ANALYSIS REPORT ON
FIRE FIGHTER FATALITIES

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Background

For a decade and a half, 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 by NFPA each year since 1974.

For more than 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 1992 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 1993.

In August, a briefing on the 1992 experience and two special analyses was presented by NFPA staff to USFA staff and guests in Emmitsburg, MU. 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 16 years of experience now classified in its 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 4.1 format, which is being delivered separately, (c) the various lists described above, and (d) the briefing provided in August. 31st.

I. Introduction

The purpose of this study is to analyze the circumstances surrounding fire fighter fatalities in the United States in 1992 in an attempt to identify potential means for reducing the number of deaths that occur each year. In addition to the 1992 findings, this study will also include special analyses of particular recurring scenarios, using NFPA's data base of fire fighter fatalities from 1983 through 1992.

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 combination; 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 local or municipal* fire fighters but also seasonal and full-time employees of the U.S. Forest Service and state wildland agencies; prison inmates serving on fire fighting 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

* For this report, the term *municipal fire* fighters refers to members of city, town, county and township fire departments, members of independent volunteer fire departments providing primary protection to a municipality and contract fire departments providing primary fire protection. It excludes federal and state employees and contractors and members of prison and industrial fire brigades.

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 in the line of 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 illness 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 while working around the station, 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, a fire inspector who fell through a skylight, and a fire fighter 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 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 after years of recurring seizures resulting from a brain injury received in 1979 when he was struck by a hose coupling. 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. This creates an ambiguous picture on the issue of occupational versus other factors as causes of fire fighter deaths. This is recognized as a gap that cannot now be filled because of the limitations in tracking the exposure of fire fighters to toxic environments and substances and the potential long-term effects of such exposure.

C. Sources 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 recorded in 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 FEMA's request for a list of the next-of-kin of the 1992 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. 1992 Findings

Seventy-four fire fighters died while on duty in 1992, the lowest total in the 16 years that NFPA has done this study. As shown in Figure 1, this is a decrease of 30.8 percent from the year before, and a 45.6 percent decrease from 1988, the most recent peak year.* This continued drop in fire fighter deaths is extremely encouraging, and although such a low total cannot be expected to repeat in 1993, it seems evident that progress has been made in reducing on-duty fire fighter fatalities. However, since these deaths do continue to occur, efforts need to be maintained and even intensified throughout the fire service. 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 (52.7 percent).

Of the 39 fire ground deaths, 20 were due to heart attacks, six to internal trauma, six to crushing injuries, five to asphyxiation, and two to burns. Fifteen of the victims were career fire fighters and 24 were volunteers.

The second largest category involved responding to and returning from alarms, which accounted for slightly more than a quarter of the deaths - a result consistent with the findings in previous years. Eleven of these 20 deaths were due

* 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 - 1992

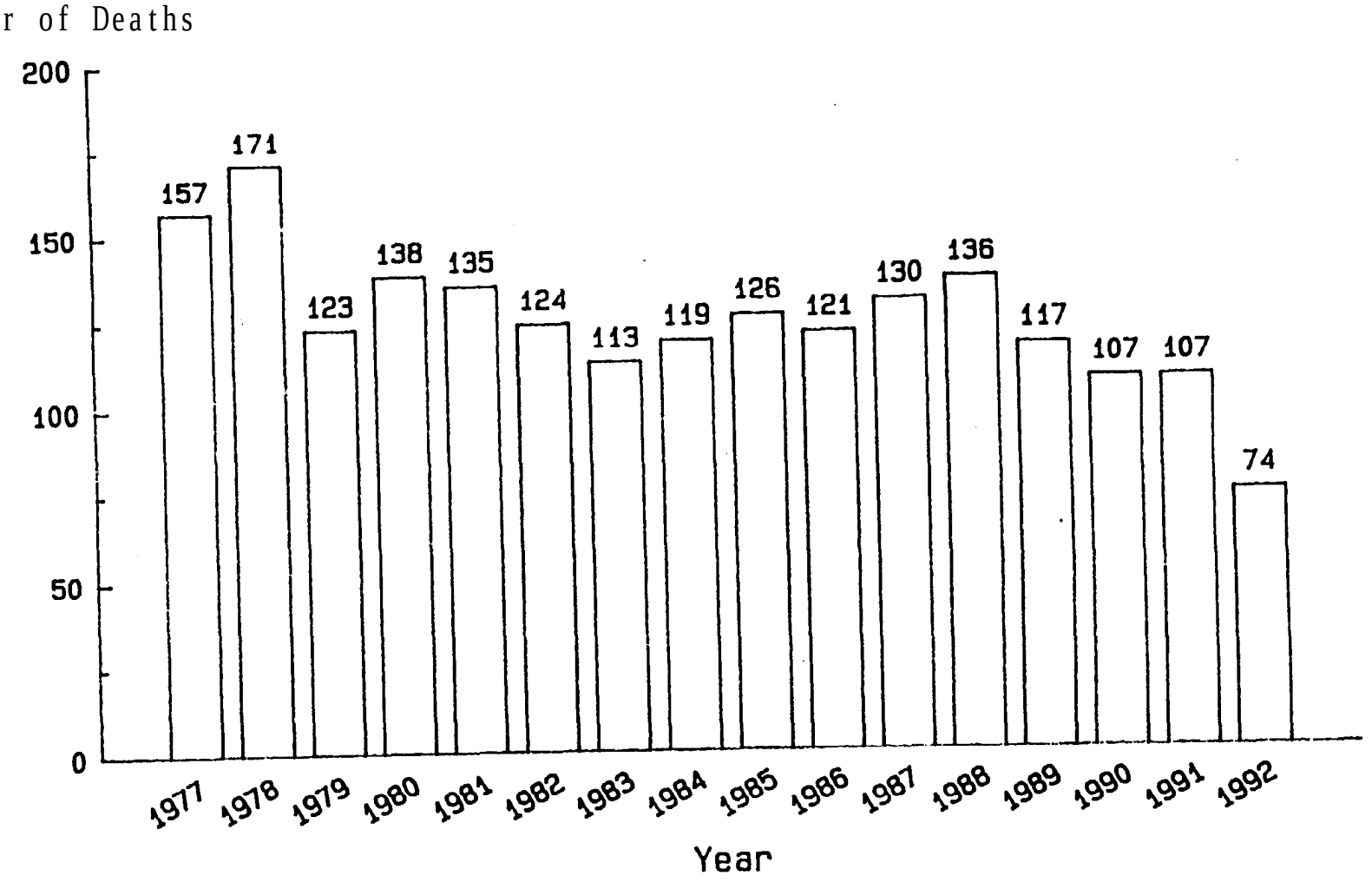
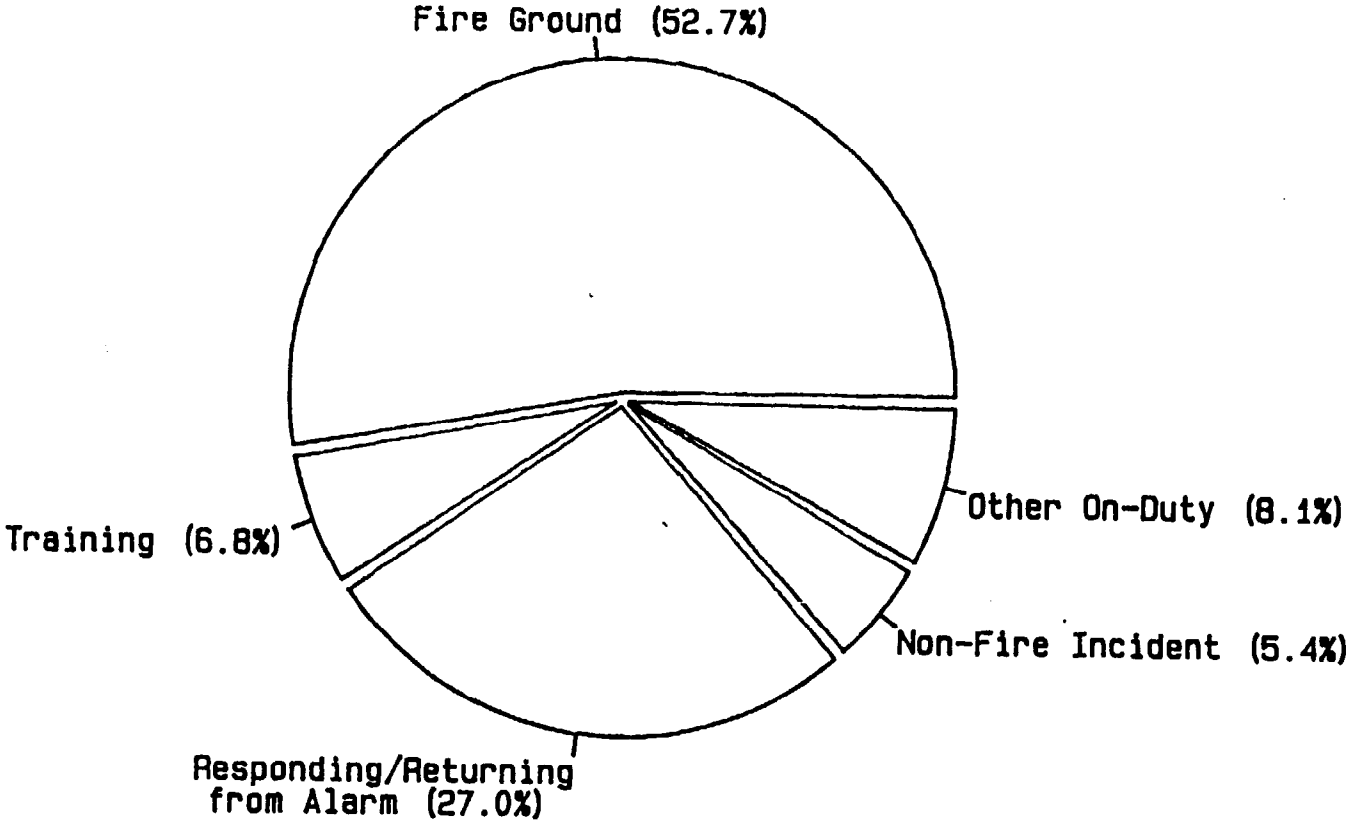


Figure 2
Fire Fighter Fatalities 1992
by Type of Duty



to heart attacks, one to a stroke, one to being struck by a fire apparatus that was backing up to a hydrant on arrival at the incident scene, and the remaining seven were due to collisions. One was a career fire fighter and 19 were volunteers. Three were killed while responding to or returning from false calls -- two had heart attacks and the third was the fire fighter mentioned above who was struck by apparatus at what turned out to be an alarm malfunction.

There were five deaths related to training activities. Of these, two were due to heart attacks. One was the result of a collision in a personal vehicle returning from a training session. A safety officer drowned at a diver training exercise. And finally, a fire fighter fell from a ladder during recruit training.

There were four deaths while working at non-fire incidents. One fire fighter was struck by a falling tree during hurricane cleanup operations. Another drowned while checking a vehicle submerged in a stream for possible victims. Two fire fighters died of heart attacks -- one while removing a gunshot victim from a canyon and the other while investigating a smoke detector activation.

The remaining six deaths occurred while performing other duties. Three of these fire fighters suffered fatal heart attacks during normal station duties. Two were performing vehicle maintenance -- one was crushed between two vehicles and the other suffered a heart attack as a result of exposure to carbon monoxide fumes. One fire fighter died of a stroke while undergoing a stress test.

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 (in this case, over half) were due to stress or overexertion. Six of these 40. 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 21 deaths included 14 from motor vehicle accidents, three by collapsing walls, two by falling snags at wildland fires and one each by a log at a burning log pile and a falling tree limb at a hurricane cleanup.

Ten fire fighters were caught or trapped -- two by structural collapses; two by rapid fire progress; two by being lost inside buildings; two underwater who drowned; one by fire department apparatus during maintenance; and one who became caught on something in a basement and was unable to escape.

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

Two fire fighters were killed as a result of falls -- one from a window while attempting to escape a backdraft and one from a ladder during recruit training.

One fire fighter died as a result of exposure to carbon monoxide fumes while working on apparatus in a closed station.

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 38 deaths, medical documentation indicated that 10 of the victims had prior heart problems, either previous heart attacks or bypass surgery; and three others

Figure 3
Fire Fighter Deaths 1992
by Cause of Fatal Injury

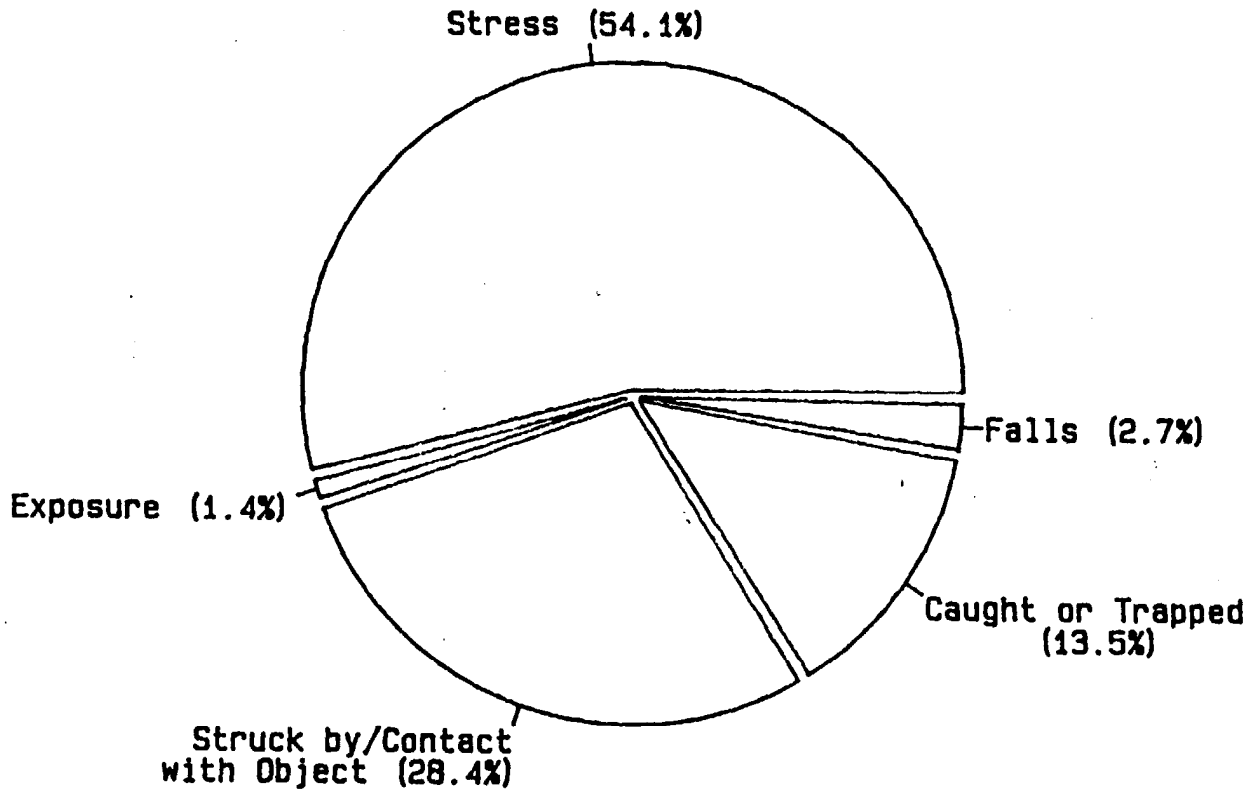
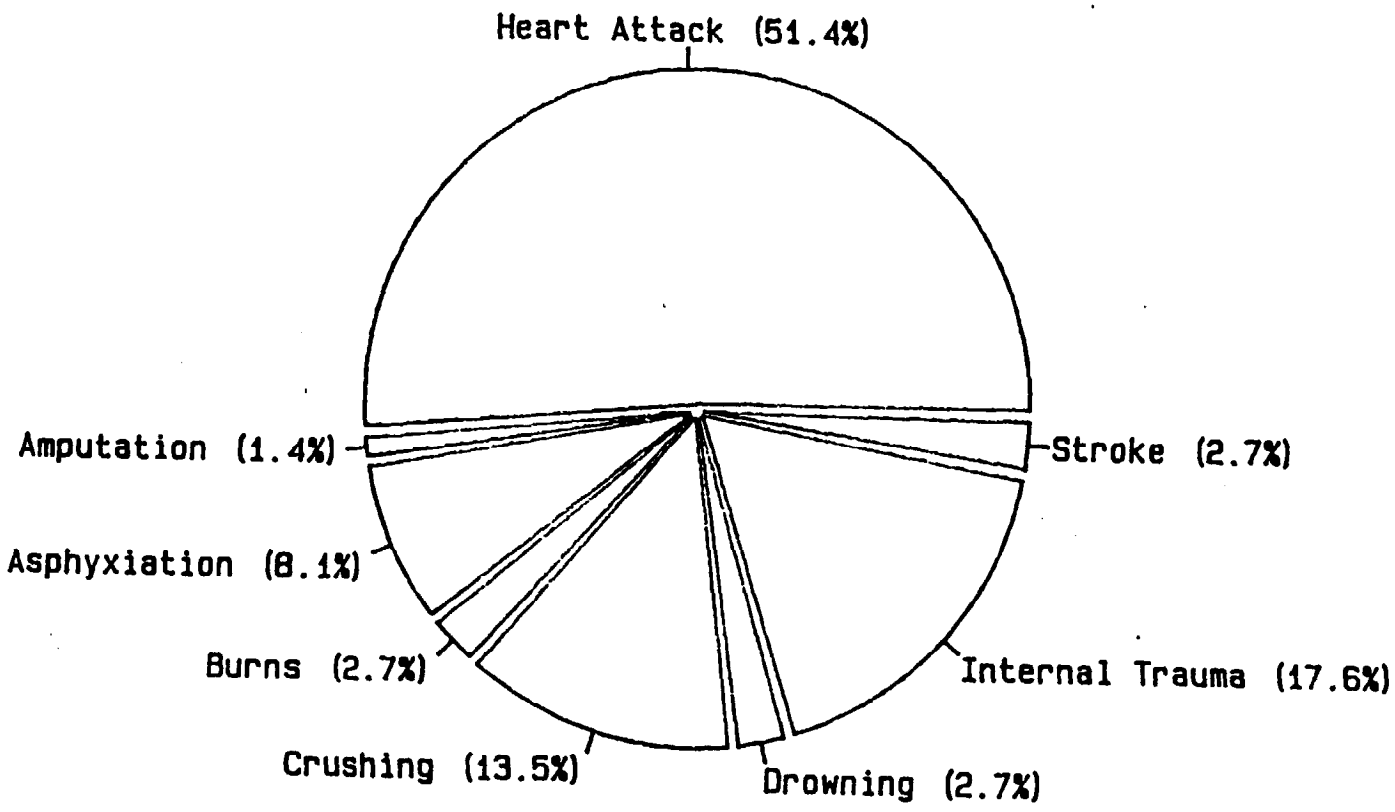


Figure 4
Fire Fighter Deaths: 1992
by Nature of Injury



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). Five other victims suffered from hypertension. Medical documentation was not available for the other 20 heart attack victims.

The other categories of nature of fatal injury were internal trauma (13 deaths), crushing (10 deaths), asphyxiation (six deaths), bums (two deaths), strokes (two deaths), drowning (two deaths) and amputation (one death). The six asphyxiation deaths included two disoriented inside buildings until their air supplies were depleted, two trapped by rapid fire progress in buildings, one trapped in a basement when caught on some object and one exposed to carbon monoxide in a closed fire station.

C. Ages of Fire Fighters

The ages of fire fighters who died in 1992 ranged from 17 to 80 years with a median age of 45.5 years.

The distribution of fire fighter deaths by age and cause of death is displayed in Figure 5. Seventy percent of the fire fighters over age 40 who died were killed by heart attacks. The youngest fire fighter who died of a heart attack was 34 years old.

Figure 6 shows the death rates by age categories using estimates of the number of fire fighters in each age group from NFPA's 1990 profile of fire departments and the fatality data from 1988 through 19921. As the graph shows, the death rate is lowest for fire fighters under age 40, slightly below 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 37 percent of the deaths from

Figure 5
Fire Fighter Deaths 1992
by Age and Cause of Death

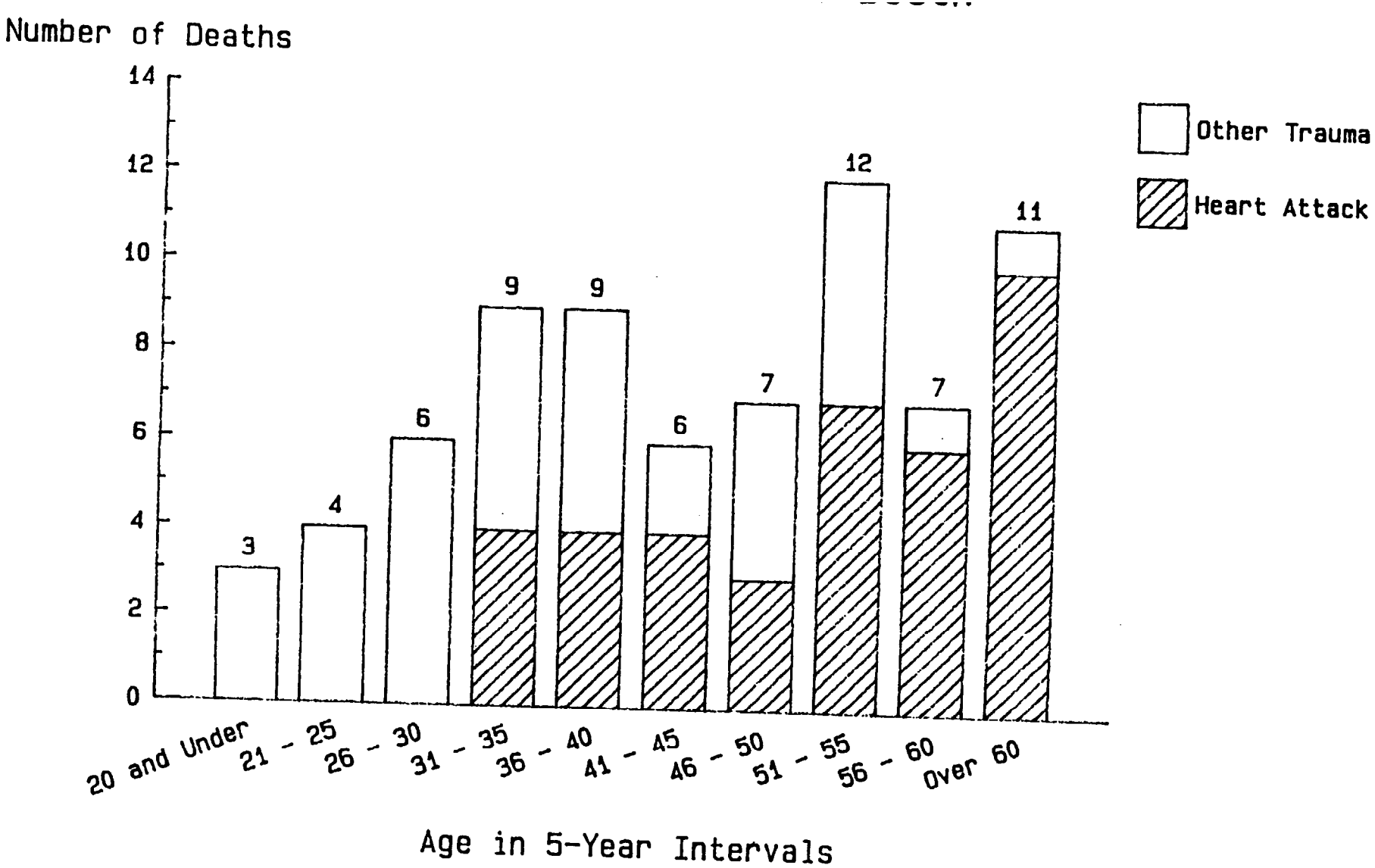
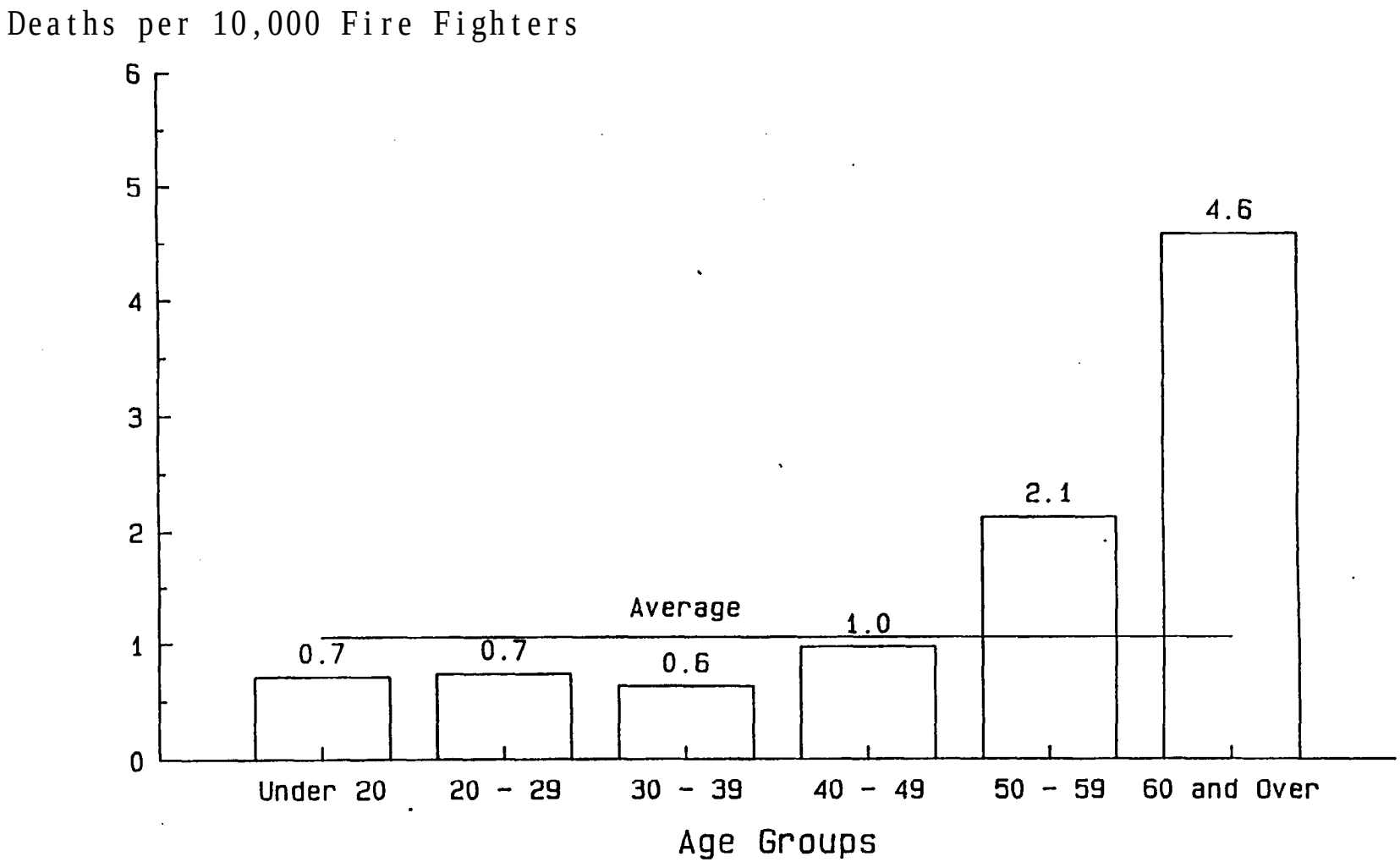


Figure 6
Average Death Rates per 10,000 Fire Fighters
1988 - 1992



1988 through 1992, including almost 60 percent 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 twice the average.

With the consistent prominence of heart attacks among the reasons for on-duty fire fighter deaths, one obvious question is whether these heart attacks might simply be age-related deaths that only coincidentally appear to be due to the unusual hazardous exposure of fire fighting. For the first time this year, data from. the U.S. National Center for Health Statistics was used to check this hypothesis.[2]

When we look at death rates due to heart attacks in the general male population and among fire fighters, we find that the heart attack death rate per 10,000 fire fighters in any age group is never more than 10 percent the rate for the general population. For example, the rate of on-duty heart attack deaths for fire fighters age 60 and over was 3.1 deaths per 10,000 fire fighters while for the general population it was 55.1 and 125.5 deaths per 10,000 population for men aged. 55 to 64 and 65 to 74, respectively. This comparison is consistent with the hypothesis that fire fighter on-duty heart attack deaths are mostly or entirely a reflection of the normal risks of the fire fighter's age and not a result of unusual job hazards. A more complete analysis would require examination of the rate of off-duty heart attack deaths among fire fighters. It is possible that job-related heart attack deaths occur off-duty as a delayed reaction to accumulated exposure to fire effects. On the other hand, it is possible -- consistent with these statistics -- that fire fighters are (as they should be) generally more fit and healthy than their respective age peers and that their total heart attack death rate (on-duty and off-duty) could be lower than the general-population average.

D. Fire Ground Deaths

The distribution of the 39 fire ground deaths by fixed property use is shown in Figure 7. The largest share of fire ground deaths (38.5 percent) occurred at residential structure fires. These 15 deaths included 12 in one- and two-family dwellings, two in a hotel and one in an apartment building. This is consistent with the 16 deaths in residential structure fires in 1991, and in line with the annual average of 17 deaths per year over the last 10 years.

There were nine deaths in wildland fires in 1992. There were five deaths in storage properties, two of which were dwelling garages. Three deaths occurred in public assembly buildings -- two in a church and one in a restaurant. There were three deaths due to fires in vacant buildings and one in a building undergoing renovations. There was one death each at a store, a manufacturing property and at a vehicle fire.

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 1992 fire loss study[3]. There were 3.2 fire fighter deaths per 100,000 residential structure fires, compared to 9.6 deaths per 100,000 nonresidential structure fires. Although 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 1992 fire ground deaths and total deaths by time of alarm are shown in Figure 8. The highest number of fire ground deaths occurred

Figure 7
Fire Ground Deaths in 1992
by Fixed Property Use

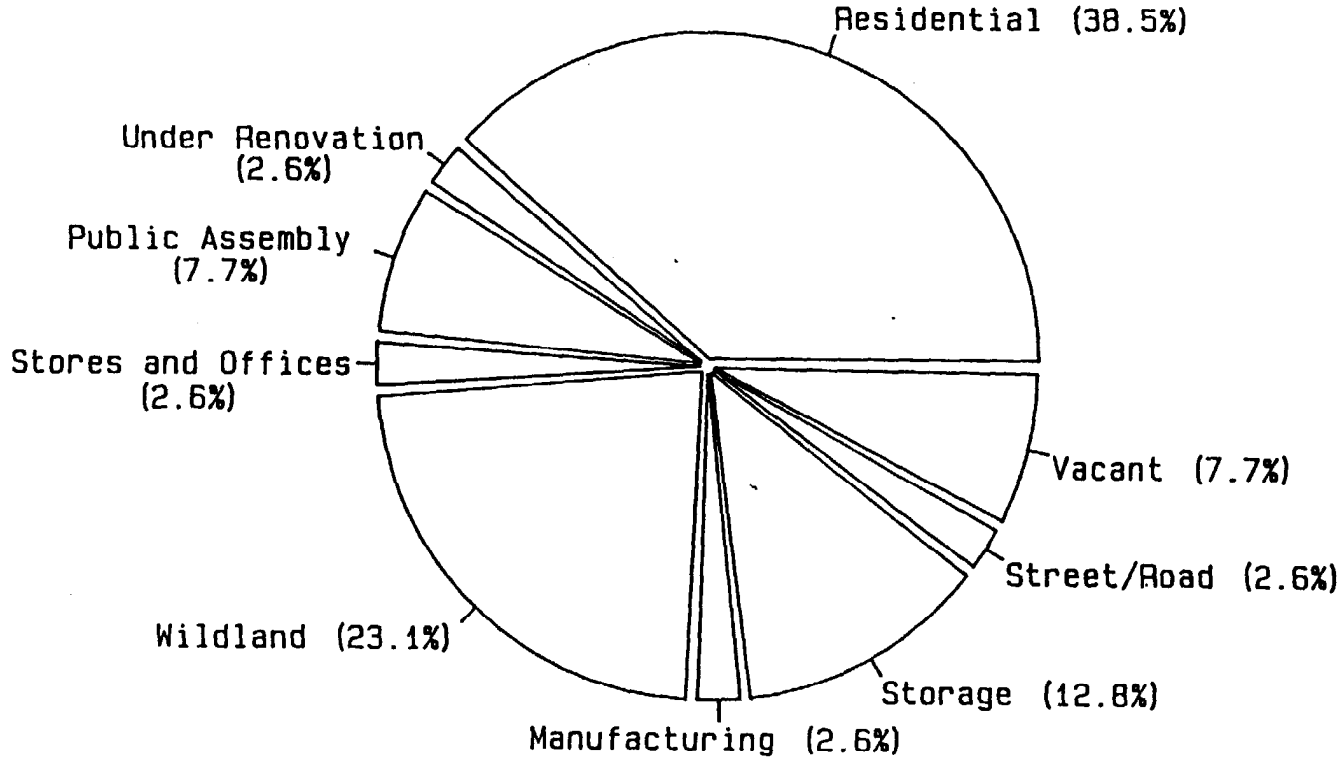
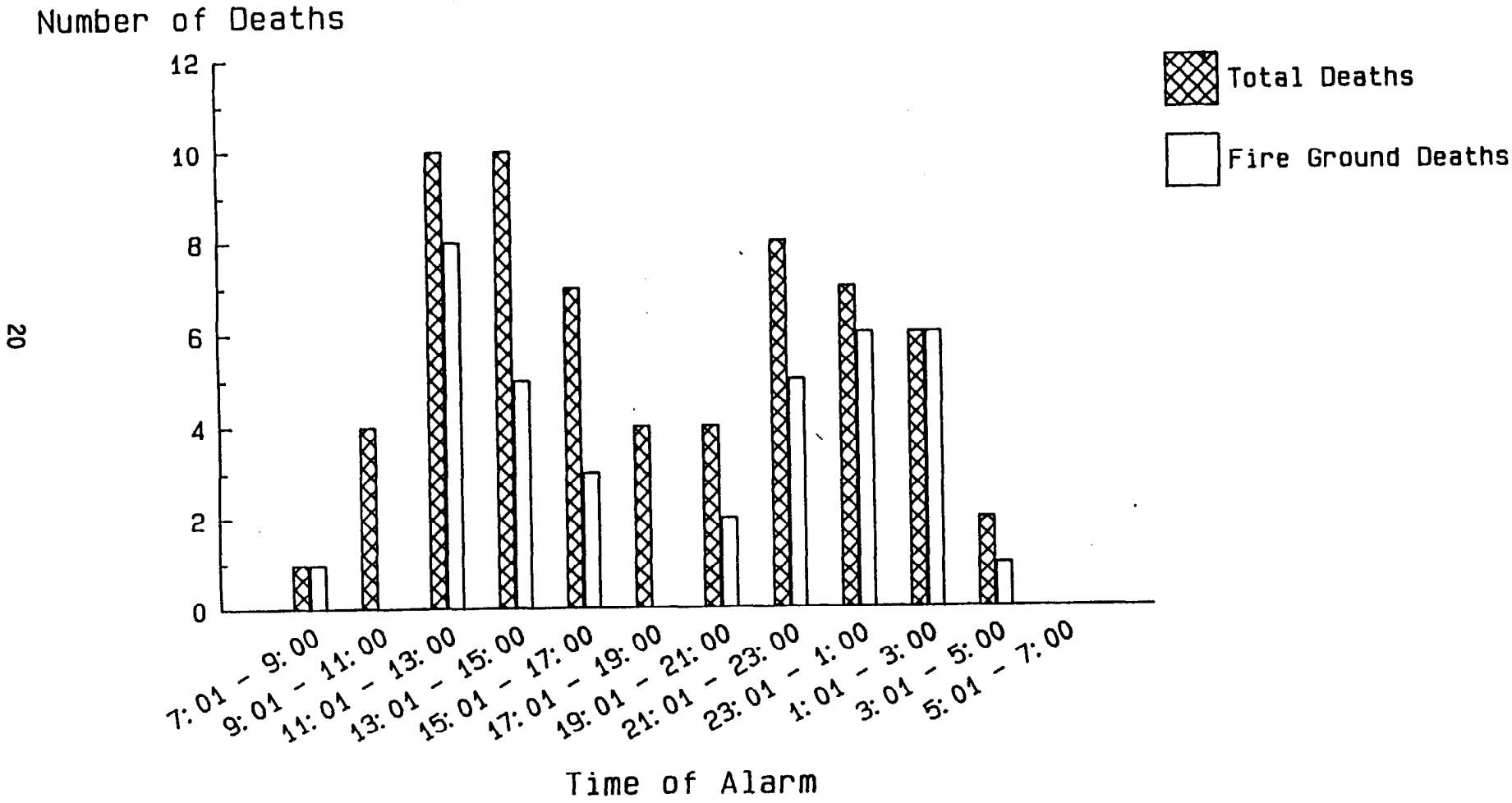


Figure B
Fire Fighter Fatalities 1992
by Time of Alarm



Based on 37 fire ground fatalities and 63 total fatalities for which alarm time was reported.

for alarms between 11 am and 1 pm. There is another peak between 9 pm and 3 am. The eight deaths in the first peak included four deaths in three wildland fires. The second peak time period included two double-fatality fires. The distributions of deaths by time of alarm over a 10-year period are shown in Figure 9. The number of deaths in both categories was at the highest level for alarms between 1 and 9 pm and dropped to the lowest level in the early morning hours.

F. Month of the Year

Figure 10 shows the distribution of 1992 fire fighter deaths by month. The same information for 1983 through 1992 is shown in Figure 11. The ten-year analysis shows that fire ground deaths are highest in the winter months and in July.

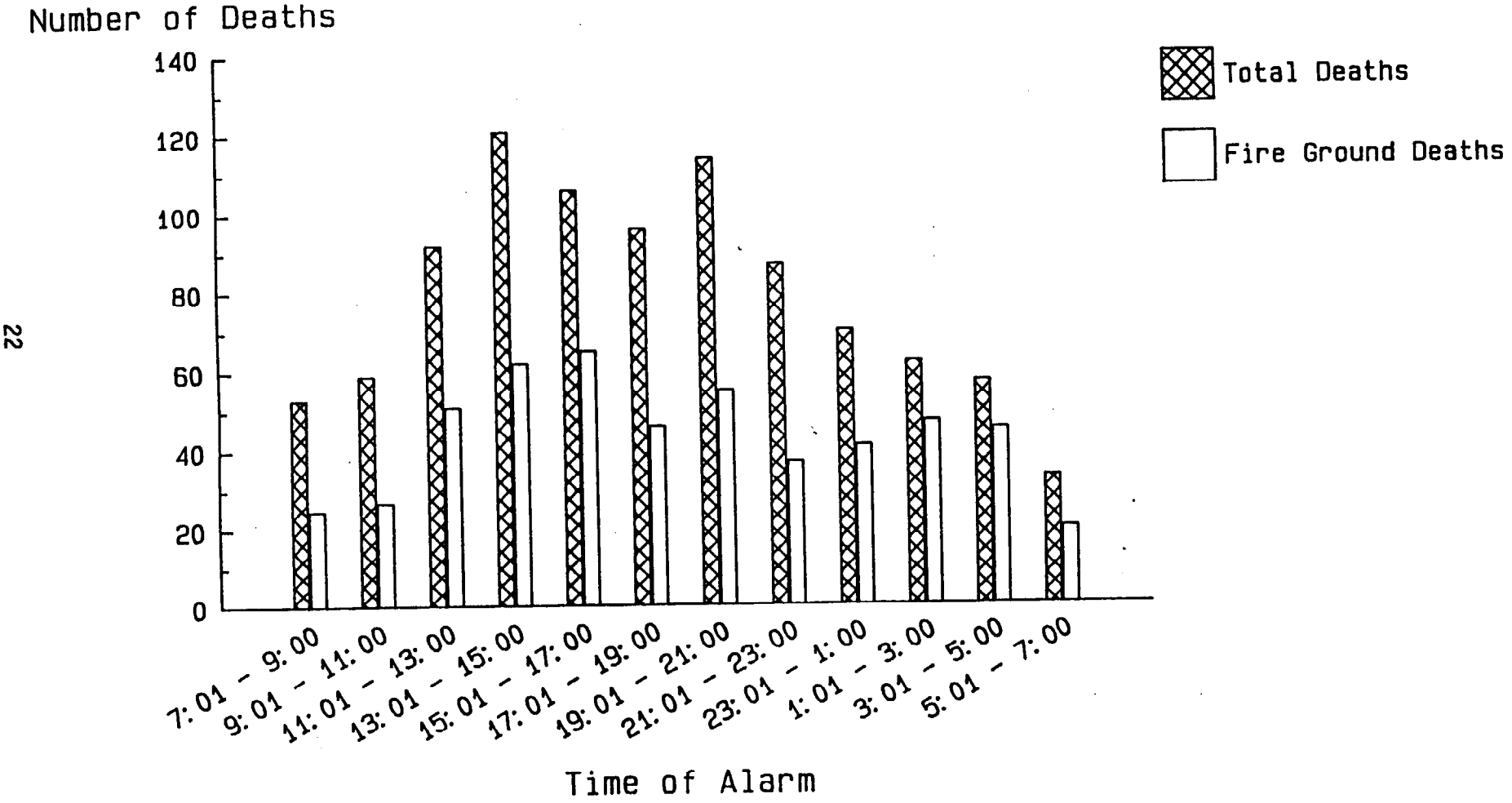
G. State and Region

The distribution of fire fighter deaths by state is shown in Table 1. Thirty-five states are represented on the list, led by Pennsylvania with eight deaths and Illinois with seven. The experience by region4 is displayed in Table 2 and Figure 12. The Northcentral region lost the largest number of fire fighters (22), followed by the South (21). The Northeast lost 18 fire fighters and the West, 13. The Northcentral region had the highest average fire ground death rate. Only the South had a rate lower than the national average.

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

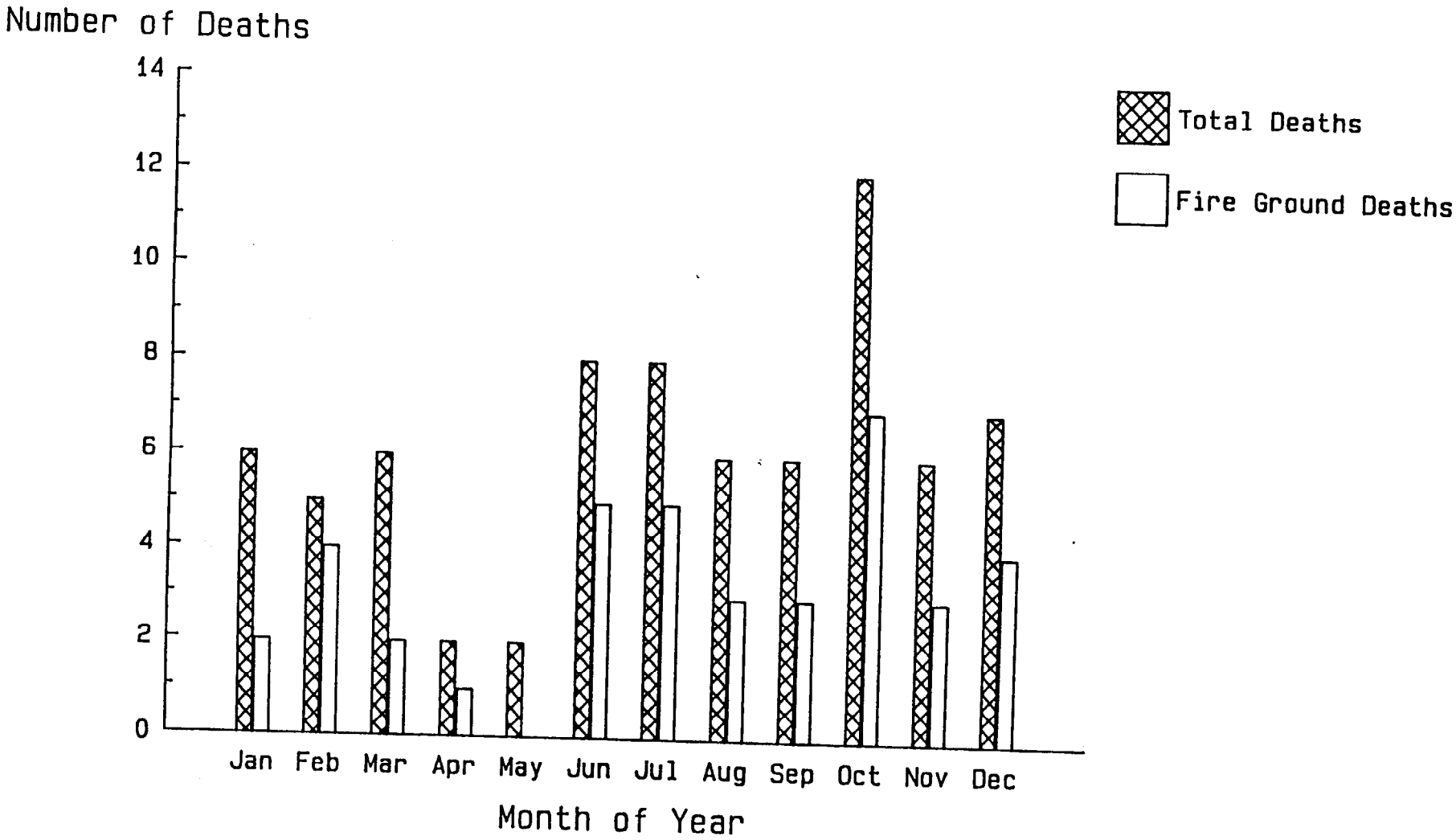
The U.S. Bureau of the Census defines *urban* as a place having at least 2,500

Figure 9
Fire Fighter Fatalities 1983 - 1992
by Time of Alarm



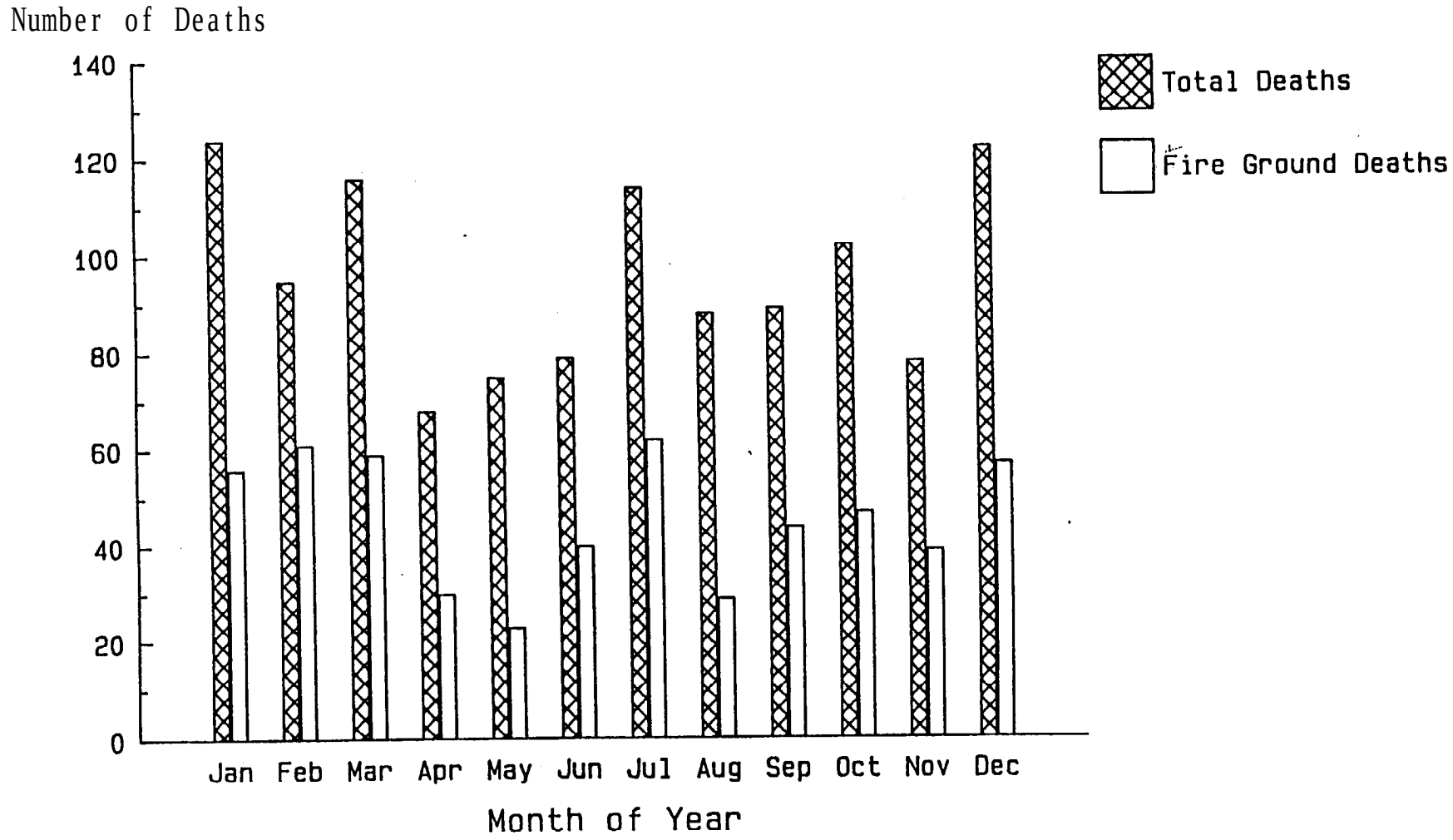
Based on 521 fire ground fatalities and 950 total fatalities for which alarm time was reported.

Figure 10
Fire Fighter Fatalities 1992
by Month of Year



Based on 39 fire ground fatalities and 74 total fatalities.

Figure 11
Fire Fighter Fatalities 1983 - 1992
by Month of Year



Based on 547 fire ground fatalities and
1150 total fatalities.

Table 1
1392 On-Duty
Fire fighter Fatalities

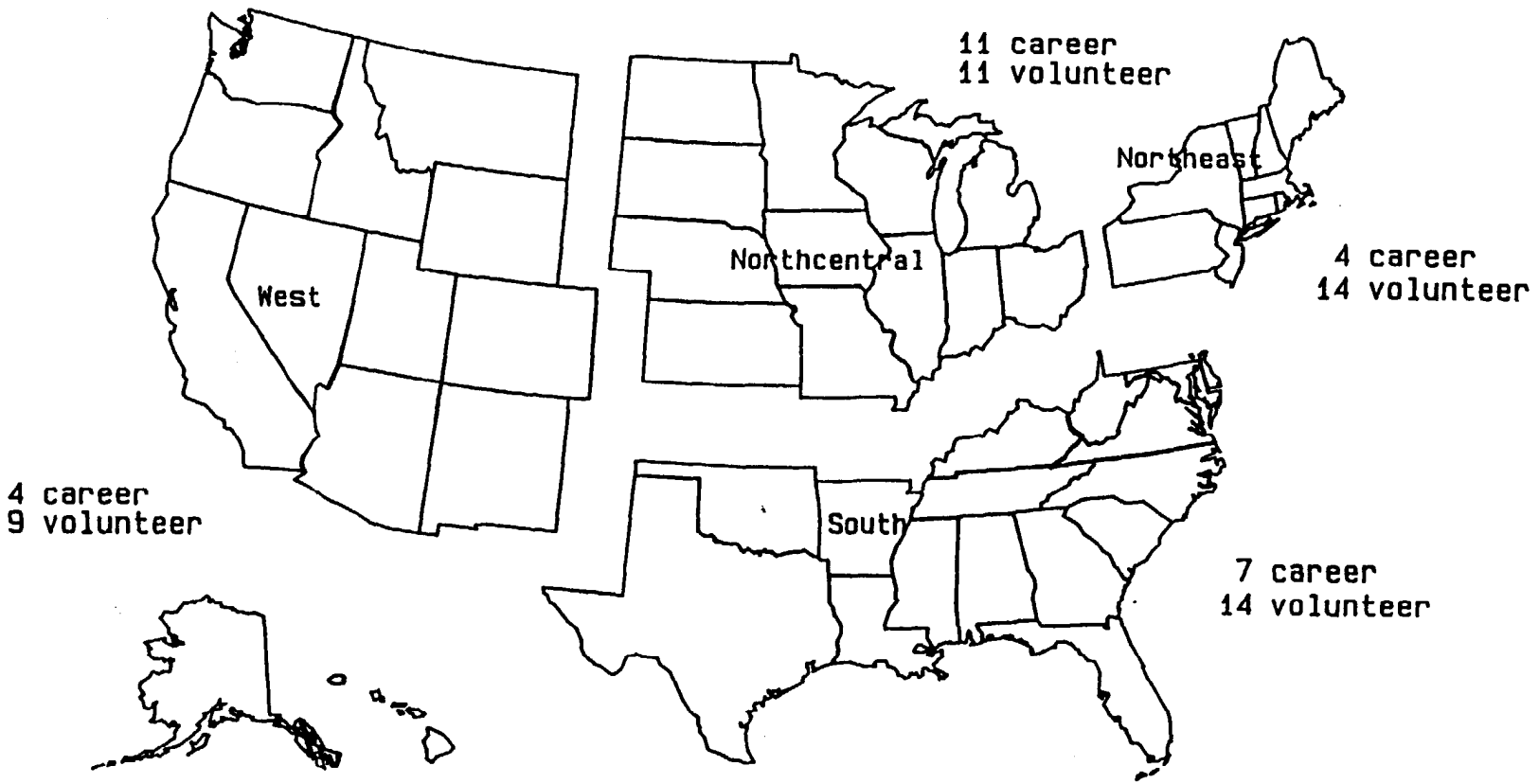
State	Number of Deaths	State	Number of Deaths
Alabama	2	Montana	1
Arizona	1	New Hampshire	2
Arkansas	2	New Jersey	1
California	4	New York	3
Colorado	2	North Carolina	1
Connecticut	1	Ohio	2
Florida	2	0klahoma	1
Hawaii	1	Oregon	1
Idaho	2	Pennsylvania	8
Illinois	7	Rhode Island	1
Indiana	2	South Carolina	1
Iowa	1	Tennessee	2
Kansas	3	Texas	5
Louisiana	1	Vermont	1
Maryland	3	Virginia	1
Massachusetts	1	Washington	1
Michigan	4	Wisconsin	2
Missouri	1		

TOTAL: 74

Table 2
Fire Fighter Death by Region
1992

Region	Number of Fatalities	Number of fire Ground Deaths	Fire Ground Death Rate per 100,000 Fires
Northeast	18	9	2.06
Northcentral	22	12	2.85
South	21	9	1.19
West	13	9	2.56
Total	74	39	1.99

Figure 12
Fire Fighter Fatalities 1992
by Region



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 organized 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.

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 1992 fire fighter fatalities	45 (61%)	29 (39%)	74 (100%)
Suburban location	7	9	16
Local fire department only**	44 (66%)	23 (34%)	67 (100%)
U.S. population (1990)	75%	25%	100%
U.S. fire fighters (1991) total***	61%	39%	100%
U.S. fire fighters (1991), career***	97%		100%
U.S. fire fighters (1991), volun.***	49%	51%	100%

* 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 military fire fighter hilled in an urban location and four federal fire fighters and contractors and two state contractors hilled in rural locations.

*** *U.S. Fire Department Profile Through 1991,* Quincy, Massachusetts: National Fire Protection Association, Fire Analysis and Research Division, October 1992. All percentages are for fire fighters in local fire departments.

As shown above, the distribution of local fire fighter fatalities fell between the distribution of the whole U.S. population and the distribution of local fire fighters. This same result was reported for 1989 and 1991 fatalities.

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 and 1990, 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.

Since the results fluctuate back and forth each year, it is not advisable to read too much into them. We can conclude though that urban fire fighters face at least as great a risk as rural fire fighters. But, more importantly, our analyses of fire fighter deaths over the years have indicated that fire fighter safety can be more reliably attributed to proper training, equipment and incident management than to geographical location.

III. Fatal Accidents Involving Tankers, 1983 - 1992

Accidents involving motor vehicles account for a significant share of fire fighter deaths each year, and the prevalence of tanker accidents among the total, particularly in the past two years, prompted a closer look at that part of the fire fighter fatality problem.

From 1983 though 1992, 173 of the 1150 fire fighter fatalities (15.0 percent) were the result of motor vehicle accidents and collisions and one in six of those deaths involved tankers.* (See Figure 13.) These 27 tanker-related deaths were the result of 25 road accidents. (Six of these deaths occurred in just the last two years.) Twenty-two of the victims were killed while responding to alarms, three were returning from alarms, one was killed at the scene of a wildland fire and one was killed while returning from refueling the apparatus.

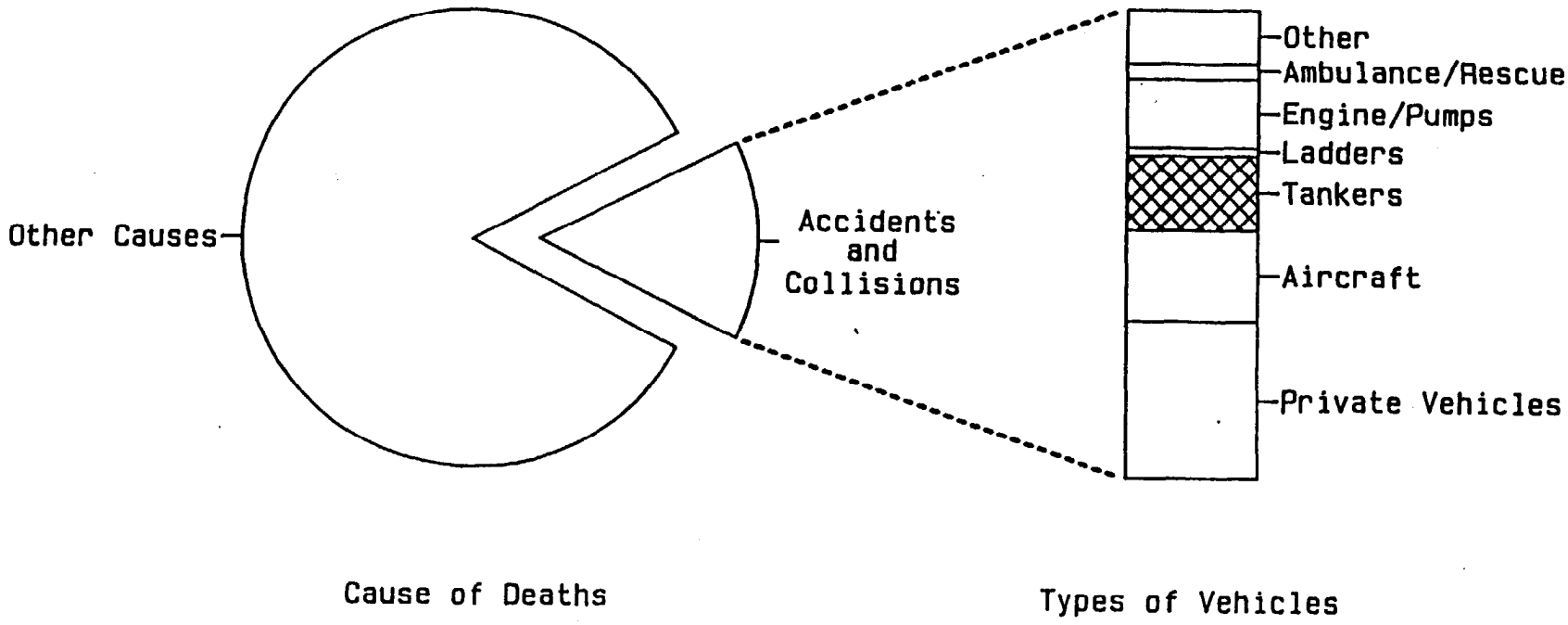
Profile of Accidents

Sixteen of the accidents were attributed to failing to negotiate curves and thereby losing control of the vehicle. These accidents resulted in 18 fire fighter deaths. Six accidents occurred when drivers went off the edge of the road and then lost control when they overcorrected the direction of the vehicles. One driver failed to heed a stop sign and the tanker was struck at an intersection by a logging truck. One driver went through a red light and struck an automobile in the intersection and overturned. One driver's brakes failed as he entered an intersection. Although he swerved to avoid a car in the intersection, they collided and the tanker overturned.

Four of the victims were riding on the outside of the apparatus and were

* This does not include an additional 77 fatalities that occurred when fire fighters fell from or were struck by moving vehicles.

Figure 13
Motor Vehicle Accidents Resulting in Fire Fighter Fatalities 1983 - 1992



either thrown from the vehicles or were crushed during rollovers. One of the deaths was due to smoke inhalation and another to bums after the tankers involved in the two separate incidents caught fire after the accidents. The remaining 21 deaths were due to traumatic injuries such as internal trauma and crushing. Of the 27 victims, 22 were not wearing seatbelts. Seventeen of the 22 were ejected or thrown from the vehicle. One victim who was wearing a seatbelt suffered fatal head injuries in a rollover.

In several of the incidents, drivers were reportedly exceeding posted speed limits, but even speeds far below posted limits can be excessive, given the effect that the shifting of the water in the tank can have in combination with a very slight shift in direction. As one accident observer reported, the driver can stop the truck, but he or she cannot stop the water. It is often reported that it is the shifting of water in the tank that caused the driver to lose control, but as reported in one incident where the tank was baffled and filled, it was the weight of the water in the tank that pulled the vehicle out of the curve. A gallon of water weighs just over 8 pounds. The reported capacity of the tankers involved in these accidents ranged from 850 to 3,500 gallons, or 7,100 to 29,200 pounds in addition to the weight of the vehicle itself.

Road conditions did not appear to be a factor in these accidents. Twenty of the 25 accidents occurred in daylight on dry, paved roads during clear weather. The roads where the other accidents occurred were gravel (two accidents), tar and gravel and dirt. In the remaining incident, the road surface was not reported. Although excessive speed was only infrequently cited in the accidents, it is interesting to note where the vehicles were headed at the time the accidents occurred. Only five were responding to reports of structure fires, situations where time would be clearly of the essence. Nine tankers were responding to forest and grass fires, two to vehicle fires and two to motor vehicle accidents (one

with a gasoline leak). The three remaining emergency responses were to a dump fire, a dumpster fire and to standby for a Life Flight. Four of the tankers were returning to stations -- two from wildland fires and two from routine fueling and topping off procedures.

Profile of Victims

Twenty-three of the victims were members of local volunteer fire departments. Since tanker apparatus are used to compensate for a limited piped water supply, they are generally used in rural areas, which are nearly all served by volunteer fire departments. Of the remaining four victims, three were seasonal employees of state or federal forestry agencies and one was a member of a prison inmate fire brigade. The distribution of deaths over the lo-year period is shown in Figure 14.

The victims in these accidents ranged in age from 19 to 77 years, with most in their 20s. Years of service ranged from one week to 45 years. Since the majority of the accidents were the result of driver error, it is worth looking at the profile of *drivers.*

The drivers' ages and years of service are shown in Figure 15. The ages of the drivers ranged from 20 through 72 years, with a median age of 28 years. Their years of service with the fire department ranged from one week to 45 years. The median was 2 1/2 years. It is important to remember, however, that time of service on the fire department is not necessarily an accurate indication of actual experience in driving a tanker. Four of the drivers, though, had no more than six months on the job at the time of their fatal accidents.

Summary and Conclusions

The use of tankers is essential in rural fire fighting, but they present

Figure 14
Deaths in Tanker Accidents
1983 - 1992

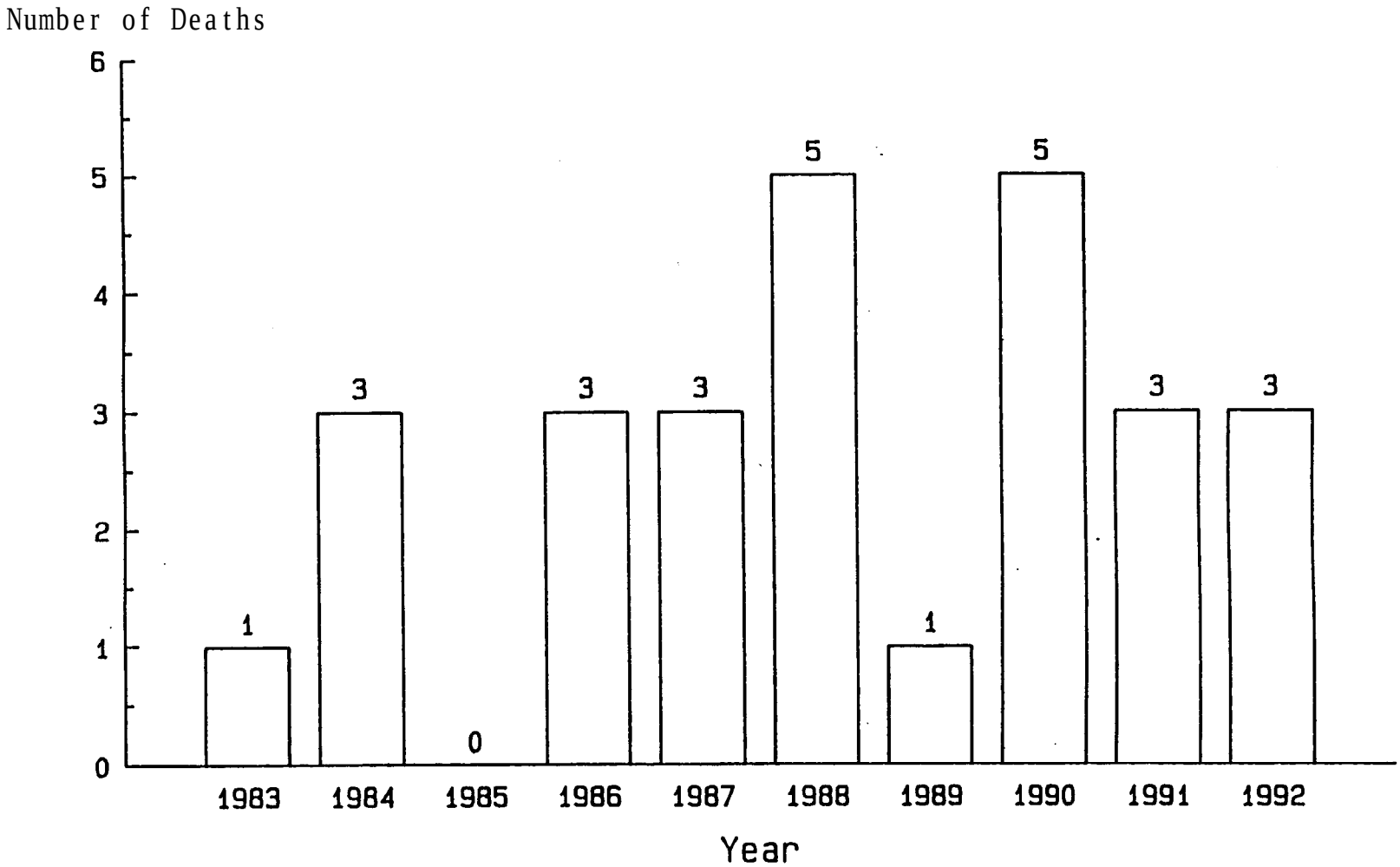
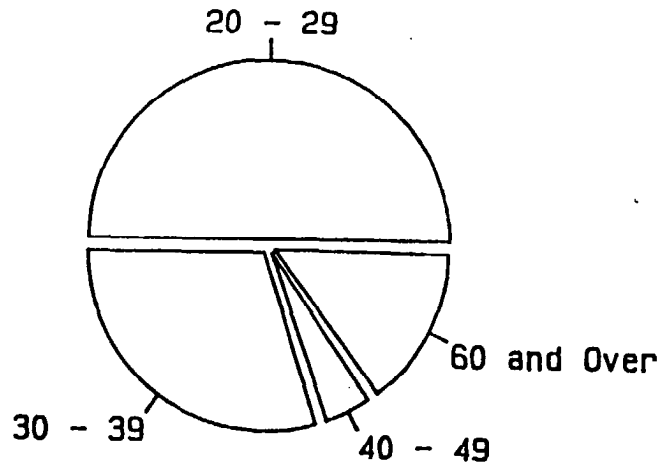
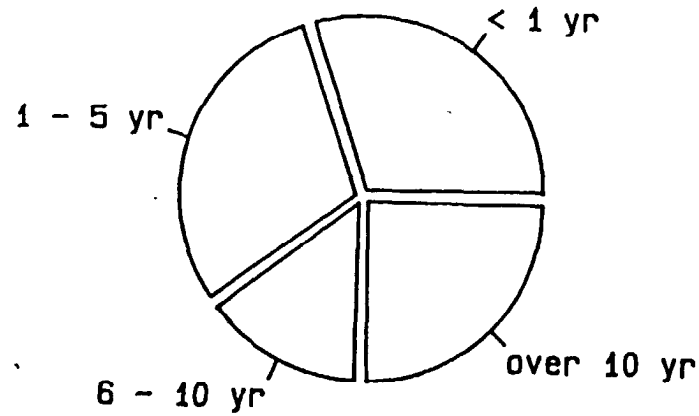


Figure 15
Profile of Drivers in Fatal Tanker Accidents
1983 - 1992



Ages



Years of Service

special problems. Large tankers tend to have a high center of gravity. When a tank is only partially full, the side-to-side center of gravity will change as the vehicle comers and water is forced to one side of the tank. Baffling in the tank will help slow the movement of water as a vehicle rounds a curve.

Some fire departments use converted military vehicles or tank vehicles designed for fuel delivery. These vehicles are not designed for emergency response. Military vehicles are built with a high center of gravity and adding a tank only raises that height, increasing the vehicles' instability at higher speeds and on turns. Fuel delivery vehicles are generally not baffled.

Of the 25 tankers involved in fatal accidents in the past 10 years, eight were designed and built as tankers and four were known to be converted. Information on whether the tankers involved in these. accidents were built to fire apparatus standards or not was generally not available. However, if a vehicle is not designed and built to be a fire apparatus, even an experienced driver can have problems operating the vehicle under emergency conditions.

The inexperience of drivers can also play a role in the incidence of fatal tanker accidents. One of the drivers had only been on the job for one week. But inexperienced drivers include not only young people, but also older fire fighters who are infrequently called upon to drive a vehicle that requires handling that is very different from maneuvering a passenger car or truck. Other reported factors included driver fatigue, failure to use seatbelts, and failure to observe traffic laws.

Although we don't know whether the tanker share of fatal accidents (or accidents generally) is disproportionate to their share of the fleet, proper construction and maintenance of the vehicle, increased training and an awareness of the potential problems with tankers are essential to reducing the frequency of deaths in tanker accidents. The major problems identified in accidents over the past 10 years included:

- inexperienced drivers
- lack of use of safety equipment
- maintenance of apparatus
- high center of gravity of the vehicle/water tanks
- failure to observe laws.

IV. Fire Ground Fatalities As a Result of Structural Collapse, 1983-1992

For the purpose of this analysis, structural collapses are defined as incidents where the failure of structural member(s) resulted in the collapse of a structure or portion(s) of a structure. This analysis breaks structural collapses into two categories: 1) incidents where fire fighters were caught or trapped in collapses and 2) incidents where fire fighters were fatally struck by collapses. Incidents in the first category generally involve fire fighters operating inside structures. Their deaths may be the result of injuries resulting from being pinned by structural components or the collapse may cause their entrapment and subsequent death as a result of running out of air. Incidents in the second category generally involve fire fighters operating outside structures who died of trauma or crushing injuries as a result of being hit by parts of the collapsing structure.

From 1983 through 1992, there were a total of 1,150 fire fighter fatalities, 547 of which occurred on the fire ground. Seventy-one of the 390 deaths at structure fires were the result of structural collapses. This included 45 fire fighters caught or trapped in 31 fires and 26 fire fighters fatally struck by collapses at 23 fires. This analysis will look at the two categories separately and discuss how such incidents can be prevented, or minimized.

Caught or Trapped

Of the 45 fire fighters caught or trapped by structural collapses, 19 were asphyxiated, 14 died of bums and 12 died of crushing injuries or internal trauma. Twelve of the victims were volunteer and 33 were career fire fighters. The largest number of deaths were the result of roof collapses (27 deaths), followed by floor

collapses (13 deaths), ceiling collapses (3 deaths) and wall collapses (2 deaths).

Of the 27 deaths caused by roof collapses, eight of the victims were operating on the roof of the structure at the time it collapsed. Six of the eight were performing ventilation, one was involved with fire suppression and one was doing forcible entry. Nine fire fighters were involved with suppression activities inside the structure at the time of the collapse. Six (including four in one incident) were attempting to gain access to the fire area when the roof collapsed. Three were trying to escape the collapse but were caught when it occurred and one fire fighter was climbing a ladder in a church when the roof collapsed.

The activities of fire fighters caught in floor, ceiling and wall collapses broke down as follows: fire suppression inside the structure (10 deaths), forcible entry (two deaths), search and rescue (two deaths), directing operations (two deaths), escaping (one death) and overhaul (one death).

Struck by Object

Of the 26 fire fighters struck by objects during structural collapses, 17 died of crushing injuries and nine died as a result of internal trauma. Twelve of the victims were volunteer and 14 were career fire fighters. All but two of the victims were struck by walls or pieces of walls. Those two were struck by collapsing chimneys.

Twenty of the victims were operating handlines at the time of the building collapses. The other six victims were performing these activities: forcible entry, ventilation, raising a ladder, escaping, directing operations and leaving the structure after searching for an occupant.

Patterns in Collapse Incidents

The breakdown of fatal incidents and associated fatalities by fixed property

use is shown in Figure 16. As can be seen, these deaths occur in a wide range of properties. Twenty-six of the 54 fires, resulting in 33 of the 71 deaths, were of incendiary or suspicious origin. Where it was possible to identify construction details, we found that 12 of the incidents, resulting in 19 of the deaths, involved buildings with truss roofs. In these fires, the estimated elapsed time between fire department notification and collapse ranged from four to 45 minutes, illustrating again, the potential risk to fire fighters of this type of construction.

The distribution of deaths over the lo-year period is shown in Figure 17. Multiple-fatality incidents occurred in six of the 10 years. The worst two incidents occurred at an auto dealership in Hackensack NJ where five career fire fighters were killed and at a printing company in Brackenridge PA where four volunteer fire fighters were killed. Overall, two thirds of the victims of these incidents were career fire fighters. The distribution of fires by region is shown in Figure 18.

Of the 54 structures involved in these fires, 45 were only one or two stories high. The other nine were three stories or higher.

Factors Identified in FataI Incident

Media reports of fatal structural collapse incidents often include quotes from people on the scene saying the building "collapsed without warning." Although it is true that imminent collapse cannot be expected to be announced there are conditions observed in some of these incidents that provided some warning that extreme caution was required. These conditions included: heavy fire conditions on arrival, roof-mounted air conditioning and heating units and/or snow load on flat roofs, and the presence of a parapet, overhang or other appendage (including chimneys). Another factor to look for is a bowed roof on a large flat roof that might indicate truss construction.

Some operations conducted on the fire scene resulted in exposing fire

Figure 16
Fire Fighter Fatalities in Structural Collapses
1983 - 1992

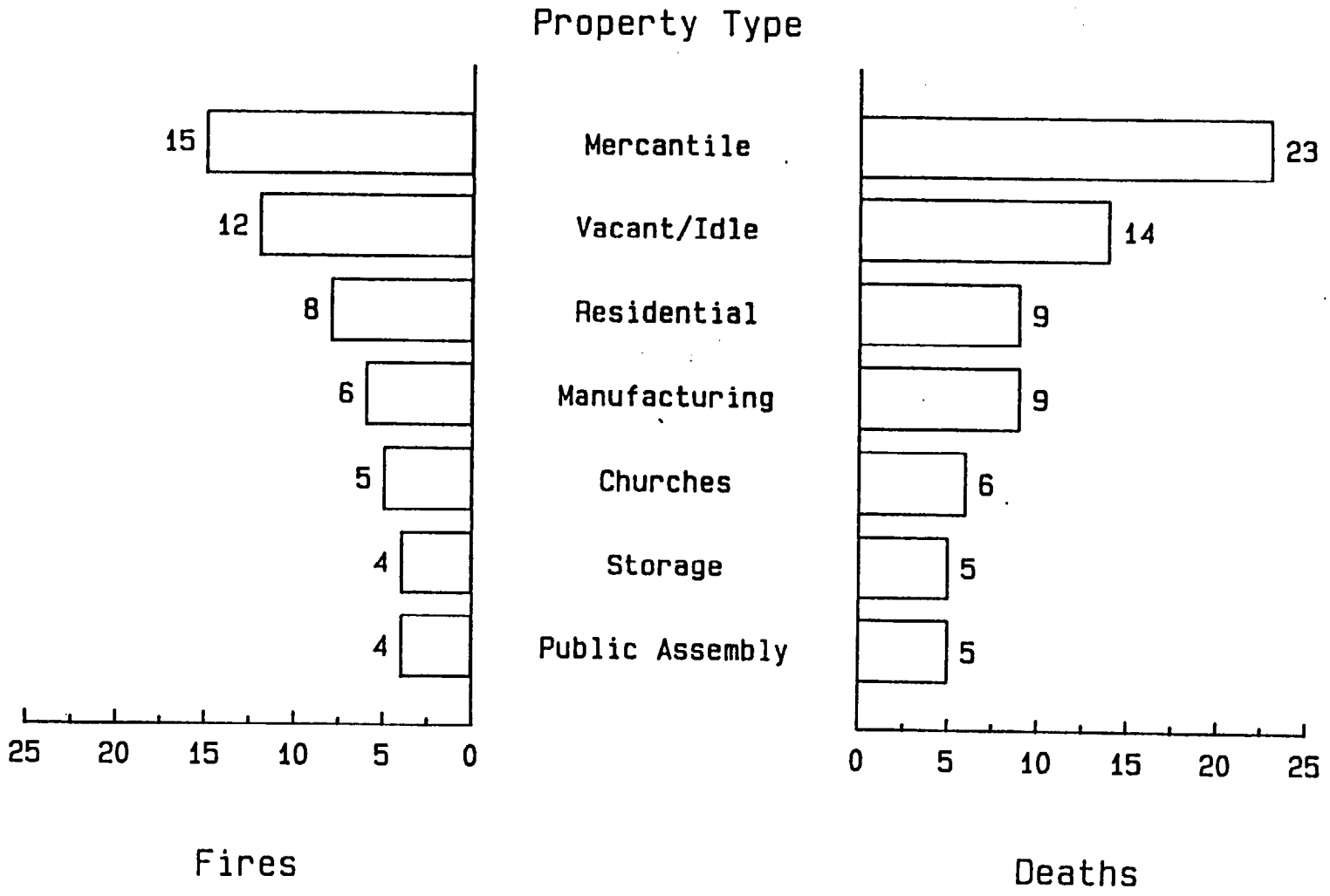


Figure 17
Fatalities in Structural Collapses by Year
1983 - 1992

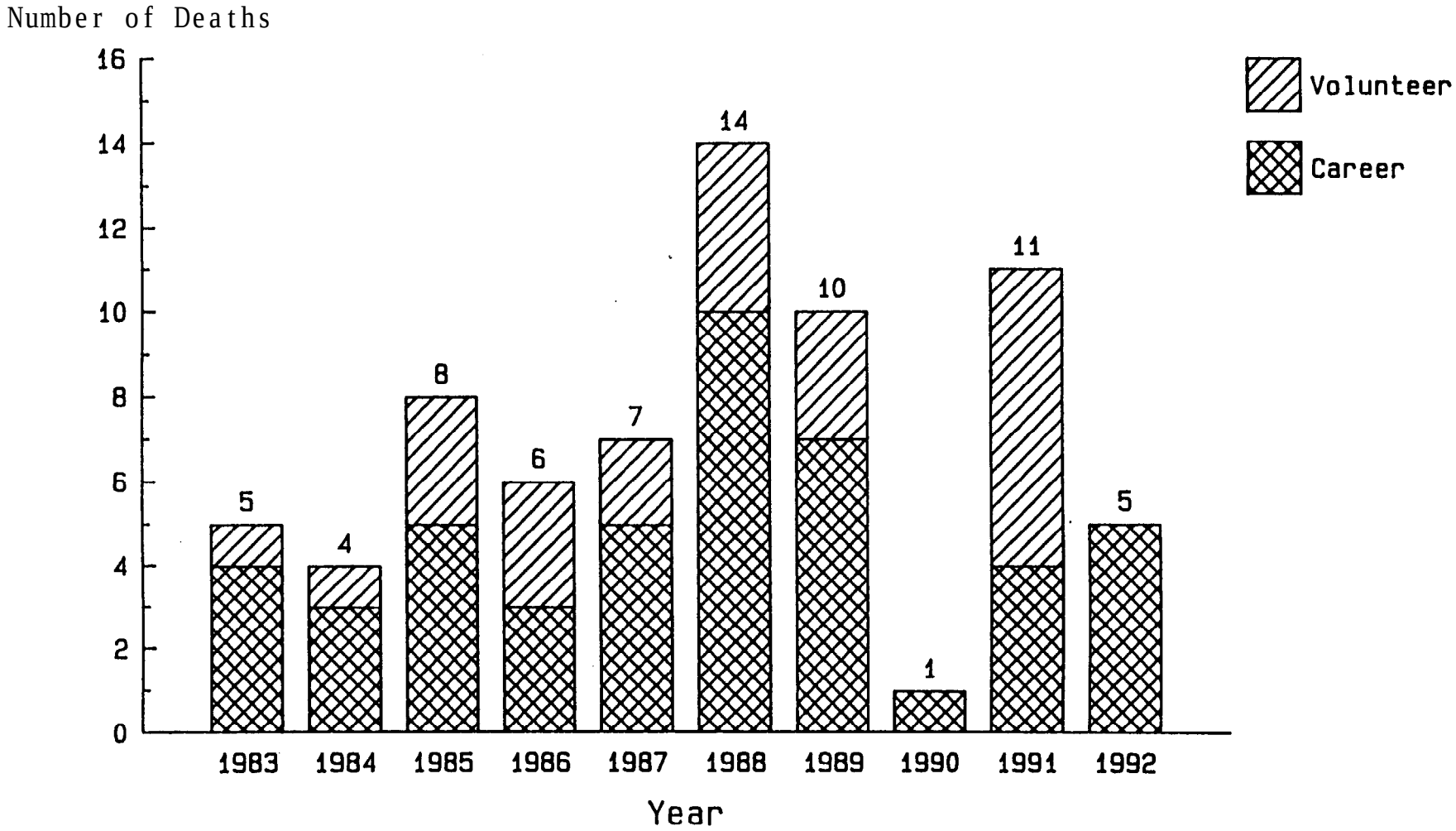
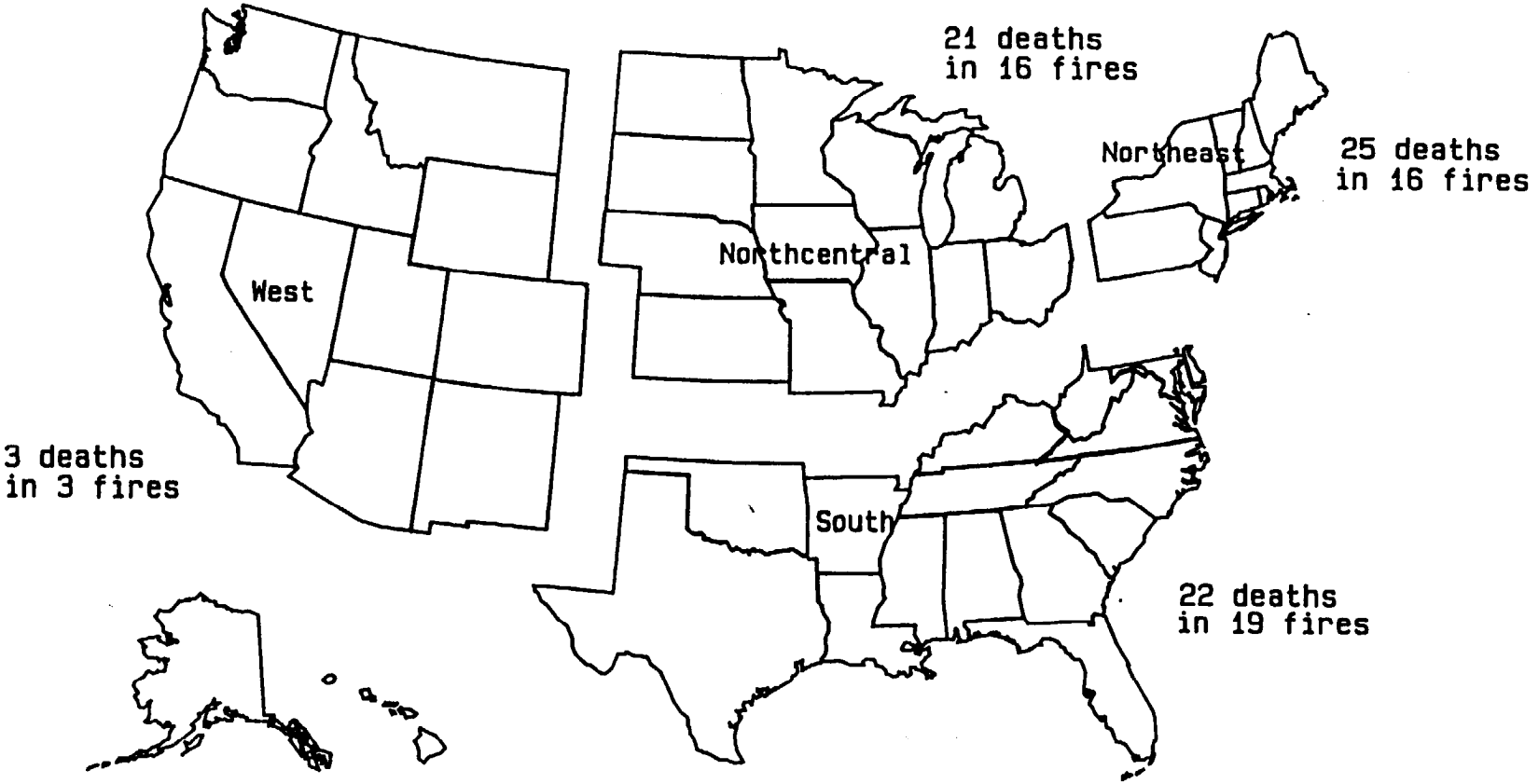


Figure 18
Fatalities in Structural Collapses by Region
1983 - 1992



fighters to increased risk of structural collapse. These included simultaneous interior and exterior suppression operations, conducting overhaul after master streams had been in use for a long period of time, exterior handline operations too close to fire-weakened structures, operating in narrow alleys between fire buildings and their exposures, freelancing and working too close to structures after safety lines had been established. Backdrafts and partial roof collapse should also be seen as indicators of potential disaster. .Failure to communicate that a structure has been evacuated and fire fighter impairment from drugs or alcohol are examples of preventable situations that occurred in some of these incidents.

How can such Deaths be Prevented?

It's easy in hindsight to point out what went wrong in a particular incident and to state what should have been done. But what can a fire department do to prevent building collapses from killing fire fighters?

Pre-fire planning is key to recognizing problems in or with a structure that may make it more likely to collapse in a fire. The factors to look for include lightweight construction features such as wood trusses and unprotected steel bar joists, Buildings that have obvious signs of weakness include those which have had a previous fire, those where an adjacent structure with a common separating wall has been removed and those where reinforcing rods are exposed. The use of dropped ceilings indicates the presence of confined spaces where a concealed fire could be growing over the heads of working fire fighters. Building alterations that have occurred within a building over time can alter the structure's integrity. If a building has no automatic suppression or detection equipment, a more advanced fire condition may exist by the time the fire department is notified.

There are signs to look for on arrival at an incident. Although it will

usually not be possible to know at the outset that a fire was intentionally set, the status of the occupancy can give a good indication of the likelihood of arson. Buildings that are vacant, condemned, under demolition or renovation, or even closed for the night are frequent targets for such fires. Heavy roof loading, including heating and air conditioning equipment as well as snow, can reduce a roofs integrity under fire conditions. Fires of long duration cause weakening of structural members. It is also important to realize that every 250 gpm stream applied to the building can add up to one ton per minute to the load the. increasingly-weakened structure is carrying.

Many fire departments work with city officials to have vacant buildings boarded up or demolished when they become a hazard. If access to a building is prevented, the likelihood of an arson fire is greatly reduced and the fire department can also be reassured that no trespassers will be in the building requiring dangerous search and rescue operations.

V. Conclusions and Recommendations

The remarkably low total for fire fighter fatalities in 1992 is less than half the total observed when NFPA began conducting annual studies of the problem 16 years ago. Although great strides have been made in reducing parts of the problem, deaths still occur and many are preventable.

Interestingly, the decrease in fatalities in 1992 occurred across the board, so we find that heart attacks still account for about half the total deaths. Motor vehicle accidents, mainly while responding to alarms, continue to account for approximately one-fifth of the deaths. Approximately half the deaths annually occur on the fire ground. These are the major areas where continued efforts must be concentrated.

This year's report included analyses focusing on parts of two of these areas. Deaths as a result of structural collapse can often be prevented through pre-fire planning, careful attention to changing conditions of the structure during the fire, and an incident management system that accounts for the location of all individuals at the fire scene.

Tanker accidents, although they constitute a small portion of the total number of deaths each year, illustrate problems that occur in the use of other vehicles as well. Failure to use safety equipment, failure to follow traffic laws, and excessive speed for road conditions apply to tanker accidents as well as to accidents that occur each year in private vehicles responding to alarms.

We do not expect to see such a low total for fire fighter deaths in 1993, but the success in 1992 shows what can be accomplished. Preventable deaths are still occurring and continued vigilance, emphasis on safe practices, health, fitness, and training must be maintained.

References

1. Michael J. Karter, Jr., *U.S. Fire Departmmt Profile through 1991,* Quincy, MA: National Fire Protection Association, Fire Analysis and Research Division, October 1992.

2. *Statistical Abstract of the United States - 1992,* U.S. Bureau of the Census, 112th Edition, 1992.

3. Michael J. Karter, Jr., "U.S. Fire Loss in 1992," *NFPA Journal,* Vol. 87, No. 5, (September 1993).

4. 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.