The National Estimates Approach to U.S. Fire Statistics

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Abstract

The development of the National Fire Incident Reporting System in the late 1970s made detailed, representative national fire statistics possible for the first time. However, calculation rules used to produce these statistics have varied among users. The authors present a detailed consensus procedure for such calculations and the supporting rationale.

Introduction

In the mid-1970s, the term *national estimates* was first used to describe procedures for combining available data bases to estimate national statistics for a specific part of the U.S. fire problem. These estimates were made using the new National Fire Incident Reporting System (NFIRS) of the Federal Emergency Management Agency's (FEMA's) United States Fire Administration (USFA), supplemented by a second national data base for calibration, typically the annual stratified random-sample survey of fire experience conducted by the National Fire Protection Association (NFPA). Leading fire data user groups, such as the USFA, the NFPA, and the U.S. Consumer Product Safety Commission (CPSC), have generally regarded the national estimates approach as the best method for developing specific decision-oriented fire statistics with current resources. Recent uses of this method include statistical analysis by NFPA of fires involving smoking materials under the Cigarette Safety Act of 1984 and statistical analysis by CPSC of fires involving lighters for background to proposed rule-making. These highly visible studies illustrate the value of the national-estimates method.

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However, the techniques used to prepare these estimates have never been fully discussed in the fire research literature, and because there are a large number of possible variations on these techniques, such a discussion is long overdue.

This article describes a consensus on the best version of the national-estimates methodology. Reasons for selecting the consensus approach also are provided. Use of a consensus methodology will move the fire community closer to a common set of assumptions to be used in analyzing firesafety issues, as opposed to the use of many different versions of the national-estimates approach, which will lead to competing statistics. Particularly in dealing with the general public and key decision-makers outside the fire community, this is likely to lead to confusion, frustration, a loss of credibility by all statistics-producing organizations, and a reduced ability to focus on real issues. Use of this consensus approach, by contrast, should lead to more agreement on facts and consequently more effective action on the fire problem.

National Estimates Methodology

Conceptual Background

NFIRS is the only national fire incident data base not limited to fires of a particular size that provides information on specific fire characteristics, but NFIRS does not cover all fires reported to U.S. fire departments and the information in NFIRS itself cannot at present be used to estimate what share of all fires it represents.* This is the most fundamental reason why a second data base is needed to project NFIRS results to national estimates. At the very least, one needs an estimate of the NFIRS fires (or the population covered by NFIRS fire departments) as a fraction of the total so that the fraction can be inverted and used as a multiplier or scaling ratio to generate national estimates from NFIRS data. (See Appendix for a more complete description of NFIRS and the NFPA survey.)

This is the first key principle of the national estimates approach: NFIRS is a detailed sample of real fire experience from a universe whose size cannot be inferred from NFIRS alone, so some second data base must be used to estimate the size of the total universe and thereby to scale up the NFIRS results.

There is, however, much more to national estimates than finding one number. Just as it is not known how large a share of the total fire problem is contained in the sample that NFIRS represents, so it also is not known how representative that sample is, and this has implications. While

*NFIRS currently requests data from each responding fire department on the size of the population it protects. Although not all of the fire departments currently report these data, it may be possible in the future to develop a procedure to extrapolate from NFIRS data alone to the universe of fire departments, stratifying by the size of population protected.

NFIRS is a very large sample, containing roughly a million fire incidents a year or roughly one-third of all fires reported to fire departments, it is not based on a random sample of fires, fire departments, or populations. Participation in NFIRS requires a significant commitment of resources and sophistication in data coding and data systems. This greater commitment makes possible the unique power of NFIRS, but the need to make such a commitment can be an obstacle to participation in NFIRS.

Small, rural communities, for example, are often served by volunteer fire departments which may use posted tote sheets or logs that record their fire calls in the form and detail required by the NFPA survey. The same department may lack the organizational framework required to institute and support an NFIRS-level data system. Also, for political and philosophical reasons, some regions are less hospitable than others to participation in a voluntary national system with federal government leadership and sizeable resource requirements.

Participation rates, therefore, are not necessarily uniform across regions and sizes of community, both of which are factors correlated with frequency and severity of fires. This means NFIRS may be susceptible to systematic biases. No one at present can quantify the size of these deviations from the ideal, representative sample, so no one can say with confidence that they are or are not serious problems. But there is enough reason for concern so that the consensus national-estimates method has been designed to project different parts of NFIRS separately.

This could be called a multiple calibration approach, and it makes use of the annual NFPA survey where its statistical design advantages are strongest. In principle, it would be possible to use the NFPA survey to calibrate NFIRS separately for each of the 17 different property categories for which the survey directly provides national fire experience totals. The consensus national estimates approach does not do this. One reason is practicality. If such an approach were used, then a calculation of, say, total smoking fires would have to be computed as the sum of estimated smoking fires in each property class, a time-consuming procedure that would substantially increase the effort required to do a full analysis of any interesting issue. The other reason is that the sampling error associated with the NFPA survey is greater for smaller subclasses. In estimating, say, the percentage of civilian deaths in structure fires that occur in stores and offices, the limitation of the NFPA survey's sample size (about 3,000 fire departments) becomes a significant consideration in the precision and confidence of the estimate. Little is lost at this level by taking a less cumbersome approach.

Basic Approach

The approach favored by the authors is one involving separate calibrations for only four major property classes (residential structures, nonresidential structures, vehicles, and other) and for each measure of fire severity (e.g., fire incidents, civilian deaths, civilian injuries, and direct property damage).

Table 1. Overall national estimates scaling ratios—1984.

	Residential Structures	Nonresidential Structures	Vehicles	Other
Definitions from NFPA 901				
Type of Situation Found	11	11	13	10,12,14-19
Fixed Property Use	400–499	All but 400–499	All	All
Fire Incidents	2.88	2.73	2.17	2.84
Civilian Deaths	2.29*	1.73	2.16	1.21
Civilian Injuries	2.10	1.73	2.33	1.35
Direct Property Damage	2.42	1.73	2.10	0.75

*The scaling ratio for 1984 civilian deaths in residential structures is equal to the total number of 1984 civilian deaths in residential structure fires reported to fire departments, according to the NFPA survey (4,240), divided by the total number of 1984 civilian deaths in residential structure fires reported to NFIRS (1,850). Therefore, 4,240/1,850 = 2.29.

Table 1 displays the national estimates scaling ratios for 1984 for these four property classes for four measures of fire severity. Table 1 also indicates how those major property classes are defined and shows an illustrative formula indicating how a national estimates scaling ratio is computed. Several points are worth noting regarding Table 1.

The scaling ratios for civilian deaths and injuries and direct property damage are often significantly different from those for fire incidents. Except for fire service injuries, average severity per fire is generally higher for NFIRS than for the NFPA survey. Use of different scaling ratios for each measure of severity, like those in Table 1, is equivalent to assuming that these differences are due either to underreporting of small fires by the NFIRS, resulting in a higher-than-actual loss-per-fire ratio, or possible biases in the NFIRS sample representation by region or size of community, resulting in severity-per-fire ratios characteristic only of the oversampled regions or community sizes.

The principal alternative assumption would be that the NFPA survey underestimated loss totals from some reporting departments (e.g., because fires with no loss cannot be distinguished from fires with loss amount unknown). This assumption, which has not been adopted, could lead one to use another source for scaling ratios for deaths, injuries or property damage, or to use the NFIRS severity-per-fire ratios across the board (or equivalently, to scale up all NFIRS statistics based on fire incident scaling ratios).

The separate calibration of different loss measures rests therefore on a judgment about the two data bases. Since further research or experience could alter this judgement, the national estimates method could be changed in the future to more precisely reflect the strengths and weaknesses of available data bases.

Note that the use of separate scaling ratios for each measure of loss also means that one should not use NFIRS data alone to calculate deaths-per-fire (or other severity-per-fire) ratios for specific kinds of fires. Instead, the numerator and denominator should each be computed according to the national-estimates methodology *before* the severity-per-fire ratio is computed. Failure to follow this procedure can mean that a deaths-per-fire ratio will not be consistent with the figures for deaths and fires, each calculated separately according to the national-estimates methodology, because the scaling ratios will not cancel out in a rate calculation.

Similarly, the detailed property-use-class results of the NFPA survey should not be used in place of national estimates derived from the methodology shown here. As an illustration, Table 2 shows 1980–1983 figures for direct property damage for each of the major nonresidential structure property classes for which both NFPA survey and national estimates results are available. While most of the figures are fairly close, differences of 10–20% are not unusual. These differences are large enough to be important, so for consistency, one should use national estimates whenever one can, even if NFPA survey results are available.

The most dramatic difference shown in Table 2 involves the 1982 figures for institutions, and this difference illustrates a caution that must be applied when calculating national estimates. The 1982 national estimate of $92 million in damage is primarily due to one hospital fire recorded as a $30 million fire. Applying the scaling ratio of 2.36, that one fire accounts for $71 million of the $92 million total; without that one fire the two figures are virtually identical. A 1980 national estimate calculation of civilian deaths in hotels would face the same problem, because the large death toll at the MGM Grand Hotel fire represented more than half of all hotel fire deaths in that year. If NFIRS excludes the MGM Grand fire, then the national estimate will fall well short of the real total; if NFIRS includes that fire, the national estimate will significantly overshoot it. The national estimate procedure does not work well in situations where a few fires represent a large share of total loss, whether loss is measured by civilian deaths, civilian injuries, or direct property damage.

Another important point is that there really was no $30 million hospital fire in 1982. A telephone check with the reporting fire department confirmed that a keypunch error turned a fire of well under a million dollars into the largest hospital fire of recent years. Data quality is generally good, but it is not perfect, so it is particularly important to double-check any unusually large fires because, real or phantom, they can exert an inordinately large effect on an analysis.

One of the scaling ratios in Table 1 is less than one, which in theory

Table 2. Property damage—type of nonresidential structure. (All dollar figures in millions.) (a) is NFPA survey; (b) is national estimate.

	1980		1981		1982		1983		Average		Average Percent	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Public Assembly	326	393	356	357	381	376	354	411	354	384	14	15
Educational	101	104	184	139	161	87	103	61	137	98	5	4
Institutions	25	29	38	36	17	92	14	25	24	45	1	2
Stores, Offices	645	534	642	701	510	703	686	530	621	617	25	24
Industry*	672	609	775	659	663	450	763	727	718	611	28	24
Storage	512	551	616	636	584	563	473	569	546	580	22	22
Special Structures	131	120	106	125	162	124	127	153	131	130	5	5
Unknown	–	77	–	60	–	83	–	44	–	66	–	3
Total	2412	2412	2717	2717	2478	2478	2520	2520	2532	2532		

*This category combines the NFPA 901 categories of manufacturing (700–799) and basic industry, utilities and defense (600–699).

should not happen since it means that a part is larger than the estimated whole. That ratio is for property damage in nonstructure, nonvehicle fires, which is by far the smallest portion of fire loss, so the uncertainties surrounding the NFPA survey figure are greatest and such an anomaly can happen. This situation poses a difficult dilemma because it contradicts, for this particular measure, the assumption that NFIRS is a sample from a universe whose size is given by the NFPA survey. Clearly, one part of that assumption is wrong here. Either the NFPA survey has underestimated the total value of the 1984 direct property damage in nonstructure, nonvehicle fires or NFIRS has exaggerated the size of its sample of that damage (e.g., by miscoding property damage on individual fires, or by misassigning some fires to the nonstructure, nonvehicle class). However, piecemeal adjustments to the procedure to remove such anomalies (such as requiring all indexes to be at least one) are not advisable, because they amount to abandoning the statistical design of the overall procedure. This kind of seeming quality control, if used, would operate in a biased fashion. First, it would amount to assuming that the NFPA survey can underestimate, but NFIRS cannot overestimate, a position on which no evidence exists. Second, it would produce biased results because there would be no compensating check for cases in which the NFPA survey overestimated or NFIRS underestimated by a similarly wide margin.

Estimates based on scaling ratios less than one nevertheless should be avoided if they are not essential to the analysis being performed. If they are essential, however, then the determined scaling ratio should be used in all cases, even for those rare instances where the ratio is less than one, avoiding the biased imposition of a requirement that all scaling ratios must be set equal to one or more.

The nonresidential structure category includes garages and some other outbuildings associated with residential properties. Because the NFPA survey includes them in this grouping and the NFPA Fire Reporting Committee believes they belong more with storage properties than with residential properties, this decision is unavoidable. Once the national estimates are computed, however, these residential-related properties can be isolated and regrouped with residential properties if the analysis warrants it. Also, structure fires with unknown fixed property use are included in the nonresidential category.

Conversely, there will be some analyses for which such residential properties as hotels and motels should be grouped with high-occupancy nonresidential properties serving the public.

The "other" category consists mostly of trash fires and fires in forests, grass, and brush. Explosions with no after fire (coded as Type of Situation Found 16; see Table 1 headings) are supposed to be included here in theory. However, the NFPA survey groups explosions with no after fire with other nonfire calls, and NFIRS may miss many of those

incidents, too. In any event, they represent much less than 1% of the NFIRS incidents, so they are either insignificant in number or excluded by design.

Handling Analyses Using Multiple Characteristics

Most analyses of interest involve the calculation of the estimated number of fires not only within a particular occupancy but also of a particular type. The types that are most frequently of interest are those defined by some ignition-cause characteristic. The six cause-related characteristics most commonly used to describe fires are:

- form of the heat that caused the ignition,
- equipment involved in ignition,
- form of material first ignited,
- type of material first ignited,
- the ignition factor that brought heat source and ignited material together, and
- area of origin.

Other characteristics of interest are victim characteristics, such as ages of persons killed or injured in fire.

For any characteristic of interest in NFIRS, some reported fires have that characteristic unknown or not reported. If the unknowns are not taken into account, then the propensity to report or not report a characteristic may influence the results far more than the actual patterns on that characteristic. For example, suppose the number of fires remained the same for several consecutive years, but the percentage of fires with cause unreported steadily declined over those years. If the unknown-cause fires were ignored, it would appear as if fires due to every specific cause increased over time while total fires remained unchanged. This, of course, does not make sense.

Consequently, most national estimates analyses use some allocation of unknowns. This is done by replacing scaling ratios like those of Table 1 with scaling ratios defined by NFPA survey estimates of totals divided by only those NFIRS fires for which the dimension in question was known and reported. Table 3 illustrates the way that this changes the scaling ratios. This approach is equivalent to assuming that the fires with unreported characteristics, if known, would show the same proportions as the fires with known characteristics. For example, it assumes that the fires with unknown ignition factor contain the same relative shares of child-playing fires, incendiary-caused fires, short-circuit fires, and so forth, as are found in the fires where ignition factor was reported.

Table 3 also shows that the scaling ratios increase when unknowns are allocated. Note that the smallest increase is for area of origin, the characteristic that is easiest for fire officers to determine of those shown.

Table 3. Illustrative national estimates scaling ratios with allocations of unknowns.

	Scaling Ratios for 1984 Residential Fires			
	Fires	Civilian Deaths	Civilian Injuries	Direct Damage
When No Unknowns Are Allocated	2.88	2.29	2.10	2.42
When Fires with Unknown Area of Origin Are Allocated	2.98	2.48*	2.15	2.63
When Fires with Uunknown Equipment Involved in Ignition Are Allocated	3.29	3.22	2.49	3.16
When Fires with Unknown Form of Ignition Heat Are Allocated	3.32	3.45	2.54	3.40
When Fires with Unknown Form of Material First Ignited Are Allocated	3.16	3.01	2.36	3.05
When Fires with Unknown Type of Material First Ignited Are Allocated	3.15	3.06	2.36	3.08
When Fires with Unknown Ignition Factor Are Allocated	3.22	3.20	2.42	3.11
When Casualties with Unknown Victim Age Are Allocated	N.A.	2.69	2.73	N.A.

*The scaling ratio for 1984 residential-structure-fire civilian deaths with a particular area of origin is developed from the NFIRS residential structure fires for which area of origin was known. As noted in the footnote to Table 1, there were 4,240 total residential-structure-fire deaths reported to fire departments in 1984 according to the NFPA survey and 1,827 reported to NFIRS; 1,708 of those occurred in fires with known area of origin. Thus, 4,240/1,708 = 2.48.

Because it is easier to determine, area of origin is less often reported as unknown, which means the scaling ratio to allocate fires with unknown area of origin differs very little from the scaling ratio when no allocation is made.

The allocation of unknowns is more difficult in an analysis involving more than one dimension. Take the case of rubber toy fires. Rubber toys are defined by Type of Material First Ignited 51 (rubber) and Form of Material First Ignited 45 (toys). Both type and form of material first ignited can be unknown. One can imagine at least two methods for allocating unknowns that would be consistent with the spirit of the approach developed thus far.

First, one could take all the fires in which either type or form of material was unknown, treat them as a single, large unknown group, and proportionally allocate them over the fires with known form and type of material. Doing this, however, would mean that fires with known type of material but unknown form of material would be treated as having both type and form unknown, and so a certain number of them would have their known type of material changed to something else. Either that, or a similar misassignment would occur for some fires with known form of material but unknown type of material. In other words, some fires would have known facts changed, a clearly undesirable outcome.

The other approach avoids this problem, but it requires the analyst to choose one dimension—in this case, type or form of material first ignited—as primary. For example, one could use a scaling ratio from Table 3 to assign proportional shares of fires with type of material unknown to (a) all fires involving rubber toys, (b) all fires involving rubber objects that are known not to be toys, and (c) all fires involving rubber objects where the form of material is unknown. Then one could proportionally allocate (c) over (a) and (b). Alternatively, one could first scale up (a) all rubber-toy fires, (b) all toy fires known not to be rubber-toy fires, and (c) all toy fires with type of material unknown, then allocate that (c) over that (a) and (b). Both of these approaches achieve the allocation of unknowns, but they will produce different results. For that reason, the consensus method does not prescribe one right way of allocating unknowns on more than one dimension. In practice, the choice of primary versus secondary variable in this illustration might be made based on whether the primary focus of the analysis was on *toys*, including rubber toys, or on *rubber products*, including rubber toys.

Calculating Fire Service Deaths and Injuries

The consensus national estimates method requires NFPA-survey-based figures for residential structure fires, nonresidential structure fires, vehicle fires, and other fires, but the NFPA survey does not produce such figures for fire service deaths and injuries. Fire service deaths are not addressed by the survey at all, because NFPA maintains a comprehensive listing of fire service line-of-duty deaths which can be used to produce answers not dependent on projection from samples. This listing is also desirable because the number of fire service deaths at the fireground for fires of a particular cause is typically very small—less than 10 a year—so sample-based estimates would have very large uncertainty ranges, relative to the statistics being estimated.

For fire service injuries, the NFPA survey does produce projections of fire service injuries at the fireground but not by major property type. Therefore, one must use a single scaling ratio instead of the four ratios (one each for residential structures, nonresidential structures, vehicles, and other properties) that are used to scale up the other measures of fire severity.

One of the authors is not comfortable using NFPA survey estimates of fire fighter injuries to scale up NFIRS figures, because NFIRS and the NFPA survey provide radically different portraits of the relative frequency of civilian versus fire service fireground injuries. In the NFPA survey there are more than two fire service injuries for every civilian injury, while in NFIRS the two totals tend to be roughly the same. Because the reasons for this are unclear, there is no consensus method for handling this calculation, and it will not be discussed further here. The issue is an important one, however, and requires further study.

Numerical Examples

In 1985, NFIRS included 15,749 smoking-material fires in residential structures, that is, fires for which the Form of Heat of Ignition was 30–39. These fires were reported to have produced 429 civilian deaths, 1,484 civilian injuries, and $103,334,425 in direct property damage, which can be expressed as $103.3 M (for million) for ease of handling in this sample.

Example 1

National estimates of the smoking-material fire problem that represent the whole country but do *not* take account of fires for which Form of Heat of Ignition was unknown or unreported would be computed as follows:

	NFIRS	× Scaling Ratio	= National Estimate
Fires	15,749	2.64	41,600
Civilian Deaths	429	2.66	1,140
Civilian Injuries	1,484	1.99	2,950
Property Damage	$103.3 M	2.22	$229 M

Scaling ratios are calculated similarly to the ratios shown in Table 1.

Here, 2.64 is the ratio of 1985 residential structure fires according to the NFPA survey (622,000) divided by the number of 1985 residential structure fires reported to NFIRS (235,365). Also, the national estimates have been expressed to three significant places, not to the nearest one (fire, death, injury, or dollar), and a limitation to two significant places could be easily justified by what is known of the precision of the sources.

Example 2

The best national estimates of the smoking material fire problem, however, should include a proportional share of fires with unknown Form of Heat of Ignition. Note that this adjustment increases the estimate of fires by 16%, civilian deaths by 44%, civilian injuries by 19%, and direct property damage by 20%.

	NFIRS	× Scaling Ratio	= National Estimate
Fires	15,749	3.07	48,300
Civilian Deaths	429	3.82	1,640
Civilian Injuries	1,484	2.36	3,500
Property Damage	$103.3 M	3.09	$319 M

Scaling ratios are calculated similarly to those shown in Table 3.

Here, 3.07 is the ratio of 1985 residential structure fires according to the NFPA survey (622,000) divided by the number of 1985 residential structure fires reported to NFIRS for which the form of heat of ignition was known and reported (202,915).

Example 3

Now suppose one is interested in the fire problem associated with smoking materials igniting upholstered furniture. Upholstered furniture is coded as Form of Material First Ignited 21. As noted earlier, this calculation requires that one of the two elements of the scenario be chosen as primary.

If the smoking material as heat source is chosen as primary, then one would begin by calculating the national estimate of smoking-material/upholstered furniture fires with proportional allocation of a share of all the fires with unknown Form of Heat of Ignition:

NFIRS	× Primary Scaling Ratio	= Initial National Estimate
3,968	3.07	12,182

The primary scaling ratio is calculated similarly to those shown in Table 3.

Then one needs a second scaling ratio that will allocate smoking-material fires with unknown Form of Material First Ignited. The formula used here would be (National Estimate of Smoking-Material

Fires) divided by (National Estimate of Smoking-Material Fires with Known Form of Material First Ignited), or:

$$48{,}349/47{,}652 = 1.01.$$

Finally one uses the second scaling ratio to produce the final national estimate of 1985 residential structure fires where smoking materials ignited upholstered furniture: (Initial National Estimate) times (Secondary Scaling Ratio) equals (Final National Estimate), or:

$$12{,}182 \times 1.01 = 12{,}360.$$

Now, suppose the upholstered furniture as item first ignited is chosen as primary. Then one would begin by calculating the national estimate of smoking-material/upholstered-furniture fires with proportional allocation of a share of all the fires with unknown Form of Material First Ignited; i.e., (NFIRS) times (Primary Scaling Ratio) equals (Initial National Estimate):

NFIRS ×	Primary Scaling Ratio =	Initial National Estimate
3,968	2.87	11,388

Note that the NFIRS component is the same for both calculations, and the primary scaling ratio is again calculated similarly to those shown in Table 3.

Next comes the calculation of the secondary scaling ratio, given by (National Estimate of Upholstered-Furniture Fires) divided by (National Estimate of Upholstered-Furniture Fires with Known Form of Heat of Ignition):

$$23{,}672/20{,}457 = 1.16.$$

Finally, one calculates the final national estimate: (Initial National Estimate) times (Secondary Scaling Ratio) = (Final National Estimate):

$$11{,}388 \times 1.16 = 13{,}178.$$

The two final estimates (12,360 and 13,178) differ by about 6%, attributable to differences in their handling of fires whose cause scenarios were partially or totally unknown.

Conclusions

A consensus approach has been developed on how to use the USFA's NFIRS, the NFPA's survey, and NFPA files on fire fighter deaths to produce national estimates of the size of specific parts of the U.S. fire

problem. The method takes advantage of the distinctive advantages of the two data bases—depth and representativeness, respectively. While further improvements undoubtedly will be possible and are being considered, all analysts are urged to follow this approach for now, so as to provide a consistent picture of the U.S. fire problem and its many components.

Appendix: Summary Description of the Two Data Bases Used in National Estimates

The NFPA survey is based on a stratified random sample of roughly 3,000 U.S. fire departments (or just over one of every ten fire departments in the country). The survey includes the following information:

- the total number of fire incidents, civilian deaths, and civilian injuries, and the total estimated property damage (in dollars), for each of the major property use classes defined by NFPA 901, *Uniform Coding for Fire Protection;*
- the number of on-duty fire fighter injuries, by type of duty and nature of illness; and
- information on the type of community protected (e.g., county versus township versus city) and the size of the population protected, which is used in the statistical formula for projecting national totals from sample results.

The NFPA survey begins with the NFPA Fire Service Inventory, a computerized file of nearly 30,000 U.S. fire departments, which is the most complete and thoroughly validated such listing in existence. The survey is stratified by size of population protected to reduce the uncertainty of the final estimate.

Small, rural communities protect fewer people per department and are less likely to respond to the survey (30% did in 1987), so a larger number must be surveyed to obtain an adequate sample of those departments. (NFPA also makes follow-up calls to a sample of the smaller fire departments that do not respond, to confirm that those that did respond are truly representative of fire departments their size.) On the other hand, large city departments are so few in number and protect such a large proportion of the total U.S. population that it makes sense to survey all of them. Most respond (63% of departments protecting populations of 100,000 or more in 1987), resulting in excellent precision for their part of the final estimate.

FEMA/USFA's National Fire Incident Reporting System (NFIRS) provides annual computerized data bases of fire incidents, with data classified according to a standard format based on NFPA 901. Roughly three-fourths of all states have NFIRS coordinators, who receive fire incident data from participating fire departments and combine the data into a state data base. These data are then transmitted to FEMA/USFA. Participation by the states, and by local fire departments within participating states, is voluntary. NFIRS captures roughly one-third of all U.S. fires each year. More than one-third of all U.S. fire departments are listed as participants in NFIRS, although not all of these departments provide data every year.

The strength of NFIRS is that it provides the most detailed incident information of any national data base not limited to large fires. NFIRS is the only data base capable of addressing national patterns for fires of all sizes by specific property use and specific fire cause. (The NFPA survey separates fewer than 20 of the hundreds of property-use categories defined by NFPA 901 and solicits no cause-related information except for incendiary and suspicious fires.) NFIRS also captures information on the avenues and extent of flame spread and smoke spread and on the performance of detectors and sprinklers.

Additional Reading

[1]Derry, L., "A study of United States fire experience, 1976," *Fire Journal*, 71, pp. 50–53 (1977). This describes some of the improvements in NFPA survey methodology when they were first made.

[2]National Fire Data Center, U.S. Fire Administration, U.S. Department of Commerce, *Fire in the United States*, 1st ed., Washington (1978). This is the first national publication to use a national-estimates methodology and refer to it by that term. Appendixes III to VI describe the data bases, methods, and strengths and weaknesses as they were understood then.

[3]National Fire Data Center, U.S. Fire Administration, U.S. Department of Commerce, *Fire in the United States*, 2nd ed., Washington, Appendices A and B (1982). This is the most detailed description of national-estimates methods published prior to this article. The appendices were bound separately and so saw limited distribution. The characterizations of the NFPA survey and the National Center for Health Statistics death-certificate data base are dated in some respects.

[4]Fristrom, G., *Fire deaths in the United States: Review of data sources and range of estimates.* National Fire Data Data Center, National Fire Prevention and Control Administration, U.S. Department of Commerce, Washington (1977). This is a comprehensive review of the strengths and weaknesses of sources of data on U.S. fire deaths, conducted prior to some of the upgrading in the NFPA survey and prior to improvements in the multiple coding of death certificates.

[5]Karter, J. M., Jr., "Fire loss in the United States, 1987," National Fire Protection Association (1988). This describes the methodology of the NFPA survey as it has been since 1980.

[6]Tovey, H., "The development of the National Fire Data System," *Fire Journal*, 68, pp. 91–96 (1974). This describes the plan developed for a national fire data system, including what would become NFIRS.