ANALYSIS REPORT ON FIREFIGHTER FATALITIES

Prepared by

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Background

For more than a decade, the National Fire Protection Association (NFPA) has developed the most complete records on U.S. fire fighter fatalities - both in breadth of coverage and depth of detail - of any organization. This data base has been used to support the fire fighter fatality studies produced each year by NFPA since 1974.

Over the past 10 years, NFPA also has worked with FEMA's U.S. Fire Administration (USFA) to provide, in a timely manner, lists of fire fighter fatalities and their next of kin to support the National Fire Academy's annual Fire Fighter Memorial Service, analyses of each year's fire fighter fatalities, and briefings on the latest experience. Under the present contract, NFPA has provided the USFA with lists, both hand lettered and typed, of 1990 fire fighter fatalities and with lists of names and addresses of next of kin and of fire department chiefs for use in the Memorial Service in October 1991.

In August, a briefing on the 1990 experience and two special analyses was presented by NFPA staff to USFA staff in Emmitsburg, MD. Through the briefing and analysis, this contract continued the trend toward more extensive analysis of patterns and trends in specific parts of the fire fighter fatality problem. With over a decade of experience now classified in a computer data base, NFPA is able to provide increasingly detailed and focused examinations of the specific parts of the problem addressable by particular strategies.

The deliverables under this contract are (a) this analysis report, (b) the incident and casualty data on diskette in NFIRS Version 4.0 format, which is being delivered separately, (c) the various lists described above, and (d) the briefing provided in August.

I. Introduction

The purpose of this study is to analyze the circumstances surrounding fire fighter fatalities in the United States in 1990 in an attempt to identify potential means for reducing the number of deaths that occur each year. In addition to the 1990 findings, this study will also include special analyses of particular recurring scenarios, using NFPA's data base of fire fighter fatalities from 1981 through 1990.

A. Who Is a Fire Fighter?

For the purpose of this study, the term fire fighter covers all members of organized fire departments, whether career, volunteer or mixed; full-time public service officers acting as fire fighters; state and federal government fire service personnel; temporary fire suppression personnel operating under official auspices of one of the above; and privately employed fire fighters including trained members of industrial or institutional fire brigades, whether full- or part-time.

Under this definition, the study includes not just municipal fire fighters but also seasonal and full-time employees of the U.S. Forest Service and state wildland agencies; prison inmates serving on state forest service crews; fire fighters for the Bureau of Land Management, the Bureau of Indian Affairs, the Bureau of Fish and Wildlife, the National Park Service, and the U.S. Department of Energy; military personnel performing assigned fire suppression activities; civilian fire fighters working at military installations; and members of industrial fire brigades.

B. What Constitutes an On-Duty Fatality?

The term on-duty refers to being at the scene of an alarm, whether a fire or non-fire incident; being en route while responding to or returning from an alarm; performing other assigned duties such as training, maintenance, public education, inspection, investigations, court testimony and fund raising; and being on call, under orders or on stand-by duty other than at home or at the individual's place of business.

On-duty fatalities include any injury sustained while on duty that proves fatal, any illness that was incurred as a result of actions while on duty that proves fatal, and fatal mishaps involving occupational hazards that occur while on duty. The types of injuries included in the first category are mainly those that occur on the fire ground, in training, or in accidents while responding to or returning from alarms. The most common examples of fatal illnesses incurred on duty are fatal heart attacks. Another example is a fire fighter who contracted hepatitis when a victim being transported by ambulance pulled out his intravenous needle and stuck the fire fighter. A few examples of fatal occupational mishaps that have occurred in the past include fire fighters who died of asphyxiation while working on fire apparatus in closed garages, a fire fighter who fell through a slide pole hole, a fire fighter electrocuted while raising a banner for a town event, a volunteer fire fighter who was fatally injured when he fell down a flight of stairs in his home while responding to an alarm, and a fire inspector who fell through a skylight. In 1990, a fire fighter was killed when the aerial ladder he was strapped to collapsed as he was hanging a banner.

Also included in the file are fire fighters who were murdered while on duty. These include fire fighters shot by snipers while on the fire ground, fire fighters shot in the station by off-duty or former fire fighters, one who was kidnapped and

shot after responding to a verbal request for assistance, and one in 1990 who was killed when a pipe bomb planted in his car exploded as he left the station.

Fatal injuries and illnesses are included even in cases where death is considerably delayed. When the onset of the condition and death occur in different years, the incident is counted on the basis of the former. For example, a Michigan fire fighter died in 1986 of a brain injury received in 1979 when he was struck by a hose coupling, resulting in recurring seizures. Because his death was the direct result of his injury, and the injury occurred in 1979, he is counted as a 1979 fatality.

The NFPA recognizes that these definitions should include chronic illnesses (such as cancer) that prove fatal and that arise from occupational factors. In practice, there is as yet no mechanism for identifying fatalities that are due to illnesses that develop over long periods of time and that thereby present an ambiguous picture on the issue of occupational versus other factors as causes. This is recognized as a gap that cannot now be filled because of the limitations of the state of the art in tracking and analysis.

C. Shot of Initial Notification

As an integral part of its ongoing program to collect and analyze fire data, NFPA solicits information on fire fighter fatalities from the U.S. fire service and a wide range of other sources. These include the U.S. Fire Administration and the Public Safety Officers' Benefits Program (PSOB). Both are organizations with whom NFPA has maintained long-standing cooperative efforts in collecting and analyzing fire fighter fatality data. Other contacts include federal agencies such as the U.S. Forest Service of the Department of Agriculture, the Bureau of Indian Affairs and the Bureau of Land Management of the Department of Interior, the

U.S. military, the Department of Energy, and the Occupational Safety and Health Administration (OSHA). In recent years, significant assistance has been received from the National Wildfire Coordinating Group, an organization made up of representatives of state and federal wildland agencies.

The NFPA also receives notification from fire service organizations such as the International Association of Fire Fighters, state fire associations, state training organizations, state and local fire marshals, and fire service publications. A network developed over the years of individuals interested in the area of fire fighter fatalities also assists in identifying incidents, especially those that occur outside of large urban areas or that involve non-fire-incident-related fatalities. Among these individuals are fire fighters, photographers, fire buffs, and members of the insurance industry.

Notification of fatal incidents also comes from NFPA members and staff and through the use of a newspaper clipping service that reads all daily and weekly newspapers in the country.

D. Procedure for Including a Fatality in the Study

After initial notification of a fatal incident is received, contact with the local fire department is made by telephone to verify the incident, its location and the fire department involved. Data collection forms for the fatality and the fire, if it was a fire incident, are sent to the responsible local official identified during the telephone follow-up. After the forms are returned to NFPA, a final decision is made to include or exclude the fatality, based on the inclusion criteria described previously. In order to make a final determination, additional information is sometimes sought, either by contacting the fire department directly to clarify some

of the details or by obtaining data elsewhere, such as medical documentation frequently available from PSOB.

Some of the material that might be received to document an incident includes casualty forms, both NFPA fire fighter fatality study reporting forms and NFIRS-type forms; NFPA's Fire Incident Data Organization (FIDO) major-fire report form or the department's own incident reporting form, if a fire incident was involved in the fatality; medical data such as death certificates or autopsy reports; special investigation reports from other agencies; police and motor vehicle accident reports, if applicable; photographs and diagrams; and additional newspaper accounts. Incidents to be included in the study are then coded into NFPA's FIDO system, which includes both incident and casualty information. By mutual agreement of the USFA and NFPA project staff, the same inclusion criteria were used for the USFA study as are used in the NFPA study.

Work described to this point was done as part of NFPA's ongoing program of data collection and analysis in the area of fire fighter fatalities and was completed at no cost to FEMA.

E. Additional Data collection Completed for the Contract

To meet FEMLA's request for a list of the next-of-kin of the 1990 fatalities and the names and addresses of the fire chiefs, a follow-up mailing was sent to all departments asking them to verify the victims' names and dates of fatal injury, the names and addresses of the departments and chiefs, and the names and relationships of the next of kin. Telephone calls were made to non-responding fire departments to obtain the information.

II. 1990 Findings

One hundred five fire fighters died in the line of duty in 1990, the lowest total in the 14 years that NFPA has done this study. As shown in Figure 1, this is a decrease of 10.3 percent from the year before, and a 22.2 percent decrease from 1988.* With this second consecutive sharp drop in fire fighter deaths, we can begin to be encouraged that the efforts made to improve fire fighter health and safety are beginning to take effect; however, efforts to further reduce the death toll need to continue. This study will report some of the most frequently occurring scenarios and will present some conclusions and recommendations to address the problem.

A. Type of Duty

The distribution of deaths by type of duty being performed is shown in Figure 2. The largest proportion of deaths occurred during fire ground operations (43.8 percent).

Of the 46 fire ground deaths, 16 were due to heart attacks, 14 to asphyxiation, seven to internal trauma, five to burns, two to stroke (CVA) and one each to crushing injuries and heat stroke. Thirteen of the victims were career fire fighters and 33 were volunteers.

The second largest category involved responding to and returning from alarms, which accounted for almost a quarter of the deaths -- a result consistent with the findings in previous years. Eight of these 24 deaths were due to heart attacks, one to a fall from the jumpseat of an apparatus, one to a fall from the back

* The totals for some earlier years have been adjusted to reflect new information received since the earlier studies.

Figure 1
On-Duty Fire Fighter Deaths
1977 - 1990

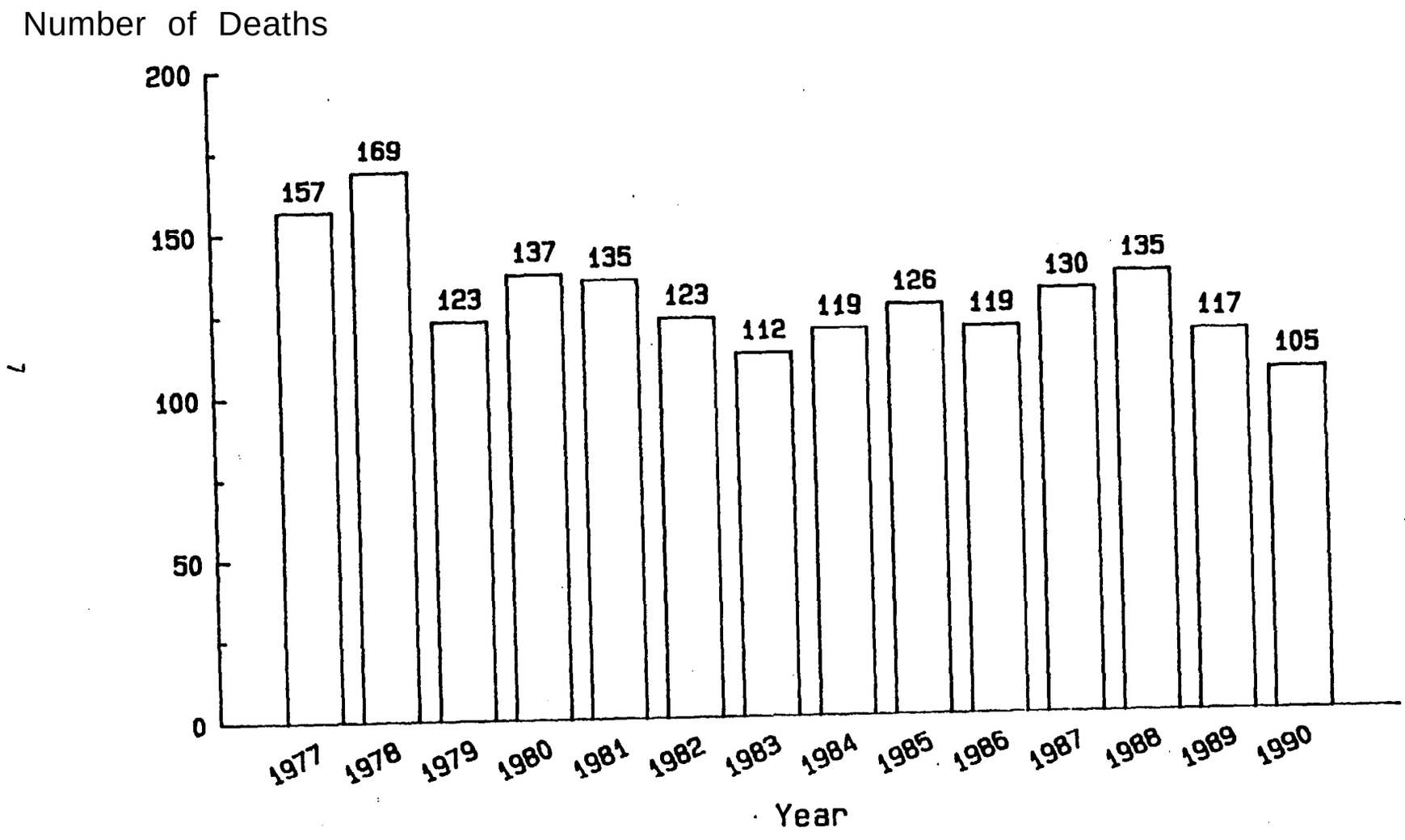
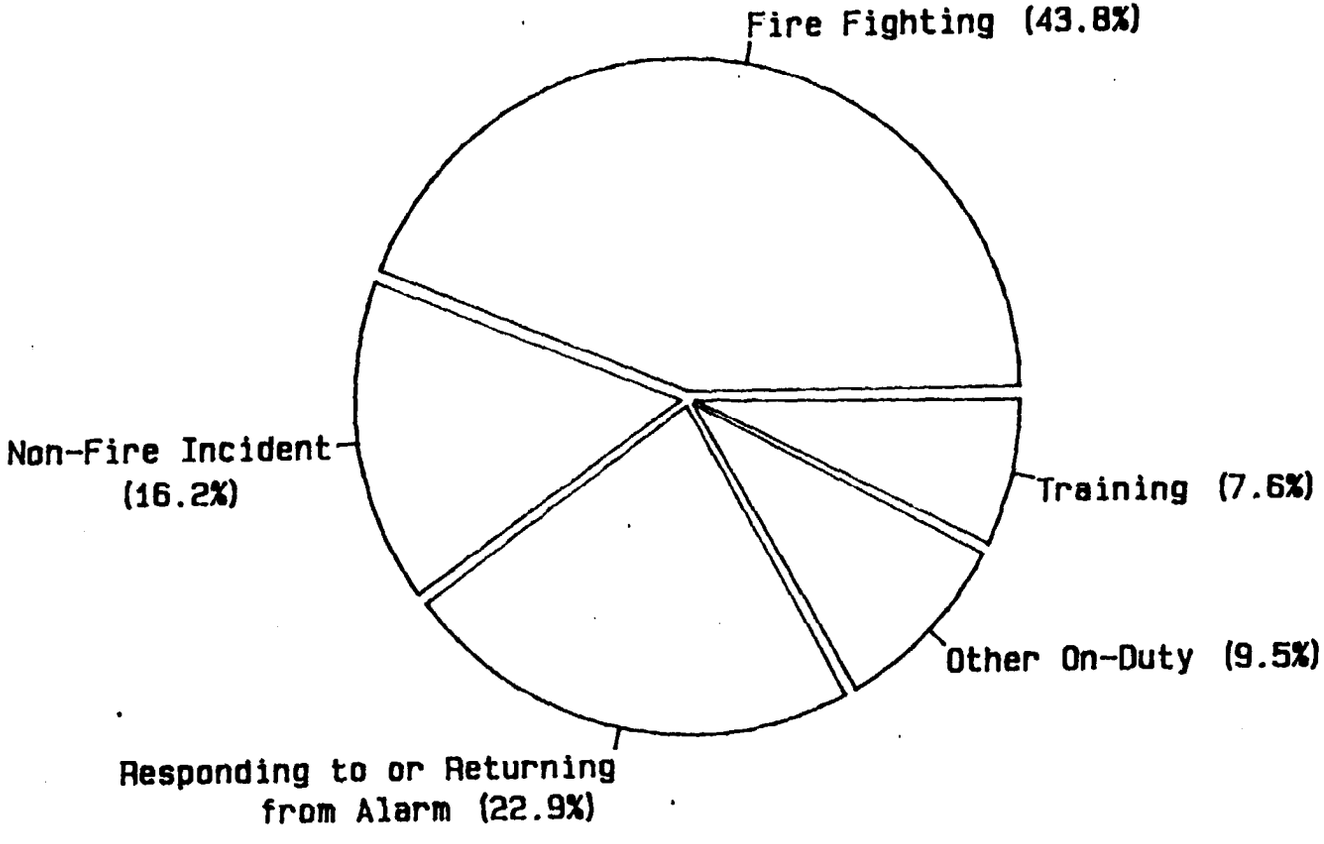


Figure 2
Fire Fighter Deaths 1990
by Type of Duty



of a pickup truck, one to a drowning in a bridge collapse and the remaining 13 to collisions. Four were career fire fighters and 20 were volunteers. Three were killed while responding to or returning from false calls -- two were responding to an accidental alarm and one was returning from a system malfunction.

There were 15 deaths while working at non-fire incidents. These included four fire fighters who suffered heart attacks while working at motor vehicle accidents, four fire fighters struck by passing vehicles while working at motor vehicle accidents, three deaths due to carbon monoxide poisoning while pumping out a well, two drowned at an ice rescue, one drowned at a water rescue and one who fell while attempting to rescue a rock climber.

There were 8 deaths related to training activities. All of the deaths were due to heart attacks -- two during physical fitness training and one each during live fire training, a smoke drill, a disaster drill., a simulated aircraft engine fire (using halon), a company drill and a muster.

The remaining 12 deaths occurred while performing other duties -- four fire fighters who suffered fatal heart attacks during normal station and administrative duties, two killed in a plane crash while returning from a visit to another fire department, two overcome by carbon dioxide while recharging the carbon dioxide system after a fire, one killed when his tractor overturned while he was working on the fire station's grounds, one whose aerial ladder collapsed while he hung a banner, one who was electrocuted and fell while attempting to retrieve a cat, and one killed when a pipe bomb exploded in his vehicle as he was leaving the station.

B. Cause and Nature of Fatal Injury or Illness

As used in this study, the term cause refers to the action, lack of action, or circumstances that directly resulted in the fatal injury, while the term nature refers to the medical nature of the fatal injury or illness, or what is often referred to as the cause of death. Often, the fatal injury is the result of a chain of events, the first of which is recorded as the cause. For example, if a fire fighter is struck by a collapsing wall, becomes trapped by the debris, runs out of air before being rescued, and dies of asphyxiation, the cause of fatal injury recorded is "struck by collapsing wall" and the nature of fatal injury is "asphyxiation."

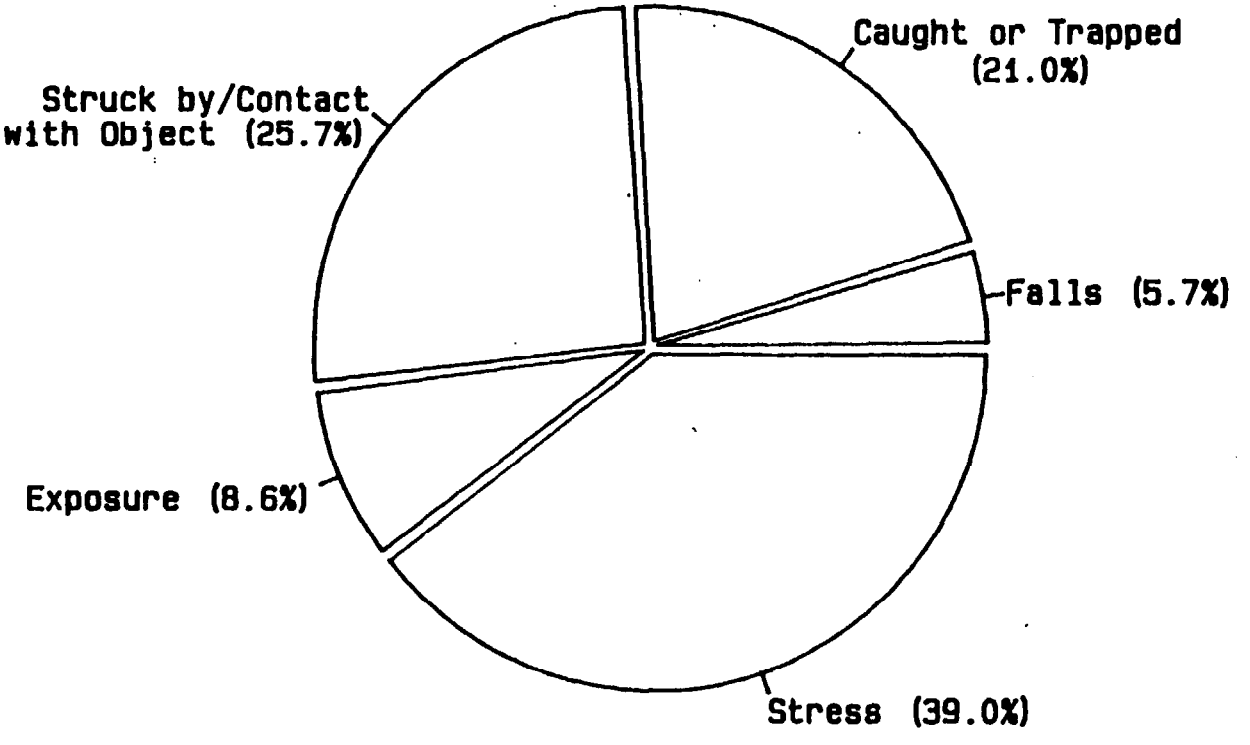
Figure 3 shows the distribution of deaths by cause of fatal injury or illness. As found in most previous years, the largest proportion of deaths were due to stress or overexertion. Three of these 41 deaths were specifically attributed to strenuous physical activities. Stress deaths usually result in heart attacks or strokes.

The next major category was struck by or contact with objects. These 27 deaths included 24 motor vehicle accidents, and one each struck by a collapsing wall, a hose coupling and a falling tree limb.

Twenty-two fire fighters were caught or trapped -- 13 by rapid fire progress; three by being lost inside buildings; three underwater, where they drowned; two in explosions (one involving a pipe bomb and the other involving the ignition of vapors leaking from a propane gas transmission pipe); and one who was strapped to an aerial ladder that collapsed.

Nine fire fighters died of various types of exposure. Of the nine, three were exposed to carbon monoxide while pumping out a well, three were exposed to carbon dioxide, one was exposed to hot weather and suffered heat stroke, one was

Figure 3
Fire Fighter Deaths 1990
by Cause of Injury



exposed to smoke and had a heart attack, and one was exposed to electricity and fell.

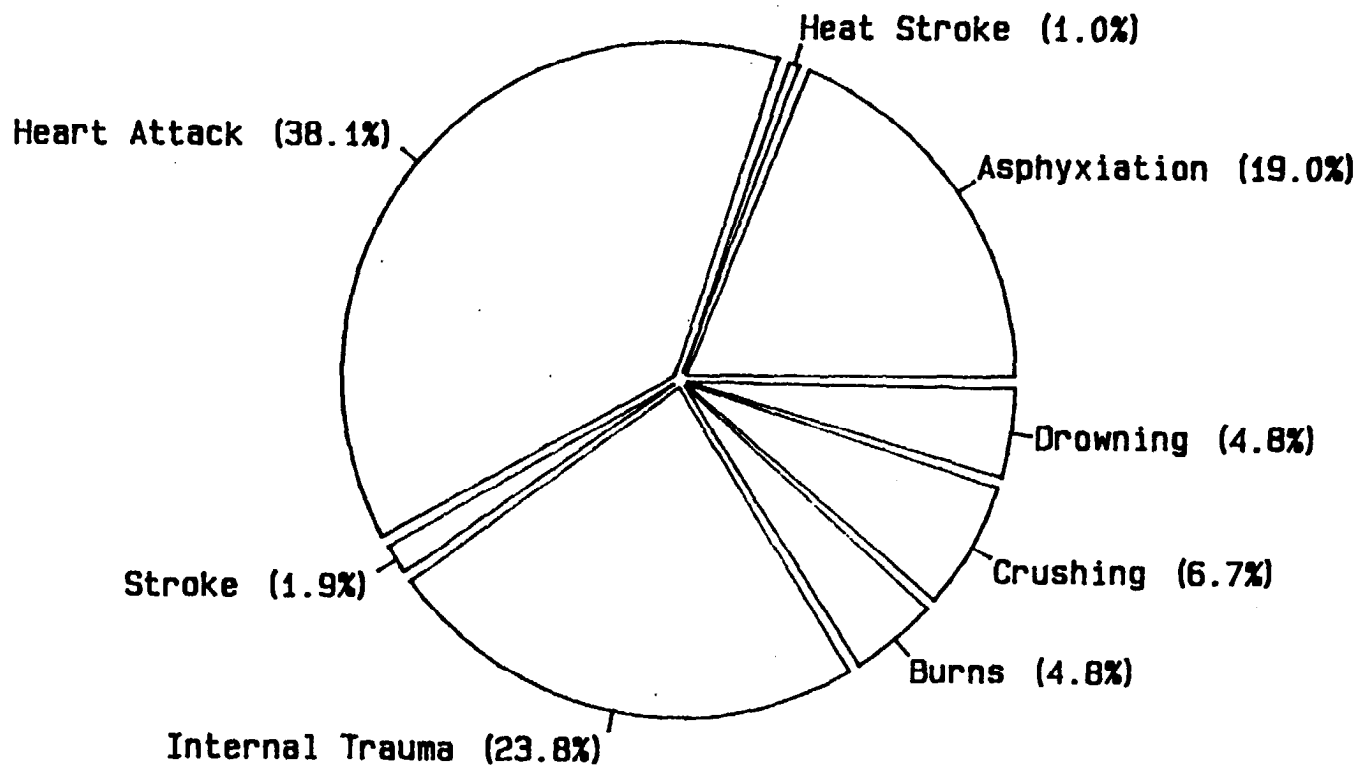
Six fire fighters were killed as a result of falls -- one from a jumpseat, one from the tailgate of a pickup truck, one at a quarry, one from a stair landing inside a structure, one into a well, and one down a hillside.

Figure 4 shows the distribution of deaths by the medical nature of the fatal injury or illness. The largest proportion of deaths were due to heart attacks. Of these 40 deaths, medical documentation indicated that 17 of the victims had prior heart problems, either previous heart attacks or bypass surgery; and six others had severe arteriosclerotic heart disease (defined for this study as arterial occlusion of at least 50 percent but usually found to be in excess of 70 percent). Two other victims suffered from hypertension and one had suffered a viral infection that had damaged his heart and lungs. Medical documentation was not available for the other 14 heart attack victims.

Fire fighter deaths over the past 10 years that resulted from heart attacks are discussed in more detail in a separate section of this report.

The other categories of nature of fatal injury were internal trauma (25 deaths), asphyxiation (20 deaths), crushing (7 deaths), bums (5 deaths), drowning (5 deaths), strokes (2 deaths), and heat stroke (1 death). The 20 asphyxiation deaths included seven at wildland fires, four in wells, three while recharging CO2 systems, three disoriented inside buildings until their air supplies were depleted, two trapped by rapid fire progress in a building and one trapped in an overturned tanker.

Figure 4
Fire Fighter Deaths 1990
by Nature of Injury



C. Ages of Fire Fighters

The ages of fire fighters who died in 1990 ranged from 18 to 77 years with a median age of 41 years.

The distribution of fire fighter deaths by age and cause of death is displayed in Figure 5. Over half of the fire fighters over age 40 who died were killed by heart attacks. Of the three youngest heart attack victims (those age 25 and younger), two had congenital heart problems and the third had suffered a viral infection that damaged his heart and lungs.

Figure 6 shows the death rates by age categories using estimates of the number of fire fighters in each age group from NFPA's 1988 profile of fire departments and the fatality data from 1986 through 1990[1]. As the graph shows, the death rate is lowest for fire fighters aged 20 to 39, slightly above the average rate for those aged 40 to 49, and much higher than average for fire fighters aged 50 and over. This is a reflection of the fact that although only 14 percent of all fire fighters are over age 50, that age group accounted for over a third of the deaths from 1986 through 1990, including over half of all heart attack deaths. When the rates are calculated for non-heart-attack deaths, fire fighters aged 60 and over have a rate more than 2 1/2 times the average.

D. Fire Ground Deaths

The distribution of the 46 fire ground deaths by fixed property use is shown in Figure 7. For only the second time since 1977, when NFPA began doing these annual studies of fire fighter fatalities, the largest proportion of fire ground deaths did not occur at residential structure fires. By far the largest proportion of deaths

Figure 5
Fire Fighter Deaths 1990
by Age and Cause of Death

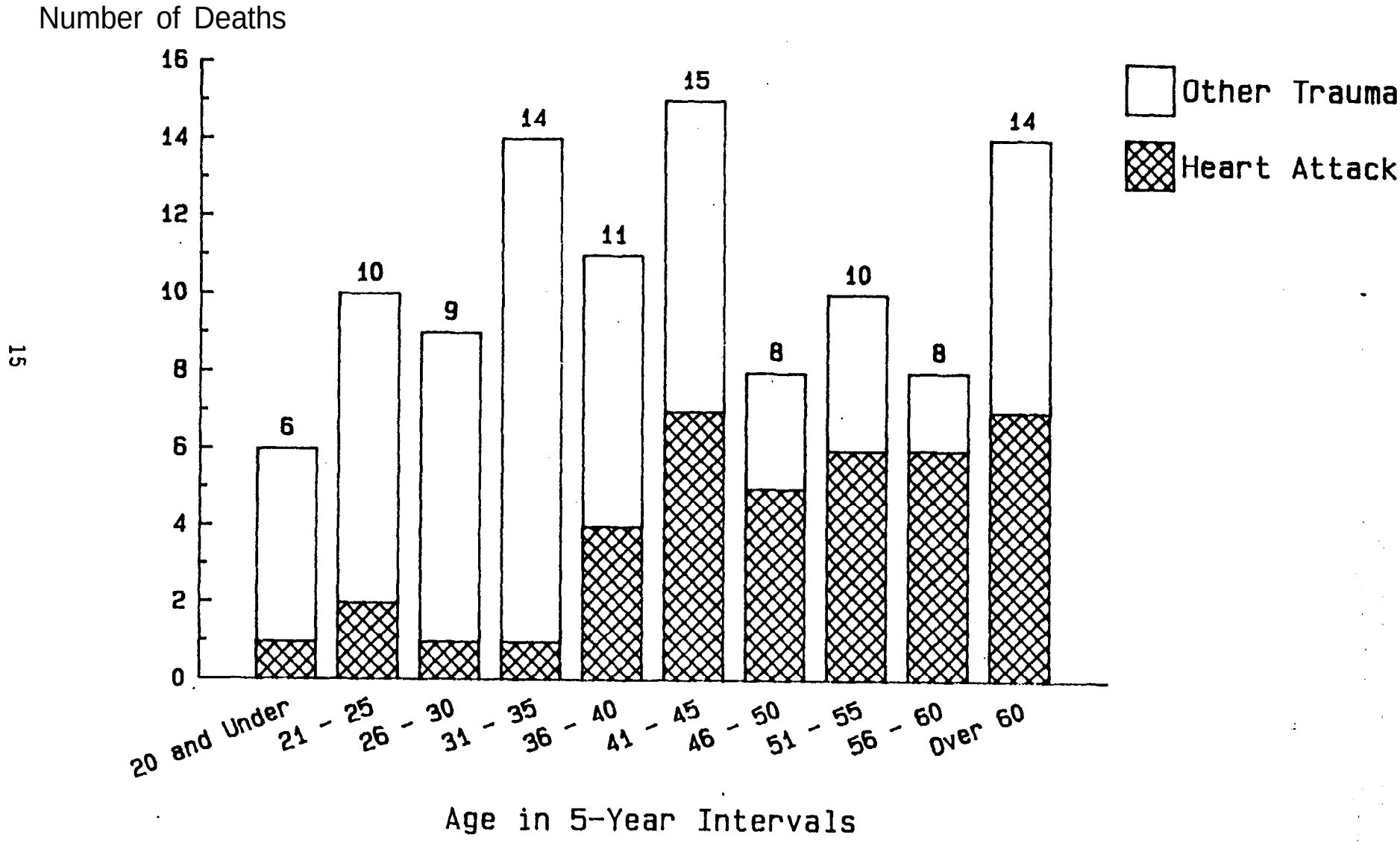
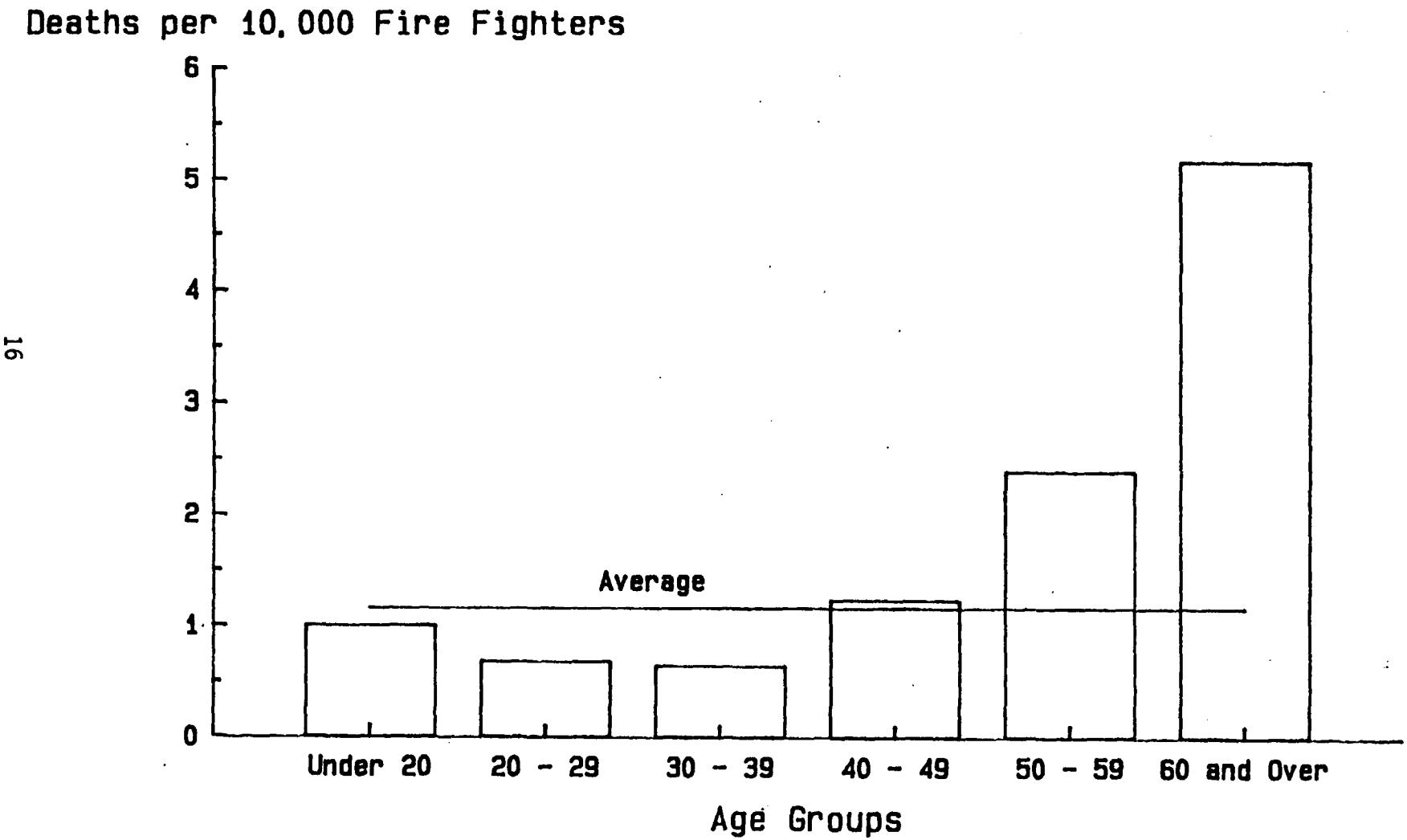
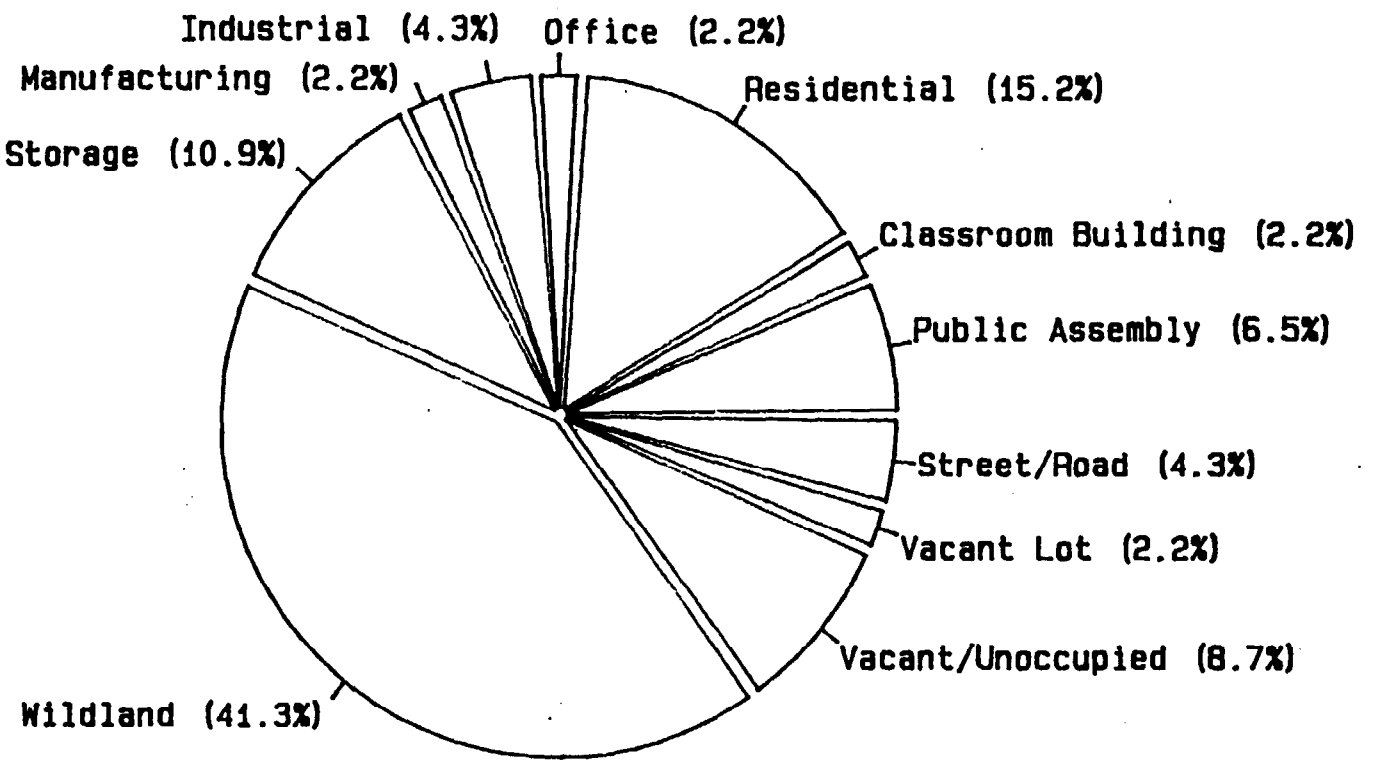


Figure 6
Average Death Rates per 10,000 Fire Fighters
1986 - 1990



Note: These figures combine career and volunteer fire fighters. The two groups may have very different age distributions, which are not reflected here.

Figure 7
Fire Ground Deaths in 1990
by Fixed Property Use



(41.3 percent) occurred at wildland fires. These 19 deaths include the single worst incident in 1990: six deaths occurred in June on the Tonto National Forest in Arizona when five members of an inmate crew and their supervisor suffered fatal smoke inhalation and burns when they were overrun by rapid fire progress. Because of the high number of deaths in wildland fires in 1990, a lo-year analysis of deaths related to wildland fires was completed and can be found, along with a discussion of the 1990 wildland deaths, in a separate section of this report.

The next largest share of fire ground deaths (15.2 percent) occurred at residential structure fires. These seven deaths all involved single-family dwellings. This is the lowest number of deaths reported at residential fires since 1977 when NFPA began doing this study. The previous low number was 12 deaths in 1987. Annually, there has been an average of 22 such deaths.

The other deaths occurred in a range of other property types. There were five deaths in storage properties -- one of which was a dwelling garage. Four deaths occurred in unoccupied buildings including two in vacant buildings and one each in a building under renovation and a building under construction. There were three deaths in fires involving public assembly buildings -- two at a fitness center and one at a restaurant. Two fire fighters suffered fatal heart attacks at motor vehicle fires. There was one death each at a college classroom building, an office building, a laboratory, a manufacturing plant and a gas pipeline. One fire fighter suffered a fatal heart attack while fighting a fire on a vacant lot.

Eleven fire fighters were killed at the scene of incendiary or suspicious fires. Nine of these deaths were at structure fires and two were at wildland fires. (Three other fire fighters died while responding to incendiary or suspicious fires.)

To put the hazards of fire fighting in various types of occupancies into perspective, the number of deaths per 100,000 structure fires was examined by fixed property use. The rates were calculated using the estimates of fire

experience from NFPA's 1990 fire loss study[2]. There were 1.5 fire fighter deaths per 100,000 residential structure fires, compared to 10.2 deaths per 100,000 nonresidential structure fires. Although almost three times as many fires occurred in residential structures, the size, complexity and special hazards often associated with nonresidential structures result in a much greater risk at such fires.

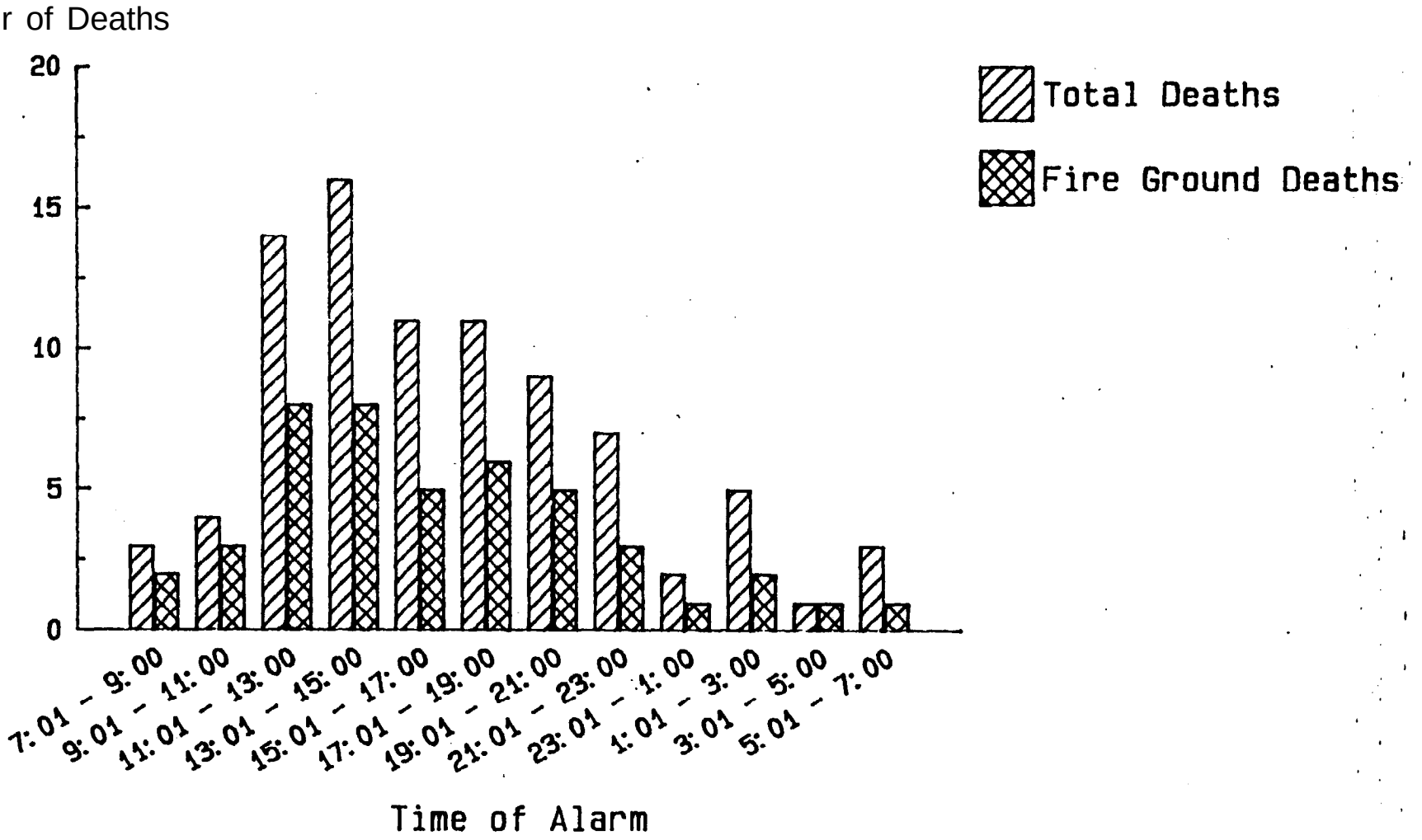
E. Time of Alarm

The distributions of 1990 fire ground deaths and total deaths by time of alarm are shown in Figure 8. The highest number of deaths occurred for alarms between 11 am and 3 pm. This time period includes the six deaths on the Tonto National Forest in June, The distributions of deaths by time of alarm over a ten-year period are shown in Figure 9: Thenumber of deaths in both categories was at the highest level for alarms between 1:00 and 9:00 pm and dropped to the lowest level in the early morning hours.

F. Month of the Year

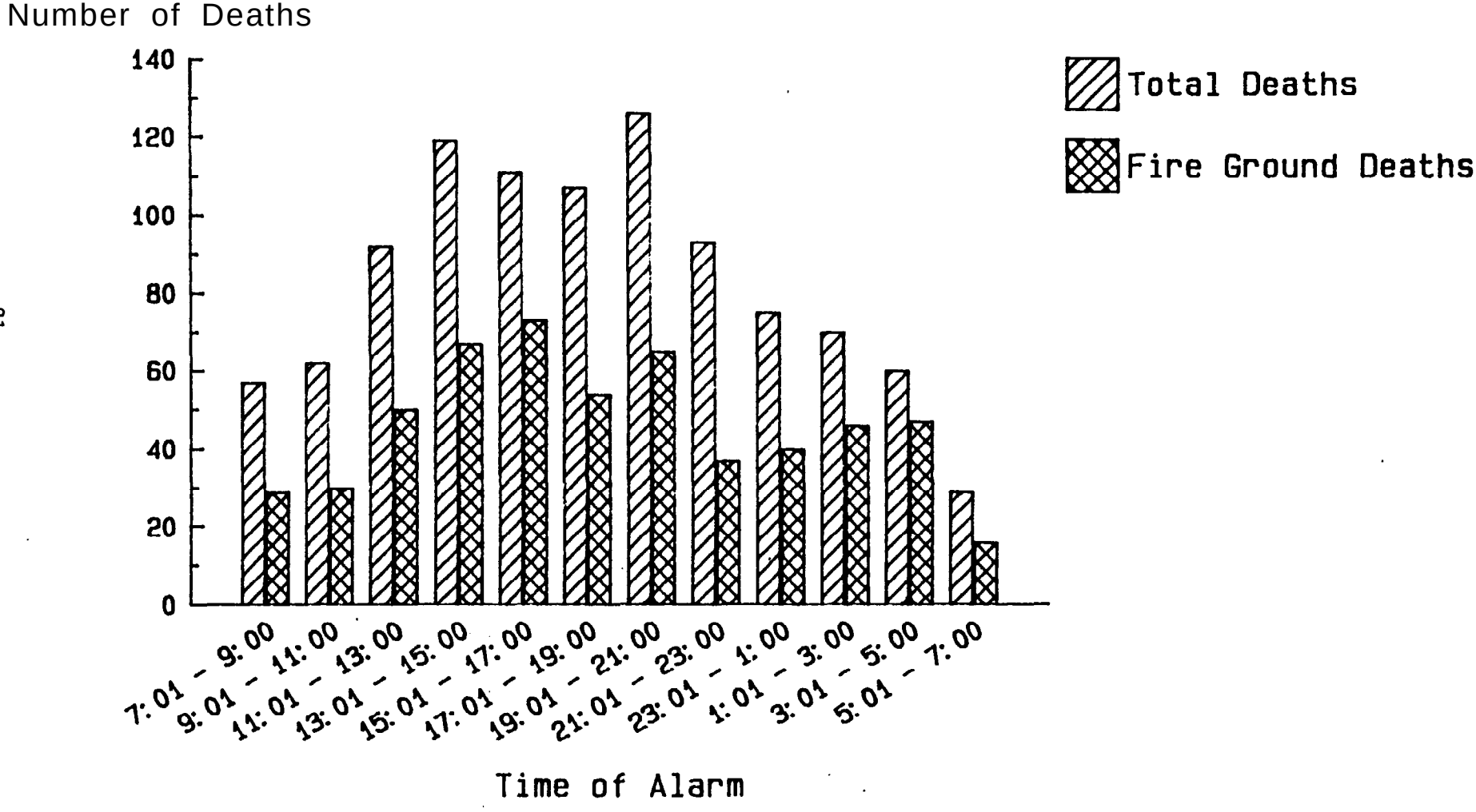
Figure 10 shows the distribution of 1990 fire fighter deaths by month. The same information for 1981 through 1990 is shown in Figure 11. The ten-year analysis shows that fire ground deaths are higher in the winter months and in midsummer.

Figure 8
Fire Fighter Fatalities 1990
by Time of Alarm



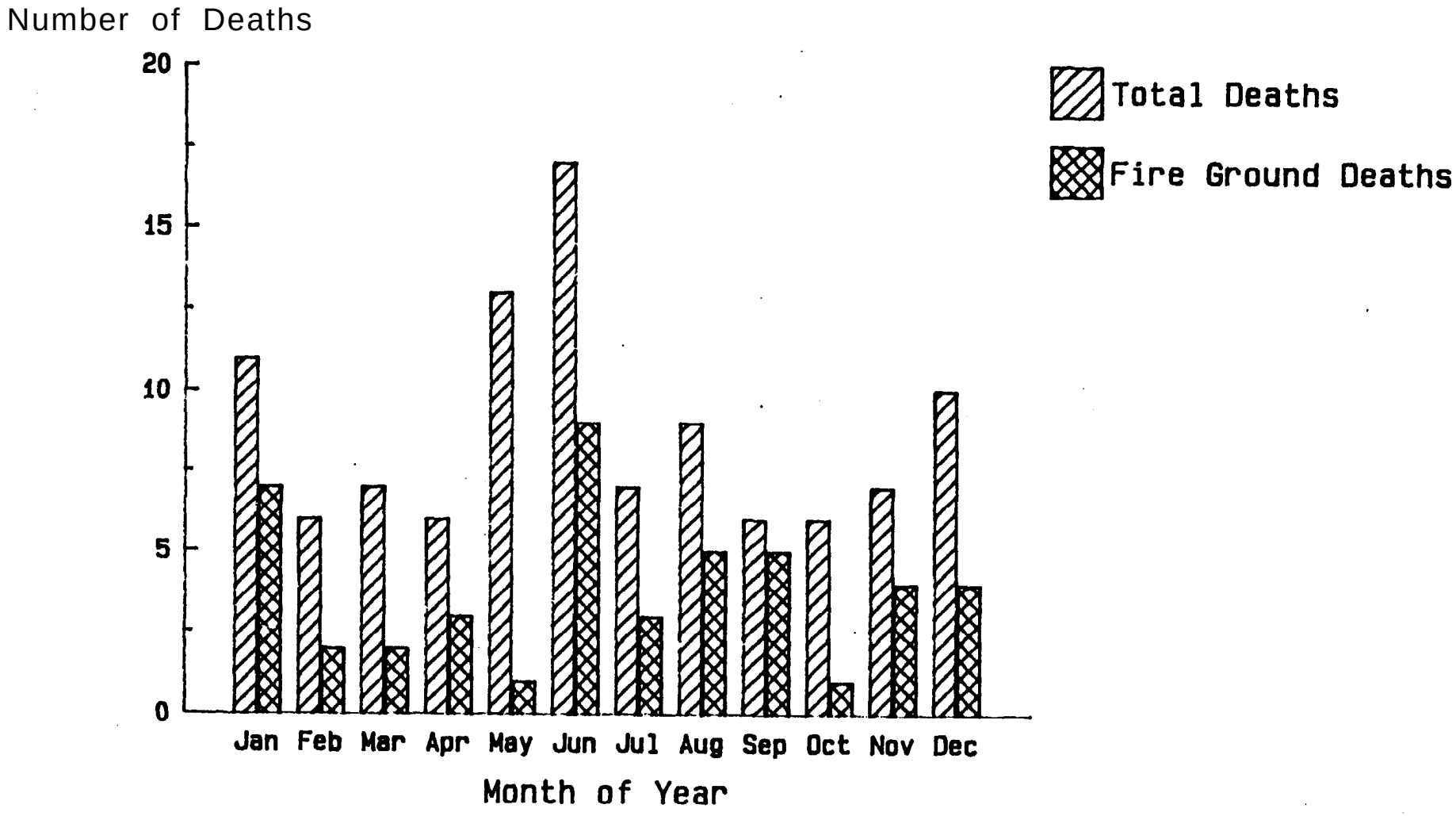
Based on 45 fire ground fatalities and 66 total fatalities for which alarm time was reported.

Figure 9
Fire Fighter Fatalities by Time of Alarm
1981 - 1990



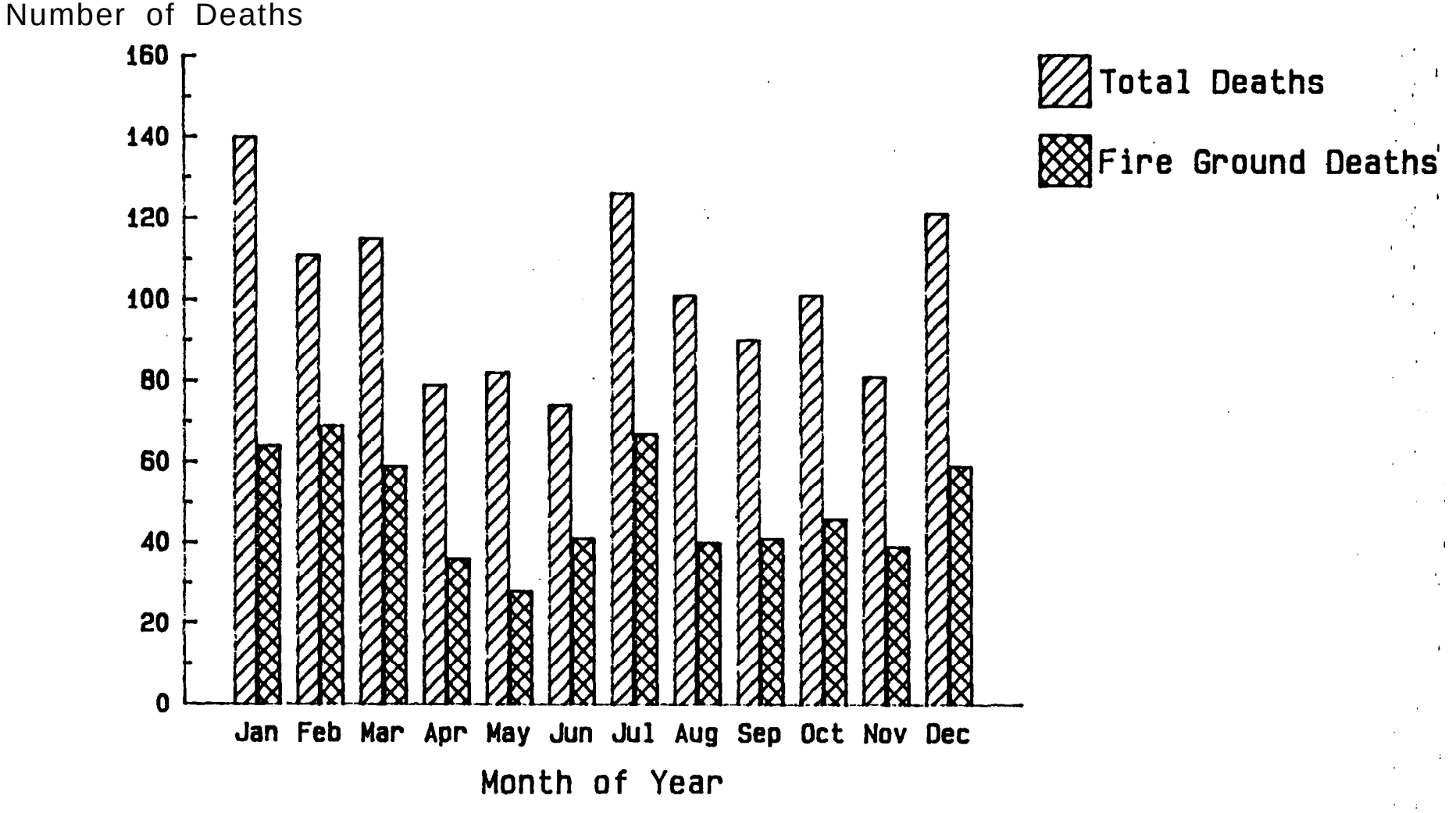
Based on the 554 fire ground fatalities and 1001 total fatalities for which alarm time was reported.

Figure 10
Fire Fighter Fatalities 1990
by Month of Year



Based on 46 fire ground fatalities and 105 total fatalities.

Figure. 11
Fire Fighter Fatalities by Month of Year
1981 - 1990



Based on 589 fire ground fatalities and 1221 total fatalities.

G. State and Region

The distribution of fire fighter deaths by state is shown in Table 1. Thirty-five states are represented on the list, led by New York with 11 deaths. The experience by region[3] is displayed in Table 2 and Figure 12. The South lost the largest number of fire fighters (38), followed by the Northeast (28), the West (23) and the Northcentral region (16). Only the West had a higher than average fire ground death rate, due to the high number of wildland fire deaths in 1990.

H. Analysis of Urban/Rural/Suburban Patterns in Fire Fighter Fatalities

The U.S. Bureau of the Census defines urban as a place having at least 2,500 population or lying within a designated urbanized area. Rural is defined as any community that is not urban. Suburban is not a Census term but may be taken to refer to any place, urban or rural, that lies within a metropolitan area defined by the Census but is not one of the designated central cities of that metropolitan area.

Fire department coverage areas do not always conform to the boundaries of Census places. For example, fire departments defined by counties or special fire protection districts may have both urban and rural sections, and there are Federal, state, and private fire fighters. In such cases, it may not be possible to characterize the entire coverage area of a fire department as rural or urban, and one must assign a fire fighter death as urban or rural based on the particular community in which the fatal injury occurred.

Table 1
1990 On-Duty
Fire Fighter Fatalities

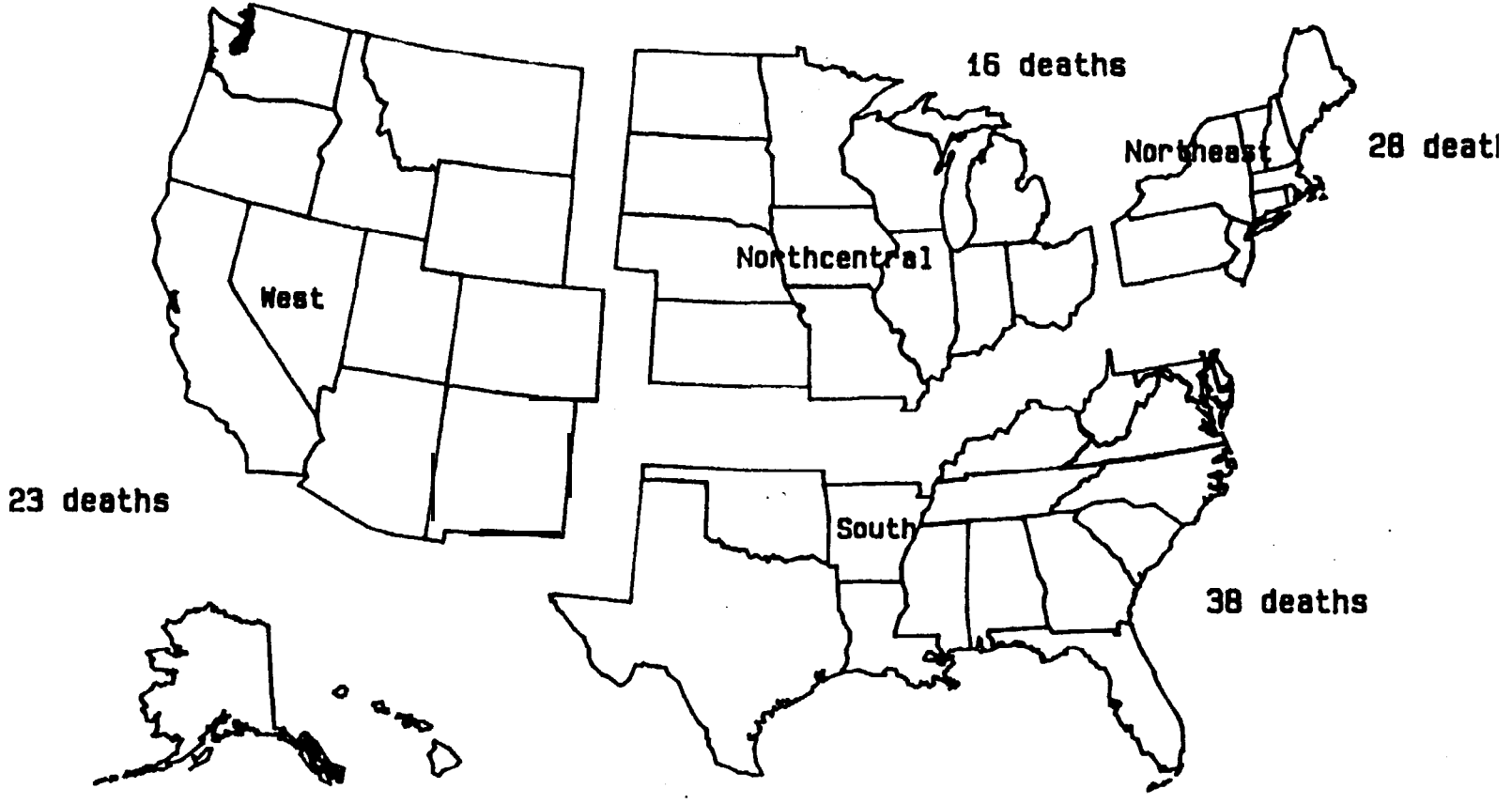
State	Number of Deaths	State	Number of Deaths
Alabama	2	Missouri	1
Arizona	6	Nebraska	1
California	8	New Jersey	1
Connecticut	3	New York	11
Delaware	1	North Carolina	2
Florida	5	Ohio	1
Georgia	3	Oklahoma	2
Illinois	3	Oregon	2
Indiana	3	Pennsylvania	10
Iowa	2	South Carolina	2
Kansas	1	Tennessee	1
Kentucky	3	Texas	5
Maine	1	Utah	2
Maryland	3	Virginia	4
Massachusetts	2	Washington	5
Michigan	2	West Virginia	3
Minnesota	1	Wisconsin	1
Mississippi	2		

TOTAL: 105

Table 2
Fire Fighter Death Rates by Region
1990

Region	Number of Fatalities	Number of Fire Ground Deaths	Fire Ground Death Rate per 100,000 Fires
Northeast	28	5	1.19
Northcentral	16	9	2.02
South	38	14	1.72
West	23	18	5.32
Nationwide	105	46	2.28

Figure 12
Fire Fighter Fatalities 1990
by Region



Based on these rules, the following patterns were found and are shown with available patterns for the general population and for the population of fire fighters specifically in local fire departments:

	Urban*	**Rural**	**Total**
Total 1990 fire fighter fatalities	52 (50%)	53 (50%)	105 (100%)
Suburban location	19	16	35
Local fire department only**	48 (57%)	36 (43%)	84 (100%)
U.S. population (1980)	74%	26%	100%
U.S. fire fighters (1989), total***	60%	40%	100%
U.S. fire fighters (1989), career***	97%		100%
U.S. fire fighters (1989), volun.***	48%	52%	100%

In 1987, we reported that the distribution of fire fighter fatalities from local fire departments was closer to the distribution of the whole U.S. population than to the distribution of fire fighters from local fire departments; suggesting that urban fire fighters faced a greater risk of dying than rural fire fighters. In 1988, we reported that the distribution of local fire fighter fatalities was closer to the distribution of local fire fighters, suggesting a similar risk of dying for urban and rural fire fighters. In 1989, the distribution of local fire fighter fatalities fell

* Note that the classification of fire fighters into urban and rural is based strictly on the population protected by the fire department and not *on* other community boundaries. However, if fire fighter fatalities were similarly classified, the distribution would shift by at most two percentage points, so the points here are not affected.

** Excludes one fire fighter in the military killed in an urban location, three members of industrial fire brigades killed in urban locations and 17 federal, state and inmate fire fighters killed in rural locations.

*** *U.S. Fire Department Profile Through 1989,* Quincy, Massachusetts: National Fire Protection Association, *Fire* Analysis and Research Division, November 1990. All percentages are for fire fighters in 'local fire departments.

exactly between the two other distributions. The 1990 results were most similar to those reported for 1988.

Since the results fluctuate back and forth each year, it is not advisable to read too much into them. It will be necessary to collect several years of data and do a multi-year analysis before any firm conclusions can be drawn.

III. Wildland Fire Fighter Fatalities, 1981 - 1990

Of the 1221 fire fighters who died while on duty from 1981 through 1990,162 (or 13.3 percent) died as a result of wildland fires. (For this analysis, the term *wildland* is used to include forest, brush and grass fires.) As shown in Figure 13, the number of deaths was generally between 15 and 22 per year with the exception of six deaths in 1982 and 12 in 1983. Over the period, 20 percent of all fire ground deaths occurred at wildland fires. This reexamination of wildland fire deaths was prompted by the fact that in 1990 the majority of fire ground deaths occurred at wildland fires for only the second year since 1977. A similar analysis was first done in 1988, using data from 1978 through 1987.

This analysis includes members of municipal fire departments who responded to grass, brush and forest fires within their jurisdictions as well as career, seasonal and contract employees of state and federal wildland agencies who were involved in assigned fire fighter activities at the time they were fatally injured. The federal wildland agencies include the U.S. Forest Service, the Bureau of Indian Affairs, the Bureau of Land Management, the Fish and Wildlife Service, the National Park Service and the military. Figure 14 compares the experience of wildland fire fighters and municipal fire fighters each year. A distribution of these 162 deaths by region is shown in Figure 15.

For the 92 wildland fires for which cause of the fire was reported, 34 were of incendiary or suspicious origin, 23 were due to misuse of heat (18 due to inadequate control of open fire, two due to children playing, two due to abandoned smoking materials and one due to a misfired teargas cannister), 19 were ,due to lightning and the rest were due to various other factors.

Figure 13
Fire Fighter Fatalities in Wildland Fires
1981 - 1990

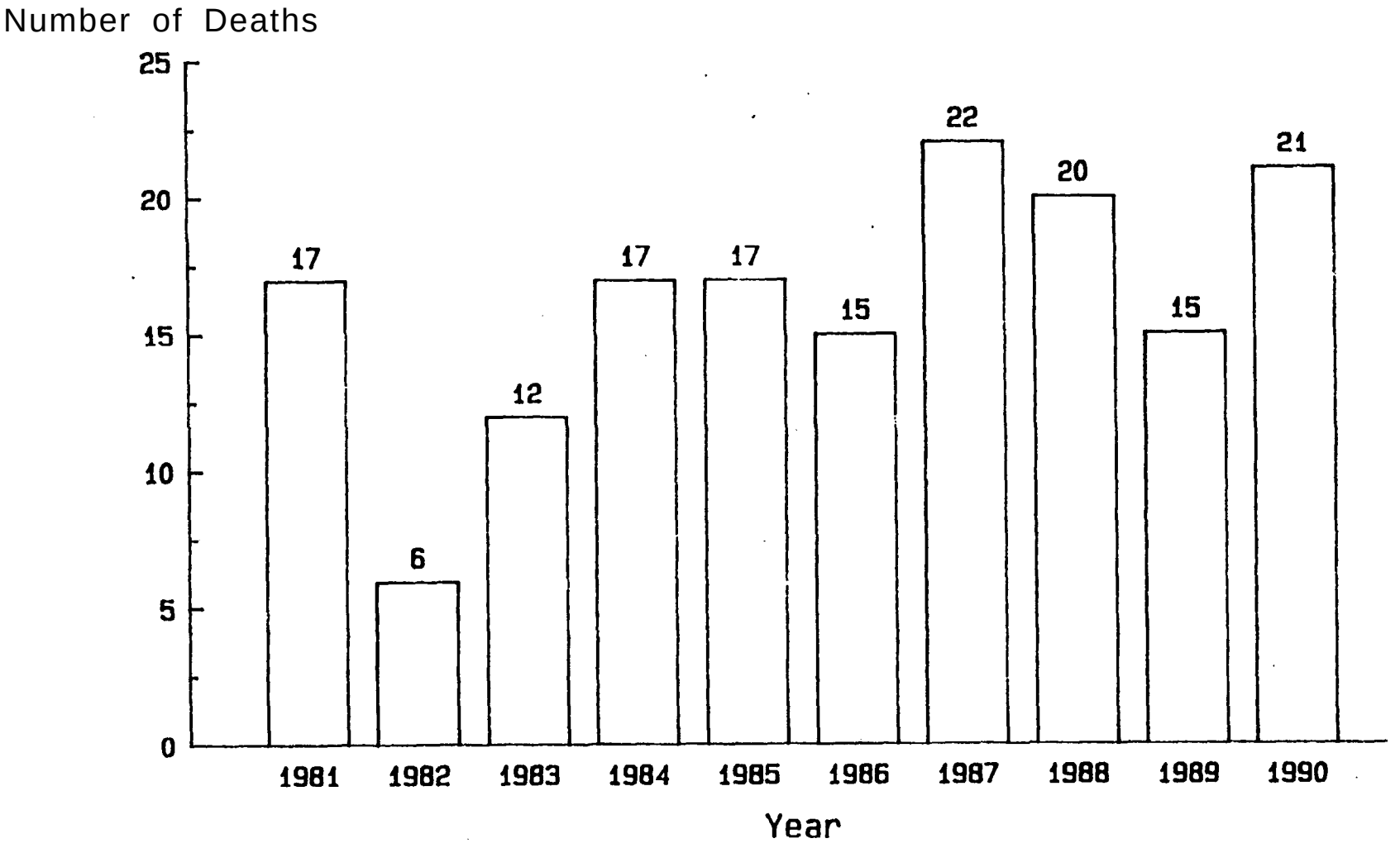


Figure 14
Fire Fighter Fatalities in Wildland Fires by Jurisdiction 1981 - 1990

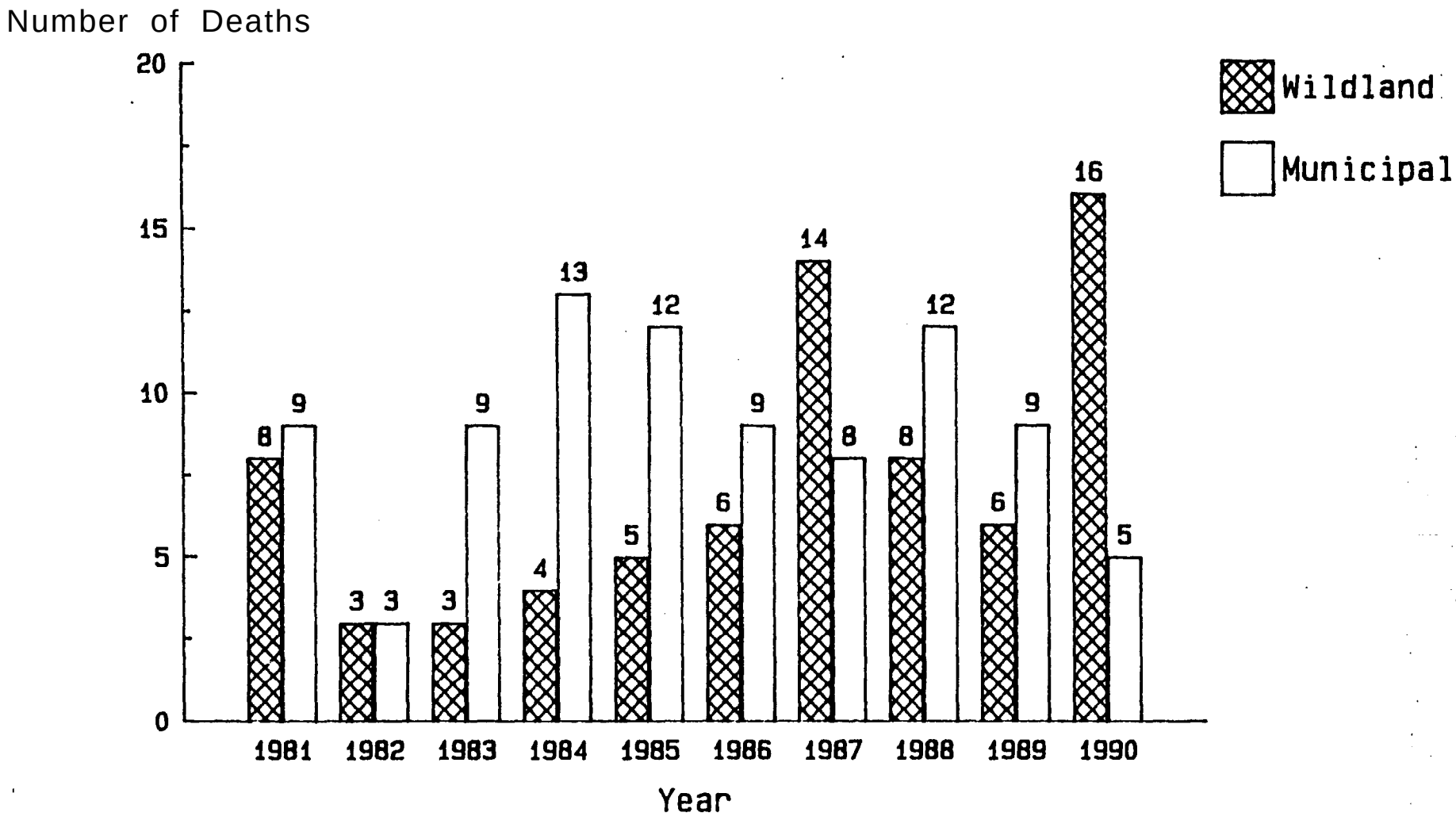
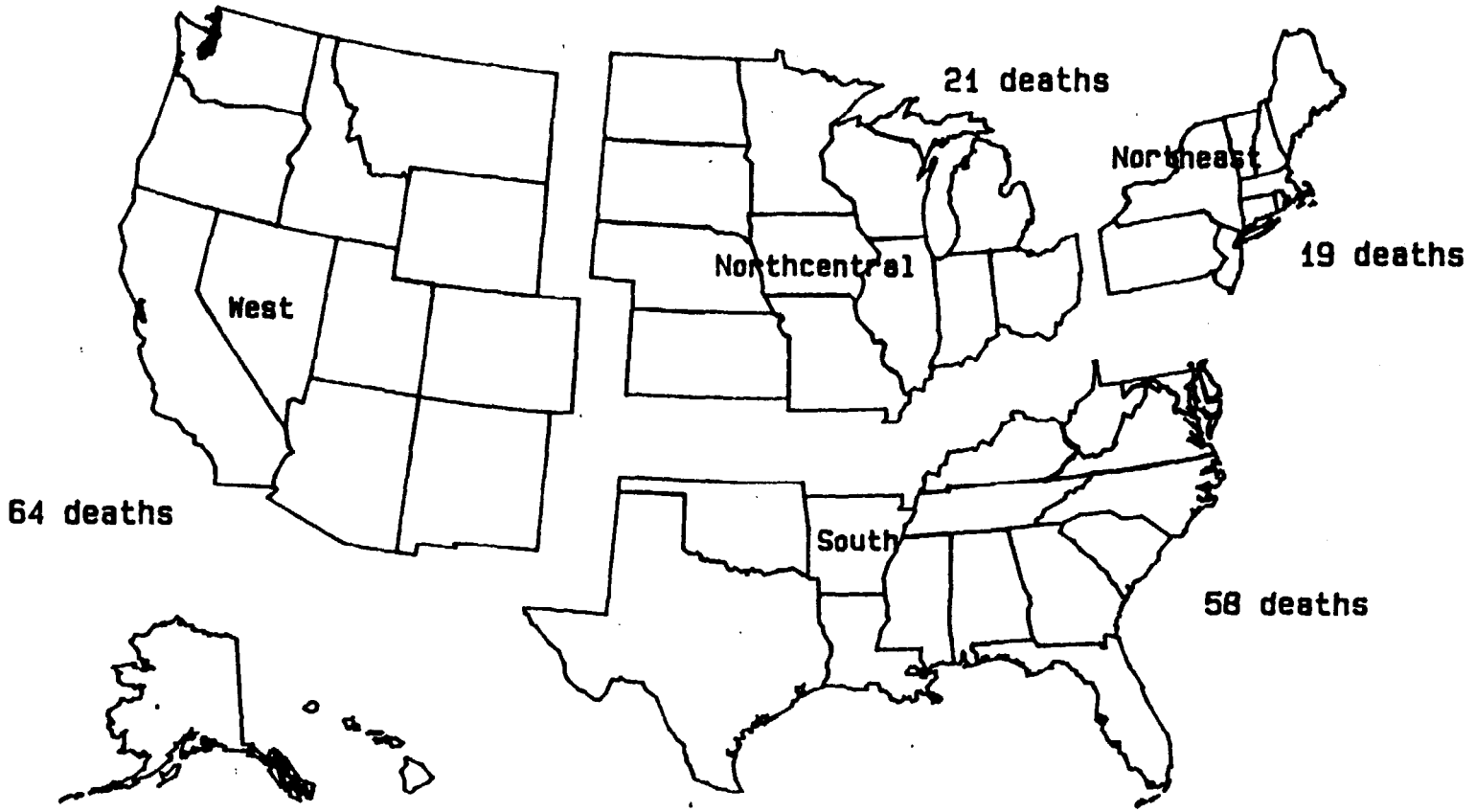


Figure 15
Fire Fighter Fatalities at Wildland Fires
by Region 1981 - 1990



The 162 victims included 11 chief officers, 16 company officers and 135 fire fighters. They ranged in age from 17 to 71, with a median age of 40 years. Seven of the victims were women.

Almost 75 percent of all wildland fire deaths (117) occurred during fire suppression activities. The remaining 45 deaths occurred when fire fighters were responding to or returning from such fires.

Deaths on the Fire Ground

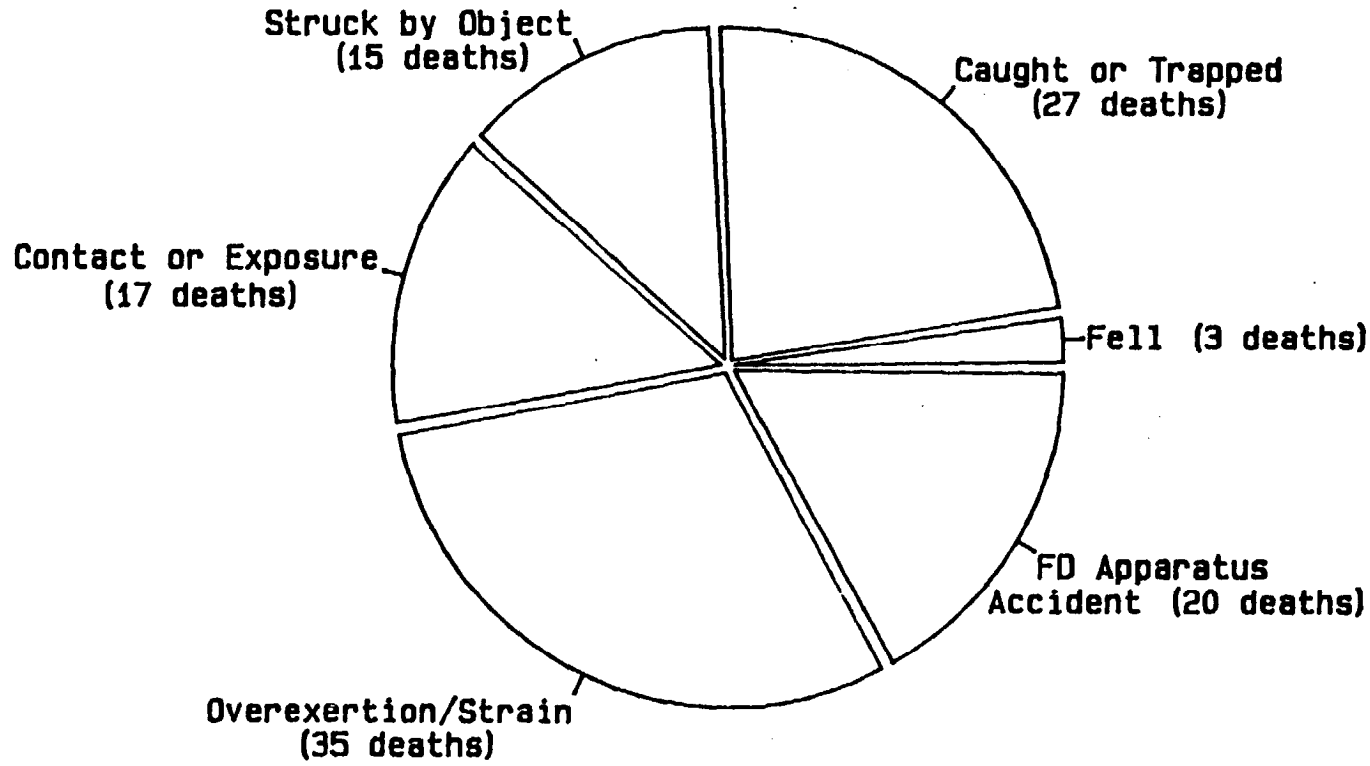
The breakdown of causes of fatal injuries on the fire ground is shown in Figure 16. The largest proportion of deaths during fire suppression activities were due to stress. These 35 deaths included 12 attributed to physical exertion on the fire ground.

The next major category was caught or trapped - 26 by fire progress and one by falling objects. Seventeen of the 26 fire fighters overrun by fire died as a result of bums; the other nine died of asphyxiation.

There were 17 deaths as the result of exposure or contact with an object. These deaths include six exposed to smoke, six exposed to electricity, three overcome by hot weather and two struck by lightning. Two of the fire fighters exposed to electricity came into contact with downed power lines, two touched guy wires that had been energized from contact with power lines, one touched a wire that had been flung over a power line and one made contact with his vehicle which had been energized.

Twenty fire fighters were killed in fire department apparatus accidents during fire suppression activities, including 16 in aircraft crashes. Fourteen of those 16 victims were contract pilots working for state and federal wildland agencies. The other two pilots were employees of a state and federal agency,

Figure 16
Fire Fighter Fatalities on the Fire Ground at Wildland Fires, by Cause of Injury 1981 - 1990



respectively. Three of the-victims were killed in one accident that was due to the structural failure of the plane. Pilot error was a factor in most of the other accidents.

Fifteen fire fighters were struck by vehicles or falling objects. The remaining three fire fighters fell -- one into a hole, one from a fire department vehicle and one down a hillside.

The next breakdown of wildland fire deaths is by nature of fatal injury, more commonly referred to as medical cause of death. State and federal wildland officials believe that their rigorous fitness requirements lower the risk of heart attack death among fire fighters under their jurisdiction. For this analysis, then, the fire ground deaths were broken down by type of department - municipal (career or volunteer) or wildland agencies. A profile of the 117 fire ground victims shows that 55 were members of municipal fire departments (48 belonged to volunteer departments and 7 to career departments). Another 59 fire fighters were career, seasonal or contract employees of state and federal wildland agencies. (The remaining three fire fighters were employees of paper companies and members of their companies' fire brigades. They are not included in this analysis. Two of them died of bums and one of a heart attack.)

As shown in Table 3, heart attacks accounted for over half of the deaths of municipal fire fighters during fire suppression activities, while most of the deaths to state and federal employees were due to internal trauma, bums and asphyxiation.

Of the 20 municipal heart attack victims for whom medical documentation was available, 12 had had prior heart attacks or bypass surgery, four had severe arteriosclerotic heart disease, two had diabetes and one had hypertension. No medical problems were reported for one fire fighter. The municipal volunteer fire fighters who suffered heart attacks ranged in age from 27 to 71, with a median

Table 3
Wildland Fire Fighter Fatalities on the Fire Ground by Nature of Fatal Injury 1981 - 1990

	Federal and State Wildland Agencies	Municipal		Total
		Volunteer	Career	
Heart attack	3	29	2	34
Internal trauma	21	5	0	26
Burns	13	1	1	15
Asphyxiation	9	1	1	11
Electric shock	3	5	0	8
Crushing	5	3	0	8
Heat stroke	0	1	2	3
Amputation	2	0	0	2
Stroke	2	0	0	2
Bleeding	0	2	0	2
Drowning	0	1	0	1
Fracture	1	0	0	1
Aneurysm	0	0	1	1
Total	59	48	7	114

Note: Another three deaths involved members of fire brigades of paper companies two died from burns and one suffered a heart attack.

age of 56 years. The two career municipal fire fighters were aged 56 and 61. Of the three wildland fire fighters who died of heart attacks, one had severe arteriosclerotic heart disease, one had hypertension and no medical documentation was available on the other victim. The three men were aged 38, 44 and 55 years.

The lower proportion of heart attacks among wildland agency fire fighters may be a result of stricter fitness requirements, but it could also be a function of age. Older fire fighters are more likely to suffer heart attacks and if the wildland agencies employ a significantly lower percentage of older fire fighters, their experience would reflect this. Looking at all fire ground deaths, municipal vs. wildland agencies, the ages of wildland fire fighters who died ranged from 18 to 64, with a median age of 35 years, while volunteer municipal fire fighters ranged in age from 17 to 71,with a median age of 52, and career municipal fire fighters ranged in age from 24 to 61, with a median age of 50 years. Other factors besides age and fitness requirements that may impact the incidence of heart attack deaths at wildland fires include the equipment provided. In many of the incidents handled by municipal fire fighters, those involved in fighting the fire did so in full protective clothing designed for structural fire fighting, while wildland fire fighters wear clothing, helmets and boots more appropriate to outdoor work.

As far as the other types of injuries suffered on the fire ground are concerned, increased use of fire shelters could result in a reduction in fatal burns and smoke inhalation deaths and safer handling of aircraft could reduce the number of deaths due to aircraft crashes during suppression activities.

Deaths While Responding to or Returning from Alarms

Of the 45 fire fighters who died while responding to or returning from wildland fires, 37 of the victims were responding to fires and 8 were either en route from fires or back at the station or base camp when they died. The breakdown of deaths while responding to or returning from alarms is shown in Figure 17.

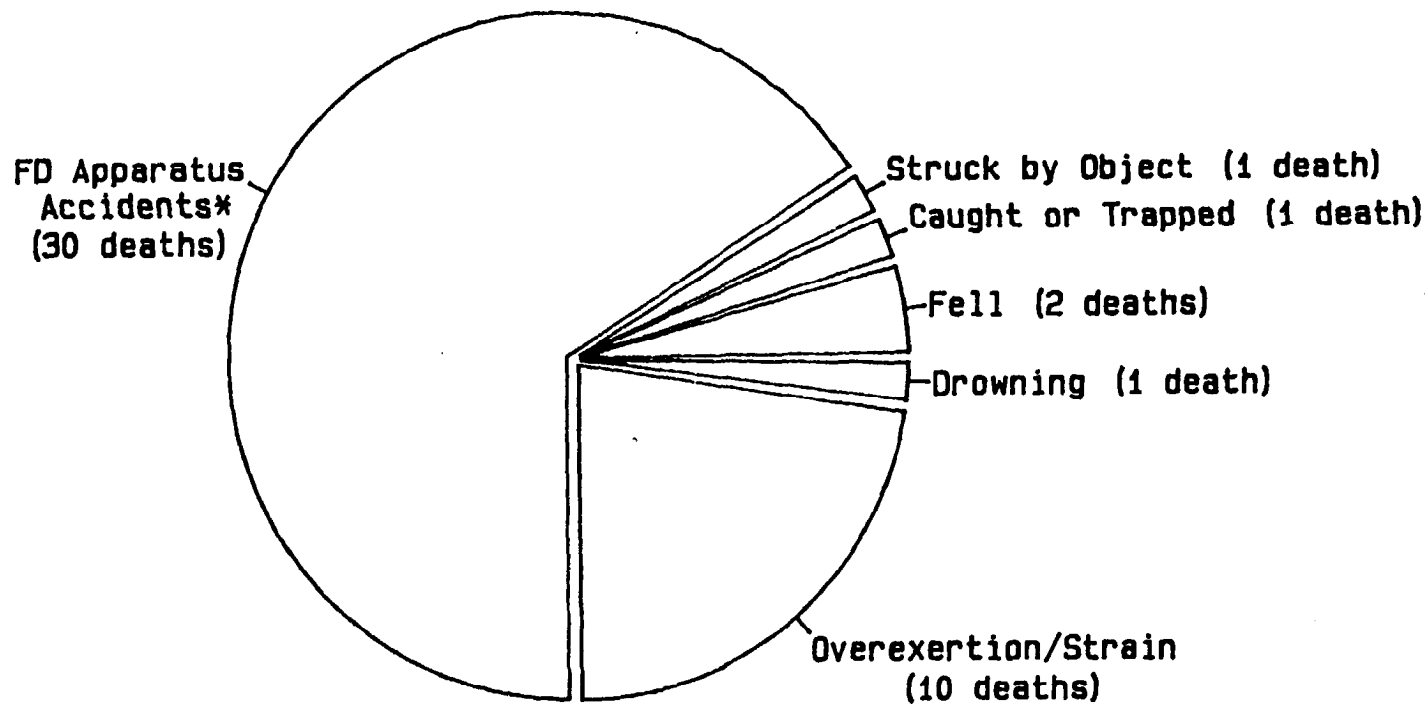
Thirty of the victims were involved in motor vehicle accidents while driving or riding on fire department apparatus, including eight in aircraft crashes. Three of the eight were killed in two aircraft crashes that resulted from mechanical failure; four were killed in one helicopter that crashed after striking a high tension wire; and the cause of the remaining crash was not reported. Ten fire fighters died as a result of stress, two fell from fire department apparatus, one was struck by a vehicle, one was caught or trapped by a falling object, and one was caught and trapped underwater and drowned.

The 45 injuries while responding to or returning from wildland fires resulted in 27 deaths due to internal trauma, 10 heart attacks, five deaths due to crushing injuries, and one death each due to fracture, bums and drowning.

Experience in 1990

As mentioned earlier in this report, 1990 was only the second year since NFPA began doing comprehensive studies of fire fighter deaths that the largest proportion of fire ground deaths occurred in wildland fires. (1987 was the first year that that happened.) In addition to those 19 deaths, two others, both volunteers, died while responding to or returning from such fires.

Figure 17
Fire Fighter Fatalities Responding to or Returning from Wildland Fires by Cause of Injury 1981 - 1990



* Includes aircraft crashes

The most serious incident in 1990 resulted in the deaths of six fire fighters --- five inmates and their supervisor. They all suffered smoke inhalation and burns when they were overrun by the fire. Ironically, the next day in a neighboring state, a similar scenario resulted in the deaths of two more inmates. Later in the summer, two fire fighters cutting a fire line with a bulldozer also were overrun by fire and fatally burned.

Two U.S. Forest Service contractors died when their plane crashed as they were dropping retardant on a fire. One fire fighter was killed when his helicopter crashed as he was dropping water on a fire.

One fire fighter died of a heart attack while operating at a grass fire. One fire fighter operating at a large fire involving brush and several dwellings fell down a steep hillside and hit a tree stump; the resulting pulmonary embolism led to his death. A fire fighter who was caught in a flare-up was fatally burned. Another was struck on the head. by a burning snag. One fire fighter suffered a stroke while attending a morning briefing before going on the fire line. And finally, a fire fighter working at a grass fire died of heat stroke.

Of the two fire fighters who were killed while responding to wildland fires, one died of a heart attack and the other was killed in a head-on collision while en route to the station.

IV. Fatalities Resulting from Heart Attacks, 1981 - 1990

NFPA's first special study on fire fighter fatalities as a result of heart attacks, strokes and aneurysms was done in 1987 and covered the period from 1977 through 1986. Since heart attack continues to be the leading cause of U.S. fire fighter deaths, that analysis is updated here to cover the period from 1981 through 1990.

The 1987 analysis included cardiac arrest, stroke (CVA) and aneurysm, because all involve the cardiovascular system. This analysis will concentrate on cardiac arrest, or heart attack, only. Of the 1221 fire fighter fatalities over the 10-year period, 560 (45.9 percent) fell into this category. (Over the same period, there were also 19 strokes and 5 aneurysms.) The aspects of the problems examined in this study include the physical condition of the victims prior to their deaths, the types of duty and activities they were engaged-in and their ranks and ages.

Over the lo-year period, the number of deaths annually has ranged from a high of 71 in 1981 to its lowest level of 40 in 1984 and 1990. As shown in Figure 18, however, there has not been a steady decrease over the period. Looked at another way, the *proportion* of total deaths each year that these deaths account for has varied from a high of 53.8 percent in 1989 to a low of 33.6 percent in 1984.

Physical Condition

Information on physical condition prior to fatal injury was available for 263 of the 560 heart attack victims. This information was obtained from medical documentation that accompanied fatality reports.* As shown in Figure 19, of

* Medical documentation used to evaluate the physical conditions of heart attack victims was in the form of death certificates and autopsy reports. Fire fighters who experienced prior heart problems may or may not have been aware of their physical conditions prior to the fatal heart attack.

Figure 18
Fire Fighter Deaths Due to Heart Attacks
1981 - 1990

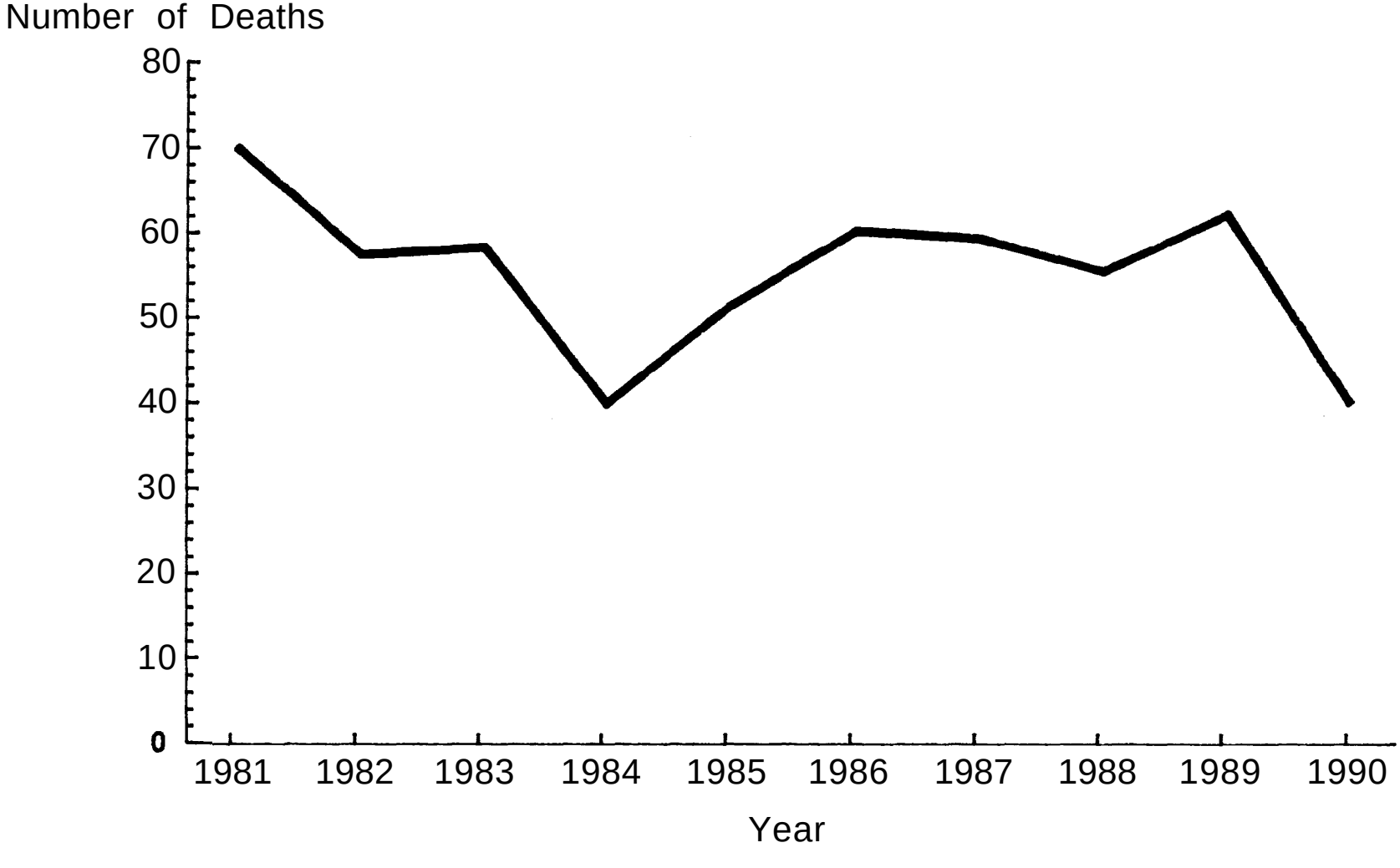
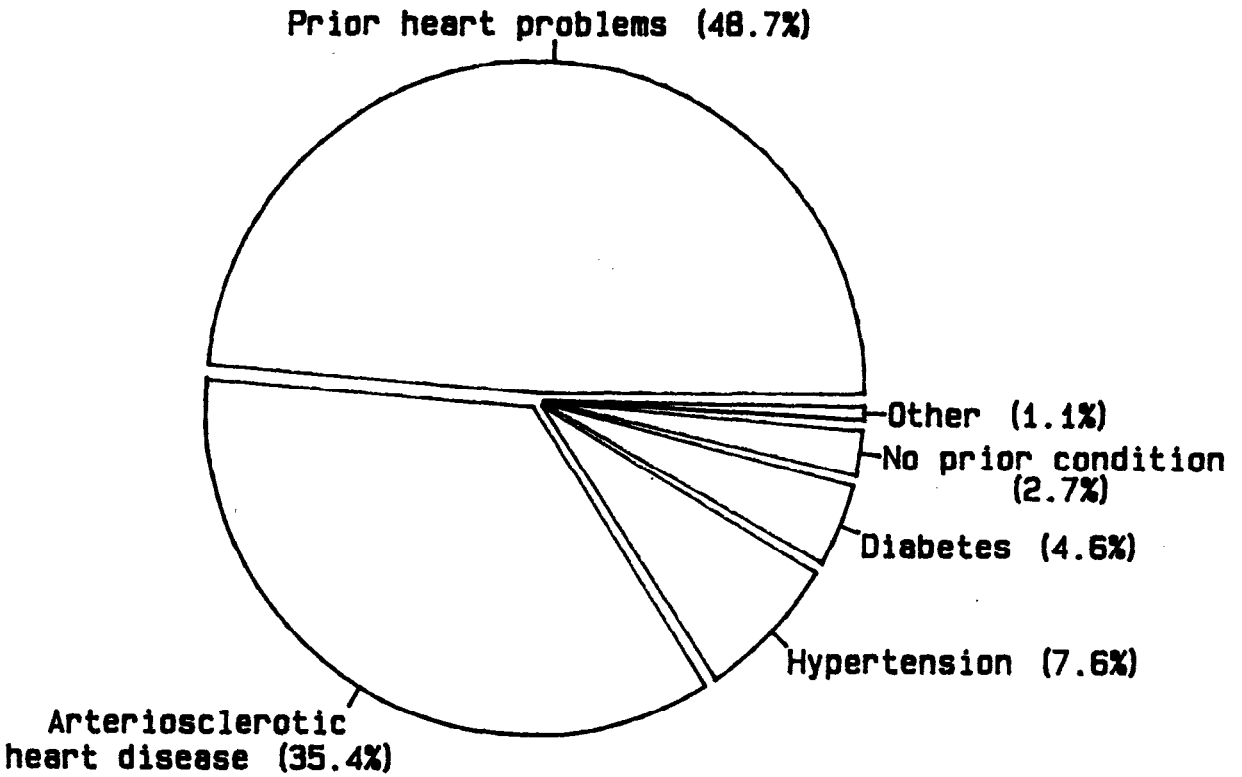


Figure 19
Fire Fighter Deaths Due to Heart Attacks by Physical Condition 1981 - 1990



these 263 fire fighters, 128 (48.7 percent) had had some prior heart-related conditions, such as previous heart attacks or coronary bypass surgery. Another 93 of tlhe victims (35.4 percent) had severe arteriosclerotic heart disease (defined for this study as medically documented arterial occlusion of at least 50 percent but usually found to be in excess of 70 percent). Taken together, then, almost 85 percent of the heart attack victims for whom medical documents were available had known or detectable heart problems and were still active in the fire service.

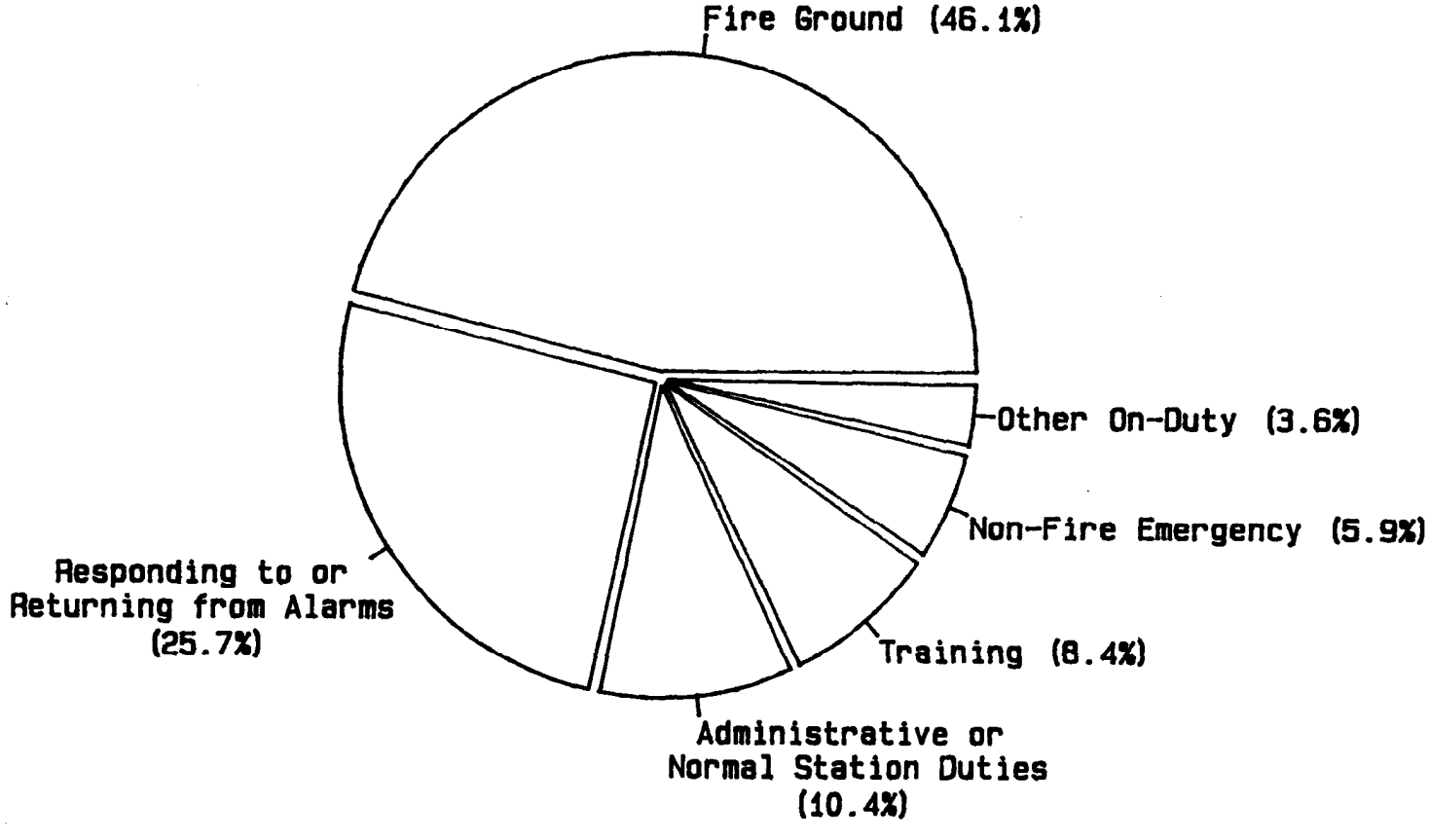
Hypertension - another easily diagnosed, serious condition - was indicated in an additional 20 (7.6 percent) of the victims, and 12 others (4.6 percent) had diabetes. One fire fighter had recently had an operation to remove the lower part of his left lung. One was taking medication for blood clotting. And one had recently suffered a viral infection that had resulted in inflammation of his heart. Only 7 of the 263 victims reportedly had no previous health problems.

Available reports on the other 297 heart attack victims did not contain enough medical documentation to determine whether previous, related problems existed.

Type of Duty

Figure 20 shows the distribution of types of duty the 560 fire fighters were engaged in when they suffered their fatal heart attacks. The largest proportion, 258 deaths (46.1 percent), occurred during fire ground activities. Of these, 233 were attributed to stress or overexertion (89 were reportedly during strenuous physical activity), 23 were due to exposure to smoke and two were due to hot weather. Four of the 23 smoke-exposure heart attack deaths occurred at wildland

Figure 20
Fire Fighter Deaths Due to Heart Attacks by Type of Duty 1981 - 1990



fires, where fire fighters do not use breathing apparatus. Two others were at vehicle fires and the remaining 17 deaths were at structure fires. In 13 of those 17 cases and 31 of the 47 stress-related deaths that occurred inside structures, the fire fighters were not using self-contained breathing apparatus (SCBA). Of the remaining four smoke exposure deaths, three had their SCBA off and on during the fire and one removed his SCBA as he left the building. All 23 victims of smoke exposure heart attacks reportedly had pre-existing heart conditions.

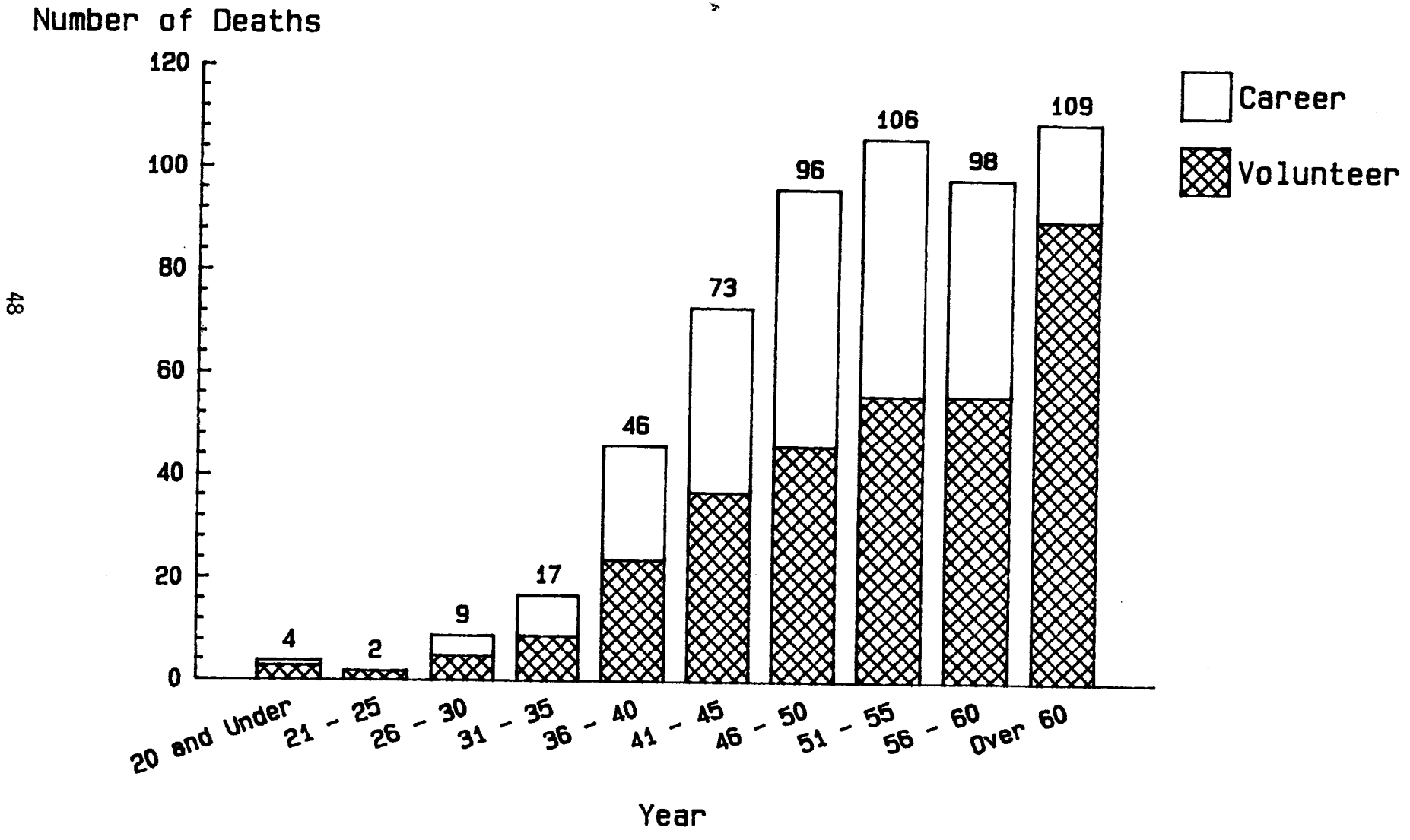
The next largest proportion involved fire fighters responding to or returning from alarms (144 deaths or 25.7 percent). Of these 144 fire fighters, 75 were responding to incidents at the time they suffered the fatal heart attack. The other 69 were returning or had returned from the alarm when they were stricken. Most of the alarms that resulted in these deaths involved actual emergencies, but there were 10 false calls involved -- five of them malicious false alarms.

The other major categories included 58 deaths during admimistrative and normal station duties (10.4 percent), 47 deaths during training (8.4 percent) and 33 deaths while working at non-fire incidents such as emergency medical and rescue calls (5.9 percent). The other 20 deaths (3.6 percent) occurred during other on-duty activities such as fire prevention, inspection, maintenance, etc. Of the 47 fire figlhters who died during training activities, 17 were engaged in physical fitness activities, such as jogging, playing basketball or undergoing stress tests.

Ages of Fire Fighters

The distribution of ages of the heart attack victims is displayed in Figure 21. The ages range from 16 to 81 years, with a median age of 52 years. Five of the six fire fighters aged 25 and under had congenital heart problems. The sixth fire fighter had had a viral infection that damaged his heart and lungs. Eleven of the

Figure 21
Fire Fighter Deaths Due to Heart Attacks by Age 1981 - 1990



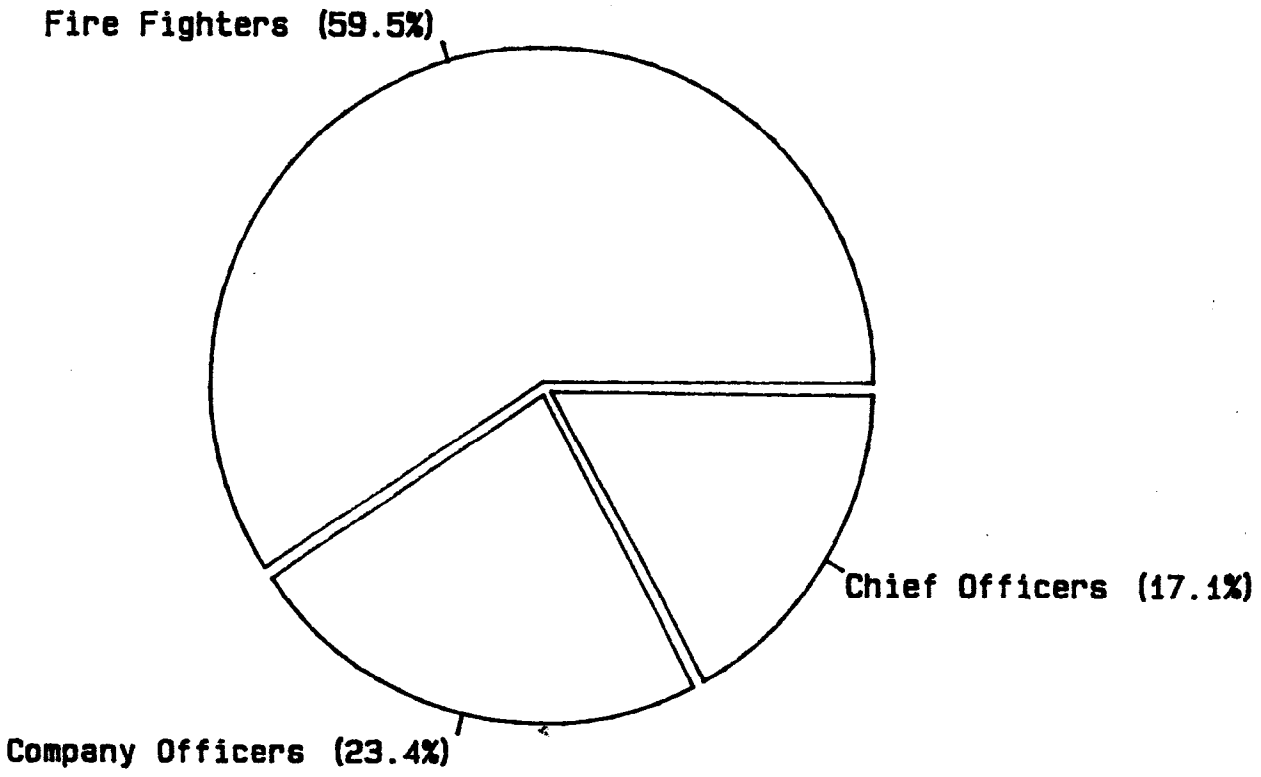
26 fire fighters aged 26 to 35 had prior heart problems (heart attacks or bypass surgery) and five others had severe arteriosclerotic heart disease. As can be seen from the breakdown by career and volunteer fire fighters (232 career fire fighters vs. 328 volunteer fire fighters) over 40 percent of the victims were career fire fighters, although it is estimated that only 25 percent of the nation's fire fighters are career. Therefore, career fire fighters suffer proportionally more heart attack deaths than volunteer fire fighters. (Career fire fighters in fact suffer proportionally more deaths of all types than volunteers, possibly because of the higher number of hours and calls per year per person for career fire fighters.) Figure 21 also shows that the victims over age 60 were mostly volunteer, possibly due to the tendency of volunteer fire fighters to remain active well beyond the retirement ages of career fire fighters. Figure 22 compares the experience of career and volunteer fire fighters over the lo-year period.

Ranks of Fire Fighters

Figure 23 shows the ranks held by the fire service personnel who suffered fatal heart attacks and whose ranks were known. The largest proportion (333 or 59.4 percent) were fire fighters. Company officers made up 23.4 percent (131 deaths) of the total and the remaining 17.2 percent were chief officers (96 deaths). These statistics indicate that, for every 2.5 fire fighters stricken with a fatal heart attack, one company officer is stricken. Based on typical complements of three or four personnel to each fire company (one officer and two or three fire fighters) this suggest's a roughly equal risk of heart attack for company officers and fire fighters. However, for every 3.5 fire fighters stricken, one chief officer died, showing a much higher risk for chiefs (although the ratio of chief officers to fire fighters; is not known). These patterns, taken together, show that fire service

Figure 22
Fire Fighter Deaths Due to Heart Attacks
Career vs. Volunteer 1981 - 1990

Figure 23
Fire Fighter Deaths Due to Heart Attacks by Rank 1981 - 1990



personnel at all ranks face increased risk of heart attack, and so prevention programs should not focus on, or exclude, any one rank.

Summary

From 1981 through 1990, 560 fire fighters, or almost half of the total number of fire fighters who died in the line of duty, died as the result of heart attacks, and over 80 percent of those with medically documented prior conditions had known or detectable heart problems. (Nearly all had some serious prior health problems.) Heart attacks among fire service personnel are serious, all-too-common occurrences. Steps to reduce the risk of heart attacks among fire fighters, along with more detailed medical evaluations, should be taken. Further study in the areas of physical fitness and dietary requirements for fire fighters is recommended.

Above all, attention must be focused on the significant problem of fire service personnel who have heart problems, yet are allowed to remain active in fire fighting.

V. Conclusions and Recommendations

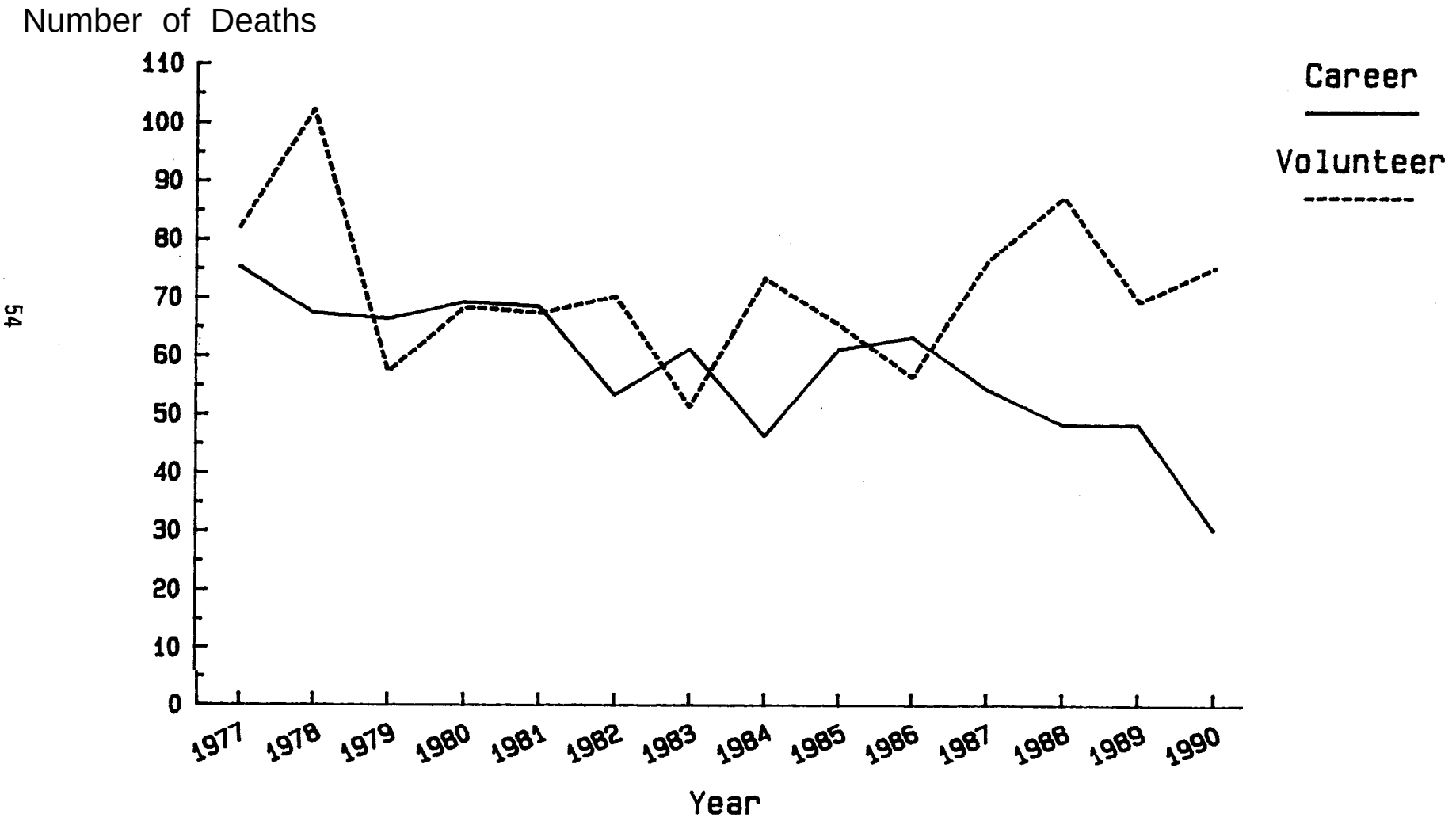
For the second consecutive year, there was a sharp drop in the number of fire fighter deaths in the U.S. Last year we reported that most of the decrease in 1989 was accounted for in the experience for volunteer fire fighters, after two years of increases for them. In 1990, the experience for volunteers held fairly steady and the decrease occurred in the experience of career fire fighters. The trends since 1977 are shown for both groups in Figure 24.

As shown in Figure 1, the annual number of fire fighter fatalities had reached a plateau throughout the 1980s. We may be seeing the beginning of a major downward trend in fire fighter deaths. Clearly, there is a major downward trend for career fire fighters, but volunteer fire fighter deaths were higher in 1990 than they were at the beginning of the decade,

Two of the areas of major concern in 1990 were highlighted id special 10-year analyses -- wildland fire deaths and heart attack deaths. The first analysis was prompted by the very high proportion of fire ground deaths at wildland fires in 1990. The second analysis addresses a chronic problem observed each year.

The analysis of wildland fires showed that almost a third of the deaths resulted in heart attacks -- mainly affecting members of municipal fire departments and that motor vehicle accidents, particularly those involving aircraft, and rapid fire progress remain significant problems. Rigorous fitness requirements for wildland fire fighters, the use of fire shelters and appropriate protective clothing and safer operation of vehicles including aircraft show real potentials in reducing losses in wildland fires. The special risks associated with operations at wildland fires warrant continued attention to command, control and communications issues.

Figure 24
Comparison of Career and Volunteer Experience
1977 - 1990



As described in the 10-year analysis of heart attack deaths, heart attacks continue to account for the largest share of fire fighter deaths annually. For over 80 percent of the cases where medical documentation was available, the victims had suffered prior heart attacks, had had bypass surgery or had severe arteriosclerotic heart disease. Others had serious health problems such as hypertension or diabetes. Detailed medical evaluations throughout the course of a fire fighter's career, as well as studies into the areas of physical fitness and dietary requirements for fire fighters, are among the steps that must be taken to reduce the incidence of heart attacks among fire fighters.

Heart attacks and wildland fires accounted for 59 of the 105 fire fighter deaths in 1990. Other serious health and safety issues continue to account for a sizeable share of the annual death toll and must also be addressed. These include motor vehicle collisions, accidents at rescue scenes, plane crashes and carbon monoxide and carbon dioxide poisoning, for example.

Basic guidelines for sound health and safety practices need to be implemented throughout the fire service. One example is *NFPA 1500, Standard on Fire Department Occupational Safety and Health Program,* which provides the framework and objectives for a comprehensive program to reduce and eliminate fire fighter deaths and injuries. Another is proposed *NFPA 1582, Standard on Medical Requirements for Fire Fighters,* which will specify minimum medical requirements for candidate and current fire fighters, including full-time or part-time employees and paid or unpaid volunteers.

Further reductions in fire fighter deaths can be accomplished if changes are made in operating procedures and attitudes.

References

1. Michael J. Karter, Jr., *U.S. Fire Department Profile through 1989;* Quincy, MA: National Fire Protection Association, Fire Analysis and Research Division, November 1990.

2. Michael J. Karter, Jr., "U.S. Fire Loss in 1990," *NFPA Journal,* Vol. 85, No. 5, (September 1991).

3. The four regions defined by the U.S. Census Bureau are as follows:

   Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

   Northcentral: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

   South: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia.

   West: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.