ARSON

AND ARSON INVESTIGATION

SURVEY AND ASSESSMENT

National Institute of Law Enforcement and Criminal Justice
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RESEARCH

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ABSTRACT

This report contains the results of a study of arson and of current methods and needs in arson investigation. Arson is a violent crime which killed 1000 people and injured 10,000 others in 1975 and which at the same time caused greater estimated property losses ($1.4 billion) than any of the major property crimes (robbery, burglary, larceny, and motor vehicle theft). Over the past decade, incendiary building fires increased 325% -- more than any other type of serious crime. Currently available arson statistics and studies of the characteristics of arsonists are presented, and their limitations are noted.

A major component of the study was a questionnaire survey of a selected group of leading arson investigators to identify needs in arson investigation. The highest priorities were given to increasing the number and the training of arson investigators, to establishing an automated data system for arson investigation, to scientific research on arson investigation methods, to improving cooperation from insurance companies, and to development of equipment to aid in arson investigation. The piece of equipment most urgently needed is an improved flammable vapor detector to help the investigator locate residues of fire accelerants such as gasoline which are the most frequent fire-setting method used by arsonists.

Another component of the study was a statistical analysis of data on arson, arson arrests, and arson convictions from 108 cities over a 4-year period. It was found that cities ranking in the upper third according to arson arrest rates had 22% fewer arsons per 100,000 population than cities ranking in the bottom third, while cities in the upper third according to conviction rate had 26% less arson.

A review of the capabilities and needed improvements in the technical methods of arson investigation is presented. A number of recommendations for the reduction of arson and the improvement of arson investigation are included.

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PREFACE

The dramatic rise in arson in this country over the past several years has resulted in an increased interest in the problem on the part of law enforcement and fire prevention officials. This report is a reflection of that interest. Its purpose is to assess the nature and magnitude of the arson problem, to review the state of arson investigation, and to delineate methods of arson reduction and improvements needed in arson investigation. Its purpose is also to provide a basis for the selection of areas for scientific research and technological development to aid in arson investigation. The contents of this report are based on the analysis of available arson statistics, a survey of prominent arson investigators, and an extensive review of the literature on arson, arsonists, and scientific methods in arson investigation.

We wish to express our appreciation to the arson investigators listed in Appendixes B and C for their participation in the survey described in Chapter V; to Harvey French for his insights and suggestions on arson investigation; to John Stuerwald, editor of The Fire and Arson Investigator, for publication of our notice in that journal; to Kendall Moll of the Stanford Research Institute for his cooperation and assistance in providing the data used in the analysis in Chapter IV; and to Mohammed Gohar of the Ohio State Arson Laboratory for data on arson evidence submission. Finally, we are grateful to the several experts in the field of arson investigation and from the insurance industry who read the rough draft of this report and made many valuable suggestions which we have incorporated.

SUMMARY

The enormity of the arson problem and its dramatic rate of increase in recent years are appreciated by few people. Although arson is a felony, it is not included in police crime statistics because, in most states, the fire service has the responsibility for arson detection and investigation. Since arson cases are characterized by both lack of witnesses and devastation of the crime scene, the arson investigator faces difficulties not posed by other types of crime. Yet less assistance -- such as training, equipment, research and development, or technology transfer -- has been given to arson investigators than to other criminal investigators. The purposes of the survey and assessment of arson and arson investigation were to assess the magnitude and trend of the arson problem, to delineate the motives and characteristics of arsonists, to examine the problems involved in the investigation and prosecution of arson cases, to analyze the statistical relation between the arson rate and the arson arrest and conviction rates, to survey a group of leading arson investigators as to the current needs in arson investigation, to review the state of the art of technical methods in arson investigation, and finally, based on these findings, to recommend ways of reducing arson and improving arson investigation.

Roughly speaking, arson is the willful and malicious burning of another's property or the burning of one's own property for some improper purpose such as to defraud an insurer. As a crime, arson is unique: usually an investigation must be conducted before it is even known that a crime was committed. Unfortunately, due to a lack of trained investigators, many fires are only perfunctorily investigated or are not investigated at all. Many experts believe that one-half the fires whose causes are classified as unknown and even some of those classified as accidental are actually incendiary in origin.

A. Magnitude and Trend of Arson

Arson is a serious and rapidly growing crime. In 1975 the estimated loss from arson was $1.4 billion (more than any offense on the Federal Bureau of Investigation (FBI) Index of serious crime). This included $1.3 billion loss in incendiary building fires, $80 million loss in incendiary motor vehicle fires, and $60 million loss in incendiary wildfires (forest and watershed areas). In addition to the property loss, it is estimated that there were 1000 deaths (including 45 firefighters) and 10,000 injuries. Over the decade ending in 1975, incendiary building fires increased 325% (again, more than any of the Index offenses: murder, rape, aggravated assault, robbery, burglary, larceny, and motor vehicle theft).

In view of the relative magnitude of arson, it is surprising that it has not received more attention in the past. This situation is likely due to the lack of a single, well known source of national statistics, as is provided for other offenses by the FBI Uniform Crime Reports.

B. Characteristics of Arsonists

The motives for arson are quite diverse and well known. They include profit, revenge, spite, jealousy, crime concealment, intimidation, vandalism, excitement, and pyromania. Unfortunately, the relative frequencies of these motives are less well known and should be the subject of further research, particularly to determine the importance of the role of fraud in arson. The limited studies available indicate that revenge was the predominant motive of adult arsonists (55%), while vandalism was that of 80% of the juveniles (who constituted about 60% of the arson arrestees in 1974). Fraud was the motive for only 5% of the arsonists studied (but was involved in 17% of a sample of arson cases). Most of the adult arsonists were problem drinkers.

C. Arson Investigation and Prosecution

Current arson arrest and conviction rates are low -- about 9 persons arrested, 2 convicted, and 0.7 incarcerated per 100 fires classified as incendiary or suspicious. (This compares with 21 arrests, 6 convictions, and 3 incarcerations per 100 Index crimes.) A number of factors contribute to this

situation. There is a shortage of trained investigators. There are usually no witnesses. There are investigative difficulties due to the destruction caused by the fire and by its extinguishment. There is sometimes confusion about the responsibilities of the police and the fire service in arson investigations. There are difficulties in prosecuting arson cases since they often rely on circumstantial evidence.

D. Statistical Relation Between Arson and the Arrest and Conviction of Arsonists

A major element of the study was an analysis of arson statistics from 108 cities during a 4-year period. The analysis showed that cities with higher arson arrest and conviction rates tended to have lower average arson rates. Cities ranking in the upper third according to arson arrest rate had 22% fewer arsons per 100,000 population than cities ranking in the bottom third, while cities in the upper third according to conviction rate had 26% less arson. These results are consistent with the belief held by many experts that increased arrest and conviction rates through improved arson investigation and prosecution are a primary means of effectively controlling arson.

E. Survey of Needs in Arson Investigation

A survey of 20 recognized leaders in the field of arson investigation was conducted to identify current needs in arson investigation and to establish their priorities. The survey questionnaire also dealt with methods used by arsonists and by investigators. Listed in order of priority rank, the following needs were each cited by at least 80% of the investigators:

- Increased training for arson investigators and for judges and prosecutors in the technicalities of arson cases
- More arson investigators
- Computerized arson investigation data system to help solve cases involving repeaters, professional "torches," and arson rings
- Scientific research on methods of analyzing burned electrical wiring (to determine whether it was the cause or effect of the fire); on the reliability of burn indicators used to determine causes of fires; on the persistence and composition of residues

of flammable liquid fire accelerants (materials like gasoline often used by arsonists to ensure and accelerate the development of the fire); on methods of determining the type and manufacturer of these accelerants; and on the burning characteristics of cigarettes (which are believed by some experts to be blamed for many more fires than they actually cause)

- Increased cooperation of insurance companies in avoiding over-insurance, in resisting fraudulent claims, and in providing information to arson investigators
- Research and development efforts aimed at developing an improved flammable vapor detector to locate residues of flammable liquid fire accelerants at fire scenes, and a device for detecting fire accelerants from the soot which they produce when they burn
- Clarification of the responsibilities of law enforcement and the fire service in arson detection and investigation
- Increased availability of crime laboratories to analyze physical evidence from arson cases

F. Technical Methods in Arson Investigation

Flammable liquid fire accelerants were cited by 62% of the surveyed investigators as the most common fire-setting method used by arsonists and constituted 80% of the evidence received for analysis by the Ohio state arson laboratory. Because of this importance and because of their current limitations, methods and devices used to detect, recover, and analyze fire accelerants should be improved. In particular, the portable flammable vapor detector -- a device originally developed for flammable gas detection by miners, gas utilities, and industry -- needs improvement and adaptation for arson investigation. It could greatly increase the efficiency of investigators in detecting arson and locating physical evidence.

Burn indicators -- the effects on materials of heating or partial burning -- are the most frequently used method for determining the points of origin and causes of fires, yet these indicators have received little or no

scientific testing. A testing program should be conducted and a handbook prepared for field use by arson investigators.

G. Other Recommendations

In addition to the needs cited in the preceding subsections, the following are recommended:

- A thoroughgoing operational analysis to determine priorities in arson reduction. For example, one element of the analysis should be a field survey of the physical evidence available at arson scenes and an estimate based on the survey data of the potential of currently unutilized evidence in increasing the arson conviction rate. Data on the frequencies of motives and methods of arsonists could be used to estimate the relative and combined effects of various arson reduction strategies (such as insurance reform, more investigators, and longer sentences).
- Arson prevention through better security, installation of sprinklers, and removal of flammable trash in arson-prone areas. For example, 75% of the fires in schools are of incendiary origin, yet most schools are not equipped with either sprinkler-operated fire alarms or effective intrusion alarms.
- Increased public awareness through accurate, authoritative, high-visibility governmental collection and publication of arson statistics. Many arson investigators have called for including arson in the FBI Uniform Crime Reporting System and listing it as a Crime Index offense. Other investigators cited a need for increased awareness on the part of fire and police supervision of the seriousness of arson and of the time, effort, and expertise required to investigate it.

CHAPTER I. THE NATURE AND MAGNITUDE OF ARSON

It has been said that arson is the costliest act of violence except war, and, indeed, it is a major and rapidly growing problem. As shown in this chapter, in 1974 there were an estimated $1.3 billion in property losses, 1000 deaths (including 45 firefighters), and 10,000 injuries from arson. The estimated property loss and the increase in number over the preceding decade (270% for incendiary and suspicious building fires) exceeded those of all seven offenses on the Federal Bureau of Investigation (FBI) Index of serious crime.

A. Definition of Arson

The word "arson" can be roughly defined as the willful and malicious burning of another's property or the burning of one's own property for some improper purpose such as defrauding an insurer. To be more precise, we quote the Model Arson Law.[1-2] First proposed in 1931 by the National Fire Protection Association, this or similar statutes had been adopted by most states by the 1950s.

> THE MODEL ARSON LAW
>
> Arson: First Degree
>
> Burning of dwellings. Any person who willfully and maliciously sets fire to or burns or causes to be burned or who aids, counsels, or procures the burning of any dwelling house, whether occupied, unoccupied or vacant, or any kitchen, shop, barn, stable, or other outhouse that is parcel thereof, or belongs to or adjoining thereto, whether the property of himself or of another, shall be guilty of Arson in the first degree, and upon conviction thereof be sentenced to the penitentiary for not less than two nor more than twenty years.

Arson: Second Degree

Burning of buildings, etc., other than dwellings. Any person who willfully and maliciously sets fire to or burns or causes to be burned, or who aids, counsels or procures the burning of any building or structure of whatsoever class or character, whether the property of himself or of another, not included or described in the preceding section, shall be guilty of Arson in the second degree, and upon conviction thereof, be sentenced to the penitentiary for not less than one or more than ten years.

Arson: Third Degree

Burning of other property. Any person who willfully and maliciously sets fire to or burns or causes to be burned or who aids, counsels or procures the burning of any personal property of whatsoever class or character (such property being of the value of twenty-five dollars and the property of another person) shall be guilty of Arson in the third degree and upon conviction thereof, be sentenced to the penitentiary for not less than one nor more than three years.

Arson: Fourth Degree

Attempt to burn buildings or property. (a) Any person who willfully and maliciously attempts to set fire to or attempts to burn or aid, counsel or procure the burning of any of the buildings or property mentioned in the foregoing sections, or who commits any act preliminary thereto, or in furtherance thereof, shall be guilty of Arson in the fourth degree and upon conviction thereof, be sentenced to the penitentiary for not less than one nor more than two years or fined not to exceed one thousand dollars.

Definition of an attempt to burn. (b) the placing or distributing of any flammable, explosive or combustible material or substance, or any device in any building or property mentioned in the foregoing sections

in an arrangement or preparation with intent to eventually willfully and maliciously set fire to or burn same, or to procure the setting fire to or burning of same shall, for the purpose of this act constitute an attempt to burn such building or property.

Burning to defraud insurer. Any person who willfully and with intent to injure or defraud the insurer sets fire to or burns or attempts to do so or who causes to be burned or who aids, counsels or procures the burning of any building, structure or personal property, of whatsoever class or character, whether the property of himself or of another, which shall at the time be insured by any person, company or corporation against loss of damage by fire, shall be guilty of a felony and upon conviction thereof, be sentenced to the penitentiary for not less than one nor more than five years.

B. Arson Determination

Fire reports classify the causes of fires into five main categories:

- Accidental: defective equipment, electrical wiring, careless smoking, children playing with matches, and other unintentional causes
- Natural: lightning, etc.
- Incendiary: intentionally set fires, including fraud fires
- Suspicious: suspected of being incendiary
- Unknown Cause: no cause established

Legally, the cause of a fire must be assumed to be accidental or natural until proven otherwise.

In most types of crime, the fact that a crime was committed is usually obvious and investigation focuses on the identification of the guilty party. Arson is different. Generally, an investigation must take place before it is even known that a crime occurred. Such investigations, however, are often cursory or nonexistent due to a number of factors, including a shortage of trained arson investigators. In addition, evidence of the crime is often destroyed by the fire or by the supression of the fire. The result is that the number of fires classified as incendiary significantly understates the actual amount of arson.

It has been established that, as investigative effort is increased, the number of fires labeled as incendiary is significantly increased. For example, in an experiment reported in 1961,[3-4] investigative efforts were greatly intensified in several cities in the United States; the result was that 20 to 25% of all fires were classified as incendiary, a figure several times higher than with ordinary investigation (arson was blamed for about 4% of the urban building fires throughout the country that year). Many arson experts believe that at least half the fires labeled "unknown cause" are actually intentionally set.[5-6] Therefore, two measures for the amount of arson will be used in this report: (1) incendiary and suspicious fires, and (2) incendiary and suspicious fires plus one-half the fires of unknown cause.

C. Sources of Arson Statistics

In order to get a picture of the magnitude and trend of arson, one must obtain statistics from a variety of sources. Estimates of the number, losses, and causes of building fires are made each year by the National Fire Protection Association based on a sample of 2000 fire departments (out of a possible 24,000 in the country). Fires are also classified by type of occupancy, including motor vehicles. Estimates for the previous year are published each September in the National Fire Protection Association monthly Fire Journal. More detail is provided every sixth year in the National Fire Protection Association Fire Protection Handbook,[7] where frequencies of causes are estimated for each type of occupancy (for example, private dwellings, hotels, churches, restaurants).

Wildfire statistics are collected and published annually by the U.S. Forest Service. These include all fires in about 92% of the nation's forest and watershed land, both public and private, and are classified by cause.

Statistics on the number of arrests for arson are published in the FBI Uniform Crime Reports. However, as is the case with other types of criminal offenders, there is no source of national data on the adjudication, sentencing, or incarceration of arsonists. Such statistics are available from certain states. California data were used in this report.

D. Incendiary Building Fires

Estimates published by the National Fire Protection Association indicate that 9% of the building fires and 17% of the building fire losses in 1974 were due to arson.[8] An additional 12% of the fires, accounting for 38% of the losses, were categorized as "cause unknown." If half the fires of unknown causes are included, arson accounted for 15% of the building fires and 36% of the building fire losses in 1974. As shown in Table 1, this would mean there were nearly 200,000 incendiary building fires in 1974, causing about $1.2 billion damage.

Figures 1 and 2 show the trend in the number of incendiary building fires and the amount of losses from 1964 to 1974.[9] Incendiary and suspicious fires rose 270% in number, and the damage they caused rose 726% during that period. When one-half the fires of unknown cause are included, the incidence of arson increased 204% and the losses increased 274%.

Figure 3 shows the growth in the rate of incendiary building fires per 100,000 inhabitants in the United States from 1964 to 1974.[9-10] During that period, the rate for incendiary plus suspicious fires increased 234%, and the increase was 175% when one-half the building fires of unknown cause are included. During the same period, the rate of building fires from all

Table 1. Incendiary Building Fires, 1974

Basis	Number of Fires	% of All Building Fires	Loss Value ($ millions)	% of All Dollar Losses
Incendiary and suspicious	114,000	9	563	17
Incendiary and suspicious plus 1/2 unknown cause	194,000	15	1,182	36

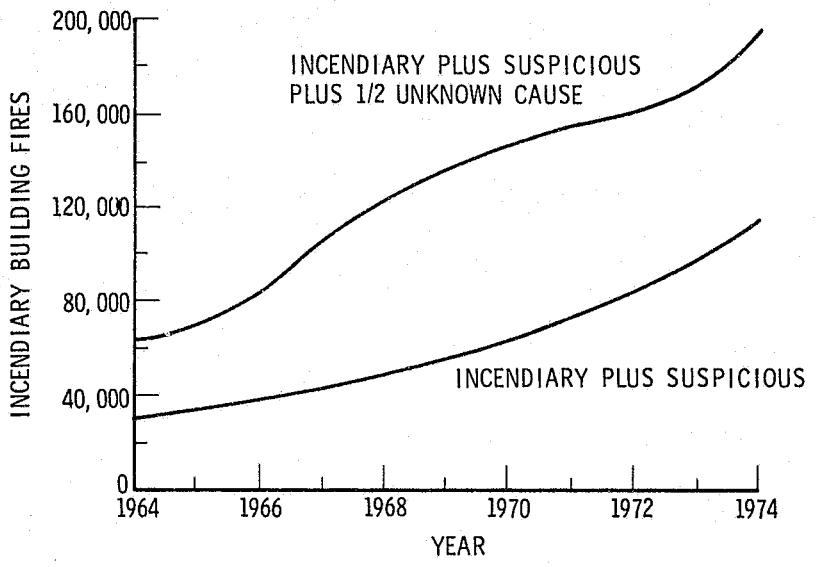

Figure 1. Incendiary Building Fires, 1964-1974

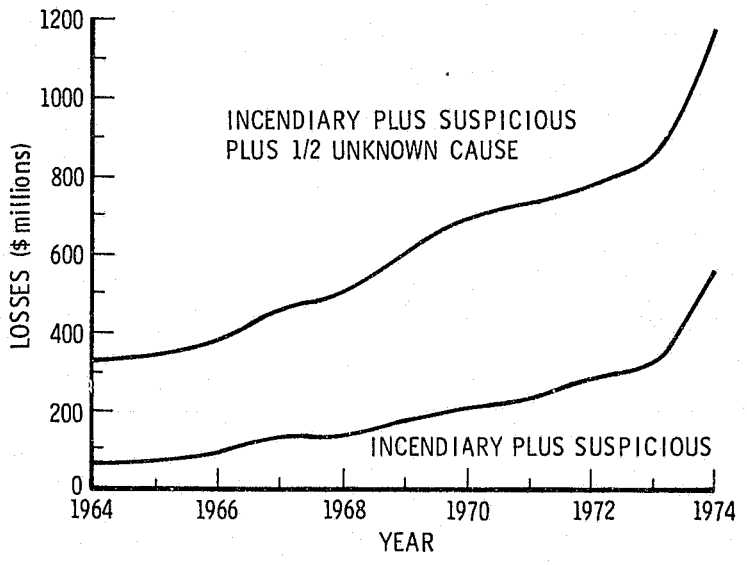

Figure 2. Losses from Incendiary Building Fires, 1964-1974

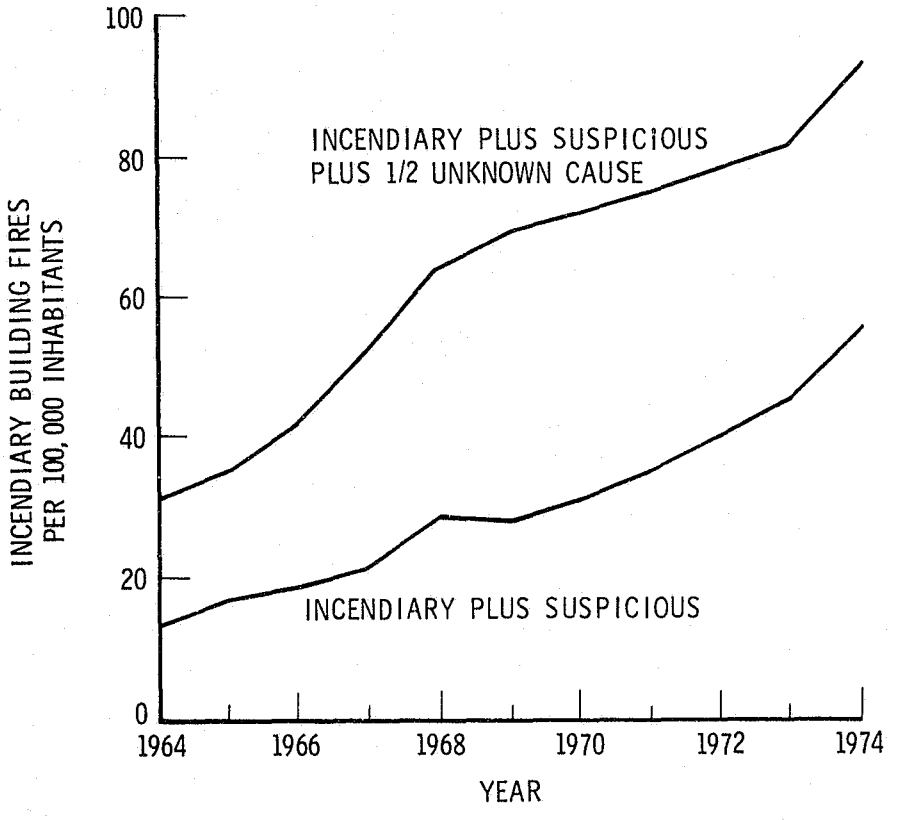

Figure 3. Building Arson Rate Trend, 1964-1974

causes per 100,000 inhabitants increased only 26% -- from 477 to 601. Thus the rate of growth in building arson has been outstripping the growth in both the population and the total number of building fires by a considerable margin.

It is not believed that these increases were due to an increased efficiency in investigating and reporting incendiary fires, as has been suggested. For example, the San Francisco Fire Investigation Bureau has observed that its incendiary fires were up by a factor of ten during the 1956 to 1971 period, while the population declined slightly and the same size arson investigation squad operated with generally consistent techniques.[11]

Figure 4 shows the trend in the dollar losses per capita from incendiary building fires from 1964 to 1974.[9-10] The losses were adjusted to 1974 dollars using the consumer price index.[12] Per capita losses from incendiary and suspicious building fires rose 370% during that period. If one-half the building fires of unknown cause are included, the per capita loss increase

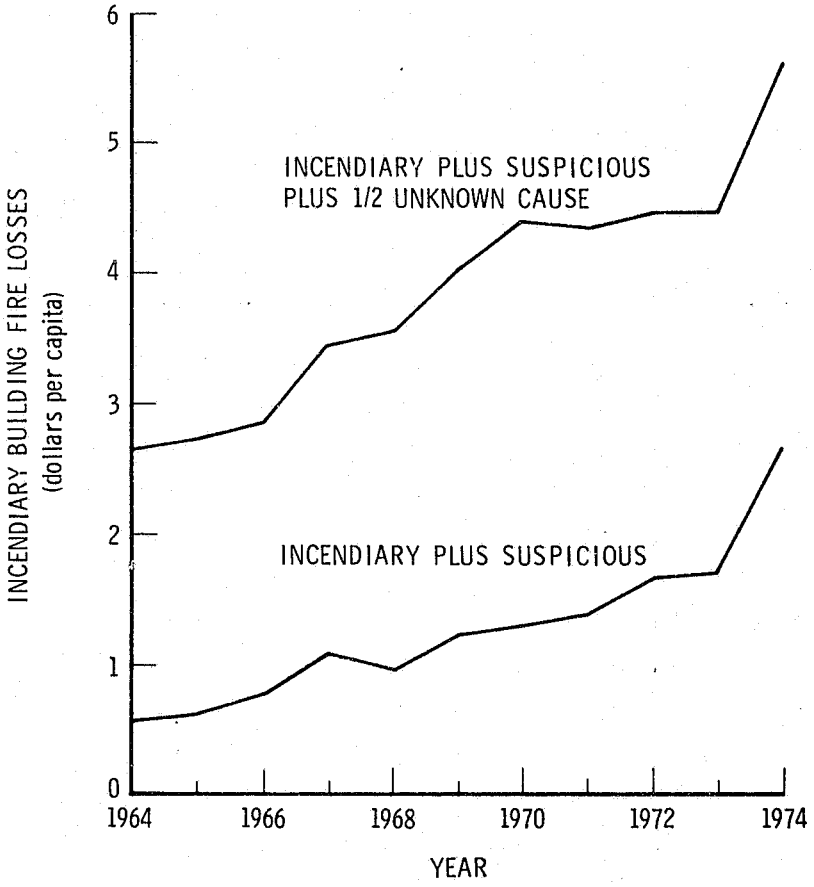

Figure 4. Trend in Incendiary Building Fire Losses per Capita, 1964-1974, in 1974 Dollars

was 113%. This compares with an increase of only 36% in the per capita losses due to building fires from all causes (from $11.33 in 1964 to $15.42 in 1974).

The proportion of building fires that are classified as incendiary or suspicious varies widely with the type of occupancy. Table 2, based on National Fire Protection Association data,[13-22] shows, for example, that 7% of one- and two-family dwelling fires were incendiary or suspicious in origin, while an alarming 75% of school fires were so classified. With an estimated $153 million in losses, incendiary storage facilities fires caused the most damage. Retail stores, schools, apartment buildings, industrial buildings, and family dwellings followed with incendiary losses of from $50 to $100 million in each class.

The data in Table 2 require a word of explanation. The percentages of fires which are incendiary or suspicious[13] are percentages of all fires of known cause in a sample of fires occurring in 1974. The estimated arson

Table 2. Incendiary Building Fire Losses by Type of Occupancy, 1974

Type of Occupancy	Total Number of Fires	% Incendiary or Suspicious	Average Loss, All Fires ($)	Estimated Loss from Arson ($ millions)
Schools and colleges	35,500	75	3,500	93
Churches	5,400	51	6,300	17
Storage	68,500	35	6,300	153
Offices and banks	8,100	34	6,900	19
Restaurants	26,800	31	2,400	20
Hotels	30,200	25	2,300	17
Retail stores	78,700	25	4,800	93
Apartment buildings	151,500	20	2,000	61
Hospitals	15,600	13	1,300	3
Nursing homes	9,300	13	600	0.8
Industrial	60,200	9	11,200	61
Mobile homes	29,700	7	2,600	5
Family dwellings	661,400	7	1,200	53

loss value was calculated by multiplying the total loss from fires due to all causes times the fraction which were incendiary or suspicious. Implicit in this calculation are the following assumptions: (1) the fraction of unknown-cause fires which are incendiary is the same as that of known-cause fires; and (2) the average loss for incendiary fires is the same as the average loss for all fires. Since, as was noted earlier, as many as half the fires categorized as cause unknown may actually be incendiary fires, the first assumption may underestimate the arson loss. Further, since the average loss per

incendiary fire is about double the average loss for fires of all causes, the second assumption also underestimates the arson loss. Consequently, the figures shown are lower bounds for the actual losses. Obviously, better statistics are needed if we are to deal rationally with the arson problem.

As previously indicated, incendiarism accounted for about three-quarters of the school fires in the sample analyzed. The school arson rate has been increasing rapidly from the 1950s, when there were approximately 500 per year, to 1974, when over 26,000 occurred.[23] This trend is depicted graphically in Figure 5.

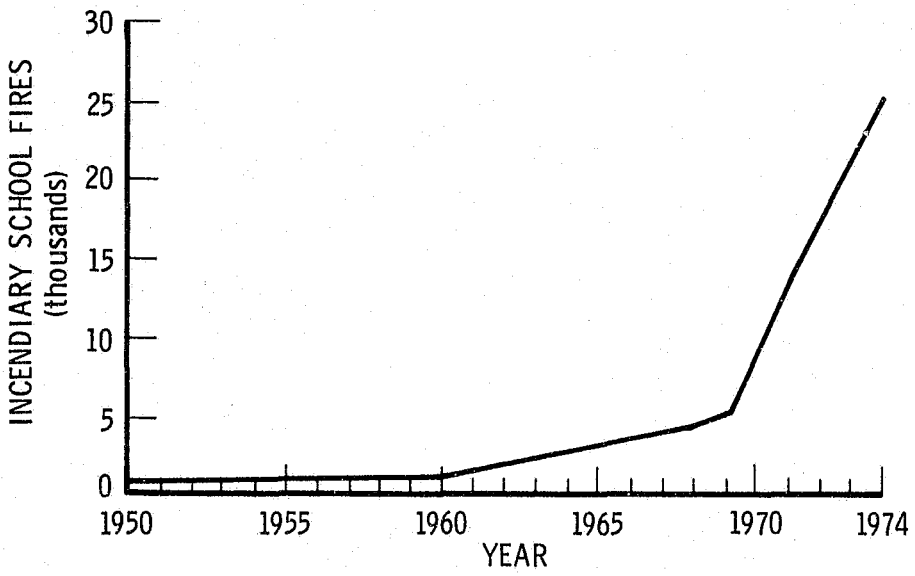

Figure 5. Incendiary School Fires, 1950-1974

E. Incendiary Motor Vehicle Fires

Although statistics on motor vehicle arson are quite sparse, many experts believe that incendiary fires represent a significant portion, perhaps a majority, of the half-million motor vehicle fires that occur each year.[24]

The primary reason for motor vehicle arson, these experts state, is to collect the insurance. They point out that uninsured automobiles seldom burn and that the vast majority of the burned autos are being financed at the time of the fire (although the relative frequencies of fires for financed-versus-nonfinanced and insured-versus-uninsured autos were not analyzed).

In 1974, 640,000 motor vehicle fires occurred, with a total loss of $135 million.[25] Based on a sample of these fires, 6.6% were estimated to be incendiary or suspicious in origin, while 72.5% were of unknown origin.[26]

The estimated amount of motor vehicle arson in 1974 is shown in Table 3.

Table 3. Incendiary Motor Vehicle Fires, 1974

Basis	Number of Fires	% of All Vehicle Fires	Loss Value ($ millions)
Incendiary and suspicious	42,000	6.6	9
Incendiary and suspicious plus 1/2 unknown cause	274,000	42.9	58

F. Incendiary Wildfires

Statistics on wildfires (that is, uncontrolled fires in forest and watershed areas), published by the U.S. Department of Agriculture, Forest Service, indicate that a fairly large fraction are incendiary in origin. In 1974, 31,400 (or 25%) of the 121,000 wildfires in the United States were classified incendiary.[27] It is the practice to attribute a cause to all wildfires, so that there are no "suspicious origin" or "unknown cause" categories. Figure 6 shows the number of incendiary wildfires from 1961 to 1974.[28]

The protected acreage (92% of all U.S. forest and watershed land is protected under the Clarke-McNary Act of 1924[29]) burned by incendiary wildfires in 1974 was 715,000 acres, which was 26% of the total acreage burned that year.[30] The incendiary dollar loss is estimated to have been $44 million (26% of total forest fire losses reported in Reference 8, page 45).

One interesting aspect of wildfire statistics is the high concentration of incendiary wildfires in the South. There, in 1974, 56% of the wildfire acreage was incendiary in origin (compared to 26% for the U.S.).[30] This was 230 acres burned by incendiary wildfires per 100,000 acres protected (compared to 50 for the U.S.).[31] Of the total U.S. acreage burned by incendiary wildfires, 81% was burned in the South. Cultural attitudes in the rural South that are responsible for this situation are discussed in References 32 and 33.

Figure 7 shows the acreage burned by incendiary wildfires in the United States from 1964 to 1974.[28] While the losses to incendiary wildfires are substantial, they at least do not exhibit the alarming rate of increase shown by incendiary building fires.

G. Total Incendiary Fires

We are now in a position to examine the total magnitude of arson, including arson in buildings, motor vehicles, and forest and watershed areas. As shown in Table 4, 187,000 fires were classified as incendiary

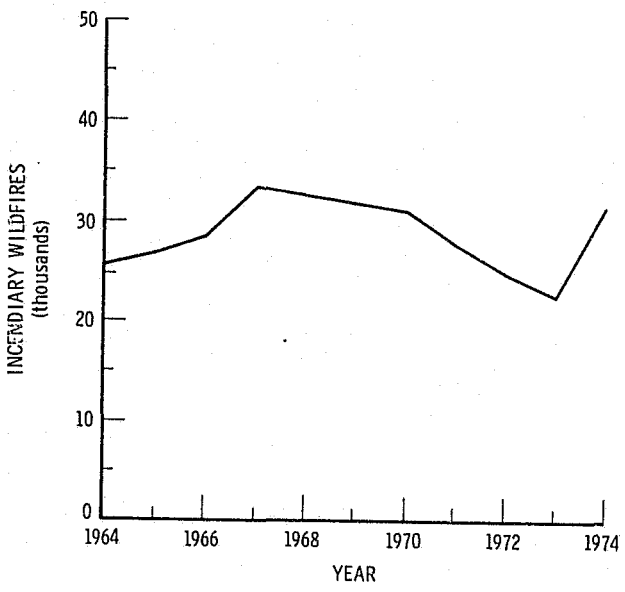

Figure 6. Number of Incendiary Wildfires, 1964-1974

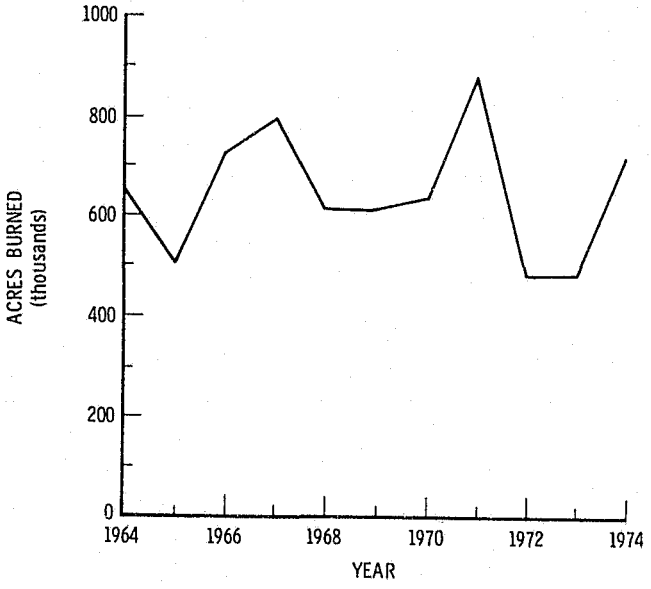

Figure 7. Acreage Burned by Incendiary Wildfires, 1964-1974

Table 4. Total Incendiary Fires and Losses, 1974

Basis	Number	Loss Value ($ millions)	% of Fires in Category
Incendiary and suspicious			
Building fires	114,000	563	9
Motor vehicle fires	42,000	9	7
Wildfires	31,000	44	26
Total	187,000	616	11
Incendiary and suspicious plus 1/2 unknown cause			
Building fires	194,000	1,182	15
Motor vehicle fires	277,000	58	43
Wildfires	31,000	44	26
Total	502,000	1,284	31

or suspicious in the United States in 1974. These fires caused $616 million in losses and were 11% of all fires reported that year.

If, as many experts believe, one-half the fires of unknown cause are incendiary in origin, there were 502,000 incidents of arson in 1974. These were 31% of the fires in 1974 and resulted in $1,284 million in losses.*

In addition to direct property loss, there are other costs associated with fires. The report of the National Commission on Fire Prevention and

*As this report was in the final stages of publication, the 1975 fire statistics became available. Incendiary and suspicious fires increased to 213,900, with $708 million in losses (144,100 and $634 million in buildings; 41,600 and $12 million in motor vehicles; and 28,200 and $62 million in wildfires). When one-half the fires of unknown cause are included, there were 511,700 arsons with a loss of $1402 million (212,800 and $1259 million in buildings; 270,700 and $81 million in motor vehicles; and 28,200 and $62 million in wildfires).

Control[34] estimated a total cost to society of about 4.2 times the direct property losses from fires when such considerations as fire department operations, burn injury treatment, insurance company operating expenses, and productivity losses are included. This would bring the total cost of arson to society in 1974 to $5.4 billion.

H. Deaths and Injuries Caused by Arson

An estimated 1000 people, including 45 firefighters, died in incendiary and suspicious fires in 1974.[35] There was a total of 11,600 deaths and 123,000 injuries due to fires from all causes that year.[36] If the ratio of injuries in incendiary and suspicious fires to total injuries was the same as for deaths, there were about 10,000 injuries in incendiary and suspicious fires. It is likely that there were many additional deaths and injuries in fires of unknown cause that were actually incendiary in origin. (Statistics on deaths and injuries in fires of unknown cause do not appear to be available.)

Some of the most tragic fires are due to arson. The National Fire Protection Association lists 23 significant fires and explosions in the United States from 1969 through 1974 that caused multiple deaths;[37] six (or 25%) of these were of incendiary origin. Of the total of 526 deaths, 135 (or 26%) were in the incendiary group.

I. Arson Compared with Other Serious Crimes

In order to put arson losses into some perspective, we compare them with losses due to other serious crimes. Table 5 shows such a comparison. Loss data for crimes other than arson were obtained from the 1974 FBI Uniform Crime Report.[38]

With the narrower definition of arson, arson losses were comparable to the other property crime categories; with the broader definition, arson losses were greater than all other crime categories. Furthermore, loss per offense was significantly higher for arson than for the other offenses.

From the point of view of the economy as a whole, losses from arson are greater still than the other crimes, for (while it may be of little consolation to the victim) robberies, burglaries, larcenies, and auto thefts may be viewed as involuntary transfers of assets with little net loss to the economy. Arson, on the other hand, causes assets to be destroyed.

Table 5. Property Losses from Serious Crimes, 1974

Offense	Property Loss ($ millions)	Average Loss per Offense ($)
Robbery	142	321
Burglary	1,181	391
Larceny	816	156
Auto theft	841[a]	1,246
Arson		
Incendiary and suspicious	616	3,294
Incendiary and suspicious plus 1/2 unknown cause	1,284	2,558

[a]69% of this was recovered.

A comparison of deaths and injuries due to arson and to other serious crimes[39] is shown in Table 6. It should be noted that the deaths and injuries due to arson are included in the total for the categories of murder and aggravated assault, respectively.

Table 7 compares the rate of increase in arson between 1964 and 1974 (Figure 1) with the increases in other serious crimes during the same period.[40] Incendiary and suspicious building fires rose more than any other crime category. When one-half the building fires of unknown cause were included, the building arson increase was somewhat less, but still greater than every crime type except robbery.

In view of the relative magnitude of arson, it is surprising that it has not received more attention in the past. This situation is likely due to the lack of a single, well known source of national statistics, as is provided for other offenses by the FBI Uniform Crime Reports.

Table 6. Deaths and Injuries from Serious Crimes, 1974

Offense	Deaths	Injuries
Murder	20,600	
Police killed	132	
Aggravated Assault		453,000[a]
Arson		
Incendiary and suspicious	1,000	10,000[b]
Firefighters killed	45	NA[c]

[a]Includes unsuccessful attempts

[b]Estimate

[c]NA: not available

Table 7. Serious Crime in 1974 and Increase, 1964-1974

Offense	Number 1974	Increase (%) 1964-1974
Murder	20,600	121
Rape	55,200	159
Robbery	441,000	239
Aggravated assault	453,000	125
Burglary	3,021,000	150
Larceny	5,228,000	109
Motor vehicle theft	974,000	107
Arson		
Incendiary and suspicious	187,000	127
Building fires	114,000	269
Motor vehicle fires	42,000	62
Wildfires	31,000	22
Incendiary and suspicious plus 1/2 unknown cause	502,000	95
Building fires	194,000	204
Motor vehicle fires	277,000	65
Wildfires	31,000	22

J. Improved Arson Statistics

There are many shortcomings in the currently available arson statistics (such as the lack of annual data on deaths and injuries according to fire cause and number of fires according to type of occupancy and fire cause, etc.). This situation will be greatly improved when the National Fire Data Center of the National Fire Protection and Control Administration of the U.S. Department of Commerce becomes operational. Under the Data Center's fire incident reporting system, local fire departments will send fire reports to the states using a national standard coding system (National Fire Protection Association Standard No. 901, "Uniform Coding for Fire Protection"). The states will compile and forward the data to the Data Center. It is anticipated that 12 states will have been incorporated into the system by the end of 1977. This data will be very useful in planning arson prevention programs. For example, it will be possible to calculate the average annual probability of arson per structure at risk for various types of occupancies and according to location (by census tract or zip code).

In addition, it is recommended that studies be performed to supplement the Data Center statistics. A sample of fires classified "unknown cause" should be analyzed in depth to determine the likely distribution of causes. Checks should be made of the accuracy with which fire fighters estimate fire losses and the accuracy with which they assign causes to fires. A study should be made of the extent of unreported fires of incendiary origin in the United States.

CHAPTER II. MOTIVES AND TYPOLOGY OF ARSONISTS

A. Motives for Arson

The motives for arson are quite diverse. They include profit, revenge, spite, jealousy, crime concealment, intimidation, vandalism, excitement, and pyromania. A fairly comprehensive list, but without frequencies of occurrence, is given by Huron.[41] The most important motives for arson are described in the following subsections, and quantitative data on their frequencies are presented in Section B of this chapter.

1. Revenge, spite, jealousy. This category includes jilted lovers, feuding neighbors, disgruntled employees, quarreling spouses, persons getting even after being cheated or abused, and persons motivated by racial or religious hostility. Lovers' disputes and domestic squabbles are the greatest contributors to this category.[41-42] In some parts of the country, particularly in rural areas, disagreements often result in the burning of homes or barns. Alcohol consumption is often associated with this type of fire.[43]

2. Vandalism, malicious mischief. Vandalism is a common cause ascribed to fires set by juveniles who seem to burn property merely to relieve boredom or as a general protest against authority. Many school fires as well as fires in abandoned autos, vacant buildings, and trash receptacles are believed to be caused by this type of arsonist.

3. Crime concealment, diversionary tactics. Criminals sometimes set fires to obliterate the evidence of burglaries, larcenies, and murders. The fire may destroy any evidence that a crime was committed, destroy the evidence connecting the perpetrator to the crime, or, in the case of murder, make it impossible to identify the victim. Persons may set fires to destroy records that contain evidence of embezzlement, forgery, or fraud. Arson has also been used as a means of diverting attention while the perpetrator burglarizes another building, and as a means of covering attempted escapes from jails, prisons, and state hospitals.

4. Profit, insurance fraud. There are a surprising number of ways to profit from arson. If a property is insured, the owner no longer wants it, and the value of the policy is greater than the sale value he could receive on the market when he needs to sell, then the insured may decide to defraud the insurance company. (Such a situation is known as a moral hazard.)

In a typical insurance fraud case, a businessman, finding himself in financial straits, will decide that the easiest way out is to "sell his business to the insurance company." His financial problems may have stemmed from a large inventory of unsaleable seasonal goods at the end of the season, an outmoded plant that requires expensive retooling, a building requiring extensive renovation to meet fire or safety standards, foreclosure of a mortgage, adverse market conditions, obsolete merchandise, poor management, or loss of utility value due to changed circumstances such as the relocation of a main highway.

In another common type of insurance fraud, a person may buy a property -- generally a vacant building in an economically depressed section of the city -- and insure it for more than its worth. A fire will then result in a substantial profit on the investment. The owner often places the deeds of such properties in the names of "straw parties" to avoid recognition of a pattern of fires on properties he owns. For example, in 1969 a man bought two properties in central St. Louis for $6000 and placed the deeds in the names of two straw parties. Within 2 years, there had been a serious fire of suspicious origin in each property, with the insurance payments totalling $33,424.[44] This same property owner had received over $415,000 in insurance payments for 54 fires occurring within a 2-year period (he was indicted for arson for one of these fires in early 1972).[45]

In some of this country's larger cities, professional arson rings have operated to defraud the insurance companies of millions of dollars. One such ring was uncovered in Detroit in 1974 when 57 persons were charged with 186 counts of arson.[46] In a typical operation of the ring, a mortgage company employee alerted a crooked repair contractor, who was a member of the ring, of an impending foreclosure. The contractor persuaded the

homeowner to contract with him for fire damage repairs. The contractor then arranged for a professional "torch" to set the fire when the insured was absent. After the fire, the contractor repaired the building with substandard materials (which would readily burn the next time) at a substantial profit, while the homeowner netted a small amount after paying off the torch, who averaged $1500 per fire.

In addition to these methods of obtaining profit, arson has been used by insurance adjusters to secure contracts to adjust fire losses; by insurance agents to stimulate business; by competitors to eliminate business rivals; by persons seeking employment as watchmen, firemen, or policemen; and by salvage handlers to be able to purchase or steal salvaged materials such as copper plumbing or bricks. Welfare recipients can obtain a cash moving allowance by having a fire in their current apartment.

5. Intimidation, extortion, sabotage. Arson has been used by striking workers and by employers to intimidate the other side during strikes. It has been used by criminals, particularly mobsters, for intimidation of witnesses and for extortion.

6. Psychiatric afflictions, pyromania, alcoholism, feeblemindedness. The pyromaniac starts fires because of an irresistible urge or passion for fire. He may derive sexual satisfaction from the fire, or he may merely enjoy the general excitement of the fire and attempts to quell it. Arsonists have been known to start fires in order to help quell them, thereby becoming heroes. Some of these persons were volunteer firemen[43] and, in one case, a fire chief. Other persons may become arsonists to demonstrate power over their environment or because they believe they are acting with divine guidance -- motives which are symptomatic of paranoia. Alcoholics who were otherwise perfectly normal have been known to start fires when under the influence of liquor.

B. Frequencies of Arson Motives

Drs. Edwin and Lilian Robbins studied 136 adults and 103 juveniles convicted of arson in New York City in 1964.[47] The motives for the two groups are summarized in Table 8.

Table 8. Motives of Convicted Arsonists, New York City, 1964

Motive	Adults (%)	Juveniles (%)
Revenge	47	5
Pyromania	30	14
Malicious mischief (vandalism)	10	80
Crime concealment	9	2
Insurance fraud	4	0

Revenge was the predominant motive for the adult offenders, while malicious mischief or vandalism was the juvenile's most frequent motive. Pyromania was significant in both groups, while insurance fraud was the motive in only five cases (4% of the adults).

A study by Inciardi[43] of 138 adult arsonists released on parole from New York state prisons from 1961 to 1966 showed patterns similar to the Robbins study.[47] As presented in Table 9, revenge was again the primary motive (58%). The motive of excitement accounted for the second highest proportion of arsonists (18%). Insurance fraud was the motive of only a small portion (7%). None of the arsonists was a professional torch. The motive labeled "transfer" pertains to nine residents of institutions for mental defectives and epileptics who set fires so that they would be transferred to other institutions.

The Inciardi study went further and analyzed some of the characteristics of the arsonists for each motive. These are also shown in Table 9. It is interesting to note that the five vandalism arsonists had very low intelligence quotients, with an average of 75. All were below 90, and two below 70. As might be expected, arsonists with the "rational" motives of fraud and crime coverup had higher average intelligence quotients than the other four groups. Problem drinking was a characteristic associated with a majority of the arsonists, a tendency corroborated by other studies of the characteristics of firesetters. Both the revenge arsonists and the pyromaniacs were

Table 9. Motives of Paroled Adult Arsonists

Motive	% of Subjects	Average Age	Average IQ	Problem Drinkers (%)
Revenge	58	28	84	64
Excitement	18	23	96	91
Crime concealment	7	22	112	40
Fraud	7	29	110	20
Transfer (see text)	7	19	<70	0
Vandalism	4	18	75	40
Average		27	90	55

generally intoxicated at the time of their crimes. Of course, their intoxicated state may have led to carelessness and enhanced their chances of getting caught, thus biasing the sample in favor of the problem drinker.

Of 304 arson cases in Detroit in 1965,[48] 149 (or 49%) were due to pyromaniacs, 125 (or 41%) were revenge fires, 22 (or 7%) were fires to conceal other crimes, and 8 (or 3%) were set to defraud insurance companies. The eight fraud fires caused half of the total $700,000 monetary loss.

The now defunct Fraud and Arson Bureau of the American Insurance Association conducted 4393 investigations of incendiary and suspicious fires throughout the United States in 1965.[49] Of these, 836 (or 19%) were considered to have been set for recovery of insurance, amounting to $46 million.

Of 1703 fires established as arson in Ohio, North Carolina, and Pennsylvania during the years 1950 through 1955,[50] 275 (or 16%) were found to have been insurance fraud fires.

Some prominent arson investigators (for example, Benjamin Huron[51]) believe that insurance fraud is the most prevalent motive for arson. The studies of convicted and incarcerated arsonists cited do not confirm this. However, arsonists less likely to get caught (for example, professional

torches) and those with better legal counsel (for example, businessmen and mobsters) and, hence, less likely to be convicted or incarcerated, would be under-represented in such sample groups. Indeed, at the investigative level in the last three samples cited,[48-50] the average proportion of the arson cases due to fraud was 17%, compared with an average of 5% for the convicted and incarcerated groups.

C. Other Characteristics of Arsonists

Characteristics of arrestees for various crime categories are published in the annual FBI Uniform Crime Reports. Figure 8 presents a comparison of the age distribution for persons arrested for arson and persons arrested for Index crimes (murder, rape, aggravated assault, robbery, burglary, larceny, and auto theft) in 1974.[52] Arson arrestees were younger: 59% of those arrested for arson were under 18, compared with 45% of the Index crime arrestees. About 10% of the arson arrestees were female. Further, 78% of the arson arrestees were white, compared with 63% of the Index crime arrestees. In brief, the typical arson arrestee was young, white, and male.

Inciardi[43] summarized his sample of 138 paroled adult arsonists as follows:

- Young: average age = 27
- White: 80% of the subjects
- Male: 98%
- Unmarried: 80%
- Problem drinker: 55%
- Low intelligence quotient: average = 90
- Unskilled laborer
- Raised by single parent
- Resident of urban slum
- Irregular working habits
- Most fires set in multiple dwelling units
- Most fires set at night

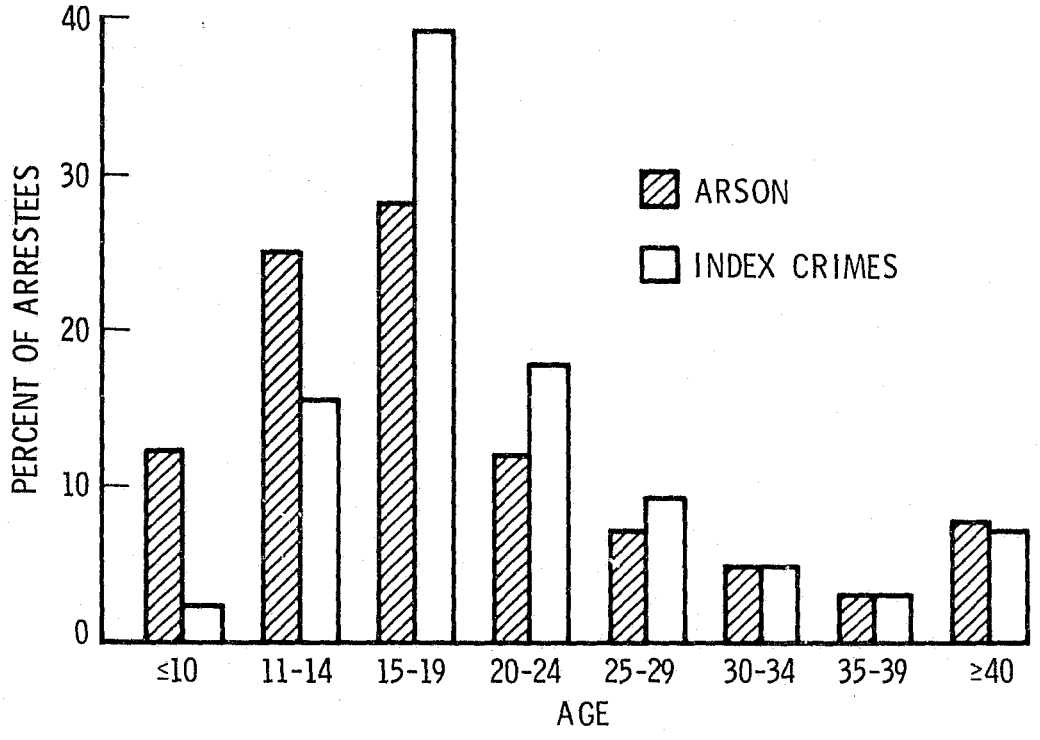

Figure 8. Age Distribution of Arrestees for Arson and FBI Index Crimes

In an extensive analysis of adult male inmates of penal institutions in Florida, South Carolina, and North Carolina,[53] 68 convicted arsonists were compared with a control group of 68 inmates convicted of other crimes. The study compared the demographic characteristics, criminal histories, and psychological profiles of the two groups. In most characteristics, the two groups did not show significant differences. However, the arsonist group did have significantly (in a statistical sense) lower intelligence quotients, less education, more divorces, more rural backgrounds, and a higher proportion of property crimes in their criminal histories. Psychological profiles indicated that the arsonists exhibited psychological characteristics

more closely resembling persons undergoing psychic stress as in culture shock than did the control group. This stress was probably in reaction to the prison environment. No significant pattern of sexual abnormality or psychopathic tendency was established. This may have been because arsonists considered psychotic were sent to mental hospitals rather than prison.

A clear understanding of the motivations and psychological and demographic characteristics of as large and representative a sample of arsonists as is possible would be useful in determining and evaluating possible counteractions to the arson problem. Consequently, research similar to the study of the 68 prison inmates should be performed on populations representative of arrested arsonists including those in prison, in mental hospitals, on probation, and on parole. Both adults and juveniles should be included in the sample, as well as male and female offenders. A control group should be used, since it is difficult to evaluate statistics on the frequencies of certain characteristics without a basis for comparison. About a quarter of the adults who are arrested for arson and convicted are found guilty of lesser charges (for example, malicious mischief), primarily due to plea bargaining; therefore, the sample should be based on the classification of the arrest rather than of the disposition.

Questions addressed by such a study might include the following:

- What are the frequencies of the various motives?
- What are the significant characteristics of arsonists?
- How do arsonists differ from other criminals?
- How do arsonists differ from the general population?
- What are the recidivism rates for the various types of arsonist?
- What proportion of the arsonists could be considered psychopathic?
- How significant is fraud as a motive for arson?

Research is also needed to provide information on certain other characteristics of arsonists about which there appear to be no data currently available. These include the frequency with which arsonists commit the crime, the susceptibility of convicted arsonists to rehabilitation, and the deterrability of arsonists through more probable and/or more severe sanctions (such as longer prison sentences). Such information could be used to estimate the effect that changes in conviction rate or sentence length would have on the arson rate. Also needed are the frequencies of the fire-setting techniques used by arsonists, the frequencies of different modus operandi, the fraction of the arsons where eyewitnesses are available, and the frequencies with which different types of physical evidence occur at arson scenes. These statistics would be useful in planning improvements in arson investigation and in estimating the potential of such improvements in increasing the apprehension of arsonists.

CHAPTER III. ARSON AND THE CRIMINAL JUSTICE SYSTEM

A. Arson Arrest and Conviction Rates

Estimates of the number of arrests for each crime type are published annually by the FBI. In 1974 there were 16,900 arrests for arson.[54] Using the narrower definition of arson -- fires actually classified as incendiary or suspicious -- there were 187,000 arsons committed in 1974. Thus the arson arrest rate (ratio of arrests to offenses) was 0.09. If the broader definition, which includes one-half the fires of unknown cause, is used for arson, the arson arrest rate was 0.03. These values are both low in comparison with other types of serious crime[55] as can be seen in Table 10.

Table 10. Comparison of U.S. Arrest Rates, 1974

Offense	Arrests per Offense Reported
Murder	0.98
Rape	0.48
Robbery	0.34
Aggravated assault	0.52
Burglary	0.17
Larceny	0.20
Motor vehicle theft	0.16
Arson	
Incendiary and suspicious	0.09
Incendiary and suspicious plus 1/2 unknown cause	0.03

The 1974 Uniform Crime Report also indicates that 41% of those arrested for arson were adults (ages 18 and over) and 59% were juveniles.[56] Of those persons charged with arson (that is, held for prosecution), 26% were adults who were convicted, 18% were acquitted or dismissed, and 56% were

juveniles who were referred to juvenile court for processing.[57] Since national data on neither the fraction of the arrestees who were charged nor the processing of juveniles are available, it is not possible to calculate the U.S. arson conviction rate (ratio of convictions to offenses). However, some indication of its value can be obtained by combining U.S. arrest data with conviction and sentencing data from a representative state. Table 11 shows the results of this procedure using California disposition data.[58-60] For each 100 arsons, about nine people are arrested, two convicted, and slightly less than one incarcerated. When the broader definition of arson (which includes one-half the fires of unknown cause) is used, these values are reduced to 3, 0.75, and 0.26, respectively.

By way of comparison, Table 12 shows dispositions for the FBI Index crimes (the first seven offenses in Table 10) similarly computed using U.S. arrest data and California disposition data.[60-61] The average arrest rate for seven Index crimes was more than twice that of arson; the conviction rate, more than three times as high; and the incarceration rate, more than four times as high.

Table 11. Dispositions of Arson Cases, 1974

Disposition	Number per 100 Incendiary or Suspicious Fires		
	Juveniles	Adults	Total
Arrests	5.31	3.73	9.04
Convictions	0.63	1.24	1.87
Sentences			
Incarcerations	0.004	0.70	0.70
Prison	-	0.10	0.10
Jail	-	0.58	0.58
Juvenile corrections	0.004	0.01	0.02
Probation	0.62	0.54	1.16

Table 12. Dispositions of Index Crimes, 1974

Disposition	Number per 100 Offenses Reported		
	Juveniles	Adults	Total
Arrests	9.56	11.64	21.20
Convictions	1.13	5.18	6.31
Sentences:			
Incarceration	0.008	3.17	3.18
Prison	-	0.66	0.66
Jail	-	2.51	2.51
Juvenile corrections	0.008	-	0.008
Probation	1.12	1.47	2.59
Fine	-	0.24	0.24
Other	-	0.29	0.29

B. Difficulties in Investigating Arson Cases

Many fires receive only a perfunctory investigation, while many others are not investigated at all. This is true both in the case of the initial investigation of the cause of the fire and in the case of the subsequent criminal investigation when incendiarism is known or suspected. This situation causes the number of fires classified as incendiary or suspicious to significantly underestimate the true level of arson and helps to cause the low arson arrest and conviction rates.

Reporting on a survey of 307 municipalities in the state of New Jersey conducted in 1975, the New Jersey Statewide Arson Network System Newsletter made the following statement:

> A new category added to the Fire-Arson Survey is the actual investigation of fires by any official agency. These figures are most revealing and indicate the lack of actual fire investigations. Of the total amount of 72,736 fires, only 16,221 had some sort of investigation made either by police, fire or any other official agency. If we take the figures of fires declared

> actual arson or of a suspicious or undetermined nature the problem becomes even more acute. A total of 31,541 fires were in these categories and just a little over half were investigated. The need is very clear, more people must get involved and more must be trained so that these fires are investigated as to their cause. To declare a fire to be of a suspicious or undetermined origin and not go any further has to be a most frustrating experience.[62]

By way of comparison, consider the large investigative effort given to bank robberies by both the FBI and local police. Yet in 1974 the 3500 bank robberies in the United States averaged $3600 in losses for a total loss of less than $13 million.[63] During the same year, the 187,000 known and suspected incendiary fires averaged $3300 in losses for a total loss of $616 million (Chapter II).

The reasons for the low rate of investigation of fires fall mainly into two categories. Reasons stemming from the physical nature of fire scenes will be discussed in this section. Reasons arising from administrative problems are dealt with in the next section.

No other type of crime scene except bombing is characterized by as much destruction and disorder as arson. Investigators must search through piles of debris and rubble, often on their hands and knees. Ashes, soot, and char make fire scenes filthy and malodorous. They can ruin clothes and cause personal problems for investigators returning home from fire scenes. An investigator's wife may be able to adjust to his late night calls, but may find the inevitable filthy and foul-smelling clothes intolerable. For this reason or because he finds such conditions undignified, an investigator may request transfer to other duties.

The fire scene search is further aggravated by water and foam remaining from the extinguishment. The scene may be a quagmire, making the rubble wet and heavy to move out of the way. Plaster fallen from walls and ceilings mixes with the water, forming a grey slush retarding the investigator's movements.

In cold weather, there is the additional pressure of completing the work before everything freezes and the investigation is severely impeded.

The fire scene may be dangerous to work in because of the imminent collapse of upper parts of the structure. It may be exposed to the elements, making work in foul weather difficult and unpleasant.

In addition to the destruction of the fire, there are further problems caused by firefighter mop-up and salvage operations immediately following the fire. The mop-up process involves finding and eliminating any smoldering spots that might rekindle the fire. This involves tearing open walls, ceilings, roofs, and other partitions, and throwing objects like mattresses and sofas out of the building. The salvage process involves removing any salvageable items, such as furnishings or machinery, to a safe place and covering them from the elements. This process hampers efforts to reconstruct the fire scene and the sequence of events that led to the arson. The original positions of objects must, as a result, usually be obtained through meticulous interviews.

The sheer physical effort involved in the investigation is usually much greater for arson than for other crimes, and the number of man-hours required is greater. Fire scene searches cannot be avoided, particularly in view of the general lack of witnesses in arson. The investigator must often put together a complex chain of circumstantial evidence to establish arson and implicate a suspect. Any physical evidence may be destroyed by the fire or lost in the debris.

With obstacles such as these, it is little wonder that many fires are never investigated.

C. Administrative Problems

Historically, the attitude of police has often been that arson is a fire problem and that responsibility for arson lies completely within the fire service. Arson, however, is a crime, and firefighters are not trained to investigate criminal matters. In their arson control program guide,[64] the International Association of Chiefs of Police and the International Association of Fire Chiefs recommend that the fire service take full responsibility for

the investigation of the causes of fires and for arson detection, and that law enforcement agencies take responsibility for the criminal investigation phase after arson has been detected. Such a program requires full cooperation and exchange of information. Table 13 (based on Reference 65) indicates that this recommended division of responsibility is not the current pattern in the United States.

As discussed in the previous section, the conditions typical of fire scenes make arson investigation unpleasant and unrewarding. Neither police nor fire agencies are anxious to take over an area with such a low success rate. Both want to improve their statistics in order to enhance their image and justify their budget. When budget cuts occur, arson units are often the first to go. The real winner in this dispute is the arsonist. The situation requires the understanding and cooperation not only of police and fire administrators, but also of city officials in charge of budgets.

There are special problems with arson in rural areas, where there often is no local law enforcement agency and where firefighters are usually all volunteers. In fact, it is estimated that 75% of all firefighters in the United States are volunteers.[66] They do not investigate fires as to cause, since they are neither trained nor paid to do so. Their job is fire suppression. In such

Table 13. Agencies Responsible for Arson Detection and Criminal Investigation

Type of Agency	Number of States	
	Detection	Investigation
Local fire department	20	8
State fire marshal	14	17
Local police	8	12
State police	6	6
Insurance companies	2	0
State department of criminal investigation	0	1

areas, the state fire marshal's office is responsible for investigations. However, because of low staff (Ohio and Illinois have 10 investigators each to cover the entire state[66]), most fires are not investigated.

D. Difficulties in Prosecuting Arson Cases

Legally, fires are assumed to be accidental in origin until proven otherwise. The proof that the origin was incendiary and that a crime occurred is called the corpus delecti (body of the crime) of the arson case. Since arson is usually committed surreptitiously, witnesses are rare. Arson must therefore usually be established using circumstantial evidence including physical evidence, such as fire accelerant residues or multiple points of origin of the fire. As pointed out previously, such evidence may be difficult to find.

Once arson has been established, the prosecution centers on implicating the defendant. Again, witnesses are few (unlike, say, robbery or assault), so a complex circumstantial case must usually be constructed. Such a case requires greater trial preparation and more experience on the part of the prosecutor. With the usual high rate of turnover in district attorneys' offices, this experience is often not available. Further, the low success rate and high work demands of arson cases make them most unattractive to prosecutors, who are usually already overburdened with cases. Advancement in the district attorney's office is based on the number of convictions returned. Finally, because of the heavy reliance on physical evidence, the prosecutor may feel uneasy with the large amount of expert scientific testimony required. This last problem could be addressed by training prosecutors in the technical aspects of arson cases.

E. Criminal Justice Expenditures on Arson

The foregoing statistics have indicated that while the average property loss per offense is much higher for arson than for other serious crimes, the average number of arrests and convictions is much lower. Furthermore, arson results in significant loss of life and personal injury. This situation would seem to justify an increase in efforts to reduce arson. It would be very useful to have a thoroughgoing analysis of the potential benefits of such things

as more arson investigators, improved investigative aids, better training, earlier arrival at fire scenes, and more extensive use of physical evidence. The cost of these improvements could be compared with the potential benefits of reduced property and life loss or compared with the benefits achieved by similar expenditures in the control of other types of crime.

In this section, we present rough estimates of the current level of investigative manpower for arson and for the FBI Index offenses. It is estimated that there were 6000 arson investigators, both public and private, in the United States in 1975.[67] Many of these investigators are employed by insurance companies and other private organizations. The fraction employed by fire, police, and other public agencies is not known. Many arson investigators perform other duties as well: they may investigate certain accidental fires or conduct routine fire safety inspections. For purposes of comparison, the number of full-time equivalent arson investigators was rather arbitrarily estimated to be 5000.

In the United States there are 324,000 local police and 39,000 state police.[68] According to a Rand Corporation study,[69] in an average police department, 17% of the personnel are detectives. This implies a total of 62,000 police investigators. In addition, there are an estimated 50,000 federal and 32,000 private investigators,[68] resulting in a total of 144,000 full-time criminal investigators. It is assumed that about 70% of the investigative effort (the equivalent of 100,000 full-time investigators) is expended for Index crimes.

Table 14 presents some comparisons between expenditures (in terms of manpower) and losses for arson and Index crimes. The reader is cautioned not to draw conclusions about the appropriateness of these manpower levels on the basis of these figures alone.

Kendall Moll pointed out[70] that most arson investigators are located in urban areas, while suburbs and rural areas have both the lowest arson arrest and conviction rates and the fastest rate of increase of incendiarism. He estimated that, nationwide, a three-fold increase in the number of arson investigators is needed to provide services already provided by the larger cities.

Table 14. Expenditures and Losses for Arson and Index Crimes, 1974

	Arson	Index Crimes	Ratio
Investigators (approx.)	5,000	100,000	20
Property loss	$1,284 million	$2,140 million	2
Deaths	1,000	20,600	20
Injuries	10,000	508,000	50
Arrests	16,900	2,160,000	130

CHAPTER IV. STATISTICAL RELATION BETWEEN ARSON AND THE ARREST AND CONVICTION OF ARSONISTS

A. Introduction

It is generally believed that the incidence of arson can be decreased through an increase in the arrest and conviction of arsonists. For example, James C. Robertson, Fire Marshal, State of Maryland, states that "... there is a growing awareness of the need to deter [arson] to cut down losses from incendiary fires. A major step in this direction is coordinated effort between police and fire agencies in the investigation of suspicious fires to bring about prosecution of the arsonist."[71] Reporting on the Conference on Arson and Incendiarism held at the National Academy of Sciences, James W. Kerr stated that "In various cases cited [by the conference attendees], there has been total uniformity as to the consequence: Reduce arson investigators and investigations and watch arson increase at once. ... In every case cited, vigorous and consistent investigations led to reduced incidence of arson, whereas reduction of the investigative staff was followed by an increase in arson-attributable loss."[67]

There are at least three possible mechanisms by which arson investigation and prosecution could conceivably lead to a reduction in arson. The first of these is general deterrence, in which potential arsonists are deterred from committing the crime because of knowledge that others were caught and punished for arson in the past. The second is specific deterrence, in which those arsonists who have been caught are deterred from repeating the crime either because they were punished or because they were rehabilitated. Finally, there is incapacitation, which involves physically preventing the arsonist from repeating his crime through incarceration. The last two mechanisms could have a significant impact only if a large proportion of arsonists are inclined to be repeaters. There are not as yet any studies on the effectiveness of deterrence or incapacitation in the control of arson.

It would be very useful to know whether there is, in fact, a general relation between the level of investigative effort and reduction in arson. Furthermore, if the relationship could be quantified, it could be used to establish the proper number of arson investigators and the proper level of support services such as arson laboratories, arson data systems, and research and development efforts related to arson investigation. It is strongly recommended that an analysis of this type be performed in order to help rationalize both public and insurance company expenditures on arson investigation.

Without doubt, many other factors in addition to the intensity of investigation and prosecution also determine the level of arson. These might include economic conditions, number of vacant buildings, age distribution of the population, cultural attitudes toward fire and arson, and the presence of organized crime. Such conditions vary from city to city and from year to year. In order to measure the sensitivity of the arson rate to the level of investigation, one would like to hold all other factors constant. This might be accomplished through sudden changes in arrest and conviction rates in a period of time too short for other factors to change. This could be done through changes in the numbers of arson investigators and prosecutors and would be repeated in a sampling of cities chosen to be representative of the country as a whole. Such an experiment would be quite expensive.

In this chapter we take an alternative approach to this question by statistically analyzing some already existing data on arson, arson arrests, and arson convictions. The data were collected by the Stanford Research Institute in conjunction with their study, "Arson, Vandalism and Violence: Law Enforcement Problems Affecting Fire Departments,"[72] and were kindly made available to us by Mr. Kendall D. Moll. The study involved sending a 17-page, 61-question questionnaire to 1042 fire departments and resulted in the receipt of 482 responses. The questions included ones dealing with the number of incendiary and suspicious building fires, the population of the jurisdiction served by the fire department, the number of persons arrested

and the number convicted for building arson during the years 1968 through 1971. Not every fire department answered every question, and the response rate was especially low for arrest and conviction data. For the present study, 108 cities were selected that had provided at least most of the arrest and conviction data and that had at least a few incendiary or suspicious fires during each of the 4 years. Table 14 shows the sample sizes for each year.

Table 15. Number of Cities in the Arson Data Samples

Year	Arrest Data	Conviction Data
1968	92	84
1969	103	95
1970	108	102
1971	105	99
Total	408	380

Table 16 shows the distribution of the sample cities by population. As can be seen, the larger cities are more heavily represented. This is a result of both an emphasis on the larger cities in the original Stanford Research Institute survey and also the fact that the larger cities more often keep records of arson arrests and convictions.

Table 16. U.S. and Sample Cities Population by Size of Place

District Population	% of Total U.S. Population	Number of Cities in Sample	% of Sample Cities Population
Over 100,000	39	55	90.8
25,000 - 100,000	24	50	9.0
10,000 - 24,999	15	3	0.2
Under 10,000	22	0	0

The definition of "arson" used in this section is "fires classified as incendiary or suspicious." The term "arson arrest rate" will be used for the ratio of the number of arson arrests in a given year to the number of arsons in that year. The arson arrest rate is thus the average risk of arrest for each arson committed. Likewise, the arson conviction rate, the ratio of the number of arson convictions to the number of arsons in a given year, is the average risk of conviction for each arson committed. Finally, in order to normalize the amount of arson in cities with different populations, we shall compare arson rates per 100,000 population per year for these cities. Table 17 shows the average arson rates and arson arrest and conviction rates for the cities in the sample.

Table 17. Average Arson Rate, Arson Arrest Rate, and Arson Conviction Rate

Year	Average Arsons per 100,000 Population	Average Arson Arrest Rate	Average Arson Conviction Rate
1968	44.3	0.210	0.116
1969	37.1	0.234	0.138
1970	52.2	0.182	0.102
1971	53.1	0.204	0.115

The sample cities have significantly higher average arrest and conviction rates than the country as a whole. This is probably due to the sample bias toward large cities, which generally have more personnel devoted to arson investigation than small cities and rural areas.

B. Changes in Arson Rate versus Changes in Arrest Rate

We now consider the relation between changes in the arson arrest rate and changes in arsons per 100,000 population. After calculating the arrest and arson rates for each city for each year, the year-to-year differences in arrest rate and corresponding differences in arson rate were calculated for

each city. These pairs of values were plotted as a scatter diagram, as shown in Figure 9, in which the horizontal coordinate of each point is a 1-year change in arrest rate for some city, while the vertical coordinate of that point is the corresponding change in arsons per 100,000 population. If an increase in arrest rate invariably led to a decrease in arson while a decrease in arrest rate caused an increase in arson, all of the points in Figure 9 would lie in the upper left and lower right quadrants. This is not the case. In fact, there are nearly as many points in the other two quadrants. A similarly constructed scatter diagram of changes in arsons per 100,000 population versus changes in arson conviction rate is shown in Figure 10. Again the points are not confined to the upper left and lower right quadrants.

As mentioned previously, it is likely that the arson rate is determined by a number of factors in addition to the arrest and conviction rates. If these factors also changed, they might have caused changes in the arson rate which masked any changes due to the arrest rate. Consequently, the horizontal axis (change in arrest rate) in Figure 9 was divided into six ranges, thereby dividing the points into six groups having between 13 and 124 points. The average change in arsons per 100,000 population was calculated for each group. If one assumes that each group is sufficiently large and diverse to be similar to the others with respect to the distribution of changes in the factors other than arrest rate, then the differences in the average change in arson rate may be ascribed solely to changes in arrest rate.

The results of this calculation are shown in Figure 11. For example, the figure indicates that the 17 points whose change in arrest rate was between -0.5 and -0.3 had an average change in arsons per 100,000 population of 14.5. In general, decreases in arrest rate are associated with increases in the average arson rate, while increases in arrest rate are associated with decreases in the average arson rate. The same calculation was performed for conviction rates, and Figure 12 shows that a similar relation holds.

These results appear to be consistent with the contention that increases in arrest rate actually cause decreases in arson. However, this type of

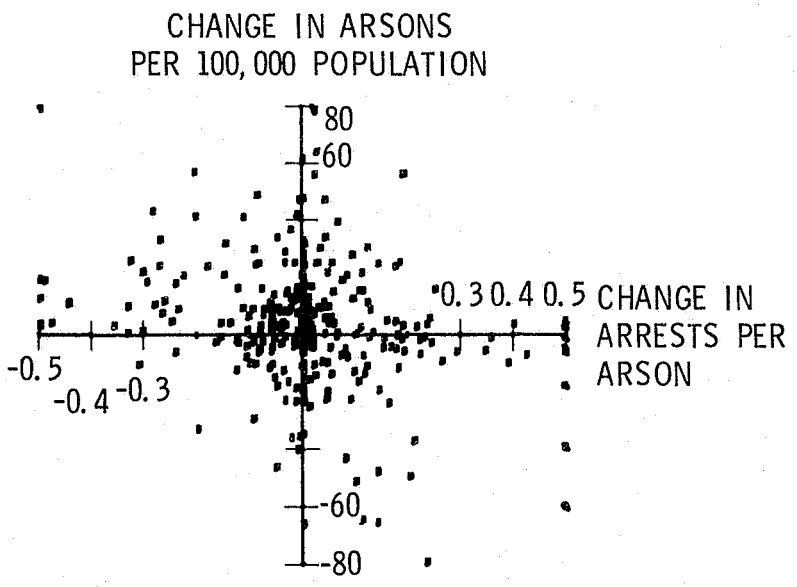

Figure 9. Changes in Arsons per 100,000 Population versus Changes in Arrests per Arson During 1-Year Periods, 108 Cities, 1968-1971 (N = 300)

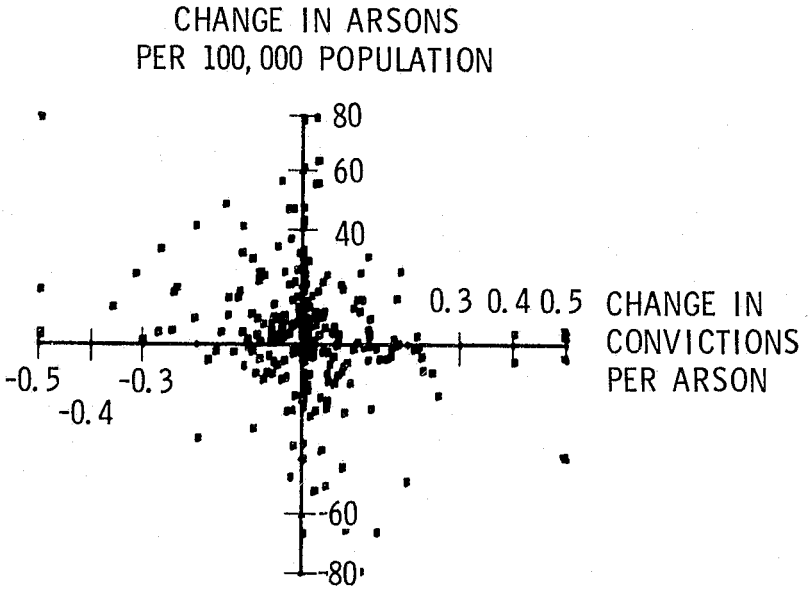

Figure 10. Changes in Arsons per 100,000 Population versus Changes in Convictions per Arson During 1-Year Periods, 108 Cities, 1968-1971 (N = 278)

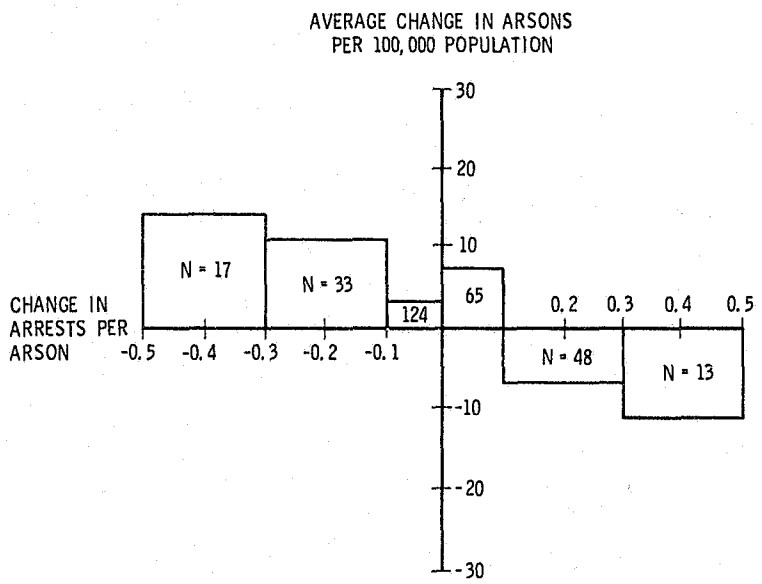

Figure 11. Average Change in Arsons per 100,000 Population for Cities Grouped by Change in Arrests per Arson (N = 300)

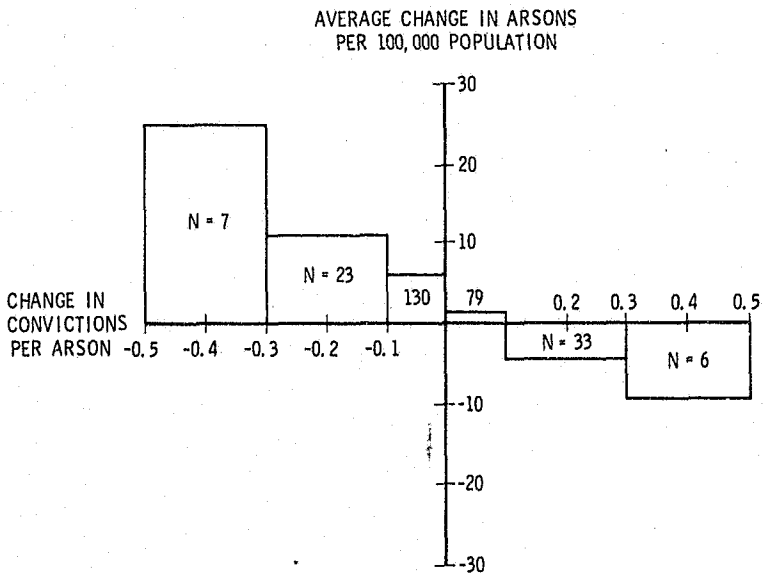

Figure 12. Average Change in Arsons per 100,000 Population for Cities Grouped by Change in Convictions per Arson (N = 278)

analysis cannot prove that a causal relation exists. Indeed, a third factor may be responsible for changes in both arson and the arson arrest rate. For example, deteriorating economic conditions might cause an increase in arson and a decreased city budget resulting in lower arrest and conviction rates. However, any such third factor would have to change the arson, arson arrest, and arson conviction rates all practically simultaneously, since the observed changes occurred during 1-year periods.

It is recognized that not all possible statistical tests have been applied to the data. One might, for example, perform an analysis of variance or calculation of confidence intervals. However, it is believed that the analysis in this and the next section are adequate for the purposes of this report. A more careful analysis using a larger data base should be part of the systems analysis of arson investigation previously recommended.

C. Arson Rate versus Arrest Rate

We now turn to the question of whether cities with higher arson arrest and conviction rates tend to have lower arson rates. Figure 13 is a scatter diagram of the 1971 arson arrest rate for 105 cities. The line through the points is the best straight line curve fit of the data (in the sense of least squared error). While there is a slight downward trend, there is considerable dispersion in the data -- the average distance of the points from the line is 28, and their standard deviation from the line is 37 arsons per 100,000 population. Figure 14 is a similar scatter diagram for the 1971 conviction rate, and Figures 15 and 16 are scatter diagrams for the arrest and conviction rates for all 4 years for which data were available. Again the lines are the best (least squares) straight line curve fits to the data.

As the test of the significance of the usual (Pearson) correlation coefficient is applicable only in the case of bivariate normally distributed data, we shall use the Spearman rank correlation coefficient to measure the degree of relation between arson rates and arson arrest and conviction rates. The statistic involves ranking the cities according to both arson rate

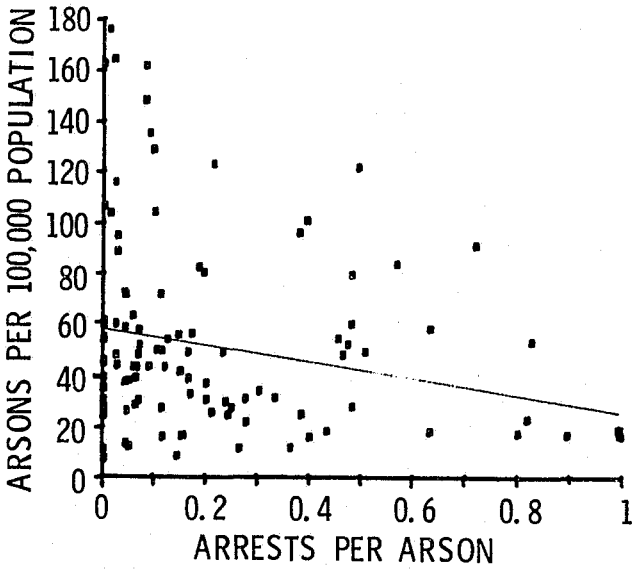

Figure 13. Arsons per 100,000 Population versus Arrests per Arson, 105 Cities, 1971

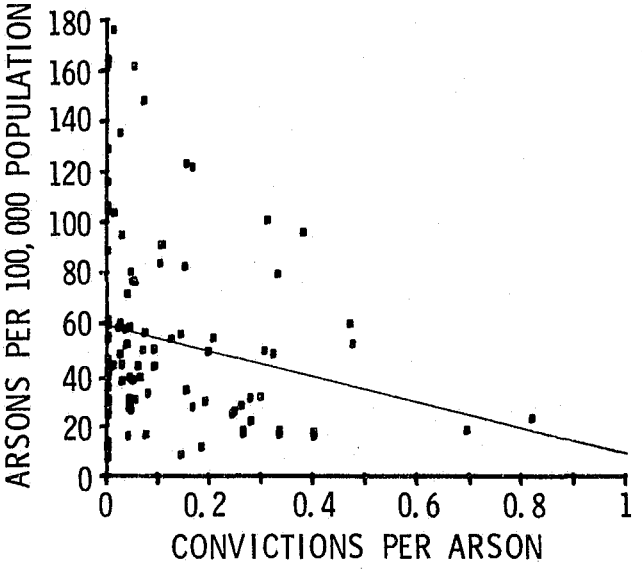

Figure 14. Arsons per 100,000 Population versus Convictions per Arson, 99 Cities, 1971

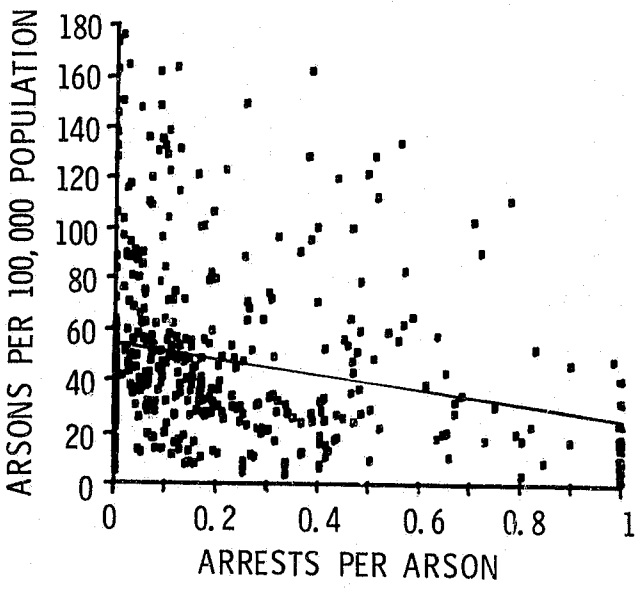

Figure 15. Arsons per 100,000 Population versus Arrests per Arson, 108 Cities, Each Year, 1968-1971 (N = 408)

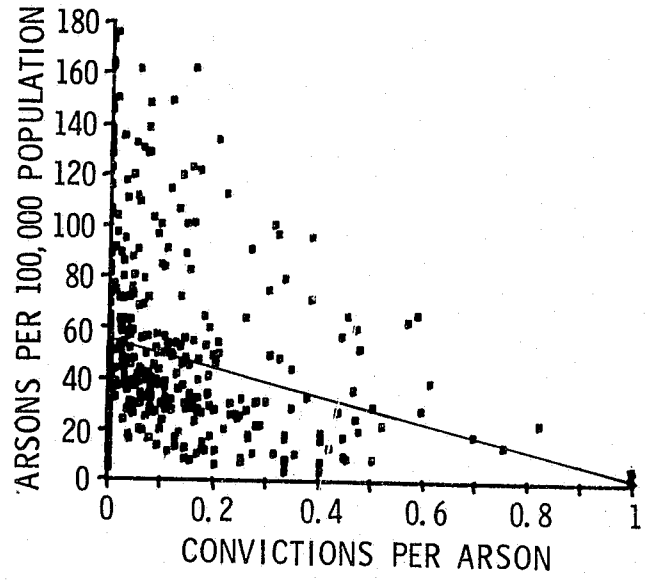

Figure 16. Arsons per 100,000 Population versus Convictions per Arson, 108 Cities, Each Year, 1968-1971 (N = 380)

and arrest (or conviction) rate, and then computing the sum over all cities of the differences of the squares of the two ranks. (The interested reader may consult Reference 73.) As with other correlation coefficients, the value ranges from -1 to 1, with a value of zero indicating that no relation exists. Table 18 shows the correlation is small in magnitude and consistently negative in sign. This means the variables are slightly related and that the relation is an inverse one -- when one is high, the other tends to be low.

Table 18. Correlations Between Arsons per 100,000 Population and Arrest and Conviction Rates

Year	Spearman Rank Correlation Coefficient	Sample Size (cities)	Level of Confidence
Arrest Rate			
1968	-0.201	92	0.974
1969	-0.225	103	0.990
1970	-0.073	107	0.773
1971	-0.131	105	0.910
1968 - 1971	-0.154	408	0.999
Conviction Rate			
1968	-0.220	84	0.979
1969	-0.235	95	0.990
1970	-0.096	102	0.833
1971	-0.118	99	0.879
1968 - 1971	-0.162	380	0.999

The level of confidence refers to the probability that there is also some degree of association between arson rates and arrest (or conviction) rates in the set of cities from which the sample cities were drawn, that is, in the entire country.

The data in the scatter diagrams of Figures 15 and 16 were grouped by arrest (or conviction) rate into five groups, and the average arsons per 100,000 population were calculated for each group. This was done as described above to remove the effects of changes in factors other than arrest (or conviction) rate. The assumption is that the distributions of the values of the other factors will be similar from group to group, so that the differences in the average arson rates for the groups will be primarily determined by the differences in the arrest (or conviction) rates. Figures 17 and 18 show the results. There is a nearly uniform tendency for the average arson rate to be lower for groups of cities with higher arrest (or conviction) rates.

The confidence which can be placed in this type of analysis depends on the extent to which the groups of cities are similar in their characteristics other than arrest (or conviction) rate. One would expect this similarity to generally increase as the size of the groups increased. Since many cities had low arson arrest and conviction rates (about 20% had an arrest rate of zero, and 30%, a conviction rate of zero) the group sizes used were very uneven. To maximize the group sizes, the cities were ranked by arrest (or conviction) rates and divided into three equal groups. The average arsons per 100,000 population for these groups are shown in Figures 19 and 20.

Again, there is a nearly consistent decline in arson rate. Cities ranking in the upper third according to arrest rate had an average arson rate that was 22% lower than those ranking in the bottom third. Cities in the upper third according to conviction rate had a 26% lower arson rate than those in the bottom third.

That the converse relation -- a decline in average arrest (or conviction) rate for cities ranking higher in arson rate -- is also true is shown in Figures 21 and 22.

In conclusion, it would appear that when averages are taken to remove the effects of extraneous factors, higher arson arrest (or conviction) rates are nearly uniformly associated with lower arson rates. These statistics are consistent with the belief held by many in a causal relation between the two variables. This belief, in turn, forms the basis for the position that

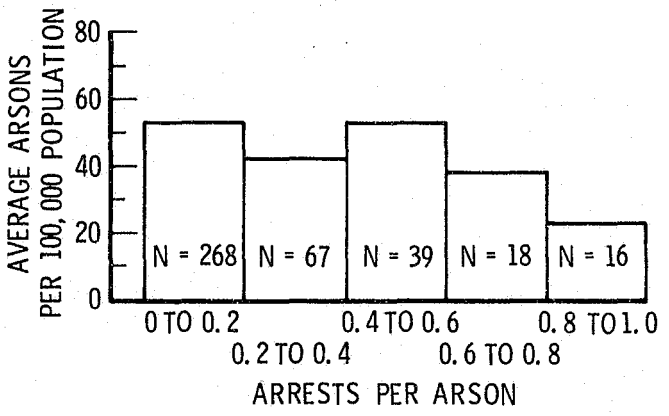

Figure 17. Average Arsons per 100,000 Population for Cities Grouped by Arson Arrest Rate, 1968-1971 (N = 408)

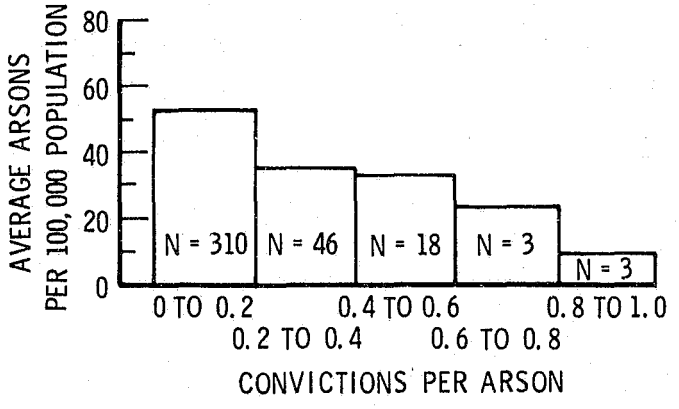

Figure 18. Average Arsons per 100,000 Population for Cities Grouped by Arson Conviction Rate, 1968-1971 (N = 390)

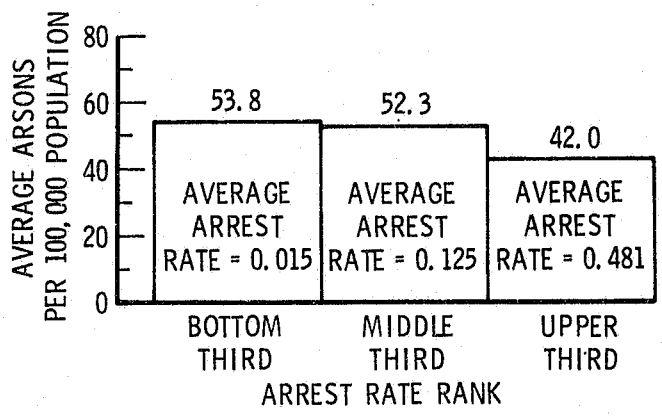

Figure 19. Average Arsons per 100,000 Population for Cities Ranked by Arson Arrest Rate, 1968-1971 (N = 408)

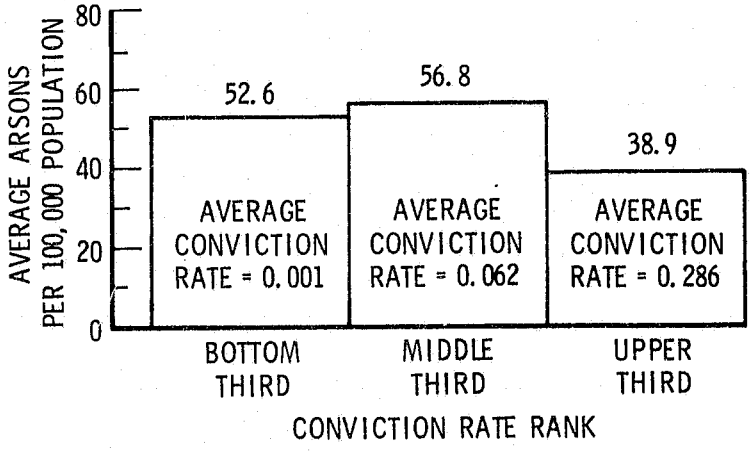

Figure 20. Average Arsons per 100,000 Population for Cities Ranked by Arson Conviction Rate, 1968-1971 (N = 380)

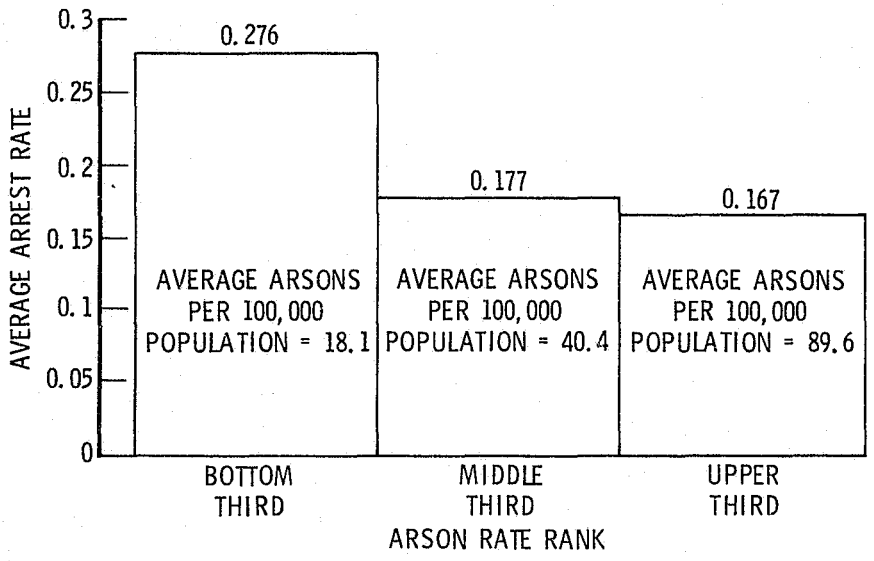

Figure 21. Average Arrest Rate for Cities Ranked by Arsons per 100,000 Population, 1968-1971 (N = 408)

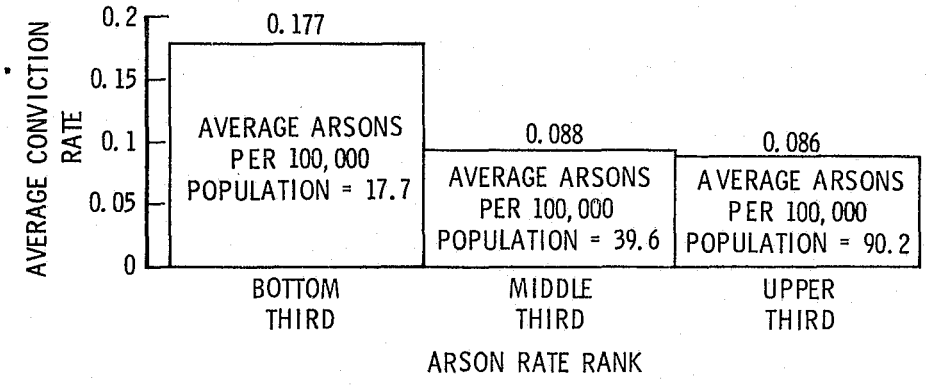

Figure 22. Average Conviction Rate for Cities Ranked by Arsons per 100,000 Population, 1968-1971 (N = 390)

improved arson investigation and prosecution are a primary means for effective control of arson.

CHAPTER V. SURVEY OF NEEDS IN ARSON INVESTIGATION

A. Introduction

A survey of some of the more prominent arson investigators in the country was conducted in order to identify needs in arson investigation and to establish their priorities. The scope of this study did not permit surveying a large and statistically significant sample of the estimated 6000 arson investigators in the country. Instead, a small sample of recognized experts was carefully chosen to maximize the amount that could be learned through a limited survey about current needs in arson investigation. Investigators were selected from those who were prominent in the literature, those who testified before the National Commission on Fire Prevention and Control, those who were prominent in the International Association of Arson Investigators, those who attended the July 1975 Conference on arson and incendiarism at the National Academy of Sciences, and those who were recommended by local (Los Angeles) arson investigators as being among the more active professionals in the field.

A questionnaire (Appendix A) was sent to the 27 arson investigators chosen in this way, and replies were received from 20 (listed in Appendix B). Additional discussions were held with many of the respondents during followup interviews. To provide an opportunity for other interested investigators to participate, an open letter of invitation was published in the October 1975 issue of The Fire and Arson Investigator, the journal of the 3000-member International Association of Arson Investigators. Eight letters containing comments and suggestions were received. The open letter, the names of the eight respondents, and a summary of their comments appear in Appendix C.

The survey questionnaire was drafted after several helpful discussions with arson investigators in the Los Angeles area. It solicits information in the following areas:

- Type of agency with which the investigator is affiliated, manpower, caseloads

- Criteria for conducting investigations, response time to fire scenes
- Methods of arson detection
- Possession and evaluation of flammable vapor detectors
- Most common fire-setting methods used by arsonists
- Types of fire accelerants found and materials in which they were found
- Frequency of physical evidence collection and submission for laboratory analysis
- Scientific and technological needs
- Priorities of needs in arson investigation

B. Characteristics of Responding Agencies

Table 19 shows the types of agencies with which the investigators were affiliated and the average number of investigators per agency.

Table 19. Types of Agencies Responding to the Survey

Type of Agency	Number Surveyed	Average Investigators per Agency
Local fire department	7	11
Private fire investigator	4	1
State fire marshal	4	17
Local police	2	8
Criminalistics laboratory	2	NA[a]
Forest Service (U.S.)	1	33
Total	20	

[a]NA: Not applicable

The average annual number of fires handled by the respondent agencies was 2338 (Table 20), and the annual caseload of their investigators averaged 173. Of these fires, 29% were suspected of being arson. The fraction of the arson cases cleared by arrest was 22%, while the fraction cleared by conviction was 16%. These clearance rates are well above the national average because of the caliber of the agencies surveyed.

Table 20. Arson Case Statistics

Category	Type of Agency				
	Local Fire Department	State Fire Marshal	Local Police	Forest Service (U.S.)	Overall Average[a]
Fires investigated[b]	3640	747	1550	1220	2338
Investigator caseload[b]	340	45	208	36	173
Fires suspected of of being arson (%)	24	53	55	13	29
Arson cases cleared by arrest (%)	18	37	23	5	22
Arson cases cleared by conviction (%)	14	13	21	5	16

[a]Averages weighted by agency caseloads

[b]Per year, averaged over all agencies of that type

Table 21 shows the criteria used by the agencies to determine whether to conduct an investigation. Only one agency (the U.S. Forest Service) routinely investigates every fire, although several others investigate whenever arson is suspected or the cause is unknown, that is, all fires but those for which a known accidental cause has been established by fire suppression personnel.

The questionnaire was directed to those agencies considered to be the most advanced in arson investigation and, thus, the survey results reflect the features of the higher caliber agencies in which the fire officer-in-charge has been trained to detect arson and routinely inspects the aftermaths of fires

to determine their cause. Arson investigations were most commonly initiated by requests for assistance from the officer-in-charge (Table 21); other criteria for initiating an investigation include suspicion of arson, uncertainty of the cause of the fire, and the size and seriousness of the fire.

Table 21. Criteria for Conducting Investigation

Criteria	Number of Agencies, By Type of Agency				
	Local Fire Department	State Fire Marshal	Local Police	Forest Service (U.S.)	Total
Always investigate				1	1
Request by firefighters	4	3	1		8
Arson suspected or cause unknown	5	1	1		7
Exceeding some number of alarms	2				2
Exceeding a monetary limit	2		1		3
Death or serious injury	2		1		3
Total agencies responding: 14					

If the cause of a fire is not investigated shortly after the fire is extinguished, very little can be done afterwards because essentially all potential evidence is destroyed by fire department mop-up and salvage operations. This is a crucial stage in the detection and investigation of arson because cases rely on evidence that is recognized and preserved at this point. As shown in Table 22, most of the investigators surveyed usually arrive at fire scenes within two hours after the criteria for an investigation have been met.

Most often the detection of arson is made subsequent to the suppression of the fire. The primary reason for this is that protection of life and property takes first priority. Occasionally, detection of arson during a fire is attempted through a team of arson investigators at the scene. Of the agencies surveyed, only two respond to fires while they are in progress and only then

Table 22. Response Time to Fire Scenes

Type of Agency	Usual Response Time (Number of Agencies)				
	0-1 Hours	1-2 Hours	2-24 Hours	24-48 Hours	Several Days
Local fire department	6		1		
State fire department		1	1	1	
Local police		1		1	
Forest Service (U.S.)	1				
Private fire investigator					1
Criminalistic laboratory					1
Total	7	2	2	2	2
Total agencies responding:	15				

if they are multi-alarm fires. Detection of arson by investigators while the fire is still in progress usually takes the form of surveillance: an over-zealous offer of assistance by a spectator, or someone constantly driving over fire hoses are grounds for suspecting arson.

In the forest fire scenario, the detection of arson is aided by the practice of U.S. Forest Service firemen en route to conflagrations to take notice of the license numbers of vehicles departing from the scene. This practice is intended to provide witnesses, if not suspects, to a possibly incendiary fire. The California Division of Forestry has an experimental project using video monitors along roadways into woodland areas which are regarded as highly potential incendiary targets. The video monitors record license numbers for the same purpose as stated above. In at least one case, this procedure has led to the arrest of an arson suspect, although it has received criticism from some quarters on the grounds of invasion of privacy.

C. Methods of Establishing Arson

Establishment of arson through the reports of witnesses or the suspicious behavior of spectators as mentioned above is infrequent. The usual methods involve examination of the fire scene. Table 23 shows the procedures listed by the respondents as being the most common method used to

establish arson. Burn indicators are the effect on materials of heating or partial burning and may be used to determine the point or points of origin of a fire. Fire accelerants are flammable materials, such as gasoline, used by arsonists to accelerate the development of fire and to increase the amount of devastation. If either multiple points of origin or traces of fire accelerants are found, arson is indicated.

Table 23. Most Common Methods of Establishing Arson

Type of Agency	Method (Number of Agencies)		
	Interpretation of Burn Indicators	Elimination of Accidental and Natural Causes	Presence of Fire Accelerant
Local fire department	3	3	1
State fire marshal	1		1
Local police	2	1	
Forest Service (U.S.)		1	
Private fire investigator	2	1	
Criminalistics laboratory			2
Total	8	6	4
Total agencies responding: 18			

Flammable vapor detectors are portable devices used by gas utility companies to locate gas leaks and by miners to measure the level of flammable gases in mines. They are also used with varying degrees of success by arson investigators to locate traces of accelerants at fire scenes. Samples of any suspected materials can then be sent to a laboratory for analysis of their chemical composition. As shown in Table 24, about half the arson investigators surveyed used vapor detector equipment. The manufacturers and types of design are shown in Table 25. For an explanation of the principles of operation of the two types of equipment, see Chapter VI.

Table 24. Use of Flammable Vapor Detectors

Type of Agency	Agencies Using Detectors
Local fire department	3
State fire marshal	3
Local police	2
Forest Service (U.S.)	1
Private fire investigator	0
Criminalistics laboratory	1
Total	10
Total agencies responding: 19	

Table 25. Types of Detectors Used

Manufacturer	Type of Equipment	Number of Agencies
Bacharach (maker of Johnson-Williams equipment)	Catalytic combustion detector	8
Davis Vapolert	Catalytic combustion detector	1
Gow-Mac(Tekmar)	Portable gas chromatographic	1

The investigators were also asked for their evaluation of the detectors (Table 26). The responses indicated only fair to poor sensitivity, fair reliability and a lack of specificity (that is, a tendency to indicate the presence of a flammable vapor when none is present).

While a sample of eight arson investigators using flammable vapor detectors is too small to draw any detailed conclusions, it is safe to say that currently available equipment is of limited value in arson investigation. Many investigators do not possess detectors because they are aware of their limitations. Two investigators in our survey, for example, stated that their noses

Table 26. Evaluation of Detectors Used

Characteristic	Good	Fair	Poor	
Sensitivity		2	1	
Reliability	3	2	2	
Specificity		3	3	
Adequate?	Yes: 3	No: 4		Marginally: 1
Total agencies responding: 8				

were more sensitive than their detectors. If their sense of smell could not detect a flammable vapor, then their detector couldn't either. On the other hand, there is a tremendous need for a device that can assist the investigator in quickly and efficiently searching fire scenes for traces of accelerants. Such a device might increase the number of investigations which can be performed with a given level of manpower and increase the level of success in attributing causes to fires and in prosecuting arsonists. As a first step in filling this need, we would recommend that the performance characteristics of detector equipment suitable for arson investigation be established and that testing of existing detector equipment be conducted to see exactly what improvements are required. Establishment of performance characteristics would involve a study of the types and amounts of residues which persist after the burning of flammable liquids.

D. Physical Evidence

The types of physical evidence at an arson scene depend on the fire-setting method used by the arsonist. Table 27 shows the methods found to be most common by the investigators surveyed (several listed two methods as being most common).

Nearly two-thirds of the methods cited involved the use of flammable liquids, particularly gasoline. One urban investigator, for example, stated that pouring gasoline into the hallways or against the sides of buildings and

Table 27. Most Common Methods of Setting Fires

Method	Number of Agencies	
Flammable liquid accelerant	13	(62%)
and flame source	12	
and time delay device	1	
Materials at scene only	8	(38%)
and flame source	7	
and time delay device	1	
Total agencies responding: 16		

igniting it with a match was the most common method he had observed. By contrast, wildlands arsonists most commonly used flammable materials at hand (dry vegetation) together with a time delay device consisting of matches attached to a smoldering cigarette.

The frequencies of the flammable liquids as determined by laboratory analysis are shown in Table 28.

Table 28. Frequencies of Fire Accelerants Found

Accelerant	Frequency (%)[a]
Gasoline	80.1
Kerosene	7.1
Charcoal lighter	4.4
Paint thinner	3.0
Lacquer solvent	0.6
Other	4.8
Total agencies responding: 8 with 5758 arson cases	

[a]Average, weighted by agency caseloads

Gasoline was, by far, the most frequently found fire accelerant, possibly because it is readily available and widely known to arsonists, and also possibly because its characteristic and familiar odor makes it easier to detect than most other flammable liquids. One would expect the sophisticated arsonist to use odorless flammable liquids, but no data are available. The widespread use of suitable flammable vapor detection equipment would resolve this question.

Fire accelerants are usually found on floors, including automobile floors. Table 29 shows the types of materials in which the accelerants are found.

Table 29. Frequencies of Materials in Which Fire Accelerants Were Found

Material	Frequency (%)[a]
Wood	38.3
Rugs	21.1
Upholstery	13.7
Rags	3.7
Paper	3.4
Other	19.6
Total agencies responding: 5 with 3823 arson cases	

[a]Average, weighted by caseloads

Wood flooring and rugs are the most common substrates, followed by furniture and automobile upholstery. These are the materials from which laboratories must separate accelerant residues. Also, the design of flammable vapor detectors for arson investigation must take into account the common substrate materials and their combustion products in order to avoid giving false positive indications. One respondent, for example, commented that the pyrolysis products (chemical fragments produced by heating) of

plastics -- hydrocarbon polymers -- are quite similar to those of fire accelerants.

Table 30 shows the frequency with which the respondents collected physical evidence at fire scenes and the frequency with which the collected evidence was submitted to a laboratory for analysis. Evidence was collected in about two-thirds of the cases and about three-fourths of it was submitted. One would expect these figures to be well above average because of the scientifically advanced nature of the survey group and because of their relatively high accessibility to laboratories (three respondents to this question maintained their own laboratories).

Table 30. Frequency of Evidence Collection and Submission

	Number of Agencies		
	Sometimes	Always	Average Frequency (%)[a]
Collection	10	8	66
Submission of collected evidence	8	10	74
Total agencies responding: 18 with 9789 arson cases			

[a]Weighted by caseloads

The reason most often cited for not submitting collected evidence to a laboratory (Table 31) was that some evidence simply did not require the services of a laboratory. Other respondents, however, stated that they sometimes did not submit evidence because they did not think the laboratory was capable of analyzing it or because the laboratory gave a low priority to arson evidence due to a high volume of drug and alcohol cases (resulting in long delays and the evaporation of poorly packaged evidence).

Table 31. Reasons for Not Submitting Evidence to a Laboratory

Reason	Number of Times Cited
Some evidence requires no further scientific analysis	3
Some evidence requires analysis which is beyond the abilities of the laboratory	2
Arson cases given too low priority by the laboratory	1
Some evidence is found to be irrelevant to the case after it is collected	1
Total agencies responding: 7	

Since the respondents generally did not have records of the frequencies with which they had submitted different types of evidence for laboratory analysis, we asked Dr. Mohammed Gohar, Director of the Ohio State Arson Laboratory, for data on types of evidence received. He kindly agreed to compile statistics from 100 recent arson case files; his results are shown in Table 32. Fire accelerant samples were by far the most commonly received type of evidence.

Table 32. Types of Evidence Received for Analysis, Ohio State Arson Laboratory, 1975

Evidence	Frequency (%)
Fire accelerant	80
Explosives	13
Incendiary devices	4
Electrical	3
Sample size: 100 arson cases	

Through discussions with criminalistic laboratories we learned that the questions most often asked in a request for the analysis of arson debris were the following:

- Is there fire accelerant present?
- Can the accelerant be identified?
- Can the accelerant be matched to a flammable liquid in the possession of the suspect?

Of these questions, the most difficult and controversial is the last. It is the process known as individualization of flammable liquids and is an appropriate subject for scientific research.

The predominant type of container used to preserve physical evidence from arson scenes is the unused metal paint can (Table 33). These containers are vapor-tight and unbreakable. Plastic bags, while convenient and inexpensive, are easily punctured, are chemically attacked by some types of evidence, and allow the loss of some volatile evidence by diffusion through the bag.

Table 33. Containers Used to Preserve Physical Evidence

Type of Container	Number of Agencies Sometimes	Always	Average Frequency (%)[a]
Metal can	14	2	79
Glass container	13	1	9
Plastic container	2	1	9
Plastic bag	11	0	3
Total agencies responding: 19 (7 gave frequencies)			

[a]Weighted by caseloads

As shown in Table 34, the type of laboratory most often used for the analysis of arson evidence was the criminalistics laboratory. This was followed by commercial laboratories where some arson investigation agencies contract for laboratory services not available through local government.

Table 34. Types of Laboratories Used for Analysis

Type	Number of Times Cited
Criminalistics	17
Commercial	7
Toxicology	2
State arson lab	1
Coroner's	1
Fire department	1
Department of water and power	1
Total agencies responding: 19	

E. Scientific and Technological Needs

The respondents were asked whether five given areas of scientific research were needed in arson investigation. The results are shown in Table 35.

Table 35. Priorities of Scientific Research for Arson Investigation

Rank	Area	Number Citing Need
1	Methods to determine whether short circuits were the cause or effect of a fire	16
2	Reliability of burn indicators	15
3	Persistence of flammable liquids in fires	14
4	Individualization of flammable liquids	10
5	Burning characteristics of cigarettes	10
Total agencies responding: 20		

The most commonly cited research need was for the development of methods to analyze electrical wiring found in the aftermath of a fire. There is, very often, electrical wiring with melted or burned insulation, and the wires themselves may be in contact, may show signs of melting, or may be fused together. If no other cause for the fire has been determined, the question then arises as to whether it had been caused by hot, overloaded wiring or whether there was some other cause (perhaps arson) and the condition of the wiring was simply the result of the fire. At the present time there is no reliable method for making this determination. The nature of and the need for the next three areas of research -- reliability of burn indicators, persistence of residues of flammable liquids, and individualization of flammable liquids -- are discussed in Chapter VI. The last area of research -- the burning characteristics of cigarettes -- involves finding the circumstances under which cigarettes can cause fires. Some experts believe that cigarettes are blamed for many more fires than is actually the case.

The respondents were also invited to suggest areas which they believed needed scientific research. The resulting list is shown in Table 36.

Table 36. Other Scientific Research Suggested

	Area	Number Citing Need
1.	Processes causing electrical fires	2
2.	Method to determine whether a fluorescent light ballast caused a fire	1
3.	Study of residues of fire accelerants	1
4.	Study of pyrolysis products of substrate materials	1
5.	Flash point determination of small evidence samples	1
6.	Research on smoke and soot as investigative aid	1
7.	Research on causes of fires	1

Total agencies responding: 5

The second area is similar to the first one in Table 35: the problem is to determine whether a charred piece of electrical equipment had caused a fire or had been burned by a fire due to some other cause. The flash point mentioned in the fifth area is the lowest temperature at which a flammable liquid gives off sufficient vapors that they can be ignited. Determination of the flash point of an unknown liquid establishes it as flammable and helps to determine its identity. The smoke and soot research refers to a study of the possibility of detecting the presence of fire accelerants from smoke during a fire or from deposits of soot left after a fire on smooth surfaces such as glass window panes.

The respondents' opinions about the need for three technological developments areas are shown in Table 37.

Table 37. Priorities of Technological Developments for Arson Investigation

Rank	Area	Number Citing Need
1	Vapor detector for arson investigation	14
2	Instrument for analyzing smoke or soot	13
3	Photography	6

Total agencies responding: 20

Two-thirds believed that a flammable vapor detector suitable for arson investigation and a device for analyzing smoke and soot for the presence of fire accelerants should be developed. Only one-third cited a need for research and development in photography. Some noted that photographic equipment is already sufficiently sophisticated, and that the real need is for training arson investigators in its effective use at arson scenes.

When asked to specify any other technological developments that are needed, the respondents cited the list shown in Table 38.

Table 38. Other Technological Development Suggested

	Area	Number Citing Need
1.	Mobile crime scene lab	1
2.	Chemical detector for presence of lead	1
3.	Application of computer science to arson investigation	1
4.	Improved polygraph techniques	1

Total agencies responding: 4

F. Priorities of Needs in Arson Investigation

The respondents were asked to assign priorities to a list of eight needs in arson investigation. Table 39 shows the eight needs listed in decreasing order of the average value of the assigned priorities. A brief discussion of each need follows the table.

1. Increased training. Arson investigators must be trained both in the technical aspects of fire and fire investigation and also in police methods of criminal investigation. Fire officers who assign causes to fires must be trained in arson detection. Prosecutors and judges must be trained in the technicalities of arson cases. Respondents commented that instructors should have field experience and that students should be exposed to a large number of practice fires involving fire accelerants.

2. More arson investigators. Many fires are never investigated because of a lack of manpower. More investigators are needed to conduct followup criminal investigations of incendiary fires to apprehend a suspect. Increased manpower would allow investigators to respond earlier and work longer on each case.

3. Computerized arson investigation data system. Many arson investigators believe that arsonists recidivate: that a single individual will cause many fires, whether the motive be fraud or pyromania. Further, these

Table 39. Priorities of Needs in Arson Investigation

Rank	Need	Number Citing Need	Average Relative Priority[a]
1	Increased training	20	2.8
2	More arson investigators	18	2.8
3	Computerized arson investigation data system	18	4.0
4	Scientific research	20	4.5
5	Cooperation from insurance companies	16	4.8
6	Technological developments	19	5.0
7	Clarified jurisdiction over arson cases	18	5.2
8	Increased availability of crime laboratories	18	5.8

Total agencies responding: 20

[a]Scale of 1 (highest) to 8 (lowest of the 8 needs listed)

individuals are not recognized because information is not shared by agencies and insurance companies and it is not transmitted from state to state. These investigators believe that a nationwide, computerized data system available to (and only to) authorized investigators should be established and should contain such information as: names, aliases, and modus operandi of previously arrested arsonists; unsolved arson fires, fraud fires, and fires suspected to be the work of organized crime; potential arson suspects such as persons who have made many fire loss claims and owners of overinsured property; unscrupulous insurance agents, brokers, and adjusters; and crooked fire repair and salvage contractors. Precedents for such a system are to be found in the hand-filed system once maintained by the now defunct National Board of Fire Underwriters and in a system currently operating in Canada.

4. Scientific research. The areas of scientific research in arson investigation thought to be needed by the respondents were listed in Tables 35 and 36. At the present time there is only minimal application of scientific resources to the control of arson. All investigators agree that the investigation of arson requires a certain level of scientific knowledge, especially in the examination and interpretation of physical evidence, but many believe that the body of knowledge available in this area has not kept pace with general scientific progress.

5. Cooperation from insurance companies. The insurance industry could play a potentially powerful role in preventing arson by taking the profit out of it. This would be through more careful and selective underwriting practices, such as avoidance of overinsuring, overseeing poor risks and multiple losses, and resistance to fradulent claims. They should avoid paying claims until the investigation has been concluded. They should defend against fradulent claims in civil proceedings (where a preponderance of evidence is sufficient) when the evidence is insufficient for a criminal conviction (proof beyond a reasonable doubt). They should provide information on extent of fire insurance coverage to fire investigators.

6. Technological developments. The technological developments in arson investigation seen as needed by the respondents were discussed in Tables 37 and 38. As with scientific research, arson control has received very little technological development effort. A reliable detector for residues of fire accelerants would be of great value, but existing vapor detectors, used by some for that purpose, were developed for other purposes. A research and development program for equipment suitable for arson investigation is needed.

7. Clarified jurisdiction over arson cases. Either law enforcement or fire service agencies may have the responsibility for arson detection and investigation, and this responsibility is too often ambiguous. Clearly, there are certain functions in the process of investigating arson cases that are performed better by policemen and others better by firemen. But without the willing cooperation of both, it is impossible for a full investigation to

materialize. The official joint position of the International Association of Fire Chiefs and the International Association of Chiefs of Police is close liaison and full cooperation between law enforcement and fire agencies in arson investigation, with fire investigation and arson detection being the responsibility of the fire service and with criminal investigation of fires established as arson being the responsibility of the law enforcement agencies.

8. Increased availability of crime laboratories. The availability of laboratory analysis can have a strong influence on the extent to which physical evidence is utilized in arson investigation. If investigators believe that the lab is incapable or too busy to analyze arson evidence, or that long delays will result in volatile evidence evaporating before it is analyzed, the evidence will not even be collected. Because of the advanced nature of the respondents to this survey (three of them maintain their own laboratories), the relatively low priority they give to increasing laboratory availability may not be representative of arson investigators at large.

The respondents were asked to suggest any other needs in arson investigation and to express any other comments they might have. Their replies are shown in Table 40. With the exception of the most commonly cited need -- including arson in the FBI Uniform Crime Reporting System and listing it as a Crime Index offense -- the comments in Table 40 are self-explanatory and need not be discussed further. The FBI Uniform Crime Report is an annual national survey of crime reported to police. In 1974, reports from 11,000 jurisdictions containing 94% of the country's population received. In order to indicate the probable total extent, geographical distribution, and temporal fluctuation of crime in the United States, the Reports use a Crime Index consisting of the offenses of murder, forcible rape, robbery, aggravated assault, burglary, larceny-theft, and motor vehicle theft. In the more than 40 years that they have been published, the Reports, and in particular the Crime Index, have become a leading social indicator. Crime Index fluctuations receive wide publicity in the news media and are used by government officials and law enforcement agencies to measure progress, or lack of progress, in the war against crime. Inclusion of arson in

Table 40. Other Needs and Additional Comments

	Area	Number Citing Need
1.	Include arson in the FBI Uniform Crime Reporting System and list it as a Crime Index offense	4
2.	Legislate police powers for arson investigators	3
3.	Increase knowledge of fire and police supervision in seriousness of arson and time, effort, expertise required to investigate	3
4.	Include a large number of practice fires using accelerants in investigator training	3
5.	Train investigators in arson scene photography	3
6.	Increase public awareness of arson as a serious and growing violent crime	2
7.	Accurately determine the causes of all fires	2
8.	Make LEAA funds available for arson investigation as they are for other serious crime investigation	2
9.	Train prosecutors and judges for arson cases	2
10.	Train investigators in both fire and police investigation methods	2
11.	Have insurance companies defend against fraudulent claims in civil court	2
12.	Train officers in volunteer fire departments in arson detection	2
13.	Have investigators respond at the time of the alarm to maximize evidence	2
14.	Increase awareness of city budget officials of arson problem	1
15.	Increase funding	1
16.	Increase manpower for followup investigations to arrest offenders	1
17.	Furnish adequate equipment for investigators	1
18.	Promote cooperation among government agencies, fire, police, insurance industry, and citizens	1
19.	Have arson investigation performed by a team of both firefighters and police	1
20.	Increase assistance to arson investigators by insurance industry	1
21.	Training by instructors with much field experience	1
22.	Improve investigator training at academic level	1
23.	Publish arson investigation field manual	1
24.	Prosecute arson cases more aggressively	1
25.	Judges fail to impose sentences available under existing laws	1

Total agencies responding: 11

the Crime Index would, undoubtedly, increase public awareness and concern, and would increase the motivation of law enforcement officials to attempt to reduce arson. However, there is a question as to the compatibility of arson with the FBI criteria for inclusion of an offense in the Crime Index, namely:

- Seriousness
- High frequency of occurrence
- Strong likelihood of being reported to the police

There can be no question that arson meets the first two criteria. Nor is the reporting rate for arson any lower than for the Index offenses.* The difficulty is that the data on the number of arson incidents does not readily come to the attention of the law enforcement agencies participating in the Uniform Crime Reporting System. As can be seen in Table 13 (Chapter III), both the detection and investigation of arson are the responsibility of the fire service in most states.

At present, the only source of arson statistics is the National Fire Protection Association, a private organization whose periodicals are sent only to its members and receive relatively little public attention. Whether it be in the FBI Crime Index as recommended by the survey respondents or in some other forum, arson statistics require accurate, authoritative, highly visible, governmental collection and publication.

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*In a 1974 survey of households and businesses conducted by the U.S. Bureau of the Census for the Law Enforcement Assistance Administration, it was found that only about 42% of the incidents of crime were reported to the police. (See "Criminal Victimization in 13 American Cities," Law Enforcement Assistance Administration, U.S. Department of Justice, Washington, D.C., June 1975.) On the other hand, if we assume that the actual number of arsons is equal to the number of fires classified as incendiary or suspicious plus one-half the fires of unknown cause, then the total arson reporting rate was 37% in 1974 and was 59% for building arson (see Table 4, Chapter I.) Even if all fires of unknown cause were actually incendiary, the reporting rate would have been 23% for total arson and 42% for building arson.

CHAPTER VI. TECHNICAL METHODS IN ARSON INVESTIGATION

A. Introduction

The purpose of this chapter is to review the status of some of the more important technical methods and equipment used in arson investigation. The emphasis is on the general principles, capabilities, and limitations of these techniques and on areas of needed improvement. As such, the chapter is neither a manual of arson investigation nor a detailed technical description of methods or equipment. A comprehensive supplemental bibliography is provided for the reader who wishes to pursue either of these topics.

This chapter focuses on technical methods and equipment for the detection, recovery, and analysis of flammable liquid fire accelerants and on the interpretation of burn indicators both because of their importance and because they constitute the bulk of the technical methods in use.

The detection, recovery, and analysis of fire accelerants are of major concern to arson investigators. Tables 27 and 32 of Chapter V, for example, indicate that flammable liquid fire accelerants were found by the surveyed investigators to be involved in 62% of arson cases and constituted 80% of the evidence received by the Ohio arson laboratory. The presence of flammable liquids can be used to establish that arson was committed and can sometimes be used to link a suspect to the fire.

The objection is sometimes raised that identifiable amounts of liquid fire accelerants rarely survive a fire so that any effort or funds expended for their detection would be largely wasted. While a scientific investigation of this subject seems to be lacking, the day-to-day experience of arson investigators, as indicated, for example, in the survey in Chapter V, is that accelerant residues are often found. Furthermore, experiments have been performed that demonstrate that accelerants can survive fires. Nicol,[74]

for example, performed the following experiment: he poured 2-1/2 gallons of kerosene over furniture and rugs in one room of a wooden building, 1 gallon of gasoline over straw in another room, and left a trail of gasoline as a fuse. The building was allowed to burn freely and completely. He was able to extract identifiable amounts (more than 1 milliliter*) of both kerosene and gasoline from the debris.

The areas most likely to contain residues of liquid fire accelerants are floors, carpets, and soil since, like all liquids, they run to the lowest level. Furthermore, these areas are likely to have the lowest temperatures during the fire and may have insufficient oxygen to support the complete combustion of the accelerant. Porous or cracked floors may allow accelerants to seep through to the underlying earth. Numerous instances have been recounted of the excellent retention properties of soil for flammable liquids.[75-76] Another place where accelerants may be discovered is on the clothes and shoes of the suspect.

Since each method of accelerant detection (including the human nose) has a threshold sensitivity, another question which arises is the vapor concentration which is produced by accelerant residues. Some idea of the order of magnitude can be obtained from the experiment of Hilliard and Thomas described in more detail in the next section. They burned small (2-milliliter) samples of various accelerants for 30 seconds and then measured vapor concentrations ranging upward from 60 parts vapor per million parts air -- within the range of detection of currently available portable detectors (Appendix D), and generally, but not always, well above readings produced by hydrocarbons from such things as burnt wood and burnt mattresses.

Another way of looking at the potential vapor concentration is to consider the following hypothetical case: suppose a gallon of gasoline is used to accelerate a fire in a 15 by 15 by 8 foot room and that 1% (39 milliliters) survives the fire in cracks in the floor. (The residue would consist of higher

*There are approximately 30 milliliters in a fluid ounce.

boiling point components, such as naphthalene.) The subsequent evaporation of 1 milliliter (3%) of the residue would produce an average vapor concentration of 2.7 parts per million throughout the entire volume of the room. Such a concentration can be detected with currently available equipment. Ventilation of the room, of course, dissipates the vapor and generally causes the vapor concentration to be highest at the points where the residues are located, a situation which can be used to advantage in locating evidence samples to be preserved for laboratory analysis.

B. Detection of Fire Accelerants

Several types of portable equipment are available to the arson investigator for detecting residues of flammable liquids at fire scenes: detectors using chemical color tests, catalytic combustion detectors, flame ionization detectors, gas chromatographs, and infrared spectrophotometers. The sensitivities, limitations, advantages, and disadvantages of each of these are discussed in the following subsections. In addition, Appendix D contains the approximate sensitivities and costs of many of the commercially available flammable vapor detectors.

1. Olfactory detection. The sensitivity of the human nose to gasoline vapor appears to be on the order of one part per ten million. Gasoline is a complex mixture of chemical compounds, the proportions of which vary with the source of the crude oil and the type of process used in its manufacture.[77] Benzene and other aromatic hydrocarbons, for example, may constitute from 0.1 to 40% of the mixture. While no data on the sensitivity of the nose to gasoline could be found in the literature, the sensitivity of the nose to benzene vapor is 0.015 parts per million.[78-79] Assuming that 15% (or more) of gasoline vapor consists of aromatic hydrocarbons to which the nose is as sensitive as it is to benzene, then the sensitivity to gasoline is one part in ten million (or greater). As can be seen in Appendix D and the following discussion, the nose is as sensitive as any of the currently available detector equipment. As mentioned in Chapter V, interviewed arson investigators using vapor detectors stated that their noses were as sensitive as their

equipment. The nose is also fairly specific and can accurately identify many fire accelerants, particularly gasoline.

On the other hand, there are flammable liquids to which the nose is not sensitive. Another problem, called olfactory fatigue, is the tendency of the nose to lose its sensitivity to an odor after prolonged or intense exposure to it. Further, the odor of fire accelerants may be masked by another strong odor such as that of burnt debris. In fact, in one case[80] an arsonist attempted to camouflage the presence of gasoline by mixing vanilla with it to mask the odor. Finally, it may be inconvenient or impossible to search for accelerant odors with the nose along floors or in recessed areas, a task which can be more easily performed with certain types of detector equipment.

2. Chemical color test detectors. Chemical color tests may be used to detect both liquid accelerant residues and their vapors. Certain dyes can be spread in suspected areas and will indicate the presence of hydrocarbons by turning red.[81-82] This method is less sensitive and less specific to flammable liquids than other methods which are available. Further, the dye may interfere with subsequent laboratory tests intended to identify the accelerant. Hydrocarbon vapors can be detected by pumping a suspected sample through a glass container of reagent which changes color in the presence of hydrocarbons. The reported sensitivity of this method is on the order of one part per thousand.[83] Again, the method is less sensitive and less specific (reacts to hydrocarbons which are not fire accelerants) than others available. Its main advantages are low cost ($100 for the vapor detector) and simplicity.

3. Catalytic combustion detector. The most common type of flammable vapor detector used by arson investigators operates on the catalytic combustion principle and is popularly known as a sniffer, combustible gas indicator, explosimeter, or vapor detector. These detectors are portable, moderate in cost ($200-$800), and fairly simple to operate. In operation, vapor samples are pumped over a heated, platinum-plated coil of wire which

causes any combustible gas present to oxidize. The heat from the oxidation raises the electrical resistance of the coil and this change in resistance is measured electronically.[84-85] A sensitivity (to hexane vapor) on the order of a few parts per million can be achieved using this method. Since oxygen is required for the operation of this type of detector, the sensitivity is reduced in oxygen-deficient areas, but these are unlikely to occur in arson investigations. (Also, an internal source of oxygen could be fitted to an improved detector if it were found to be required.) Another problem is the gradual loss of sensitivity when this type of detector is exposed to gasoline containing lead. Lead deposits form on the platinum catalyst and interfere with its operation.

Table 41 shows the results of testing a commonly used detector of this type (the Johnson-Williams Model SS-P) by staff of the Crime Detection Laboratory of the Michigan State Public Health Department.[86] While the detector correctly indicated the presence of the more volatile fire accelerants (gasoline, paint thinner), it gave low readings for the less volatile accelerants (fuel oil, turpentine). This situation is serious since it could cause an investigator to overlook such accelerants while searching a fire scene. The problem of false positive indications (from rubber carpet padding, ammonia, sewer gas) is less serious since the lack of an accelerant would be observed by the laboratory when the debris was submitted for analysis.

4. Flame ionization detector. In the flame ionization detector, the sample gas is mixed with hydrogen and the mixture is burned. Ionized molecules are produced in the flame in proportion to the amount of combustible organic gases in the sample. (Pure hydrogen, air, and water vapor produce little ionization.) The degree of ionization is then measured by using an electrometer to determine the resulting increase in the electrical conductivity of the gas. The sensitivity of this method (to methane) is on the order of one part in ten million. It is thus more sensitive but more complex and expensive (about $3000) than the catalytic combustion method.

Table 41. Vapor Detector Readings from Burnt Materials

Material	Reading (parts per million)	
	Immediately After Extinguishment	24 Hours Later[a]
Typical Background Readings		
Newspaper	10	0
Asphalt tile	10	10
Acrylic carpet with jute backing	40	0
Wood (pine)	210	30
Cotton mattress padding	220	670
Wood (maple)	400	110
Accelerant Residues[b]		
Lighter fluid	400	0.20 LEL[c]
Coleman fuel	650	0.64 LEL
Paint thinner	760	0.16 LEL
Gasoline	0.22 LEL	0.77 LEL
False Negative Indications		
No. 2 fuel oil	60	60
Turpentine	300	300
False Positive Indications		
Nylon carpet with rubber backing	0.20 LEL	0
Ammonia vapors	1.0 LEL	1.0 LEL

[a]After storage in a sealed plastic container

[b]2-milliliter sample burned on wood 30 seconds, then extinguished

[c]LEL: lower explosive limit (= 11,000 parts per million for hexane)

5. Gas chromatograph. The portable gas chromatograph adapted for field use, sometimes called the arson chromatograph, is, to our knowledge, the second most common type of vapor detector used by arson investigators. Each of the 10 state arson investigators in Ohio has one, and state arson investigators in West Virginia are using five more. In the gas chromatograph, the sample gas is first separated into components based on the speed with which the components travel through a tube filled with a packing material. The amounts of each of the separated components are then measured with either a catalytic combustion or flame ionization detector. The sensitivity ranges from a few hundredths of a part per million to a few parts per million depending on the type of detector used. The main advantage is a great enhancement in specificity because of the preliminary separation process: the distribution in the amounts of components with various travel times tends to be a unique characteristic of chemical compounds. The principal disadvantages are its size, weight, and cost ($2000 to $4000). Also, the time required for the analysis of each sample is about one-half hour, which can be a disadvantage in some situations. (In addition, there is an initial setup time of about one hour.) The operation of the gas chromatograph is considerably more complex than the detectors mentioned and requires a certain amount of technical training.

6. Infrared spectrophotometer. To the best of our knowledge this type of flammable vapor detector is not currently being used by arson investigators. Infrared spectrophotometers can achieve very high specificity to flammable liquids and high sensitivity (on the order of hundredths of a part per million). In operation, infrared light of varying wavelength is directed through the sample and the amount of light passing through is plotted on a pen recorder. The recording can then be compared with those of known compounds to determine the identity of the sample. Since the chemical bonds in a compound determine the way in which it absorbs infrared radiation, these recordings (called spectrograms) are unique for different compounds.

However, evidence mixed with impurities must be purified before it can be successfully identified. In particular, since water vapor absorbs infrared light, it interferes with the identification of flammable vapors. This is a disadvantage in arson investigation, where water is commonly present. A final disadvantage is the high cost of this type of detector ($3000 to $5000).

7. Ultraviolet fluorescence. This is a relatively new and untested method which may prove to be very useful in arson investigation.[87] The procedure consists simply of illuminating the darkened fire scene with an ultraviolet lamp. Certain substances, including constituents of gasoline and its residue, absorb the ultraviolet light and release the energy as visible light. These substances appear to glow against the darkened background. The color with which the substances glow is affected by exposure to heat, and thus, the method can be used not only to locate accelerant residues but also to help locate the point of origin of the fire. The only equipment required is an ultraviolet lamp and a portable power supply (total cost: $50 to $200). The sensitivity of the method appears to be comparable to other methods of detection. One of the authors, for example, performed an experiment in which two drops of gasoline were burned to completion on a block of wood. Examination of the wood under ultraviolet light revealed a distinct glow in the area where the gasoline had burned. The main disadvantage of the method is that it requires testing -- particularly to identify those fire accelerants to which it does not respond. In view of the simplicity, low cost, and high potential of this method for rapidly searching fire scenes for accelerant residues, it is recommended that the method receive thorough scientific testing and that a procedural manual be prepared for use by arson investigators.

C. Considerations for an Improved Fire Accelerant Detector

The equipment currently being used by arson investigators for the detection of accelerant residues was originally developed for other purposes. As discussed in the previous section, these detectors have certain disadvantages and limitations when applied to the problems of arson investigation.

The development of a detector specifically for arson investigation should take into consideration the chemical composition of the commonly used accelerants and their residues. Research aimed at finding distinguishing characteristics of these substances should be performed to serve as a basis for their detection. A first step in this direction was taken by Mach[88] who found that a common feature of gasoline and its burnt residue was the presence of a class of compounds known as polycyclic aromatic hydrocarbons.

Some operational criteria for a suitable detector are the following:

- Sensitivity. The equipment should be at least as sensitive to accelerant vapors as the human nose. It should respond to all commonly used accelerants.
- Portability. The detector in its carrying case should be small enough and light enough to be carried to the fire scene easily by one man.
- Cost. The cost should be moderate. Since capital outlays of more than $1000 are usually considered major expenditures requiring extensive justification, this is probably an upper practical limit for the cost.
- Simplicity. The equipment should require a minimum of operator training for reliable operation and a minimum of setup time for each use. It should be rugged enough for field use.

D. Recovery and Individualization of Fire Accelerant Residues

Before they can be analyzed, accelerant residues must first be separated from the ashes, wood, carpeting, or other material in which they are found. This extraction is usually accomplished by one of three types of distillation: simple, steam, or vacuum. They are listed in increasing order of efficiency of extraction, particularly of the higher-boiling-point petroleum products, and also in order of increasing complexity of the apparatus. Both steam and vacuum distillation are capable of extracting 64% of any gasoline from debris, while for heating fuel oil the efficiencies are 30% and 90%, respectively.[89]

There are some problems remaining to be solved in the extraction of accelerants. Yates,[90] for example, has cited the need for simpler, less expensive methods so that the less well equipped criminalistics laboratories may use them. He also called for a simple method of removing contaminants (such as adhesives and plasticizers) from the recovered accelerants to allow their analysis without damaging the equipment (usually a gas chromatograph).

We use the term "individualization" to refer to the process of analyzing physical evidence for distinguishing properties so that it may be characterized as uniquely as possible. In order of increasing degree of individualization, an evidence sample from a fire scene might be established as: (1) a flammable liquid, (2) a certain kind of flammable liquid (for example, kerosene or gasoline), or (3) the product of a certain manufacturer. Such information can be used to establish the fire as arson and may be helpful in locating or implicating a suspect.

Until the appearance of the gas chromatograph around 1960, samples of flammable liquids were identified by measuring such physical properties as flash point (lowest temperature at which its vapor can be ignited), boiling point, density, and optical refractive index. Flash point is of particular interest since a number of states prohibit the possession of firebombs or other incendiary devices, which are defined as containing flammable liquids with a flash point below 150°F.

The gas chromatograph separates gases or liquids (which are first vaporized) into components according to their travel time through a long, thin, filled column, and then measures the amount of each of the components as they emerge. These distributions tend to be unique for different organic compounds and mixtures (such as gasoline) and can be used to identify an unknown sample. Very small samples (one-tenth of a microliter) are required, and even burned accelerant residues can be identified as to type. However, the question of whether the manufacturer of a sample of gasoline can be identified is a matter of controversy. Cadman,[91] Lucas,[80] and Chisum[92] have reported success in determining gasoline brands and even batch differences within the same brand, as well as differences between

regular and premium grades. Midkiff[93] disputes such claims, contending that the current wholesaling practices and marketing agreements in the petroleum industry make this an uncertain, if not futile, endeavor. Yates[90] cites the resolution of this question as a current research need in arson investigation.

The separated components emerging from the gas chromatograph may be routed to a mass spectrometer for identification of their chemical composition. The mass spectrometer measures the molecular weight of the unknown compound by ionizing it and passing it through a magnetic field where its trajectory is determined by its mass and electrical charge. The combined gas chromatograph-mass spectrometer is a very powerful instrument but its high cost ($50, 000) limits its ownership by crime or arson laboratories. An important application has been research work such as that of Mach[88] on the composition of burned gasoline residues. Such research may lead to simpler methods for detecting these compounds.

A final type of instrument useful in the identification of accelerant residues is the spectrophotometer. In this device, light (which may be infrared, visible, or ultraviolet) of varying wavelength is directed through the sample and the amount passing through is measured. This distribution is a unique characteristic of organic compounds and can be used to identify very small unknown samples (two-tenths of a microliter). A limitation is that the substance to be analyzed must be purified before the analysis can be made.

E. Burn Indicators

Burn indicators are the effects on materials of heating or partial burning which are used to indicate various aspects of a fire such as rate of development, temperature, duration, time of occurrence, presence of flammable liquids, and points of origin. Interpretation of burn indicators is a principal means of determining the causes of fires. The surveyed arson investigators cited interpretation of burn indicators as the most common method of establishing arson (Table 23, Chapter V). Some of the burn indicators used are the following:[94-96]

- Alligatoring effect: checking of charred wood, giving it the appearance of alligator skin. Large, rolling blisters indicate

rapid, intense heat, while small, flat alligatoring indicates long, low heat.

- Crazing of glass: formation of irregular cracks in glass due to rapid, intense heat -- possible fire accelerant.
- Depth of char: depth of burning of wood -- used to determine length of burn and thereby locate the point of origin of the fire.
- Line of demarcation: boundary between charred and uncharred material. On floors or rugs, a puddle shaped line of demarcation is believed to indicate a liquid fire accelerant. In the cross section of wood, a sharp, distinct line of demarcation indicates a rapid, intense fire.
- Sagged furniture springs: because of the heat required for furniture springs to collapse from their own weight (1150°F) and because of the insulating effect of the upholstery, sagged springs are believed to be possible only in either a fire originating inside the cushions (as from a cigarette rolling between the cushions) or an external fire intensified by a fire accelerant.
- Spalling: breaking off of pieces of the surface of concrete, cement, or brick due to intense heat. Brown stains around the spall indicate the use of a fire accelerant.
- Freezing of leaves: drying of leaves in a forest fire into their position at the time of the fire. Since leaves turn during the day to face the sun, their position indicates the time of day.

Although burn indicators are widely used to establish the causes of fires, they have received little or no scientific testing. There appears to be no published material in the scientific literature to substantiate their validity. In reference to freezing of leaves Derr[96] states that "Some persons are inclined to regard this evidence as unreliable because of insufficient clinical and research confirmation and the influence of the fire wind." Kirk[97] cautions that puddle-shaped lines of demarcation may be due to many causes which have nothing to do with flammable liquids. He also

points out[98] that depth of char is strongly affected by factors other than burning time (such as temperature and species of wood) and that much greater care must be taken in its interpretations than is frequently the case.

It is recommended that a program of carefully planned scientific experiments be conducted to establish the reliability of currently used burn indicators. Of particular importance is the discovery of any circumstances which cause them to give false indications (of, say, a fire accelerant). A primary objective of this testing would be to avert the formidable repercussions of a court ruling on the inadmissability of burn indicators on the grounds that their scientific validity had not been established. In addition, the research might well uncover new methods of value to fire and arson investigators. A handbook based on the results of the testing program should be prepared for field use by arson investigators.

CHAPTER VII. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

Arson is a violent crime. In 1975, 1000 people were killed and another 10,000 were injured by arsonists. It is also the costliest of property crimes. That same year, the estimated total loss due to arson was $1.4 billion. And it is growing at a prodigious rate. Between 1965 and 1975 the number of building arsons increased 325%.

Unfortunately, the magnitude of the arson problem is not widely appreciated, probably because of the lack of a well known source of reliable arson statistics. The collection of statistics is complicated by the fact that the type of agencies responsible for arson detection and investigation vary from state to state and from city to city. Depending on the locale, the responsibility may lie with the local police, state police, local fire department, state fire prevention bureau, state fire marshal, or insurance company involved. At present, the only source of national arson statistics is the National Fire Prevention Association, a private, nonprofit organization which conducts an annual survey of 2000 fire departments (out of a possible 24,000). Results are published in its Fire Journal, which is sent to members of the association. On the other hand, national statistics on all other types of crime are collected by the FBI under its Uniform Crime Reporting System, which collects reports from 11,000 local law enforcement agencies. The annual FBI Uniform Crime Report is one of the best known sources of social statistics in the United States.

The plethora of types of agencies responsible for arson extends to the federal level, where at least three executive departments (Justice, Commerce, and Agriculture) have jurisdiction. In spite of this, or perhaps because of it, there has not been a major effort against arson. In particular, there has been little scientific research in the arson area or research and development of equipment for arson investigation.

A unique aspect of arson as a crime is that usually an investigation must take place before it is even known that a crime was committed. Because of the difficulties involved and because of a shortage of trained arson investigators, such investigations are often cursory or nonexistent. About 40% of building fire losses are in fires of unknown origin. Many experts believe that one-half of these and some of those classified as accidental were actually incendiary.

Studies of convicted and imprisoned arsonists showed a tendency for the adult arsonists to be motivated by revenge (55%), while vandalism was the motive of 80% of the juveniles (who constituted 60% of the arson arrestees in 1974). Fraud was the motive of only 5% of these arsonists (but was implicated in 17% of a sample of arson cases). Most of the adult arsonists were problem drinkers. If certain types of arsonists are more likely to be convicted and imprisoned, however, these may well not be the characteristics of the class of all arsonists. These characteristics should be established in order to develop and evaluate methods of arson prevention.

Current arson arrest and conviction rates are low -- about 9 persons arrested, 2 convicted, and 0.7 incarcerated per 100 fires classified as incendiary or suspicious. (This compares with 21 arrests, 6 convictions, and 3 incarcerations per 100 Index crimes.) A number of factors contribute to this situation. There is a shortage of trained investigators. There are usually no witnesses. There are investigative difficulties due to the destruction caused by the fire and by its extinguishment. There is sometimes confusion about the responsibilities of the police and the fire service in arson investigations. There are difficulties in prosecuting arson cases, since they often rely on circumstantial and physical evidence.

A statistical analysis performed as part of this study showed that cities ranking in the upper third according to arson arrest rates had 22% fewer arsons per 100,000 population than cities ranking in the bottom third, while cities in the upper third according to arson conviction rate had 26% less arson. These results are consistent with, but do not prove, the belief held

by many that intensive investigation and prosecution of arson cases are an effective means of arson reduction.

A survey of 20 prominent arson investigators was conducted to identify the current needs in arson investigation and their priorities. These needs are included in the list of recommendations below. The survey questionnaire also dealt with methods used by arsonists and by investigators. Flammable liquid fire accelerants were cited by 62% of the survey respondents as the most common fire-setting method used by arsonists, and this type of evidence constituted 80% of the submissions to the state arson laboratory surveyed. Gasoline was by far the most frequently used accelerant. The existing flammable vapor detection equipment used by the investigators to locate traces of accelerants at fire scenes was found to be of limited value.

B. Summary of Recommendations

The following is a compilation of the recommendations made in this report. Following the collection and reporting of improved arson statistics, which we consider to be of fundamental importance, we list the most important needs cited by the surveyed arson investigators in the priority order which they assigned to them. The last recommendations (15 through 19) are those of the authors and are not given in any particular order.

1. Statistics. The collection and dissemination of arson statistics should be improved.

2. Reporting. The crime of arson should be reported with other serious crimes in the FBI Crime Index.

3. Training. There should be increased training for arson investigators in both the technical aspects of fire and fire investigation and also in police methods of criminal investigation. There should be increased training in arson detection for fire officers who assign causes to fires and training for prosecutors and judges in the technicalities of arson cases. Instructors should have field experience, and students of fire investigation should be given a large number of practice fires involving fire accelerants.

4. Manpower. More arson investigators are needed so that more fires can be investigated as to cause and more followup criminal investigations can be conducted in order to apprehend and convict the offender.

5. Investigation data system. An automated nationwide data system available only to authorized arson investigators should be established to help solve cases involving repeaters, professional "torches," and arson rings. The system should contain data on unsolved arson cases and on known arsonists and allied criminals such as crooked fire repair contractors, salvage contractors, insurance agents, brokers, and adjusters.

6. Fire research. Methods are needed by investigators to determine whether burned and melted electrical wiring had been the cause of a fire or was the result of a fire due to some other cause such as arson. The burning characteristics of cigarettes should be studied and disseminated in order to reduce the number of fires which are falsely attributed to careless smoking.

7. Burn indicators. A testing program should be conducted to establish the reliability of burn indicators used by investigators to establish the causes of fires. A handbook based on the results of the tests should be prepared for field use by arson investigators.

8. Accelerant residues. The amounts, chemical compositions, and persistence lifetimes of the residues of the flammable liquid fire accelerants used by arsonists should be established by a scientific testing program and distributed to arson investigators.

9. Accelerant individualization. The question of whether it is possible to distinguish fire accelerant samples manufactured by different companies should be resolved.

10. Insurance company cooperation. Insurance companies can help to eliminate the profit motive for arson through more selective underwriting, greater avoidance of overinsurance, not paying claims until the investigation has been concluded, more defense of fraudulent claims in civil court, and providing more information on insurance coverage to arson investigators.

11. Vapor detector. A flammable vapor detector especially adapted for use by arson investigators in locating traces of accelerants at fire scenes should be developed. Operational requirements should be established, and currently available equipment should be tested for suitablity in arson investigation. Test results should be distributed to arson investigators. New

methods of detection such as ultraviolet fluorescence should be explored, and field guides should be prepared for methods which are found to be successful.

12. Soot analyzer. The feasibility of the detection of fire accelerants from the deposits of soot which they leave at fire scenes should be studied.

13. Investigative responsibility. In order to clarify agency jurisdiction in arson detection and investigation, it is recommended that the official joint guidelines of the International Association of Chiefs of Police and the International Association of Fire Chiefs be adhered to. These guidelines call for close liaison and full cooperation between law enforcement and fire agencies, with fire investigation and arson detection being the responsibility of the fire service and the criminal investigation of fires established as arson being the responsibility of the law enforcement agencies.

14. Laboratory availability. Access of arson investigators to crime laboratory analysis of physical evidence should be increased in order to reduce processing delays and increase the utilization of physical evidence in arson cases.

15. Arsonist characteristics. Research should be conducted aimed at obtaining information about arsonists useful in designing arson prevention programs. The information needed includes: frequencies of motives and methods, tendency to repeat, frequency of commission, susceptibility to rehabilitation, and deterrability through sanctions such as fines and imprisonment.

16. Physical evidence survey. Thoroughgoing searches of a random sample of arson scenes by an independent team of criminalists should be conducted to establish the frequencies of various types of physical evidence and to identify any types of evidence useful in solving arson cases which are not currently being utilized.

17. Public awareness. Public awareness should be increased through the improved reporting of arson recommended above and through publicity about the deaths, injuries, property losses, and insurance premium increases caused by arson. City officials and police and fire supervision should be made aware of the seriousness of arson and of the time, effort, and expertise required to investigate it.

18. Operational analysis. An attempt should be made to estimate the effectiveness and the cost of various arson reduction strategies (such as insurance reform, more investigators, and longer prison sentences) through studies of current operations and mathematical modeling of proposed programs. Such estimates would be useful in setting priorities in arson control.

19. Prevention. Arson in high-risk locations such as schools should be reduced, or its effects minimized, through removal of flammable trash, better security, intrusion alarms, sprinklers, sprinkler-operated fire alarms, and so forth.

20. Other needs. These recommendations are based on the most urgent needs in arson control and arson investigation. A number of other needs are listed in Tables 36, 38, and 40, and in Appendix C.

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APPENDIX A. SURVEY QUESTIONNAIRE

Name_____ Date_____

Organization_____ Interviewer_____

Location_____

Arson Investigation Questionnaire

Investigators - Responsible Agency

Police Dept. _____

Fire Dept. _____

Both _____

Other (specify) _____

Number of Investigators _____

Criteria used to determine whether an investigation is conducted.

How soon is arrival at arson scene after onset of fire?

On a per year basis, please answer the following questions for your agency:

How many total fires handled? _____ Total suspected arson cases:_____

No record_____

How many total arson cases are cleared?

By arrest_____ By conviction_____ No record_____

What is the most common method of establishing the fire was arson?_____

If flammable liquid/vapor detectors are used, indicate type:

Detectors

Olfactory _____

Instrumentation _____

Manufacturer _____ Reliability _____

Sensitivity _____ Cost _____

Specificity _____ Is it adequate? _____

Physical Evidence

What types - percentage of each in which fire accelerant is found?

Wood _____ Rags _____

Paper _____ Upholstery _____

Rug _____ Other (specify) _____

How often is physical evidence collected? Give percentage _____ or state:

Always _____ Sometimes _____ Never _____

How often is the physical evidence that is collected submitted to a laboratory for scientific analysis? Give percentage _____ or state:

Always _____ Sometimes _____ Never _____

If evidence not sent to laboratory, why?

Preservation of evidence -- container:

Plastic bag _____ Glass container _____

Can _____ Other (specify) _____

Type of laboratory that physical evidence is sent to for analysis:

Criminalistics _____ Commercial _____

Toxicology _____ Other (specify) _____

Coroner _____

What type or types of analysis are requested from the laboratory? If fire accelerant, indicate percentage in which listed flammables are found.

Fire accelerant _____ Incendiary devices _____

Gasoline _____ Soot _____

Kerosene _____ Smoke _____

Paint thinner _____ Ashes _____

Lacquer solvent _____ Other (specify) _____

Charcoal lighter _____

What is the most common method arsonists use to set a fire?

What scientific research is needed in arson investigation?

Persistence of flammable liquid through/after a fire_____

Individualization of flammable liquids_____

Reliability of char patterns and other burn indicators_____

Determine whether a short circuit was the cause of or the effect of a fire_____

Establish under what conditions a cigarette can cause fire_____

Other (specify)_____

Other (specify)_____

What technological developments are needed in arson investigation?

Improved, more reliable flammable vapor detector_____

Instruments for analyzing smoke or soot_____

Photography_____

Other (specify)_____

Other (specify)_____

Problems needing to be solved--Number as to priority (1, 2, 3, etc.)

Further scientific research (as listed above)_____

Further technological developments (as listed above)_____

Increase number of investigators_____

Increase advanced training courses_____

Clarify jurisdiction -- fire department, police department, or both

_____

Computerize information. File of poor risks, over-insured owners, unscrupulous adjusters, property losses, and suspected arsonists_____

Increase cooperation from insurance companies_____

Increase crime laboratory availability_____

Other (specify)_____

Additional Comments:

APPENDIX B. ARSON INVESTIGATORS PARTICIPATING IN THE SURVEY

Captain Raymond J. Bishof, Jr.
Arson Squad
Newark Fire Department
Newark, New Jersey

Chief John P. Breen
District of Columbia Fire Department
Washington, D.C.

Captain Dean B. Browne
Arson and Explosives Unit
San Diego County Sheriff's Department
San Diego, California

Capt. Ward W. Caddington
Prince George's County
Maryland Fire Department
Brentwood, Maryland

Mr. Jack Cadman
Chief Criminalist, Orange County Sheriff's
Department Crime Lab
Santa Ana, California

Mr. Robert E. Carter
Supervisor, State of Virginia Fire Service Training
Richmond, Virginia

Mr. Philip C. Culp
Director, State of Wisconsin Arson Bureau
Madison, Wisconsin

Mr. William Derr
Special Agent, U.S. Forest Service
San Francisco, California

Mr. John Farber
Chief Investigator, Portland Fire Bureau
Portland, Oregon

Mr. Harvey M. French
Fire and Explosives Consultant
Santa Ana, California

Mr. Edwin Hatcher
Private Arson Investigator
Los Angeles, California

Chief Eugene L. Jewell
State of Ohio Arson Bureau
Columbus, Ohio

Sgt. Bruce K. Kamman
Arson/Explosive Detail
Los Angeles County Sheriff's Department
Los Angeles, California

Mr. Robert E. May
Executive Secretary, International Association
of Arson Investigators
Marlboro, Massachusetts

Mr. A. F. Mazzone
Chief, State of Illinois Arson Bureau
Chicago, Illinois

Dr. Charles R. Midkiff
Forensic Chemist, Bureau of Alcohol,
Tobacco, and Firearms
U.S. Department of Treasury
Washington, D.C.

Captain James J. O'Neill
Arson Investigation Section
Los Angeles City Fire Department
Los Angeles, California

Captain Herbert C. Redfield, Sr.
Officer-in-Charge, Fire Investigations
Norfolk Fire Department
Norfolk, Virginia

Captain William R. Rucinski
Fire Marshal Division
Michigan State Police
Lansing, Michigan

Chief H. Ray Vliet
Edison Fire Department
Edison, New Jersey

APPENDIX C. NEEDS CITED BY OTHER ARSON INVESTIGATORS

1. Notice Published in The Fire and Arson Investigator, October, 1975

Arson is of increasing nationwide concern because of the serious economic losses and its rising incidence. The Law Enforcement Assistance Administration (LEAA), through the National Institute for Law Enforcement and Criminal Justice (NILECJ) has initiated a survey and technical assessment of methods for detecting and investigating arson, which may lead to the development of more effective techniques of combatting this crime. The Aerospace Corporation, a non-profit, public trust corporation, is assisting in this effort by conducting a survey to identify critical problem areas, and to make recommendations.

At the present time, we are soliciting comments from arson investigators as to what they see as problems and needs, technical or otherwise, what types of solutions they would like to see, and the priorities for carrying them out. Arson investigators are encouraged to freely discuss any pertinent subject and address their written replies to:

Genevieve Denault or Quon Kwan
The Aerospace Corporation
P. O. Box 92957
Bldg. 130, Room 108
Los Angeles, CA 90009

Your answers and replies to this survey will help to determine the direction of realistic research, to develop objectives, and to avoid approaches that might not be useful. All respondents will automatically receive the compiled results of the survey as soon as they are available.

In addition to your written reply, if there are any questions you might have we would be happy to have you contact us via the telephone. Our numbers are (213)-648-7415 for Genevieve Denault, and (213)-648-6069 for Quon Kwan. Feel free to call us collect.

Thank you for your attention.

Sincerely yours,

Genevieve Denault
Forensic Science Section
The Aerospace Corporation

2. Arson Investigators Responding to the Notice

Capt. William C. Alletto
Chicago Fire Department
Chicago, Illinois

John R. Carroll
President, Forensic Engineers, Inc.
Mound, Minnesota

Bruce A. Dean
Supervisor, Investigative Service Division
First Security Services Corp.
Boston, Massachusetts

Frances M. Dulle
St. Louis County Fire Inspector
Clayton, Missouri

Capt. Dale Martin
Bureau of Fire Prevention
Shreveport, Louisiana

Robert Treharn
Supervisor, Bernalillo County Fire
Prevention Bureau
Albuquerque, New Mexico

James T. Upton
Fire Inspector
Newport Beach, California

Batt. Capt. W. E. Woods
Fire Marshal, Ocala Fire Department
Ocala, Florida

3. Summary of Comments Received

The eight respondents to the notice cited the following needs in arson investigation:

	Need	Number Citing Need
1.	Include arson in the FBI Uniform Crime Reporting system and list it as a Part I offense	3
2.	Increase number of trained investigators	3
3.	Increase funding	3
4.	Computerize arson investigation data system	3
5.	Create arson investigation teams from fire service, police, insurance companies, prosecutors, crime labs	3
6.	Clarify police and fire service responsibilities in arson	3
7.	Train fire officers to determine cause of fires	3
8.	More aggressive prosecution of arson cases	2
9.	Increase public awareness	2
10.	More resistance from insurance companies to fraudulent claims	2
11.	Make LEAA funds available for arson investigation	1
12.	Provide federal funding for training of arson investigators	1
13.	Legislate police powers for arson investigators	1
14.	Increase awareness of budget officials of problem of arson	1
15.	Furnish adequate equipment for investigators	1
16.	More assistance from insurance companies to arson investigators	1
17.	Train prosecutors and judges in arson cases	1
18.	Police shouldn't rotate arson investigators to other duties	1

	Need	Number Citing Need
19.	Insurance companies should police unscrupulous agents and brokers	1
20.	Set up federal fire investigation agency for certain types of fires, fund by taxing insurance companies	1
21.	Better arson training schools	1
22.	Bachelor and associate degree college programs in fire and arson investigation	1
23.	System to avoid overinsurance	1
24.	Better reporting system for arson fires and losses for more accurate statistics	1
25.	Technical methods in arson investigation should receive scientific testing	1

APPENDIX D. SURVEY OF FLAMMABLE VAPOR DETECTORS

The following list of flammable vapor detectors is intended to provide a picture of the types, sensitivities, and costs of currently available equipment. The list is intended for illustrative purposes only and does not constitute an endorsement of any of the equipment mentioned. Every effort was made to make the list as complete as possible; however, one or more manufacturers may have been overlooked. This should not be interpreted as an indication that their equipment is in any way inferior to the equipment listed. A discussion of flammable vapor detectors is contained in Chapter VI.

Model	Manufacturer	Threshold Sensitivity	Approximate Cost
Chemical Color Test Detectors			
1. Gas-Tech Precision Gas Detector System	Bendix Environmental Instruments, Inc. Warwick, RI	50ppm[a] (hexane)	$ 100
Catalytic Combustion Detectors			
1. Vapor-Tect	Andermac, Inc. Yuba City, CA	ppm range	$2500
2. J-W Model SS-P	Bacharach Instruments (formerly Johnson-Williams Co.) Pittsburg, PA	10ppm (hexane)	$ 600
3. Model TLV	Same	2ppm (hexane)	$ 800
4. MSA Portable Combustible Gas Indicator, Model 5	Mine Safety Appliance Co. Pittsburg, PA	5% LEL[b] or approximately 550ppm (hexane)	$ 200
5. Vapotester D-16	Scott Aviation Lancaster, PA	ppm range	$ 260
6. Vapolert D-17	Same	ppm range	$ 240

[a] ppm: parts per million concentration

[b] LEL: lower explosive limit

Model	Manufacturer	Threshold Sensitivity	Approximate Cost
Flame Ionization Detectors			
1. Portable Heated Total Hydro-Carbon Analyzer	Analytical Instrument Development, Inc. Avondale, PA	0.1ppm (methane)	$3000
2. Organic Vapor Analyzer	Century Systems Arkansas City, KA	ppm range	$3680
Gas Chromatographs			
1. Portable Gas Chromatograph	Analytical Instrument Development, Inc. Avondale, PA	0.05ppm (propane)	$4000
2. Arson Chromato-graph Model AGC-1	Tekmar Co. Cincinnati, OH (Components made by GOW-MAC Instruments Madison, NJ)	ppm range	$2000
Infrared Spectrophotometers			
1. Miran 101 Specific Vapor Analyzer	Wilks Scientific Corp. Norwalk, CT	0.028 ppm (hexane)	$3000
2. Miran 1A Portable Gas Analyzer	Same	0.02 ppm (hexane)	
Electronic Semiconductor Detectors			
1. Electronic Nose Gas Detector Model B	Grace Industries Transfer, PA	20ppm (methane)	$ 149

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