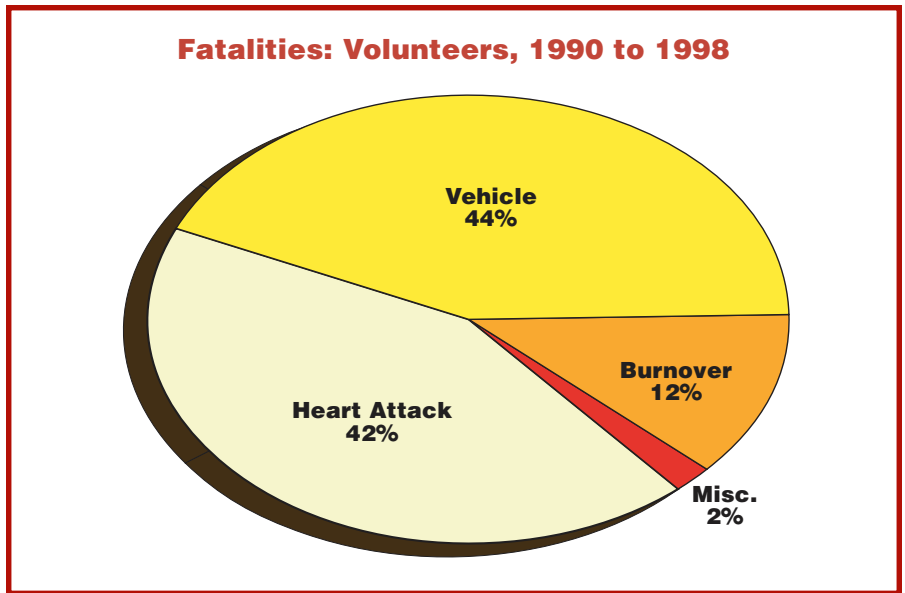


Figure 4—The causes of death for the 41 volunteers.

Two private citizens were burned over and died while attempting to suppress a wildland fire in Montana during 1996.

One person in the military was killed in a ground-based aircraft accident while supporting wildfire suppression during 1994.

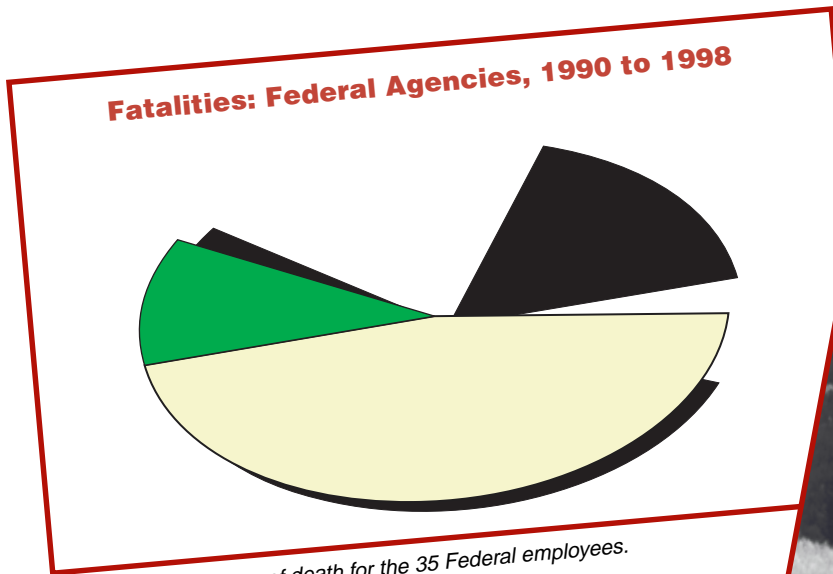


Figure 5—The causes of death for the 35 Federal employees.



Figure 6—Aircraft accidents were the second-most-common cause of fatalities for persons who died while involved in fighting fires from 1990 to 1998.

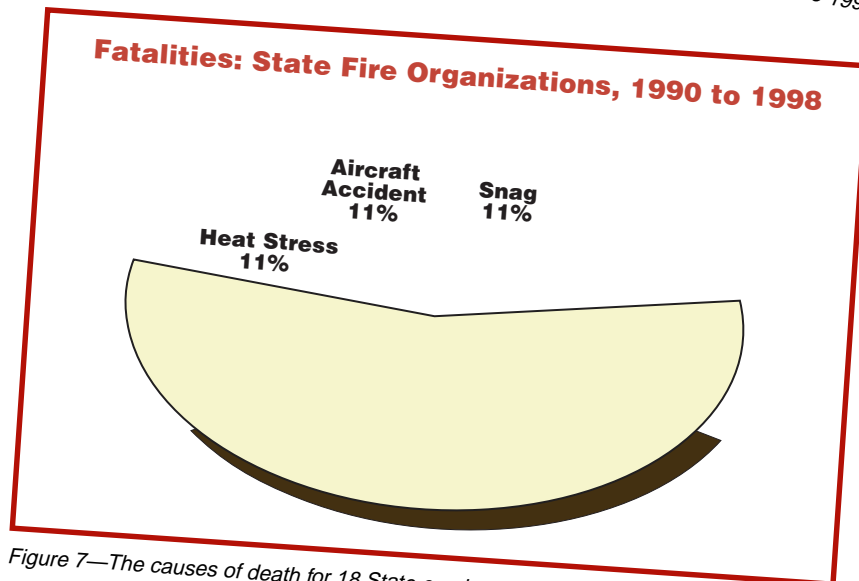


Figure 7—The causes of death for 18 State employees.

Geographic Areas

Wildland fire fatalities occurred in a majority of the States during the period being analyzed. Personnel died in 33 States from 1990 to 1998.

Thirteen States experienced three or more deaths, five had two, and 10 States had a single firefighter death. Figure 8 shows fire fatalities by region.

On a State-by-State basis, California had the highest number of fatalities (26), followed by Colorado (16). Fourteen of Colorado's fatalities occurred on one incident (South Canyon Fire, 1994). Arizona had 9 fatalities, and Montana had seven fatalities. Six of Arizona's fatalities occurred on one incident (Dude Fire, 1990). Montana's fatalities occurred during aircraft accidents (4), burnovers (2), and training (1). Other States that had more than three fatalities include New Mexico (8), Texas (8), Idaho (7), Alabama (5), Oregon (5), Utah (4), and Oklahoma (4).

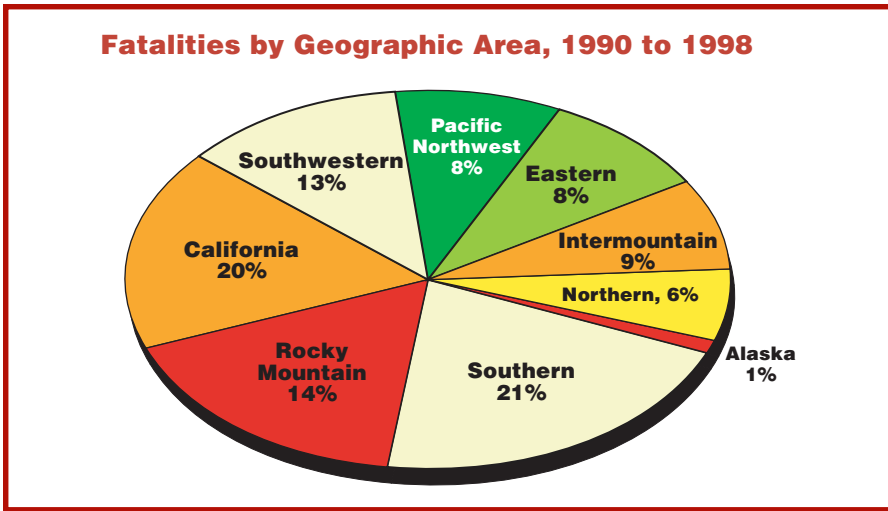
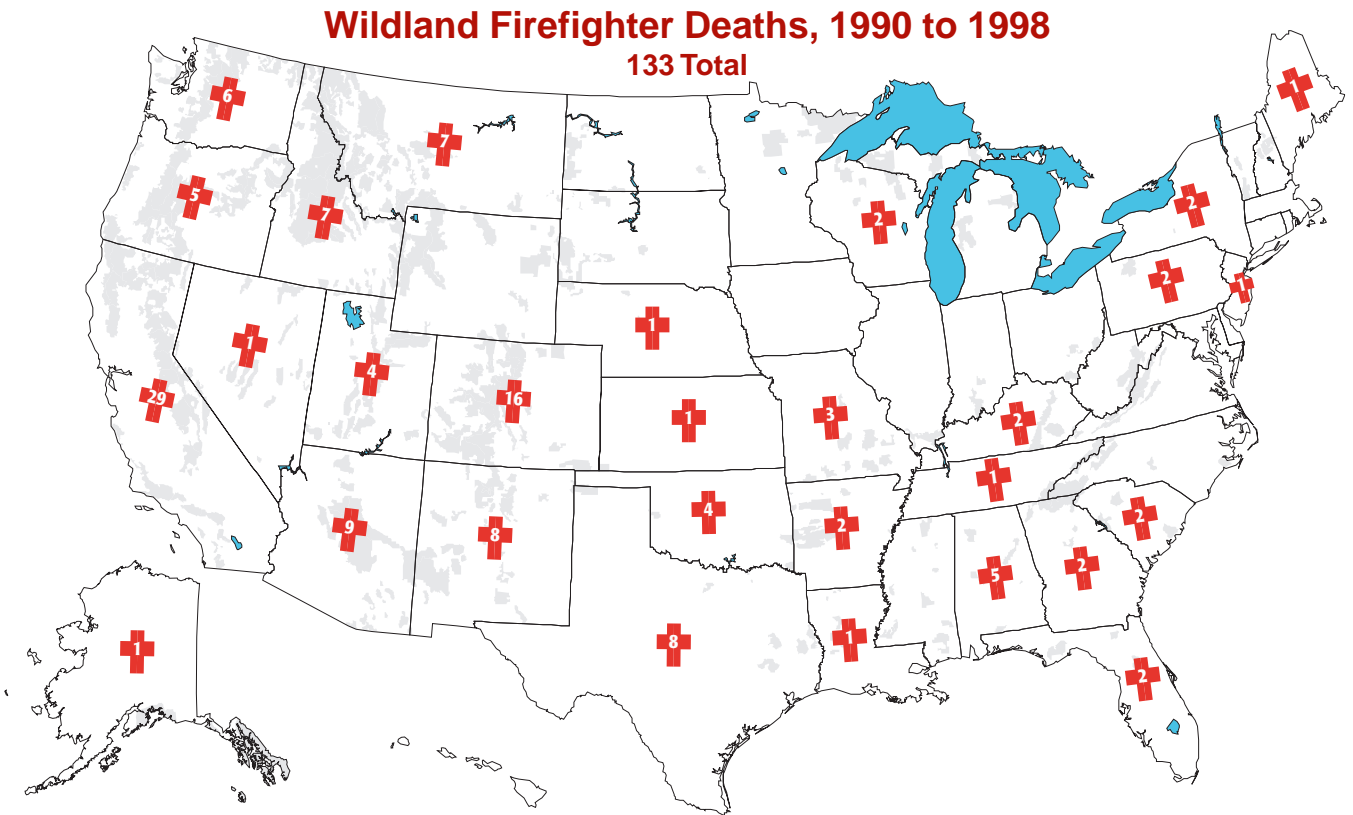


Figure 8—More than half of the fatalities from 1990 to 1998 occurred in the Southern, Rocky Mountain, and California Regions.



Analysis of Fatalities and Fatal Incidents

The deaths of 34 firefighters in 1994 focused the fire community's attention on wildland fire, and resulted in numerous initiatives at the Federal and State levels to improve firefighter safety. The primary emphasis of these initiatives was reducing injuries and deaths from burnovers; however, the data shows that events other than burnovers result in significant numbers of firefighter deaths.

□ Twenty-eight deaths (21%) associated with wildland fire operations resulted from heart attacks. A large volume of medical literature details the relationship between physical fitness and cardiac health. Regular exercise programs have a demonstrated record of reducing heart attacks. This is especially important to individuals who are over 40 years old and who may not live an active lifestyle until called on for fire suppression. The incidence of heart attacks is relatively low among the firefighters in the Federal, State, and city/county groups. They are often younger than 40, and have a period of their work day dedicated to physical conditioning, indicating the potential value of exercise.

□ Aircraft with both rotary and fixed wing have become increasingly important in wildfire suppression and are perhaps the most visible public symbol of aggressive fire suppression. A combination of factors resulted in 30 deaths from 1990 to 1998:

- Many fire operations take place in steep mountainous terrain with limited room to maneuver aircraft if problems arise.
- Weather during wildfires is often hot and windy, frequently adversely affecting flight performance.
- The increasing age and flight hours on the air tanker fleet (Figure 9) is a growing concern that has been addressed at the Congressional level.



Figure 9—The increasing age and flight hours on the air tanker fleet are a growing safety concern.

- Rotary wing operations frequently require helicopters to hover for long periods, reducing the likelihood that the helicopter can autorotate to a safe landing if engine problems occur.
- Helicopter operations are often conducted at or near the maximum usable weight of the helicopter. In addition, helicopters may have buckets suspended 25 to 150 feet beneath them on a cable that may become entangled in trees, snags, or powerlines (Figure 10).
- The aircraft operations often occur less than 500 feet above ground level (AGL) in heavy smoke where hazards such as trees, snags, and powerlines may not be clearly visible.

The majority of aircraft fatalities occur in the contractor category. This is because Federal agencies do not own or operate many helicopters or air tankers. These services are contracted



Figure 10—The hazards of helicopter operations include long cables that can tangle in trees, snags, or powerlines.

on a scheduled and an “as-needed” basis. The Federal aircraft accident fatalities include two lead plane pilots and two helitack crewpersons killed in a helicopter crash that also killed the contractor pilot.

❑ Vehicle accidents while traveling to the fire, at the fire, and while returning from the fire resulted in 25 fatalities (18%) from 1990 to 1998 (Figure 11). Volunteers accounted for 18 fatalities (72%), with a preponderance (total: 12, 48%) occurring in the Southern geographic area. The high rate of fatalities volunteers suffer from vehicle accidents may be a result of infrequent opportunities to drive the engines. Other factors may include volunteers’ areas of response being more congested than the Federal and State wildlands, the heavier weight (and longer braking distances) of rural engines compared to the Federal engines, and possibly the age or condition of engines obtained through the Federal excess property program. A disturbing fact in vehicle-caused fatalities is the number of firefighters killed while riding outside engines: these individuals are often killed by being thrown off an engine (Figure 12), or by being crushed when the engine leaves the road and rolls over them. Four Federal employees died in vehicle accidents related to wildfires. Three were transporting supplies from fire caches to an incident when the accidents occurred, and a fourth was enroute to a fire when his vehicle was struck by a stolen pickup truck.

❑ Falling snags (dead standing trees without leaves or needles in the crowns) killed five wildland firefighters. Although this hazard has resulted in relatively few deaths, and only one has occurred since 1992, the risk of death or injuries from falling snags remains a serious concern. The deterioration of forest health in the Western United States has resulted in enormous areas of forested land becoming susceptible to wildfire. Snags typically have much lower fuel moistures than live green




Figure 11—Vehicle accidents were the fourth-most-common cause of fatalities for persons who died while involved in fighting fires from 1990 to 1998.



Figure 12—Firefighters who ride outside an engine can be killed when they are thrown off or when the vehicle rolls.

trees and burn more readily. In the process, they often throw spot fires far in advance of the main fire, and often burn through more quickly than green trees, falling with little or no warning. The risk of injuries from falling snags increases during the night operational

period when visibility is greatly reduced. While the cooler nighttime period is generally a more effective time to gain control on wildfires, the increased risk from unseen falling snags may limit the widespread use of crews at night in areas of dead and dying timber. 

Burnovers

Burnovers are the leading cause of death. Fifteen separate burnover events from 1990 to 1998 killed 39 firefighters (Figure 13). Twenty were killed in two incidents. Six firefighters died on the Dude Fire in Arizona in 1990, and 14 died on the South Canyon Fire in Colorado during 1994. Both fires occurred during extreme conditions and have been thoroughly investigated and analyzed to learn lessons that will help other firefighters and fire managers prevent such tragedies from recurring. Another 13 burnover events killed 19 firefighters. What can we learn from those burnovers?

Phase of the Fire

Most of the burnover events occurred during the initial attack or extended initial-attack phase. This is when the firefighters are often involved in independent action, either as members of a small crew, an engine, or even as individuals. The higher level incident management teams are not on the scene, communications may be confused, fire weather and behavior conditions may not be widely known or recognized, and the chain of command may not be well established.

Transition Phase

The other dangerous phase of a wildfire is the “transition phase,” when the fire has escaped initial attack efforts and higher level incident management teams are being brought in. During this phase some confusion may exist over areas of responsibility; locations of different resources such as crews, engines, or line overhead; or appropriate radio frequencies for tactical operations. This is often the time the fire is exceeding the capability of the initial-attack resources.

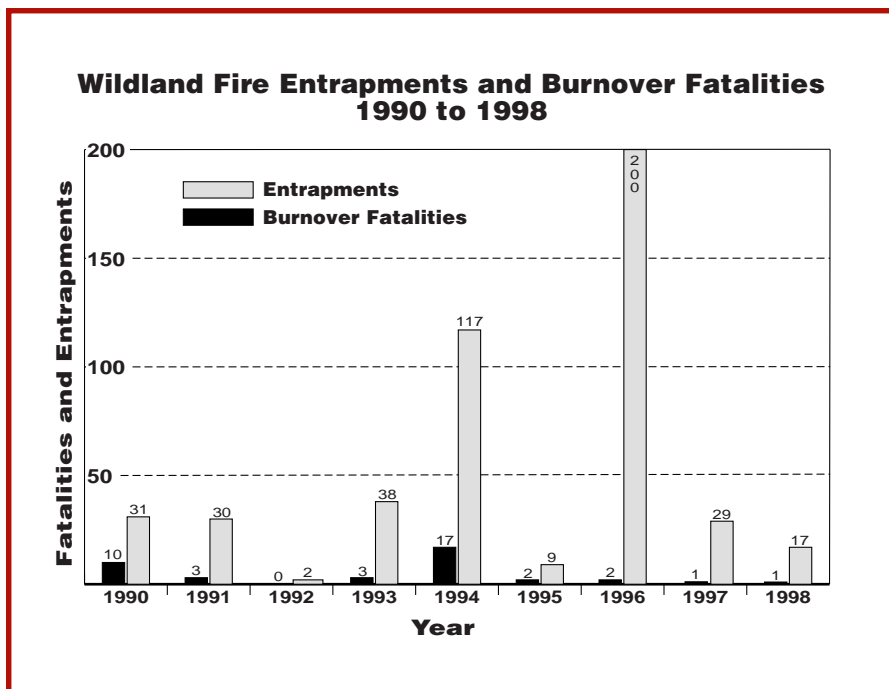


Figure 13—The increasing number of entrapments raises concerns that the number of fatalities might increase as well.

Strategies and Tactics

Many of the wildland fire fatalities from burnovers can be directly attributed to the failure to follow the basic guidelines that are the basis for all wildland fire strategy and tactics:

- 10 Standard Fire Orders
- 18 Situations That Shout “Watch Out!”
- 9 Guidelines for Downhill Line Construction

These situations, orders, and guidelines have been synthesized by Paul Gleason, former Superintendent of the Zig Zag (Oregon) Interagency Hotshot Crew, into one easily remembered acronym, LCES. The letters stand for “Lookout, Communications, Escape Routes, Safety Zones.” These guidelines will help firefighters stay out of burnovers on a wildland fire, and should be a key component of future training.

Personal Protective Equipment (PPE)

The lack of PPE, or the failure to use it correctly, has been a direct factor in many of the 39 burnover fatalities. The fire shelter is perhaps the most critical piece of PPE in a burnover situation (Figure 14). In numerous incidents, fatally burned firefighters did not have a fire shelter, and in several others they had shelters but could not readily reach them. Other fatalities have occurred when firefighters attempted to outrun the fire rather than deploy their shelters, or failed to remain inside the shelters after successfully deploying them. The minimally accepted standards for wildland fire PPE can be found in NFPA 1977 (1998 version).



Figure 14—Investigations of fatalities provide information that can save lives.

Discussion and Recommendations


The challenges of wildland fire suppression in the United States are growing with each passing year because of:

- ❑ The growing area of wildland-urban interface where increased values-at-risk affect traditional wildfire suppression techniques.
- ❑ The changing wildland fuel conditions, often resulting from past fire exclusion policies, make the wildlands more flammable and increase the size and intensity of many fires.

- ❑ The implementation of the Federal Fire Policy Review, more clearly defining the areas of wildfire suppression responsibility for Federal and State wildfire agencies.
- ❑ The age and experience levels of fire managers and wildland firefighters, combined with the trend to downsize government at all levels.

Because of these factors, it is essential that positive steps be taken to ensure the safety of fire personnel during

wildland fire operations. The main components of a program to successfully reduce fatalities and injuries include:

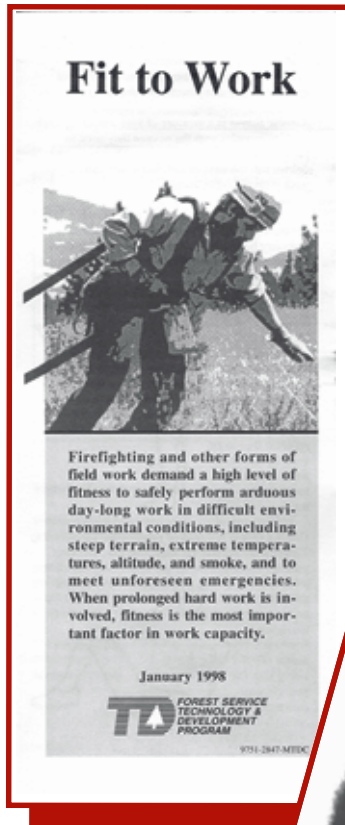
- ❑ Individual responsibility
- ❑ Training and qualifications
- ❑ Strategy and tactics
- ❑ Personal protective clothing and equipment. 

Individual Responsibility


All firefighters are ultimately responsible for their own safety and well being. Several areas are totally within the individual's control:

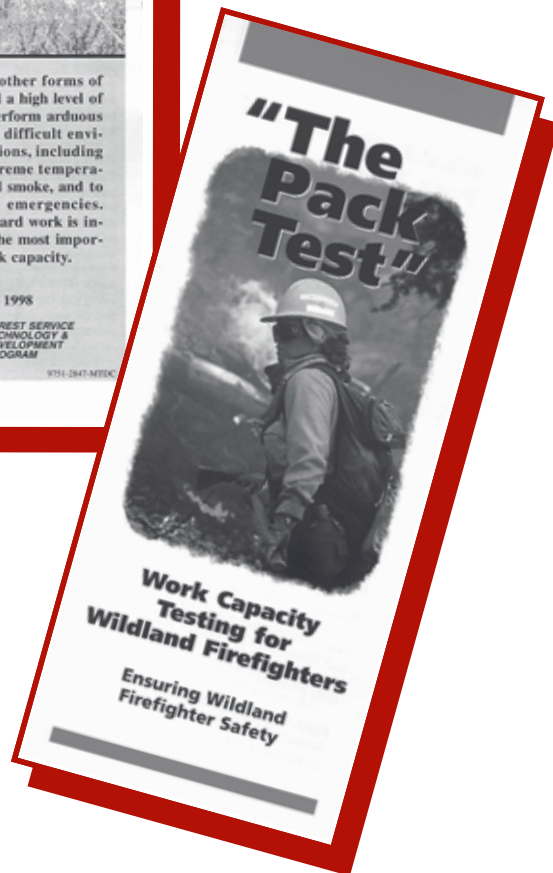
Physical Fitness

Wildland firefighting requires a high level of fitness that anyone can achieve who is willing to invest an hour a day in a physical-conditioning program such as aerobics, running, or bicycling. An excellent firefighter fitness program is *Fitness and Work Capacity*, (9751-2814-MTDC) by Dr. Brian Sharkey of the USDA Forest Service Technology and Development Center (MTDC) in Missoula, Montana. Dr. Sharkey discusses the components of a fitness program, and details the procedures for the Pack Test, the new fitness test that wildland firefighters working for all Federal agencies and many State agencies must pass each year.



Self Discipline

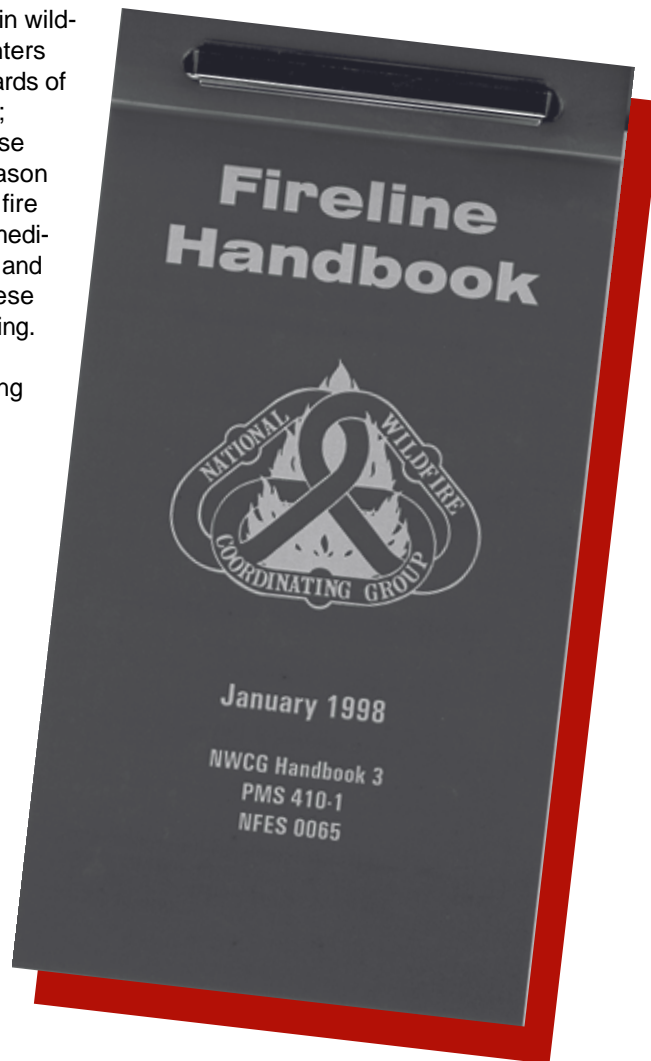
Whether someone is driving an engine, flying an aircraft, or attacking a wildfire, self-discipline can reduce fatalities. When individuals adhere to Agency policies, standard operating procedures, driving laws, work/rest cycles, and other guidelines, they help ensure a safe operation and the successful completion of the fire mission. 



Training

Training is especially critical in wildland fire operations. Firefighters need to understand the hazards of steep, winding, unpaved roads; and dead vegetative fuels whose flammability varies with the season as well as the time of day; and fire behavior that is directly and immediately affected by both the terrain and the weather. Understanding these factors requires specialized training.

The National Wildfire Coordinating Group has developed courses



from the most basic to the most advanced levels of wildfire suppression and management. These courses, along with the accompanying task books that require demonstrated performance in a field setting, should be the basis of a well-rounded training and qualifications program. Another valuable source of information is Standard for Wildland Fire Fighter Professional Qualifications (NFPA 1051).

Strategy and Tactics

The way we fight fire, both on the ground and in the air, can play an important part in reducing wildland fire fatalities.

Guidelines can help the firefighter operate safely in a hazardous environment:

- ❑ The *18 Situations That Shout “Watch Out”* are intended to call attention to various conditions or events that, if not mitigated, can have potentially serious or fatal consequences.
- ❑ The *10 Standard Fire Orders* are direct statements of positive actions a wildland firefighter must take to operate safely. They have evolved over the years as a direct result of wildfire fatalities that occurred when those actions were not taken. The *18 Situations* simply alert firefighters


to events, but the *10 Standard Fire Orders* are rules that must be adhered to.

- ❑ Many other guidelines and memory joggers have evolved over recent years. The acronym LCES does the best job of focusing attention on the critical factors affecting wildland fire safety.

Numerous opportunities exist to reduce accidents and fatalities during aircraft operations, both fixed and rotary wing.

- ❑ Exposure rate, measured in numbers of hours flown, can be reduced by properly applying strategy and tactics. Air tankers and water-dropping helicopters should only be used when they can help the fire suppression. Air tankers are often ineffective under

conditions of extreme fire behavior in heavy fuels with high winds. The grounding of aircraft limits their exposure, saving them for a more appropriate time and place. Although the public and media have come to expect aircraft operating continuously during daylight hours, it is often not the best or safest approach.

- ❑ With aircraft being mobilized nationwide to support wildfire suppression, it is possible to have more than 20 aircraft operating on a fire at one time. Highly qualified air operations personnel are essential to ensure safety. When they are not available, some or all of the aircraft should be grounded until a safe operation can be guaranteed. 

Personal Protective Clothing and Equipment

Personal Protective Equipment can help protect firefighters when they find themselves in areas of high radiant heat or direct-flame contact.

Wildland protective clothing should comply with NFPA 1977. This standard offers adequate levels of protection for the wildland firefighter without causing undue heat stress or fatigue. An alarming trend of heat-stress injuries and fatalities on wild-fires is developing. In addition, several wildland agencies are requiring double layering of either Nomex or a Nomex/cotton combination on both the upper and lower torso to increase protection from radiant heat, allowing firefighters to stay closer to the fire

for a longer time. In Australia, the recently completed *Project Aquarius* looked at the physiological effect of PPE on firefighters, and concluded that the majority of heat stress in a firefighter was internally generated. The study found that PPE should be “designed to let heat out, not keep heat out.”

Fire shelters should be carried by every wildland firefighter and on every piece of apparatus involved in wildfire suppression. Fire personnel should be trained using the practice fire shelter, with a mandatory refresher each year. Training should NOT be conducted during live fires because of the safety risks.

A pamphlet entitled *Fireline Safety References* has been published by the NWCG Safety and Health Working Team in cooperation with MTDC. It lists a wide variety of publications, videos, and training packages available to enhance firefighter safety, as well as the sources for the materials. It can be requested from MTDC at:

Phone: (406) 329-3978
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The deaths of wildland firefighters are tragedies we must strive to prevent. We must not fail to apply the lessons learned from those deaths.



About the Author

Dick Mangan has been Program Leader for Fire, Aviation, and Residues at MTDC since 1989. Before coming to the Center, he spent more than 20 years working on Ranger Districts and National Forests in Washington and Oregon, participating in the full range of wildland fire activities. He serves on the National Wildfire Coordinating Group (NWCG) Fire Equipment and Safety and Health Working Teams, and is chairperson of the National Fire Protection Association (NFPA) 1977 Technical Committee for Wildland Fire Personal Protective Clothing and Equipment. Dick remains active in the field, representing MTDC on fire entrapment investigations and serving as Operations Section Chief on a National Type 1 Overhead Team.

Library Card

Mangan, Richard. 1999. Wildland fire fatalities in the United States: 1990 to 1998. Tech. Rep. 9951-2808-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 17 electronic p.

Summarizes the causes of death for 133 persons who died while involved in fighting wildland fires in the United States from 1990 to 1998. Burnovers were the leading cause of death, followed by aircraft accidents, heart attacks, and vehicle accidents. Fatalities are analyzed by geographic area and by agency. The main components of a program to reduce fatalities and injuries would include: individual responsibility, training and qualifications, strategy and tactics, and personal protective clothing and equipment.

Keywords: fire fighters, fire fighting, firefighting, safety, safety at work

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