A publication of the
National Wildfire Coordinating Group

NWCG Report on Wildland Firefighter Fatalities in the United States: 2007-2016

PMS 841 DECEMBER 2017

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The *NWCG Report on Wildland Firefighter Fatalities in the United States: 2007–2016* is a report examining the causes of death for firefighters who work for various organizations across the United States. We assessed trends and common factors of fatalities to help mitigate those factors and reduce future firefighter fatalities. This report is an update of the publication *Wildland Firefighter Fatalities in the United States: 1990-2006,* PMS 841, in which the NWCG examined wildland firefighter fatalities between 1990 and 1998 and between 1999 and 2006.[1] In this current report, we assess fatalities between 2007 and 2016 (the most recent period).

The National Wildfire Coordinating Group (NWCG) provides national leadership to enable interoperable wildland fire operations among federal, State, Tribal, and local partners. NWCG operations standards are interagency by design; they are developed with the intent of universal adoption by the member agencies. However, the decision to adopt and utilize them is made independently by the individual member agencies and communicated through their respective directives systems.

Contents

Introduction **1**

Study Protocol **1**

Data Sources 2

Causes of Death **3**

Heart Attacks 3

Vehicle Accidents 4

Aircraft Accidents 4

Entrapments 4

Falling Trees or Rolling Rocks 6

Medical Causes Other Than Heart Attacks 6

Miscellaneous Causes of Death 6

Incidents with Multiple Fatalities 6

Locations of Fatalities **8**

Organizations **9**

Volunteer Firefighters 10

City/County/Rural Firefighters 10

Federal Firefighters 11

State Firefighters 11

Ground Contractors 12

Aviation Contractors 12

Military Personnel 12

Trends and Conclusions **12**

Trends by Fatality Events 14

Trends by National Preparedness Level 15

Final Conclusions 16

References **17**

Introduction

Wildland firefighting is a high-risk occupation that can result in injuries or death on or off the fireline. Wildland firefighting requires coordination between federal, state, tribal, and local agencies. These agencies often use contract workers and sometimes military personnel to provide additional resources for firefighting operations.[1]

Between 1990 and 2016, 480 firefighters died during wildland firefighting operations. According to the previous wildland firefighter fatalities report, fatalities increased by 26 percent during the 1999 to 2006 period when compared with the 1990 to 1998 period. In that assessment, aircraft accidents, and vehicle accidents were the leading causes of death, followed closely by heart attacks.[1] In 2017, a review of wildland firefighter fatalities surveillance systems (2001 to 2012) reported that medical events, such as heart attacks and strokes, were the leading causes of death, followed by vehicle-related incidents and aviation-related incidents among the 247 identified unique death records.[3]

After reviewing initial reports of wildland firefighter fatalities between 1990 and 2012, agencies developed programs and policies to increase firefighter safety and reduce injuries and fatalities. After the 1994 fire season, when 34 firefighters died (including 14 firefighters at the South Canyon Fire), the National Wildfire Coordinating Group (NWCG) approved the Wildland Firefighter Safety Awareness Study. The study suggested many human factor-related goals and recommendations. Recommendations included the implementation of the Human Factors/Leadership training series and SAFENET, an anonymous firefighter safety reporting database.[4] To assess how this culture shift affected safety, Loveless and Hernandez[4] examined changes in entrapment rates after agencies implemented human factors training beginning in 2000. They concluded that there was a significant decrease in the probability of entrapments for both federal and non-federal firefighters.[4]

Established in 2002, the Wildland Fire Lessons Learned Center (WFLLC) mission is to "promote learning in the wildland fire service by providing useful and relevant products and services that help to reveal the complexity and risk in the wildland fire environment." The 2012 WFLLC's 10-year anniversary report highlighted products they developed, including quarterly newsletters that discuss wildland fire issues (such as safety topics); the "Incident Review Database," which includes incidents dating back to 1908; and the "Rapid Lessons Sharing" platform, which provides firefighters with an easy way to share in-the-field lessons (such as successes, challenges, or close-calls) to increase safety.

Study Protocol

This study is a follow-up to the 2007 NWCG publication "Wildland Firefighter Fatalities in the United States: 1990-2006." The previous report used information on wildland firefighter fatalities from the NWCG's Risk Management Committee "Safety Grams." For this study, in addition to "Safety Grams" data, we obtained firefighter fatality information from The National Institute for Occupational Safety and Health (NIOSH) Firefighter Fatality Investigation and Prevention Program (FFFIPP) and the U.S. Fire Administration (USFA) firefighter fatality incident database.

Data Sources

The NWCG "Safety Grams"

The NWCG "Safety Grams" includes data on fatalities, entrapments, and other life-threatening accidents and injuries associated with wildfire.[5] The "Safety Grams" includes the date, location and jurisdiction, activity engaged in at time of death, agency/entity of personnel involved, and type of incident. We included all fatality entries in the "Safety Grams" in our analysis.

The NIOSH Firefighter Fatality Investigation and Prevention Program

The NIOSH FFFIPP conducts independent investigations of firefighter line of duty fatalities. NIOSH prioritizes and selects investigations based on the type of incident and whether the incident meets the USFA criteria for on duty fatalities.[6,7] Generally, these investigations focus on fatalities during on duty structural firefighter activities, but NIOSH also investigates some wildland fire fatalities. Reports provide detailed information about the events that occurred before, during, and after the incident; medical/autopsy findings; and information about the decedent's employer and his or her training and experiences. We extracted fatality reports from the NIOSH FFFIPP's "Completed Investigations" web page by searching the database with the keywords "wildland fire," "wildland firefighter," "wildfire," "brush fire," "grass fire," "timber," "outdoor fire," and "work capacity test." We also identified investigations related to wildland fire by scanning and reviewing all report titles and descriptions and using the interactive map feature to locate investigation reports by selecting the variable "Wildland Fire Fatalities" for each year between 2007 and 2016.[8]

U.S. Fire Administration Firefighter Fatality Incident Database

The USFA collects and maintains a database of the causes of on duty firefighter fatalities that occur in the United States.[9] We downloaded the publicly available firefighter fatality incident database and identified wildland fire incidents with the search terms "wildfire," "brush," "grass," "timber," "wildland firefighter," "wildland fire," and "work capacity test." Reports included the name, age, classification of the firefighter, details on the cause of death and activity of the firefighter, and an initial summary.

Inclusion Criteria and Case Matching

For this report, we included fatalities for all firefighters and emergency responders engaged in any wildland fire activity, such as support, fire suppression, damage repair, fire rehabilitation work, mobilization status, demobilization status, training, and work capacity tests. We expanded this case definition from previous studies of WLFF. We included fatalities if the firefighter was on duty or if the firefighter's death met the provisions of the Hometown Heroes Survivors' Benefit Act of 2003. This act presumes that a heart attack or stroke is in the line of duty if the firefighter was engaged in a non-routine, stressful, or strenuous physical activity while on duty, and the firefighter became ill while on duty or within 24 hours after engaging in the activity.[10] We also included fatalities resulting from vehicle accidents if the firefighter responded to a wildland fire incident in his or her personal vehicle. After we reviewed all data sources and identified wildland fire-related fatality incidents, we combined all reports into one database and deleted duplicate incident reports. From each data source, we collected the date, incident name and location, agency and organization type, and type of accident.

Causes of Death

Between 2007 and 2016, 170 firefighters died during wildland fire operations. The four major causes of death—heart attacks (41 fatalities, 24 percent), vehicle accidents (34 fatalities, 20 percent), aircraft accidents (31 fatalities, 18 percent), and entrapments (28 fatalities, 17 percent)—were responsible for 79 percent of the total number of fatalities.

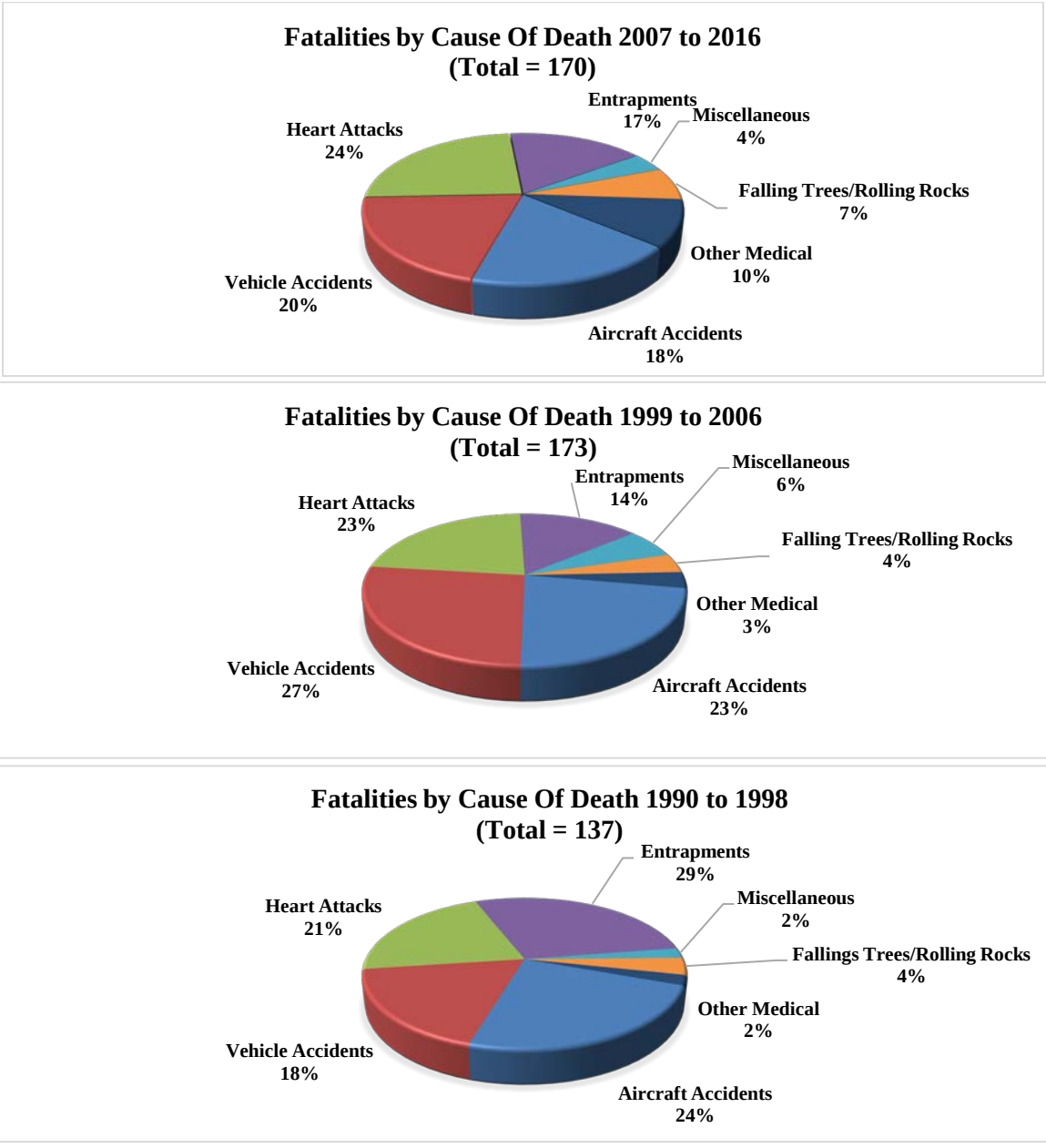

Figure 1–Fatalities by cause of death between 2007 to 2016, 1999 to 2006, 1990 to 1998.

Heart Attacks

Heart attacks were the most common cause of death during the most recent period. There were 41 heart attack fatalities (4.1 fatalities per year) between 2007 and 2016, compared with 39 heart attack fatalities

(4.9 fatalities per year) between 1999 and 2006. The number of fatalities from heart attacks decreased by 0.8 fatalities per year between the two periods. Although there was a slight increase in the number of heart attack fatalities between 2007 and 2016 when compared with the period between 1999 and 2006, we expanded our case definition in this report to include cases and data sources that the 2007 report did not include. In this report, we included heart attacks that met Hometown Heroes Survivors' Benefit Act of 2003 provisions. The number of heart attack fatalities for this report would be lower if we only included fatalities from the "Safety Grams." Of the 41 heart attack fatalities that occurred during the most recent period, nine individuals (22 percent of all heart attacks) died of delayed heart attacks after returning from wildland fire incidents, which met the criteria for the Hometown Heroes Survivors' Benefit Act of 2003, but which previous reports would not have included. If we exclude these cases, there were 32 fatalities (3.2 fatalities per year) between 2007 and 2016, compared to 39 fatalities (4.9 fatalities per year) between 1999 and 2006. Since 2007, only three individuals have died of heart attacks during or after the work capacity test. This is considerably lower than the 11 firefighters who died from heart attacks while taking or preparing for the work capacity test between 1999 and 2006. The implementation of a medical standards program, which requires physical examinations and health screening questionnaires, may have contributed to the overall decrease in heart attack fatalities.

Vehicle Accidents

Vehicle accidents were the second major cause of death for wildland firefighters during the most recent period, resulting in 34 deaths (3.4 fatalities per year). This report also included four fatalities where firefighters responded to wildfire incident calls in their personal vehicles. However, even with these cases, there was a 28 percent decrease in the number of vehicle accident deaths between 2007 and 2016 when compared with the period between 1999 and 2006 (46 fatalities, 5.8 fatalities per year).

Aircraft Accidents

Aircraft accidents were the third major cause of death during the most recent period, resulting in 31 wildland firefighter fatalities (3.1 fatalities per year). There was a 15 percent decrease in the number of aircraft accident fatalities between 2007 and 2016 when compared with the period between 1999 and 2006 (39 fatalities, 4.9 fatalities per year).

Entrapments

Entrapments were the fourth major cause of death during the most recent period, resulting in 28 firefighter fatalities (2.8 fatalities per year). Between 1999 and 2006, there were 25 entrapment fatalities (3.1 fatalities per year), or 14 percent of the total fatalities. The percentage of entrapment fatalities compared to other causes of death drastically increased during the most recent period, primarily because of a multiple-fatality event on the Yarnell Hill Fire in 2013 where 19 firefighters died from entrapment (68 percent of all entrapment deaths). In addition, three firefighters died from entrapment on the Twisp Fire in 2015 and two firefighters died from entrapment on the Blue Ribbon Fire in 2011. Compared with the period between 1999 and 2006, entrapment caused fewer single-fatality incidents between 2007 and 2016 (16 to 4). Although entrapments were the fourth highest major cause of death, most of the incidents were multiple-fatality events.

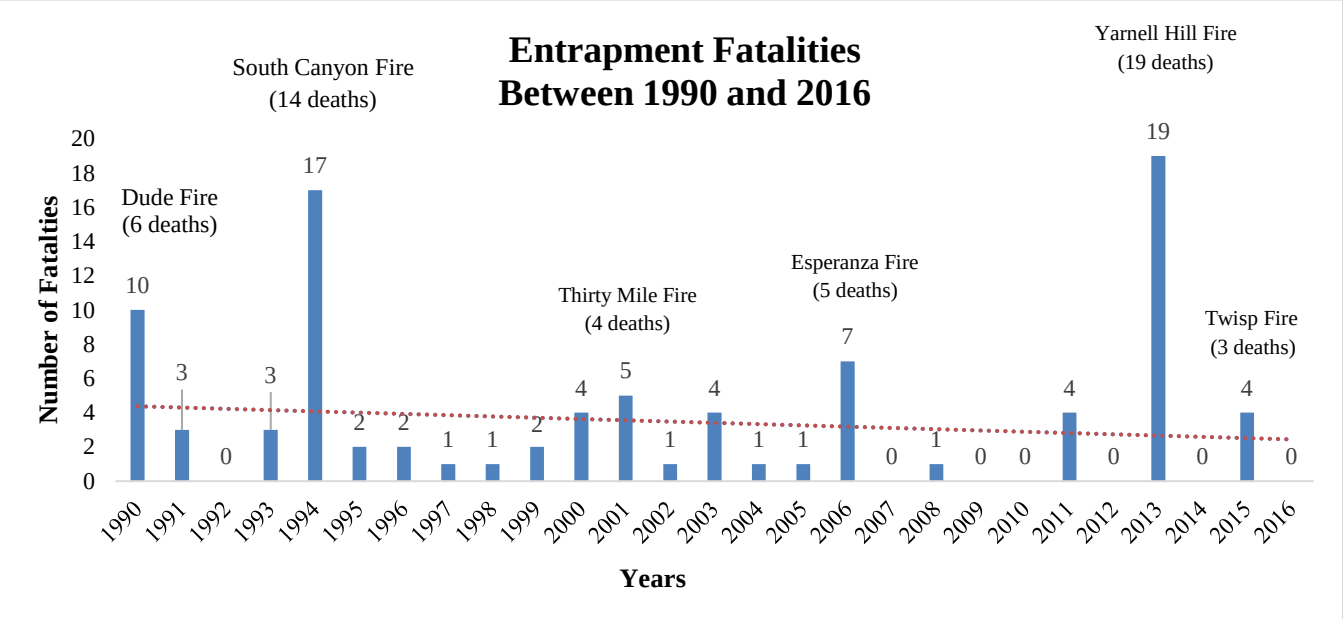

Figure 2–Annual entrapment fatalities between 1990 and 2016 (92 total deaths).

The number of fires reported to the National Interagency Fire Center (NIFC) in Boise, ID, decreased from an annual average of 79,313 between 1999 and 2006 to 70,413 between 2007 and 2016. Despite fewer fires during the recent period, the number of acres burned each year increased from an annual average of 6.79 to 7.0 million acres.

Year	Fires	Acres	Acres (Alaska only)	All Cause Fatalities	Entrapment Fatalities (average per year)
2007	85,705	9,328,045	525,017	15	0
2008	78,979	5,292,468	62,648	12	1
2009	78,792	5,921,786	2,951,597	10	0
2010	71,971	3,422,724	1,125,419	36	0
2011	74,126	8,711,367	293,018	16	4
2012	67,774	9,326,238	286,887	15	0
2013	47,579	4,319,546	1,316,876	12	19
2014	63,312	3,595,613	233,561	15	0
2015	68,151	10,125,149	5,111,404	27	4
2016	67,743	5,509,995	496,467	12	0
Total 2007 to 2016	704,132	65,552,931	12,402,894	170	28 (2.8 per year)
Total 1998 to 2006	634,501	54,397,065	14,183,112	173	25 (3.1 per year)
Total 1990 to 1998	749,664	29,440,741	-	137	39 (4.3 per year)

Table 1–Number of wildland fires, acres burned, and fatalities between 1990 and 2016. [1, 11]

Falling Trees or Rolling Rocks

Falling trees or rolling rocks claimed the lives of 12 firefighters during the most recent period (1.2 fatalities per year), compared with seven firefighters during the period between 1999 and 2006 (0.9 fatalities per year). The total number of firefighter fatalities caused by falling trees or rolling rocks between 2007 and 2016 was equal to the combined total between 1990 and 2006. Four of the deaths during the most recent period occurred in California; two in Kentucky; and one each in Colorado, Oregon, Washington, Idaho, Nevada, and Florida.

Medical Causes Other Than Heart Attacks

Medical causes other than heart attacks were responsible for three firefighter fatalities between 1990 and 1998 (0.3 fatalities per year), six between 1999 and 2006 (0.8 fatalities per year), and 17 during the most recent period (1.7 fatalities per year). Conditions included unknown or never determined medical reasons (seven fatalities), heat-related injuries (two fatalities), stroke (two fatalities), trauma accidents (two fatalities), complex cardiac issues (one fatality), intracranial hemorrhage (one fatality), pulmonary embolism (one fatality), and smoke inhalation and a cardiac event (one fatality). The increase of fatalities in this category may not be as substantial if we use the same study protocol used in the previous report. For example, we found three fatalities in this category in the USFA or the NIOSH FFFIPP database that were not reported on the "Safety Grams." Also, trauma from falls caused two deaths in this category. In one case, a firefighter fell onto a log and sustained a broken neck. In the other case, a firefighter fell out of a truck and hit his head. These could fit into the "miscellaneous causes of death" category, which listed two incidents of falls from substantial heights. However, even with the exclusion of these five cases, the number of fatalities from other medical causes was still higher during the most recent period when compared with the previous periods. This could be because of an actual rise of deaths in this category, more thorough investigations and better reporting, a broadening of inclusion criteria, or a combination of all three.

Miscellaneous Causes of Death

Miscellaneous causes of death that did not fit into any of the above categories were responsible for three firefighter fatalities between 1990 and 1998 (0.3 fatalities per year), 11 between 1999 and 2006 (1.4 fatalities per year), and seven (0.7 fatalities per year) between 2007 and 2016. The causes of death in this category during the most recent period include falls (two fatalities), strikes by a vehicle caused by reduced visibility from dense smoke (two fatalities), electrocution (one fatality), smokejumper training (one fatality), and a strike by a piece of water tank that failed under pressure (one fatality).

Incidents with Multiple Fatalities

Six multiple-fatality events with three to 19 fatalities each occurred during the most recent period, contributing 41 of the 170 total fatalities (24 percent of all fatalities).

Aircraft Accidents

Iron Complex Fire (2008)—9 Fatalities[12]

A Sikorsky S-61N helicopter, assigned to the Iron Complex Fire in California's Trinity Alps Wilderness, impacted trees and terrain during the initial climb after takeoff from a helispot located in mountainous

terrain at an elevation of about 6,000 feet. The contracted pilot-in-command, the U.S. Forest Service safety crewmember, and seven contract firefighters sustained fatal injuries, and the copilot and three firefighters sustained serious injuries. Impact forces and a post-crash fire destroyed the helicopter operated by the U.S. Forest Service as a public flight to transport firefighters to another helispot. The U.S. Forest Service had contracted with Carson Helicopters, Inc. (CHI) of Grants Pass, OR, for the use of the helicopter.

Stead Airport (2008)—3 Fatalities[13]
A Lockheed P2V-7/SP-2H aircraft was destroyed shortly after takeoff. The aircraft impacted terrain after loss of power and loss of control about two miles northwest of the Reno/Stead Airport in Reno, NV. Three contractors, the pilot, copilot, and flight mechanic died as a result of the accident.

Response to Four Mile Fire (2009)—3 Fatalities[14]
A Lockheed P2V-7 airtanker with a crew of three impacted terrain near Toole, UT. All three contractors onboard died as a result of the accident. The aircraft was traveling from Missoula, MT, to respond to the Four Mile Fire in Chaves County.

White Draw Fire, Black Hills National Forest, South Dakota—4 Fatalities[15]
A C-130 aircraft equipped with a Modular Airborne Fire Fighting System (MAFFS) crashed near Edgemont, SD, while supporting firefighting missions on the White Draw Fire. Four members of the North Carolina Air National Guard died and two sustained serious injuries.

Entrapment Events

Yarnell Hill Fire (2013)—19 Fatalities[16]
While suppressing the Yarnell Hill Fire, the Granite Mountain Interagency Hotshot Crew was traveling through an unburned area toward a safety zone when the high-intensity fire rapidly advanced and overtook them. The fire's extreme speed of 10 to 12 miles per hour eliminated any opportunity for the crew to reach the safety zone or return up to the canyon rim. The crew had less than two minutes to improve a shelter deployment site by using chain saws and burning out the area. The crew had deployed their fire shelters close together in a small area when the fire overtook them. The fire shelter deployment site in the box canyon was not survivable because the heavy brush caused direct flame contact to the fire shelters and temperatures exceeded 2000 °F as the fire swept through the site.[10]

Twisp River Fire (2015)—3 Fatalities[17]
During initial attack, the Twisp River Fire entrapped 16 firefighters. Three federal firefighters died in a Forest Service Type 6 engine. The entrapment also severely injured another federal firefighter who escaped from the engine; resulted in the entrapment and injury of three state firefighters who took refuge in a structure until it was unsafe and then deployed fire shelters; and entrapped the remaining firefighters in three engines who survived without injuries.

These multiple-fatality events had a significant impact on the causes of death assessment. When we omitted these fatalities from our analysis because of their disproportionate impact, the causes of death of the remaining 129 fatalities were:

- Heart attacks (41 fatalities, 32 percent)
- Vehicle accidents (34 fatalities, 26 percent)
- Medical causes other than heart attacks (17 fatalities, 13 percent)
- Falling trees/rolling rocks (12 fatalities, nine percent)
- Aircraft accidents (12 fatalities, nine percent)
- Miscellaneous causes of death (seven fatalities, six percent)
- Entrapments (six fatalities, five percent)

Locations of Fatalities

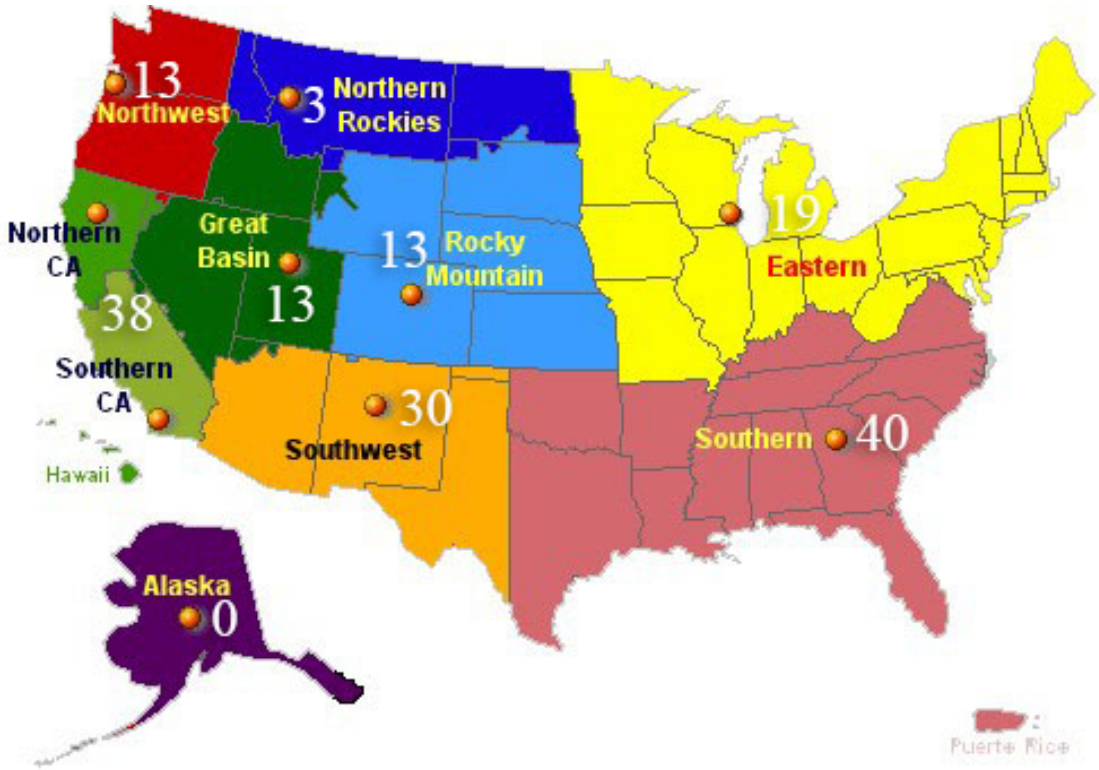

Figure 3–Locations of wildland firefighter fatalities by Geographic Area Coordination Center (GACC). The number of fatalities for California GACCs (northern and southern) is a combined total.

Between 2007 and 2016, the Southern Region had the most fatalities (40); however, there was a slight decrease in fatalities in the region when compared with the period between 1999 and 2006 (45 fatalities). Heart attacks were the leading cause of death in the region (11 fatalities), followed by vehicle accidents (10 fatalities). California was the state with the most fatalities (38 fatalities), showing an increase when compared with the period between 1999 and 2006 (35 fatalities) and the period between 1990 and 1998 (29 fatalities). Aircraft accidents were the leading cause of death in California (15 fatalities), followed by heart attacks and vehicle accidents (seven fatalities each). The Southwest Region fatalities increased from nine fatalities during the period between 1999 and 2006 to 30 fatalities during the most recent period. This extreme increase resulted from the entrapment event on the Yarnell Hill Fire that killed 19 firefighters from the Granite Mountain Interagency Hotshot Crew. Firefighter fatalities in the Eastern Region decreased slightly, from 21 fatalities during the period between 1999 and 2006 to 19 fatalities during the most recent period. In the Northwest, Great Basin, and Rocky Mountain

Regions, fatalities decreased from 17, 17, and 20 (respectively) during the period between 1999 and 2006 to 13 fatalities in each region during the most recent period. Aircraft accidents were the leading cause of death in the Great Basin and Rocky Mountain Regions (six and five fatalities, respectively), while heart attacks were the leading cause of death in the Northwest Region (five fatalities). In the Northern Rockies, fatalities decreased from eight between 1999 and 2006 to three between 2007 and 2016. One falling tree, one heart attack, and one vehicle accident caused these fatalities.

Organizations

The "Safety Grams" categorizes firefighters by seven organizations—federal firefighters, state firefighters, volunteer firefighters, ground contractors, aviation contractors, military personnel, and county/rural firefighters. For this report, we included firefighters who worked for city fire departments in the county/rural category. During the most recent period, the "Safety Grams" reported no fatalities of any private individuals because it no longer reports private individuals acting on their own behalf.

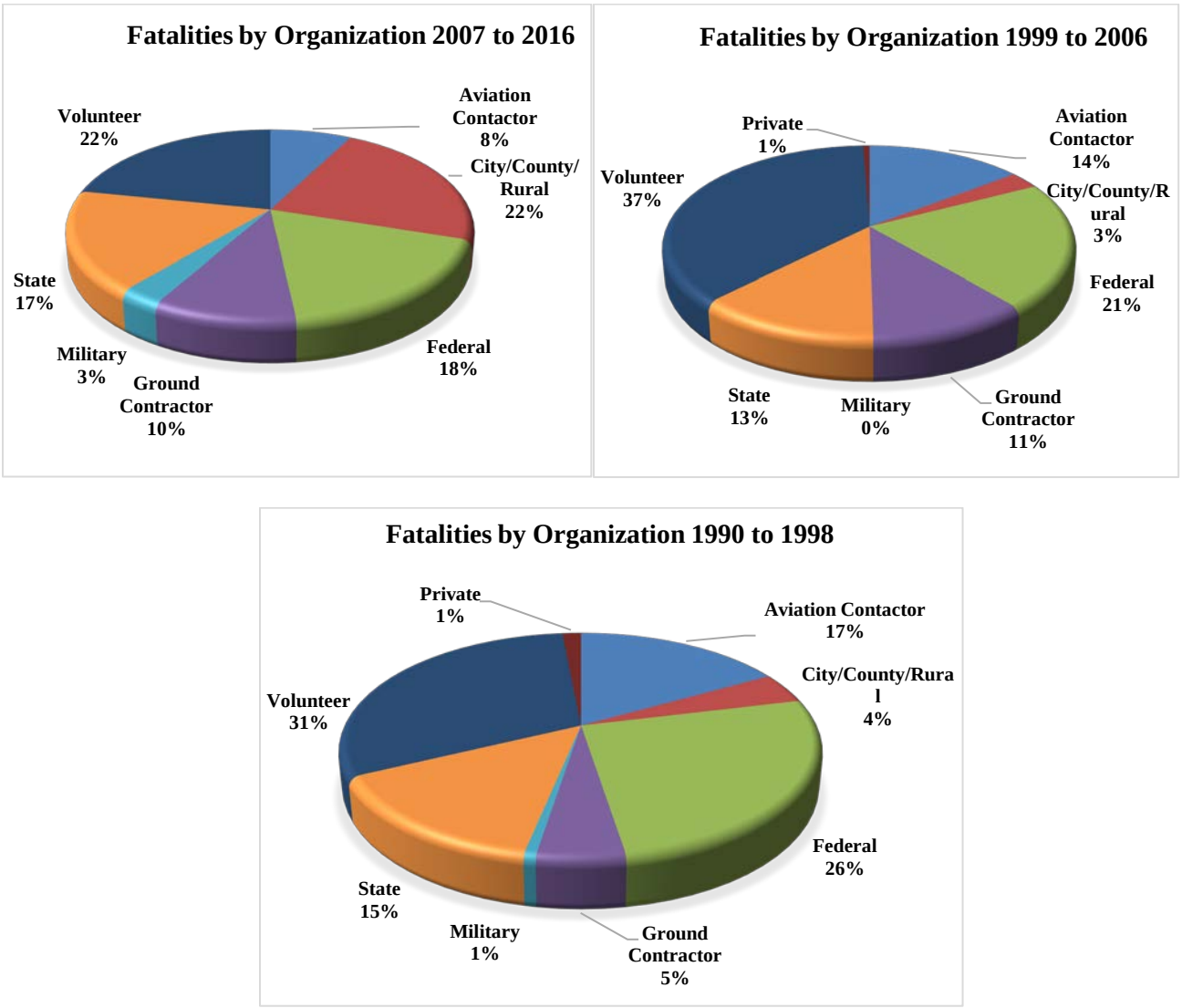

Figure 4–Fatalities by firefighting organization for the periods between 2007 to 2016, 1999 to 2006, and 1990 to 1998.

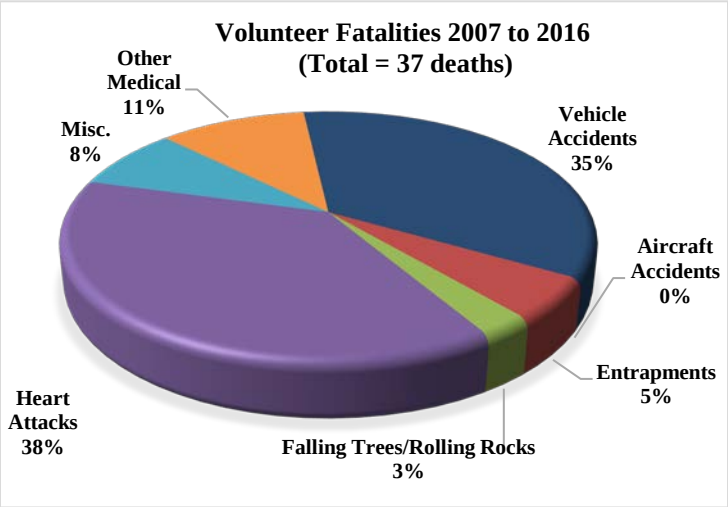

Figure 5–The causes of death for volunteer firefighters.

Volunteer Firefighters

Between 1990 and 2016, volunteer firefighters died more often on wildland fires than firefighters from any other group. Volunteers accounted for 22 percent of all firefighter fatalities during the most recent period (37 fatalities). However, the percentage of volunteer firefighter fatalities for the period between 2007 and 2016 decreased by 12 percent when compared with the period between 1999 and 2006.

For the most recent period, heart attacks were the leading cause of death for volunteers (14 fatalities) and vehicle accidents were a close second (13 fatalities). When compared with the period between 1990 and 2006, the percentage of total deaths from these two causes were about the same, while the number of entrapment fatalities (two fatalities) decreased by six percent. Of the 14 volunteers who died from heart attacks during the most recent period, five occurred after a wildland fire event, and one occurred after a work capacity test. Other causes of volunteer firefighter fatalities included other medical causes (four fatalities), miscellaneous causes (three fatalities), and falling trees/rolling rocks (two fatalities).

City/County/Rural Firefighters

Thirty-eight firefighters working for city, county, and rural fire departments died during the most recent period. These fatalities accounted for the same percentage of all firefighter fatalities as did volunteer firefighter fatalities (22 percent of total deaths). This was an increase of about 19 percent of total deaths when compared with the period between 1990 and 2006. However, this severe increase was because of the entrapments on the Yarnell Hill Fire that killed 19 firefighters from the Granite Mountain Interagency Hotshot Crew. There was also one heart attack fatality and one vehicle accident fatality during the period between 1999 and 2006, compared with eight heart attack fatalities and four vehicle accident fatalities during the most recent period. Three of the eight heart attack fatalities that occurred during the most recent period resulted from delayed heart attacks after wildland fire events. Other causes of death among city, county, and rural firefighters included other medical incidents (five fatalities), miscellaneous causes (one fatality) and falling trees or rolling rocks (one fatality).

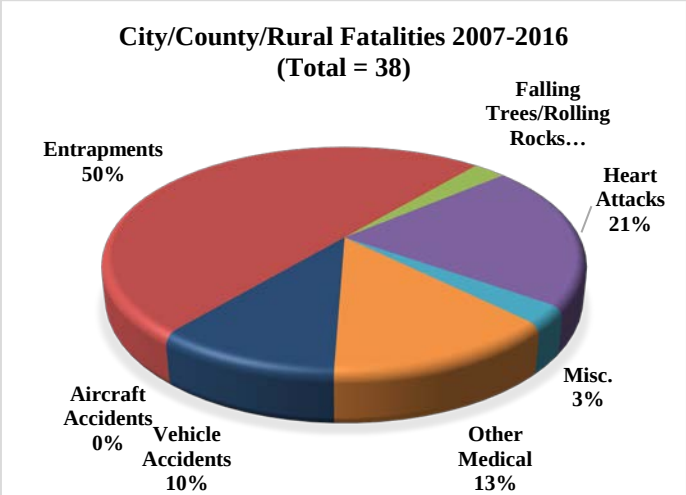

Figure 6–The causes of death for city, county, and rural firefighters.

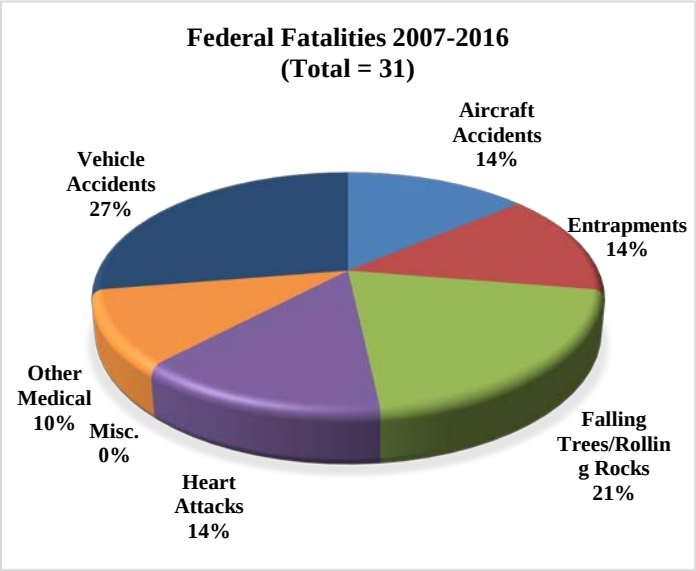

Figure 7–The causes of death for federal firefighters.

Federal Firefighters

Thirty-one federal firefighters died during the most recent period. These fatalities accounted for 18 percent of all firefighter fatalities (3.1 fatalities per year). The number of federal firefighter fatalities between 2007 and 2016 was lower than for the period between 1999 and 2006 (37 fatalities, 4.6 fatalities per year).

Between 2007 and 2016, vehicle accidents were the leading cause of death for federal firefighters (eight fatalities), followed by falling trees or rolling rocks (six fatalities). The percentage of fatalities from these causes increased when compared with the period between 1990 and 2006. Entrapment fatalities among federal firefighters decreased from 23 federal firefighter fatalities during the period between 1990 and 2006 to four fatalities during the most recent period. Compared with the previous report, there were fewer multiple-fatality entrapment incidents, such as South Canyon. Other causes of death for federal firefighters included heart attacks (four fatalities), aircraft accidents (three fatalities), and other medical causes (three fatalities).

State Firefighters

Twenty-nine state firefighters died during the most recent period. These fatalities accounted for 17 percent of all firefighter fatalities. This is a slight increase when compared with the period between 1990 and 2006. State firefighters included firefighters from agencies, such as state departments of natural resources, Cal Fire, divisions of forestry, and various inmate organizations. Between 2007 and 2016, heart attacks were the leading cause of state firefighter fatalities (11 fatalities). Heart attacks resulted in three state firefighter fatalities during the period between 1990 and 1998 and six state firefighter fatalities during the period between 1999 and 2006. Three of the heart attacks between 2007 and 2016 occurred during the work capacity test. The second leading cause of state firefighter fatalities was vehicle accidents, which killed six state firefighters. Other medical causes, falling trees or rolling rocks, and entrapments each accounted for three state firefighter deaths during the most recent period. Aircraft accidents decreased from 27 percent during the period between 1999 and 2006 to seven percent during the most recent period.

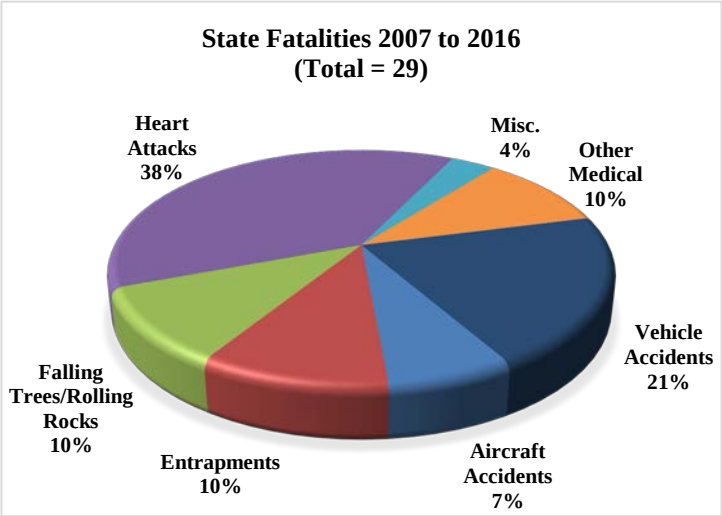

Figure 8–The causes of death for State firefighters who died between 2007 and 2016.

Ground Contractors

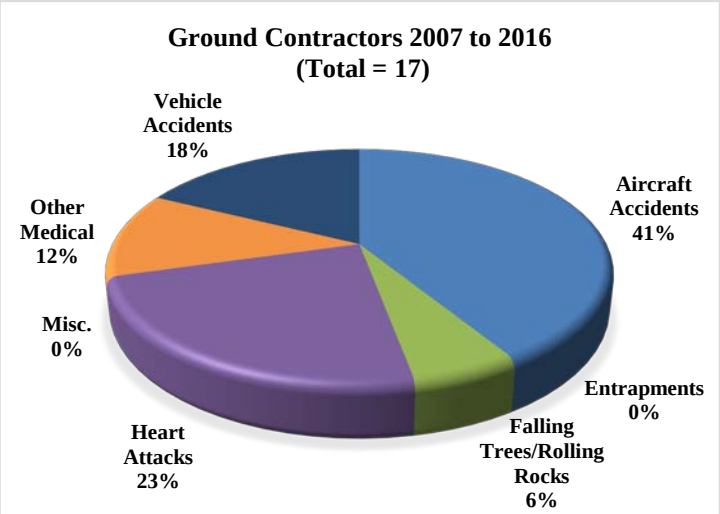

Figure 9–The causes of death for ground contractors.

Seventeen ground contractor firefighters died during the most recent period. This accounted for 10 percent of all firefighter fatalities, similar to the 11 percent (19 fatalities) during the period between 1999 and 2006. Aircraft accidents were the leading cause of ground contractor fatalities, which killed seven ground contractor firefighters. All of these firefighters died from a helicopter crash on the Iron Complex Fire in 2008 (see "Incidents with Multiple Fatalities" for more information). Heart attacks, the second leading cause of ground contractor fatalities, resulted in four fatalities during the most recent period, compared with three during the period between 1999 and 2006. Three of the fatalities during the most recent period were from vehicle accidents, a significant decrease from the period between 1999 and 2006, when vehicle accidents killed 14 ground contractors; two accidents resulted in 12 of these fatalities.

Aviation Contractors

Fourteen aviation contactor firefighters died (1.4 fatalities per year) during the most recent period, which was eight percent of all firefighter deaths. The Stead Airport crash and the Four Mile Fire crash each resulted in three fatalities. Events during the White Rock Fire resulted in two aviation contractor fatalities, and the remaining five accidents each resulted in one fatality. The number of aviation contractor fatalities decreased between 2007 and 2016 when compared with the previous two periods; there were 23 fatalities (2.6 fatalities per year) between 1990 and 1998 and 25 fatalities (3.1 fatalities per year) between 1999 and 2006.

Military Personnel

Four military personnel (three percent of all firefighter fatalities) died during the most recent period as a result of an aircraft accident. A MAFFS C-130 airtanker crash in South Dakota caused all four fatalities. Only one military member fatality occurred between 1990 and 2006. The Government usually orders military personnel to assist in fire suppression activities during extreme fire seasons when all other resource types have been committed.

Trends and Conclusions

Overall, 170 firefighters died between 2007 and 2016 while performing wildland fire operations (17 fatalities per year). There was a two percent decrease in the total number of fatalities and 4.6 fewer fatalities per year during the most recent period when compared with the period between 1999 and 2006 (21.6 fatalities per year). Although the number of acres burned (including Alaska) increased by 14 percent from the period between 1999 and 2006 when compared with the most recent period, the

average number of fatalities during the most recent period only increased by 1.8 fatalities per year when compared with the period between 1999 and 2006 (15.2 fatalities per year). However, when comparing our results to the previous report, it is important to consider that, in this report, we included additional data sources and expanded the types of fatality incidents. If we only considered fatalities from the "Safety Grams" during the most recent period (155 fatalities), the average number of fatalities per year would have been 15 percent lower than the average number of fatalities per year during the period between 1990 and 2006.

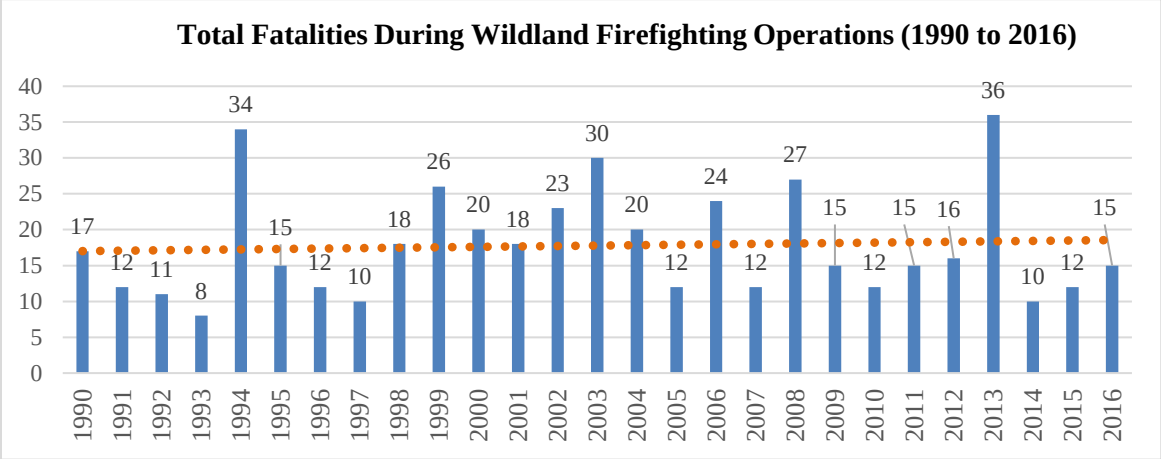

Figure 10–Total annual firefighter fatalities (all causes) during wildland fire operations between 1990 and 2016 (480 total fatalities).

During the most recent period, the leading causes of death were:

- Heart attacks (41 fatalities, 24 percent)
- Vehicle accidents (34 fatalities, 20 percent)
- Aircraft accidents (31 fatalities, 18 percent)
- Entrapments (28 fatalities, 16 percent)

Heart attacks were the leading cause of death during the most recent period and included three individuals who died from heart attacks during or after the work capacity test. Although the number of firefighter fatalities from heart attacks increased slightly (two fatalities), the number of firefighter fatalities resulting from work capacity test-related heart attacks decreased considerably (eight fatalities). Heart attacks were the leading cause of volunteer and state firefighter deaths. Similar to earlier assessment periods, vehicle accidents were the second leading cause of wildland firefighter deaths. Most vehicle accidents were single-fatality incidents and involved rollovers and firefighters being struck by vehicles. Vehicle accidents were the leading cause of federal firefighter deaths. In addition, we reported four vehicle accidents that involved firefighters responding to wildland fire incidents in their personal vehicles. Aircraft accident fatalities decreased from 39 during the period between 1990 and 2006 to 31 during the most recent period. Aircraft accidents during the most recent period included multiple-fatality events that resulted in 61 percent of the total aircraft accident fatalities. Entrapments killed 28 firefighters between 2007 and 2016; 1.8 fatalities per year fewer than the average number of entrapment fatalities per year (3.3 fatalities) between 1990 and 2006. Between 2007 and 2016, two entrapment events—the Yarnell Hill Fire (19 fatalities) and the Twisp Fire (three fatalities)—were responsible for nearly 79 percent of the total entrapment fatalities.

Trends by Fatality Events

Of the 170 deaths during the most recent period, 41 fatalities occurred during six events. These events can cause a disproportionate impact on the analysis of fatalities and causes of death. When we examined the number of fatality events (defined as an event where one or more firefighters died) rather than the number of individual deaths, there were more consistent trends from year to year. Generally, the number of annual fatality events were similar throughout the most recent period, with an average of 13 fatality events per year. The highest number of fatality events occurred in 2013 and the lowest number of fatality events occurred in 2015.

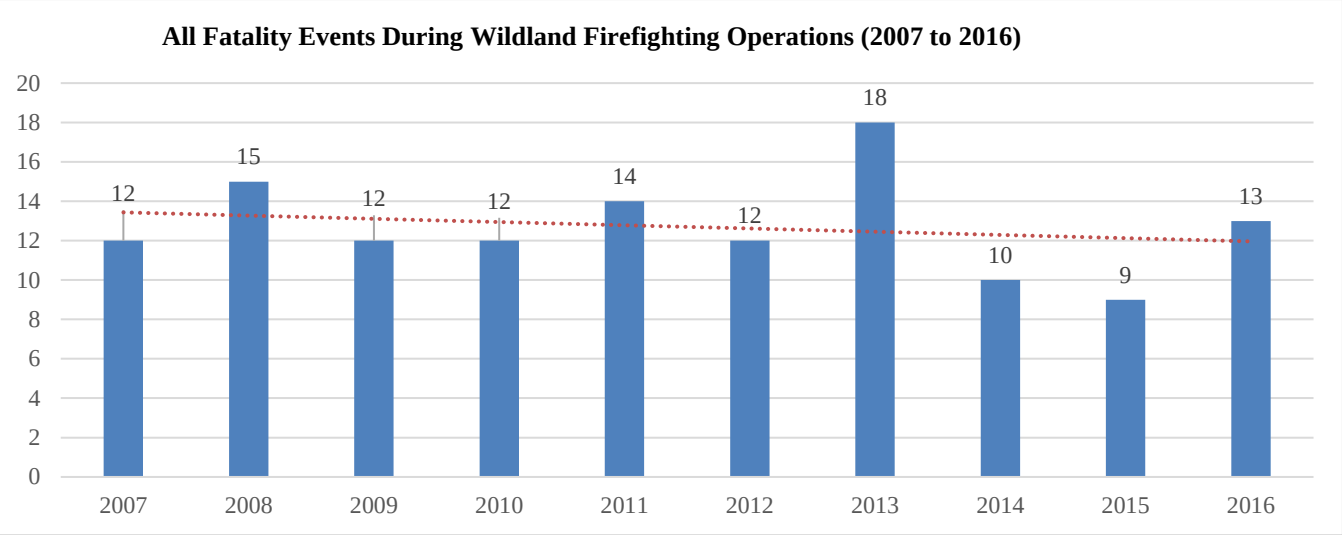

Figure 11–Annual fatality events during wildland fire operations between 2007 and 2016.

Additionally, when we examined causes of death by fatality events rather than by individual deaths for the most recent period, there were changes in the leading causes of death. Heart attacks increased by nine percent and vehicle accidents increased by four percent. Entrapments decreased from 17 percent to five percent and were no longer a leading cause of death. Aircraft accidents also decreased by six percent. The shift in causes of death can inform managers about which areas to focus on when it comes to training and risk mitigation.

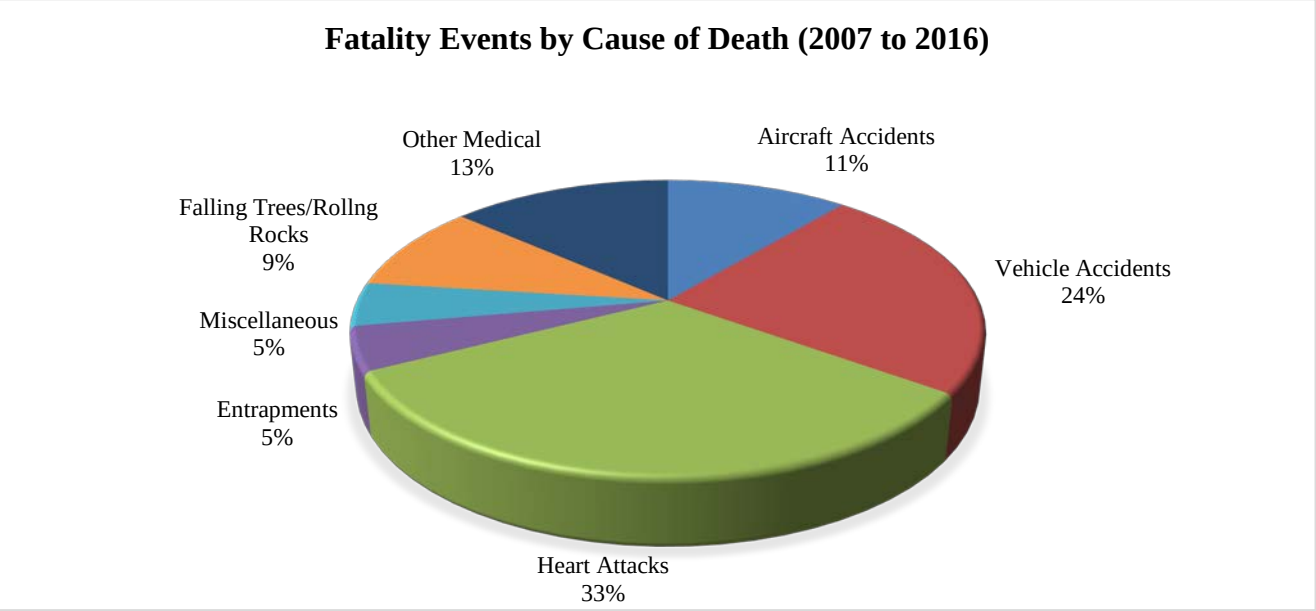

Figure 12–Fatality events by cause of death during wildland fire operations between 2007 and 2016.

Trends by National Preparedness Level

Between 2007 and 2016, half of all fatality events occurred during a national preparedness level (PL) of 1—the lowest PL level. Over the last 10 years, as the PL increased, the number of fatality events decreased. Only five percent of all fatality events occurred during a PL 5 period. However, when intrepreting these trends, it should be noted that throughout the year, most days are at PL 1. Over this ten-year period, 2,345 total days were spent at PL 1 compared with 92 days spent at PL 5.[11] During a PL 1 period, firefighters had the highest fatality events caused by heart attacks, vehicle accidents, aircraft accidents, and falling trees or rolling rocks. Two entrapment fatalities occurred during a PL period of 2 and 3 each, while one entrapment event occurred during a PL of 1, 4, and 5 each. During a PL 5 period, no fatality event occurred from falling trees, rolling rocks, or miscellenous causes.

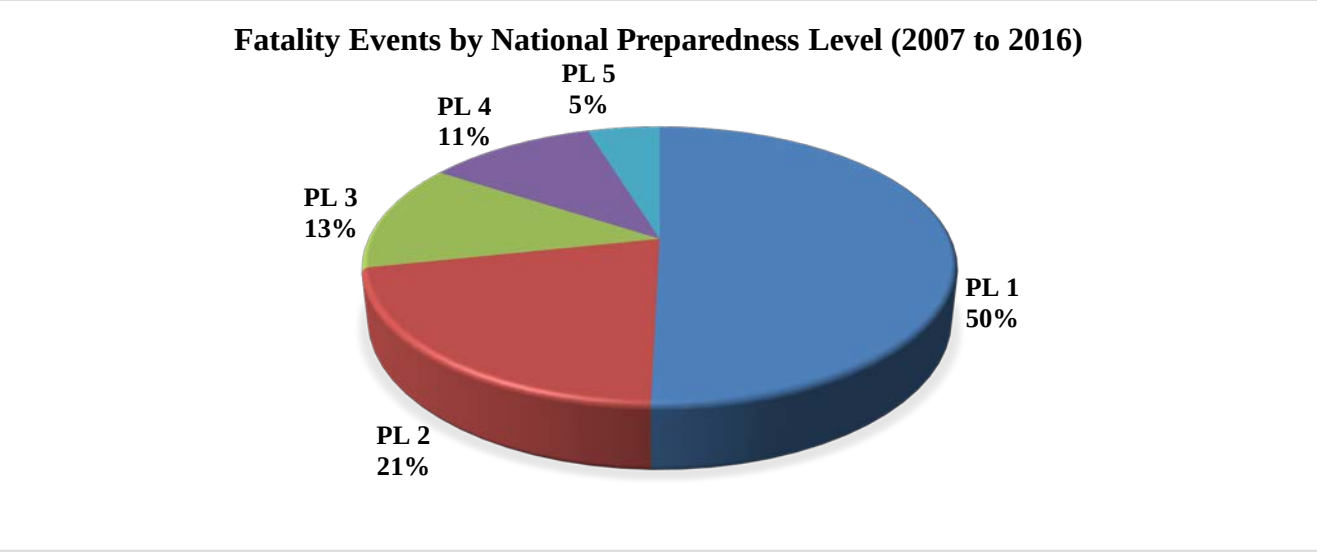

Figure 13–Fatality events by national PL during wildland fire operations between 2007 and 2016.

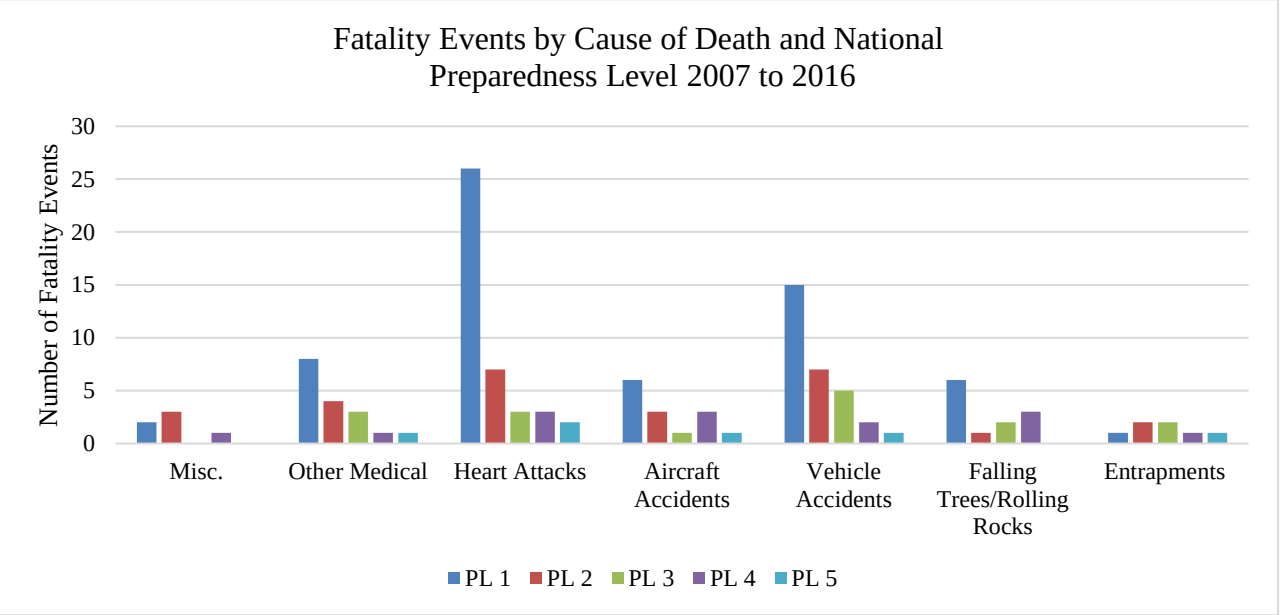

Figure 14–Fatality events by cause of death and national PL during wildland fire operations between 2007 and 2016.

Final Conclusions

In the 2007 "Wildland Firefighter Fatalities in the United States 1990-2006" report, Dick Mangan identified his recommendations as four "21st century common denominators for wildland firefighter fatalities:"[1]

1. Reducing the number of flights and personnel used in aircraft missions.
2. Increasing driver safety by wearing seatbelts, driving slower and not rushing to a fire incident, and not driving home while exhausted after firefighting.
3. Decreasing the risk of heart attacks by increasing fitness levels.
4. Learning to anticipate unexpected events, such as falling snags, rolling rocks, downed power lines, and lightning strikes.

Based on our analysis, we also advise the following recommendations to avoid wildland firefighter fatalities:

1. Employees should maintain and monitor their health and fitness, not only during the fire season, but also in preparation for the season and all year round, because not all agencies work seasonally.
2. Vehicle accidents continue to be a leading cause of death—firefighters must continue to drive safely to prevent rollovers and to increase situational awareness near vehicles or traffic to reduce vehicle strikes.
3. Multiple-fatality entrapment incidents continue to occur and take many firefighter lives. Wildland firefighters face a work environment with constantly evolving risks, so there must be an ongoing discussion on how to mitigate these risks and prevent future fatalities.

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NWCG Report on Wildland Firefighter Fatalities in the United States: 2007–2016 was prepared and is maintained by the Risk Management Committee (RMC), an entity of the National Wildfire Coordinating Group (NWCG).

Previous editions: 2007, 1999, 1997.

This publication is available electronically at https://www.nwcg.gov/publications/841.

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