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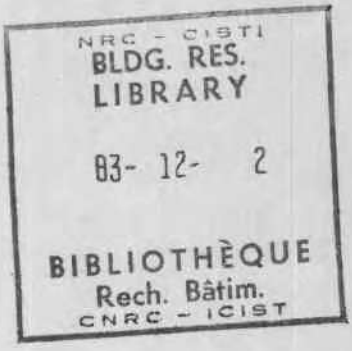
FIRE COST CONTROL IN CANADA

by G. Williams-Leir



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RÉSUMÉ

Cet exposé se veut un complément au rapport intitulé "Étude sur la prévention et la lutte contre l'incendie au Canada" (Switzer et Baird, 1980). Il se propose d'analyser les réponses au questionnaire distribué dans le cadre de cette étude et aborde les points suivants:

- caractéristiques qui distinguent les corps de sapeurs-pompiers professionnels des corps de sapeurs-pompiers bénévoles ou mixtes.

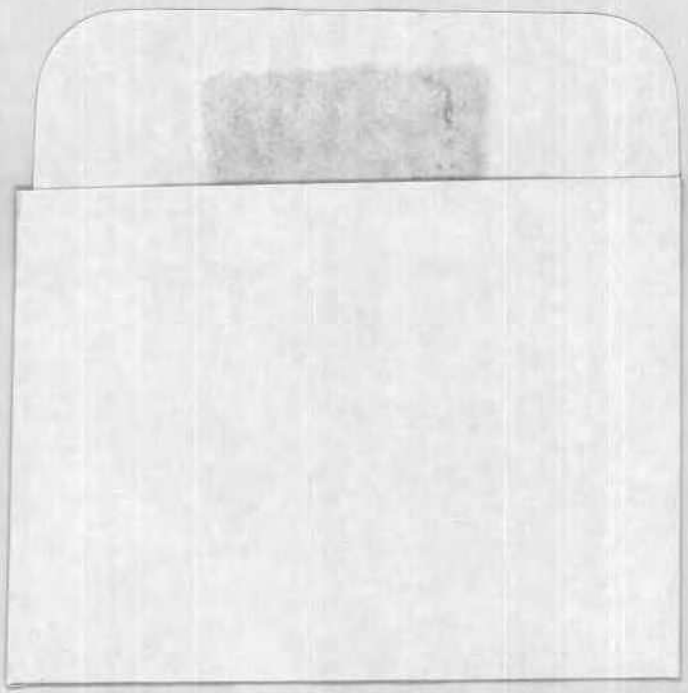
- comparaisons entre les dépenses des services d'incendie et d'autres paramètres connus.

- nombre de sapeurs-pompiers qui peuvent être employés compte tenu des sommes allouées.

- estimation du coût brut d'un incendie en fonction de la population et du type de service d'incendie.

- comparaisons de coûts entre des groupes de services d'incendie classés selon divers attributs.

On y présente finalement une série de conclusions avec certaines réserves et un histogramme de la rémunération des sapeurs-pompiers bénévoles.



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FIRE COST CONTROL IN CANADA

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This account supplements the Report of the Study on Fire Prevention and Control Systems in Canada (Switzer and Baird, 1980), and analyzes the replies to the questionnaire distributed in connection with that Study. It investigates the characteristics that distinguish municipal councils maintaining fulltime fire departments from those that choose volunteer or composite departments. Comparisons are provided between fire department expenditures and other known parameters. The number of firefighters who can be employed for a given expenditure is also noted.

The gross cost of fire is tabulated in relation to population and type of fire department. A series of cost comparisons is made between groups of fire departments classified by a variety of attributes. A series of tentative inferences is shown, with qualifications. The pay rates of volunteer firefighters are presented as a histogram.

INTRODUCTION

In 1978 a team comprised of R.A.W. Switzer, the recently-retired Dominion Fire Commissioner, and D. M. Baird of the Insurers' Advisory Organization, was appointed by the National Research Council of Canada to conduct a Study on Fire Prevention and Control Systems in Canada. A questionnaire was one of the techniques used to gain information for this Study. It was distributed to fire chiefs in nine provinces and two territories and was returned by over 1000 of them. Numerous facts derived from tabulation of the responses are included in the Study report; this by no means exhausts the useful information derivable from them. Much of the analysis calls for interpretation which is, in some cases, speculative and there is some merit

in separating such studies from the Report proper. It would be regrettable, however, if the analyses were not made accessible to those to whom they might be of interest, hence this paper.

Some of the subject matter relates to the cost of maintaining a fire department (FD) and to the value of the services it provides. This may perhaps be of use to municipal councils (MC) faced with decisions on whether to change from volunteers to fulltime firefighters. It shows that, in many environments in Canada, one or the other of these two is the only choice.

This study is not intended to be a complete investigation of the subject. It reveals the relation between certain of the responses to the questionnaire, and nothing more; in some cases further investigation could be expected to explain these relations. Many of the indications are no more than speculative.

ADEQUACY OF RESPONSES

The bulk of the 1008 responses came from volunteer FDs; 61 were from fulltime FDs and 53 from composite FDs (these terms are defined in the next section). Thirteen thousand, two hundred fulltime and 22,900 volunteer firefighters serve in these FDs; the jurisdiction of the fulltime FDs has a population of 7.8 million, that of the composites 1.7 million and the volunteers 3.6 million, a total of 13.1 million, well over half the country's population.

In general, the respondents appear to have answered the questionnaire carefully and the great majority of the responses appear to be valid. There were, however, some obvious inconsistencies. In the analyses such cases were treated as "no reply" and left out of subsequent analysis, except where the intentions of the respondent seemed to be clear.

DEFINITIONS

For convenience, the following definitions will be adopted:

Expenditure: The total amount of the annual operating and capital expenditure of an FD, plus 10 per cent interest on the value of inventory: i.e., the money deliberately spent for no other purpose than to control fire loss.

Losses: The FD's estimates of property loss, lives lost and businesses closed down or relocated as the result of a fire. Information on other categories of loss, e.g., injuries, was not requested in the questionnaire.

Community Loss: To make it possible to present a single figure instead of three as a measure of relative magnitude of loss, $200,000 for each life and $1,000,000 for each business was added to the stated property loss. Because the estimate in the questionnaire of businesses lost is for 1974-78, the responses have been divided by 5 to obtain an annual figure for use in this calculation.

It is unnecessary to justify the precise choice of the sums of money used in this definition as their only purpose is, as stated, to give a measure of relative magnitudes of loss. Other reasonable but quite different figures, if substituted, would be unlikely to alter the principal inferences to be derived from comparisons of the totals.

Gross cost of fire: Total of expenditure and community loss.

Volunteer fire department: Any department having fewer than 10 fulltime staff.

Fulltime fire department: Any department with more than five times as many fulltime staff as volunteers.

Composite fire department: Any department excluded by the two previous definitions.

Effective firefighters, or effective strength: The number of effective firefighters is arbitrarily defined as the number of fulltime staff plus one-fifth of the number of volunteers.

Dense: Refers to volunteer FD's where the population density exceeds 100 per sq. mile.

Sparse: Refers to volunteer FD's where the population density is less than 100 per sq. mile.

OPTIMAL EXPENDITURE ON FIRE PROTECTION

This paper would be of more value if it could address the question of whether the optimal amount is being spent on fire protection. This is not possible, however, because experiment is excluded; so precise definition of

TABLE I

Population and Area Both Influence Choice of FD Type

(FD'S = Number of FD's; POP = Population, Thousands; GCPH = Gross Cost, $ per Head)

FD Area (Sq. km) To:–							
				26			82
FD TYPE:		Full	Comp	Vol	Full	Comp	Vol
Population (Thousands) To:–							
	FD'S	1	0	216	0	1	103
10.0	POP	1	0	549	0	9	327
	GCPH	821	0	81	0	73	76
	FD'S	2	4	9	0	1	7
13.3	POP	21	46	98	0	13	77
	GCPH	108	120	59	0	61	42
	FD'S	2	4	3	2	3	6
17.8	POP	31	61	46	30	45	90
	GCPH	46	127	72	79	69	52
	FD'S	3	2	3	0	1	0
23.7	POP	58	40	60	0	18	0
	GCPH	92	64	40	0	193	0
	FD'S	2	3	0	1	1	0
31.6	POP	53	75	0	31	27	0
	GCPH	72	94	0	53	13	0
	FD'S	2	1	1	5	0	1
42.2	POP	74	33	35	184	0	38
	GCPH	63	81	0	76	0	1
	FD'S	0	0	0	4	0	0
56.2	POP	0	0	0	206	0	0
	GCPH	0	0	0	70	0	0
	FD'S	1	0	0	4	0	0
75.0	POP	71	0	0	273	0	0
	GCPH	98	0	0	63	0	0

		259			819			2590
Full	Comp	Vol	Full	Comp	Vol	Full	Comp	Vol
0	0	103	0	0	151	0	0	106
0	0	350	0	0	398	0	0	360
0	0	59	0	0	79	0	0	73
0	0	11	0	1	6	0	0	6
0	0	116	0	13	61	0	0	66
0	0	55	0	158	77	0	0	32
0	1	4	0	3	2	0	0	0
0	17	62	0	44	33	0	0	0
0	58	44	0	71	31	0	0	0
0	3	0	0	0	3	0	0	0
0	56	0	0	0	63	0	0	0
0	74	0	0	0	31	0	0	0
2	1	0	0	1	6	0	0	1
57	26	0	0	30	161	0	0	30
69	78	0	0	37	44	0	0	14
0	4	1	1	0	3	0	1	0
0	141	36	35	0	104	0	36	0
0	53	42	41	0	33	0	36	0
1	2	0	0	0	2	0	1	0
45	89	0	0	0	95	0	55	0
129	69	0	0	0	86	0	54	0
3	3	0	1	2	0	0	1	0
208	199	0	68	129	0	0	60	0
101	89	0	48	64	0	0	50	0

continued

TABLE I (continued)

FD Area (Sq. km) To:–							
				26			82
FD TYPE:		Full	Comp	Vol	Full	Comp	Vol
	FD'S	0	0	0	0	1	1
100	POP	0	0	0	0	76	76
	GCPH	0	0	0	0	46	5
	FD'S	1	0	0	1	0	0
133	POP	102	0	0	117	0	0
	GCPH	40	0	0	96	0	0
	FD'S	1	0	0	0	0	0
over	POP	141	0	0	0	0	0
	GCPH	49	0	0	0	0	0

"optimal" is unnecessary. Both losses and deliberate expenditures range widely from one FD to another even when population and area are the same. There is no way of knowing how one depends on the other in a given jurisdiction.

Consequently, this paper is limited to presenting how reported losses and costs vary with the reported characteristics of the FD's territory. The study could have indicated where the total was high relative to the average, but cannot infer that such jurisdictions are high-risk ones, because the estimate of losses is for only one year, and in all but the largest cities the random variation from year to year would probably be enough to invalidate such inferences.

In spite of these limitations, the study has yielded information that will be of interest to any MC reviewing its policy on fire protection. This information will, however, have to take the form "Expenditure on activity A is greater/less than in the average of comparable areas" rather than the more useful form "expenditure is greater/less than optimal."

If one believes that, owing to experience and good judgment in the country as a whole, the over-all expenditure is optimal, and that the hazards of the locality under consideration are near average, then the foregoing statements in quotations may be thought of as equivalent to one another; but these are hypotheses that the data collected cannot be used to test.

		259			819			2590
Full	Comp	Vol	Full	Comp	Vol	Full	Comp	Vol
4	0	0	1	1	0	0	0	0
344	0	0	100	98	0	0	0	0
52	0	0	111	51	0	0	0	0
0	1	0	1	1	0	0	0	0
0	112	0	112	129	0	0	0	0
0	40	0	81	65	0	0	0	0
13	0	0	2	0	0	0	0	0
4403	0	0	1015	0	0	0	0	0
61	0	0	81	0	0	0	0	0

FIRE DEPARTMENT TYPE

Possibly the first question an MC should consider is how much ought to be spent on fire protection. But before discussing this question the council would have to decide whether a volunteer or fulltime FD was appropriate, or whether the MC should compromise on a composite department.

Table I shows how the three types of FD are distributed in relation to population and area; gross costs per head are also shown. Figure 1 presents the same information in another way, without costs. As might be expected, large areas with small populations are generally served by volunteer departments, and large populations by fulltime departments. A more precise statement, ignoring minor irregularities in the table, is: Municipalities smaller than 32 sq miles (8200 hectares) generally have volunteer departments for a population of up to 18,000, fulltime departments for over 32,000, and composite departments for populations in-between. For municipalities between 32 and 100 sq miles (8200 to 25,900 hectares), the same changeovers occur at populations of 18,000 and 56,000. Over 100 sq miles (25,900 hectares) they occur at 42,000 and 100,000.

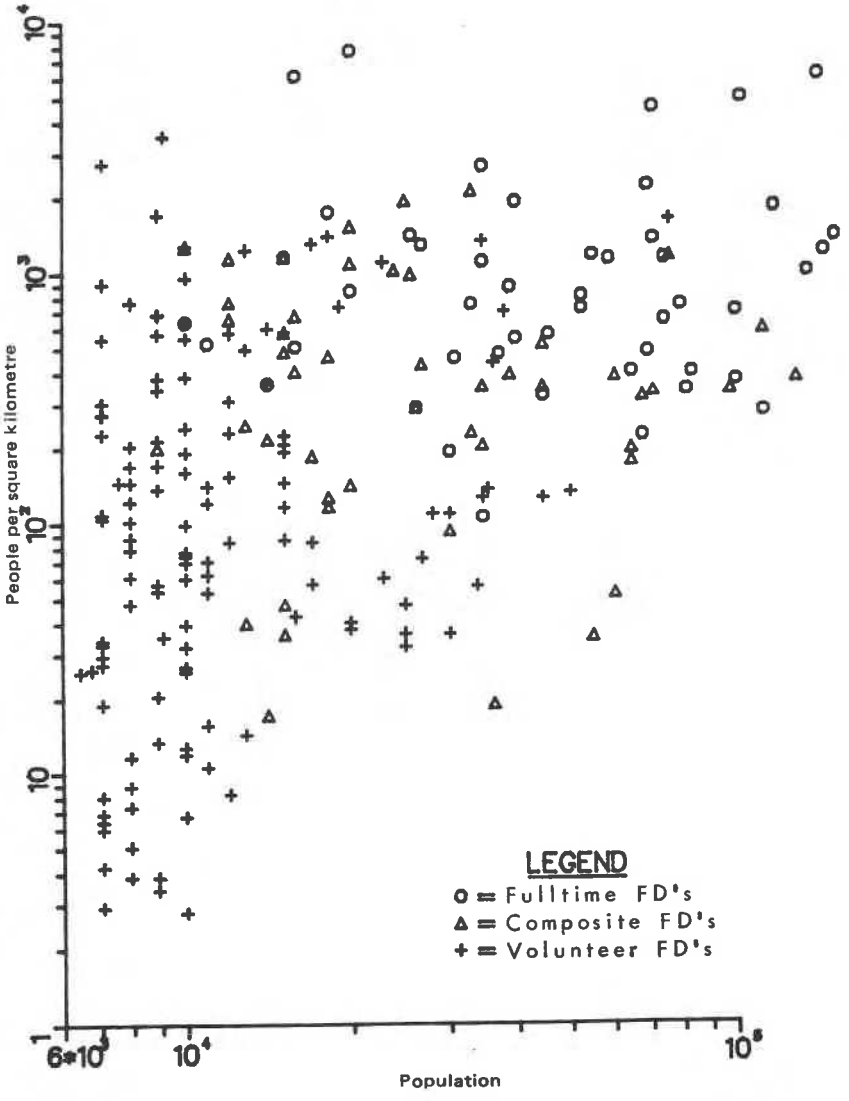

FIGURE 1. Population and area determine type of FD

FIRE DEPARTMENT COSTS

To return to the question: How much should be spent overall on fire protection? Or, rather: How much would an "average MC" spend? This is obviously dependent on their total budget. Figure 2 presents the proportion of total budget that is spent on fire protection as a function of population, and the sum in dollars per head, again as a function of population.

The results can be summarized briefly. Fulltime fire departments generally cost between $40 and $50 per head of population per year and between 9 and 12 per cent of the municipal budget. Composite FD's cost between $30 and $35 per head or 6 to 9 per cent. Volunteer FD's cost $5 to $35 per head or 1 to 7 per cent.

Thus the MC can calculate two estimates of FD cost, one from its own budget, the other based on population. In addition, a third (and probably better) estimate can be obtained from one of the following regression formulae, if the necessary information is available. (Note: OPCAP = total of operating + capital costs in dollars.)

a) For fulltime fire departments: OPCAP = 23.78 X population + 0.014 X municipal budget + 0.785 X property loss + 390 X fire calls (excluding false alarms and calls for services other than fire-fighting).

b) For composite fire departments: OPCAP = 26.94 X population + 534 X fire calls.

c) For volunteer fire departments: OPCAP = 2145 + 5.14 X population + 11937 X life loss + 629 X fire calls.

These equations were chosen from among many others as being most in accordance with common sense. A caveat has to be attached to the predictions, however, because of the incompleteness and wide variability of the data, especially in the case of volunteer FD's. As all the regressions were weighted by population, they will be most accurate for the largest units. An idea of their reliability may be conveyed as follows. The prediction is within a factor two of the actual costs, i.e., between half and double, for 47 out of 49 fulltime FD's. (The remaining two include 1.49 per cent of the population served by these fulltime FD's.) The prediciton is within a factor two for 48 out of 51 composite FD's.

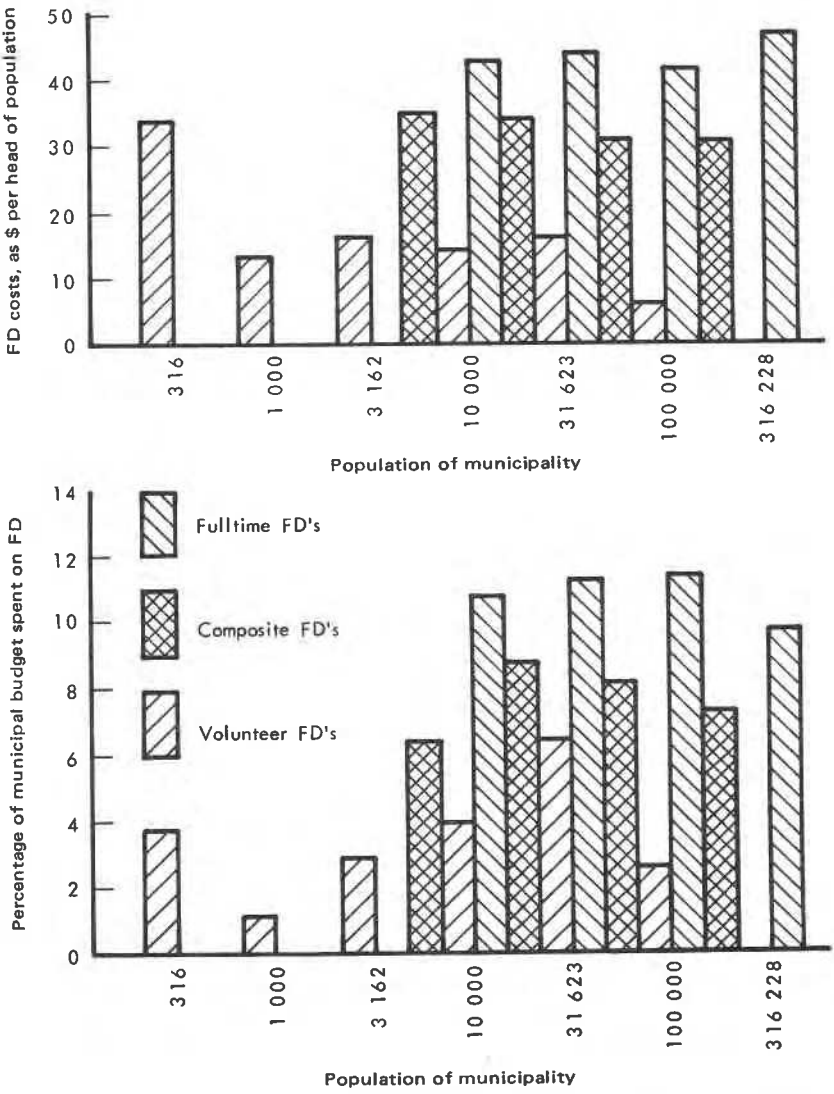

FIGURE 2. Fire department operating and capital cost in relation to population and municipal budget.

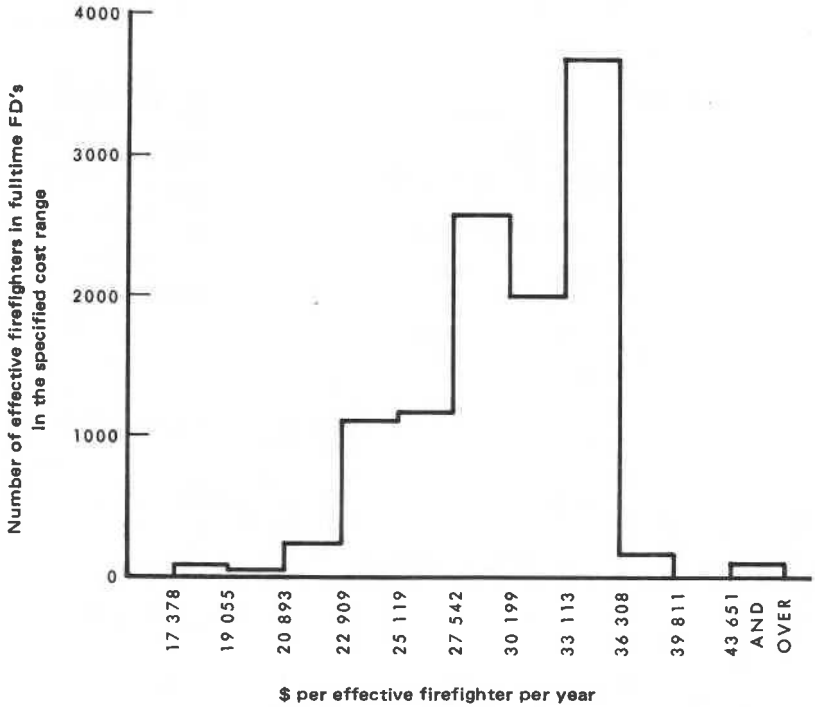

FIGURE 3. Operations and capital cost of a fulltime fire department in 1978.

(The remaining three include 6.5 per cent of the population served by these composite FD's.) The prediction is within a factor two for 51 out of 80 volunteer FD's. (The remaining 29 include 22 per cent of the population served by these volunteer FD's.)

FIRE DEPARTMENT PERSONNEL

Given the type of FD and the estimate of funds needed, the "average MC" is now ready to calculate how many firefighters it can afford to hire. The required information is in Figures 3 and 4, which show the ratio of operating plus capital costs to the number of effective firefighters. The range is much wider for the volunteers.

A regression analysis relating operating plus capital costs of FD's to the numbers of each kind of firefighter reveals that the costs may be estimated by adding $31,900 for each fulltimer to $1,900 for each vol-

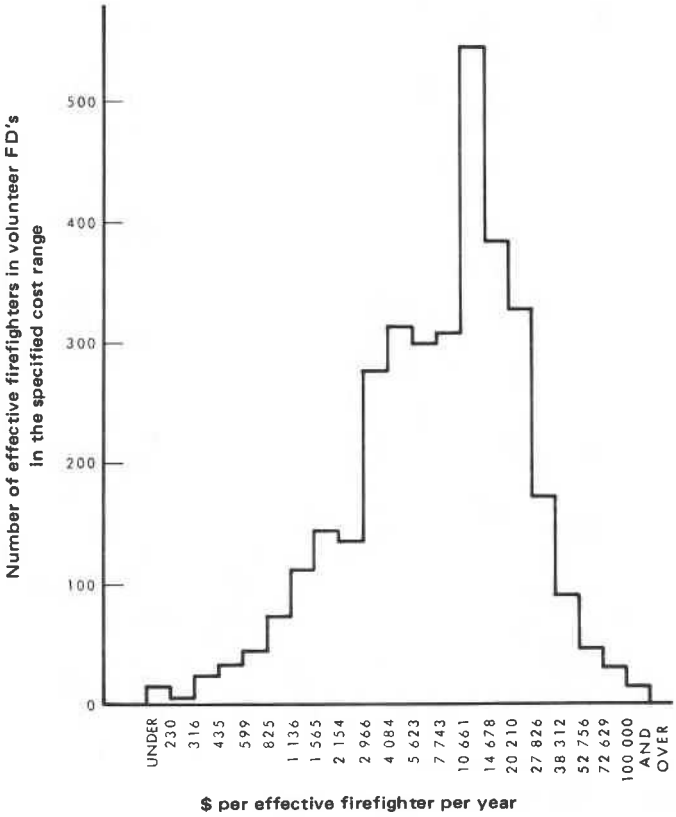

FIGURE 4. Operating and capital cost of a volunteer fire department in 1978

unteer. This of course includes equipment, accommodation and other overhead expenses in addition to the firefighters' pay.

This completes the analysis of information on expenditure by MC's for FD's except to add that all figures relate to 1978, and some allowance should be made for inflation.

GROSS COST OF FIRE

So far only the deliberate expenditure for combating fire has been dealt with.

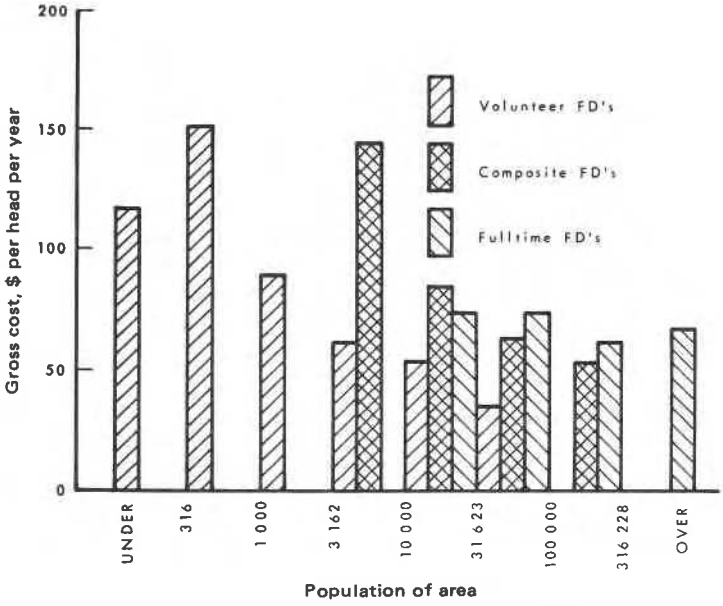

FIGURE 5. Gross cost of fire by population and FD type

To arrive closer to the gross cost of fire the property loss must be added; an allowance must be made related to the number of lives and businesses lost; and interest on the capital tied up in FD inventory must be added (10 per cent has been taken as a conservative rate).

The results (Figure 5) show that the gross cost of fire in areas served by small volunteer FD's ranges from over $150 per head of population down to $35 for the largest volunteer FD. The variation for fulltime FD's is in the same direction, but the range is much narrower, from $75 to $60 per head. Composite FD's are associated with gross costs $145 to $50 per head. In areas of comparable population, composite FD's cost about the same as fulltime, and much more than volunteer FD's.

It should be mentioned that we are dealing with totals and averages that conceal a remarkable diversity in costs. There are 41 FD areas with costs exceeding $300 per head of population; all but 3 were volunteer departments; there are some others costing less than $1 per head. The diversity between different types of FD is best illustrated by Table II in which the average values of 18 key parameters are presented.

TABLE II

Mean Values of Key Parameters

	Full-Time	Composite	Dense	Sparse	
1	12.57	4.20	1.45	1.39	Stations per FD
2	2.52	3.46	4.59	3.00	Apparatus per station
3	15.44	5.31	1.97	1.90	Effective firefighters per apparatus
4	732.64	934.97	2142.94	1149.32	Population per effective
5	0.33	2.58	2.78	84.43	Area, sq. miles per 1000 pop.
6	15.12	1.84	0.20	0.10	$ millions, operating plus capital budget
7	1156.17	474.18	151.95	83.55	$ thousands, budget per station
8	327.17	55.19	18.15	6.63	Population of area, thousands
9	56.94	42.28	19.01	19.36	Preventive inspections per 1000 pop.
10	11.10	8.79	6.82	5.08	Volunteer training, hours per month
11	1.35	1.32	1.38	1.86	Fire prevention budget, $ per head
12	4.69	4.29	2.96	2.29	Mun. bdg. inspection budget, $/head
13	8.90	9.48	10.30	10.25	Average age of apparatus, years
14	42.27	27.67	12.82	12.10	Inspector training, days per year
15	30.74	16.72	12.30	10.88	Admin. training of officers, days/year
16	0.00	7.42	6.16	6.36	Pay of volunteers, $/hour
17	21.71	36.47	46.98	67.43	Community loss, $/head
18	67.19	71.30	62.94	86.60	Gross cost, $/head

Supposing a hypothetical average MC was looking for advice on how to set up an FD, the information so far supplied would help it to decide what funds to allocate, and how many firefighters to hire. There would then be numerous questions of policy to decide; the questionnaire answers cast light on some of these matters, though clear leads are uncommon. Some thought should, however, be given to the purpose of the exercise before pursuing this subject.

OBJECTIVES OF FIRE PROTECTION

Those controlling expenditure should be governed by two considerations. Firstly, the purpose of expenditures on fire protection is to reduce loss of life, prevent injuries and dislocations of businesses, and limit property damage. The second consideration is to do all this at the least possible expense.

If both losses and costs reduce, this is clearly success. If losses reduce but costs do not change, this is still considered success because it is better to spend money on staff and facilities for fire protection than on compensating the victims of fire. If losses remain steady while costs rise, this constitutes failure. The question "at what point does success turn into failure" is subjective; it will be discussed further, with an example, later.

COST COMPARISONS: METHOD AND QUALIFICATIONS

What follows is a hypothetical example to illustrate an important point.

Suppose that in certain areas fire hydrants are painted red and in others yellow. It would be possible to add up the gross cost of fire in all the red and yellow areas separately, and to do the same for the population, divide cost by population, and report that for one color the cost rate was x dollars per head, and for the other y. It is unlikely that x and y would be exactly equal. The point of this example is that it would *not* be correct to infer that the difference in cost was a direct consequence of the different color, and that when repainting became necessary all hydrants should be repainted in the apparently more successful color. However, it *would* be correct to infer, if the difference was significant and other influences were random, that some characteristic of the

areas of those FD's that chose one color over the other was correlated with more efficient performance or less severe hazards. For this example, a question was deliberately chosen that was not asked in the questionnaire, but the same line of reasoning applies to many questions that were asked.

COST COMPARISONS A

Table III presents the responses to 29 questions that called for a choice between two or more alternative answers. The correlated population, loss and cost are given.

It should be noted that, where the population related to a given response is small, random effects can produce loss and cost rates that are much higher or lower than the average; in such cases the apparent implication is often unreliable. For example, on Item 9, Question 66, responses 1 and 4 related to about 2 per cent, a small fraction of the total population, so that only responses 2 and 3 need be taken seriously. Between these the difference in cost is not significant, so the inference is that a 42-hour working week is associated with slightly lower losses than a 40-hour week, and with little difference in cost.

Some Special Points

Evidently all fulltime firefighters in the fulltime departments that responded are members of a trade union, (Item 6).

It may be that the areas that do more frequent inspections do so because the local hazards or loss records are perceived as higher than average. These results may be compared with Figure 6 in Section B, which relates loss rates to inspections per head of population, and with Figure 16, which deals with training of inspectors, (Items 24, 25).

COST COMPARISONS B

The purpose of this section is to examine the correlation between each of 14 different attributes of an FD or of the jurisdiction supporting it, and the losses from fire within the jurisdiction and the costs of the FD.

Since the correlation is found to depend on the FD type, separate

TABLE III

Costs Related to Responses to 29 Questions

F.D's Giving this response:	Include this Population: (Millions)	Community Loss Per Head ($ Yearly)	Gross Cost Per Head ($ Yearly)
1. Question No.:	**1 Province**		
1 B.C.	1.865	36.36	76.99
2 ALTA	1.588	34.86	82.52
3 SASK	0.590	35.74	72.47
4 MAN	0.977	32.57	62.32
5 ONT	6.159	27.20	63.34
7 N.B.	0.263	54.24	100.05
8 N.S.	0.591	28.65	58.23
9 PEI	0.045	42.59	53.45
10 NFLD	0.149	50.50	72.04
11 YUKON	0.019	112.56	152.89
12 NWT	0.023	83.55	115.14
2. Question No.:	**2 Municipality Class**		
1 City	8.708	23.14	67.37
2 Rural M.	1.169	44.66	66.38
3 Town	1.797	52.34	72.58
4 L.I.D.	0.111	67.04	94.75
5 Village	0.319	87.21	105.00
6 County	0.174	31.29	53.69
3. Question No.:	**5 Are There Hydrants?**		
1 Yes	11.817	30.83	69.01
2 No	0.417	53.41	72.23
4. Question No.:	**28 Is the FD the Primary Occupation of the Chief?**		
1 Yes	10.432	27.02	68.10
2 No	1.833	57.98	74.77
5. Question No.:	**37 Volunteer FD's only: The Chief is appointed by:**		
1 M. Council	3.525	47.90	72.56
2 Volunteers	0.748	53.42	71.57
3 Otherwise	0.227	47.57	70.91
6. through 10.	**Apply only to Full-Time FD's.**		
6. Question No.:	**61 Are Firefighters Unionized?**		
1 Yes	9.317	24.45	68.14
7. Question No.:	**64 What part does the Chief take in Union negotiations?**		
1 Active	1.324	32.87	77.28
2 Advisory	7.680	21.40	65.31
3 Not involved	0.418	50.09	86.05

continued

TABLE III (continued)

F.D's Giving this response:	Include this Population: (Millions)	Community Loss Per Head ($ Yearly)	Gross Cost Per Head ($ Yearly)
8. Question No.:	**65 Is There a Union Management Committee?**		
1 Yes	6.799	22.12	68.37
2 No	2.061	34.94	72.87
9. Question No.:	**66 Shift Firefighter's Average Work Week**		
1 Less than 40 H	0.033	44.99	81.37
2 40 H	0.655	29.52	70.56
3 42 H	8.520	24.21	68.21
5 48 H	0.214	8.01	45.74
10. Question No.:	**67 Normal Shift Length**		
1 8 H	0.103	39.10	69.70
2 10 & 14 H	8.865	24.51	68.40
3 24 H	0.437	16.83	58.55
4 Other	0.016	4.47	40.07
11. Question No.:	**68 Composite FD's only: Do Full-Timers work days, Volunteer's nights?**		
1 Yes	0.040	35.33	81.18
2 No	1.586	34.95	69.65
12. through 15. Apply only to Volunteer FD's			
12. Question No.:	**85 Payment Mode**		
1 Hourly	2.425	47.24	71.90
2 Per Call	0.292	55.21	77.18
3 Annual	0.538	40.00	61.89
4 By Points	0.431	69.30	100.08
5 Other	0.206	40.44	63.03
6 None	0.326	48.56	65.95
13. Question No.:	**87 Call-Out Mode**		
1 Pagers	2.717	41.08	65.49
2 Phones	0.932	68.79	91.54
3 Siren	0.535	59.55	78.21
4 Tap Bell	0.012	22.52	45.95
5 Other	0.260	33.14	61.39
14. Question No.:	**89 Availability of Recruits**		
1 Excellent	0.340	44.59	67.84
2 Good	1.921	45.74	71.08
3 Fair	1.669	50.97	73.31
4 Poor	0.429	54.98	74.49
15. Question No.:	**90 Attendance at Fires and Training**		
1 Excellent	0.794	54.71	75.84
2 Good	2.751	44.91	69.01
3 Fair	0.793	58.36	82.29
4 Poor	0.033	31.76	35.42

continued

TABLE III (continued)

F.D's Giving this response:	Include this Population (Millions)	Community Loss Per Head ($ Yearly)	Gross Cost Per Head ($ Yearly)
15. Question No.:	**90 Attendance at Fires and Training**		
1 Excellent	0.794	54.71	75.84
2 Good	2.751	44.91	69.01
3 Fair	0.793	58.36	82.29
4 Poor	0.033	31.76	35.42
16. Question No.:	**91 Training Manual Used**		
1 IFSTA	4.870	34.22	68.85
2 Provincial	0.755	68.83	98.90
3 Own	5.923	21.85	64.29
4 Another FD's	0.105	88.27	108.60
5 None	0.289	66.86	80.29
6 Other	0.295	32.33	66.53
17. Question No.:	**92 Type of Instructor**		
1 Full-Time	8.098	23.30	67.52
2 Part-Time Chief	0.826	54.18	75.44
3 Other Officer	0.926	48.64	73.54
4 Shift Officer	0.888	31.61	68.60
5 Volunteer officer	1.161	54.61	72.13
6 None	0.359	49.64	70.41
18. Question No.:	**93 Training Facilities**		
1 Own drill tower	7.297	22.29	67.48
2 Another FD's	0.178	25.37	44.41
3 Fire Station	4.651	45.69	72.22
4 None	0.132	61.34	82.30
19. Question No.:	**104 Number of Weeks of Training**		
1 Less than 2	1.112	58.11	82.24
2 2	0.743	36.60	78.34
3 3	0.561	50.92	89.02
4 4-5	2.513	20.94	60.84
5 More than 5	5.327	21.71	67.16
20. Question No.:	**105 Composite FD's only: Are Recruits always previous Volunteers?**		
1 Yes	0.509	49.87	84.07
2 No	1.136	30.47	65.58
21. Question No.:	**106 Fire Prevention Program is run by:**		
1 FD	9.907	27.62	68.16
2 FM-FC	0.426	75.61	88.14
3 Shared	0.996	38.75	67.92
4 Not Regular	0.511	53.20	72.67
5 Other	0.077	20.26	33.68
6 None	0.142	55.15	70.71

continued

TABLE III (continued)

F.D's Giving this response:	Include this Population (Millions)	Community Loss Per Head ($Yearly)	Gross Cost Per Head ($ Yearly)
22. Question No.:	**124 Written Orders on Violations?**		
1 Yes	10.909	29.26	68.53
2 No	0.501	62.56	81.16
23. Question No.:	**125 Automatic Follow-up?**		
1 Yes	11.002	29.53	68.52
2 No	0.438	65.37	85.01
24. Question No.:	**126 Dwellings Inspected per Year**		
1 up to 25%	7.680	32.92	70.18
2 26-50%	1.584	18.45	61.14
3 51-75%	0.685	23.26	66.81
4 over 75%	0.138	43.53	78.19
5 None	1.334	41.22	77.24
25. Question No.:	**127 Non-Residential Inspections**		
1 Selective	2.117	36.80	72.76
2 Not Regular	1.560	54.61	87.41
3 6-Monthly	1.374	29.28	68.65
4 Annually	3.826	30.19	71.26
5 2-Yearly	1.749	18.15	58.90
6 Longer intervals	0.938	11.97	45.92
26. Question No.:	**224 Volunteer FD's: Location of Alarm Receipt**		
1 Own Station	2.247	42.10	72.47
2 Another FD	0.293	42.18	64.59
3 Muni C.C.	0.158	42.04	65.51
4 24-Hr Ind-Inst	0.299	60.18	75.16
5 Police Station	0.299	38.22	48.71
6 Answering service	0.210	47.95	62.47
7 FF's Homes	0.860	68.44	85.01
8 Other	0.127	52.39	70.39
27. Question No.:	**226 Automatic Alarm Service**		
1 Yes	10.024	28.14	68.67
2 No	1.719	57.60	77.44
28. Question No.:	**245 Chief's Assessment of FP Program**		
1 Very Good	3.634	24.71	70.44
2 Good	4.955	30.00	65.38
3 Fair	3.208	39.15	72.17
4 Poor	0.433	49.58	73.24
29. Fire Department Type (Questions 23 and 24)			
1 Unspecified	0.038	99.31	113.13
2 Full-Time	7.777	21.71	67.19
3 Composite	1.645	36.47	71.30
4 Volunteer	2.818	55.31	72.35

graphs (see Figures 7 to 24) have been plotted for each of four types of FD: full time, composite, volunteer FD's serving populations exceeding 100 per square mile ("dense VFD's"), and the remaining volunteer FD's ("sparse VFD's"). The octagonal symbol used to represent each FD on the graphs is drawn proportional in area to the population served.

To avoid unduly small scales and consequent congestion of the graphs, the scales have been so chosen that extreme values can be shown only at the limits of the scales. This effect will be noticed in, for example, Figure 9.

With 14 attributes and four FD types, there are potentially 56 plots to present. In actual fact it is necessary to present only one-third of these, as will be explained.

"REDEPLOY?"

A minority of the 56 graphs (see Figures 6 to 23) convey a message that will be categorized as "Redeploy?." These will be discussed first, and then the majority, categorized as "Status Quo."

In these figures the broken curve represents the apparent trend of losses, while the solid curve relates to costs. The *latter* is calculated from the points shown.

When both lines trend downward, they identify a parameter that could, at least in principle, be altered with advantage, especially if the trend can be clearly seen in the distribution of the points. (Upward, not downward, applies in the case of the parameter "mean age of apparatus.") To repeat the caveat above, all that can be firmly stated is that, on the average, some characteristic of the administrations that devote more resources to a particular service is associated with more efficient performance or less severe hazards. For instance, the curves suggest that losses and costs can be reduced by:

a) increasing fire prevention inspections in fulltime FD's (Figure 6),

b) increasing municpal building inspection budgets, where there are composite FD's (Figure 7),

c) increasing the ratio of budget to number of apparatus in both fulltime and sparse volunteer FD's (Figures 8 and 9),

d) reducing the mean age of apparatus in composite and volunteer FD's (both dense and sparse) (Figures 10, 11 and 12),

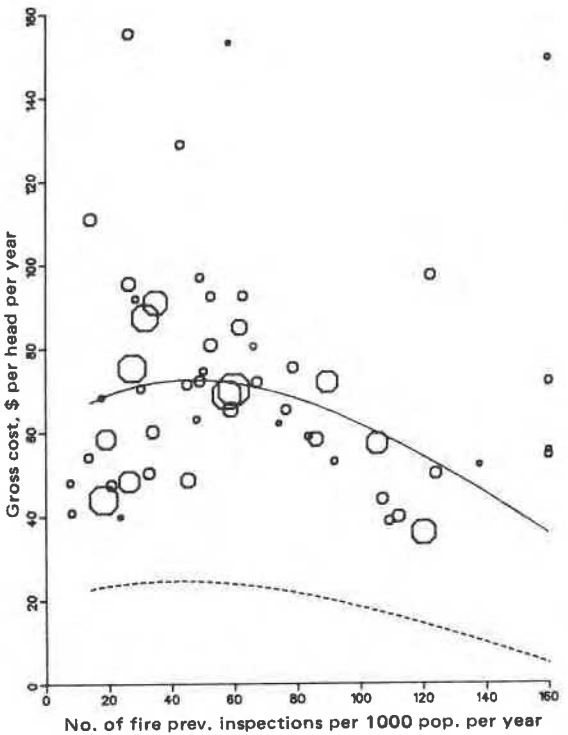

FIGURE 6. Costs in relation to number of inspections by *fulltime* FDs

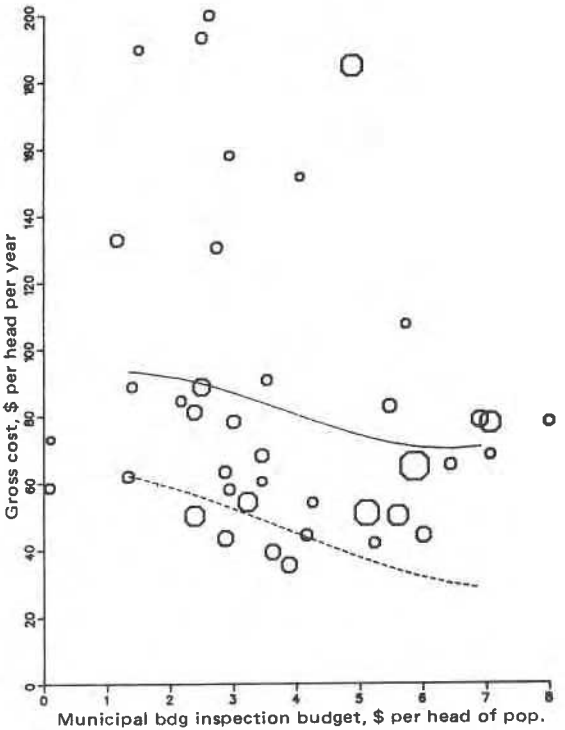

FIGURE 7. Costs in relation to building inspection budgets in *composite* FD areas

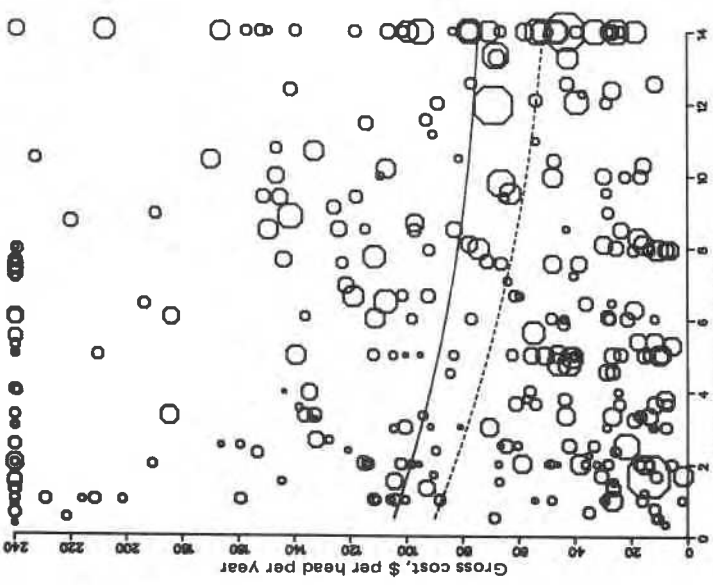

FIGURE 8. Costs in relation to ratios of *fulltime* FD budgets to numbers of apparatus

FIGURE 9. Costs in relation to ratios of *sparse volunteer* FD budgets to numbers of apparatus

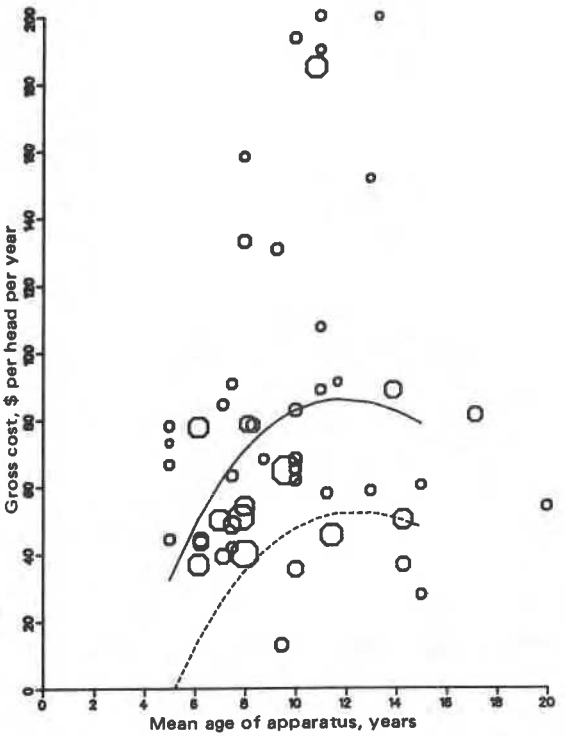

FIGURE 10. Costs in relation to age of apparatus used by *composite* FDs

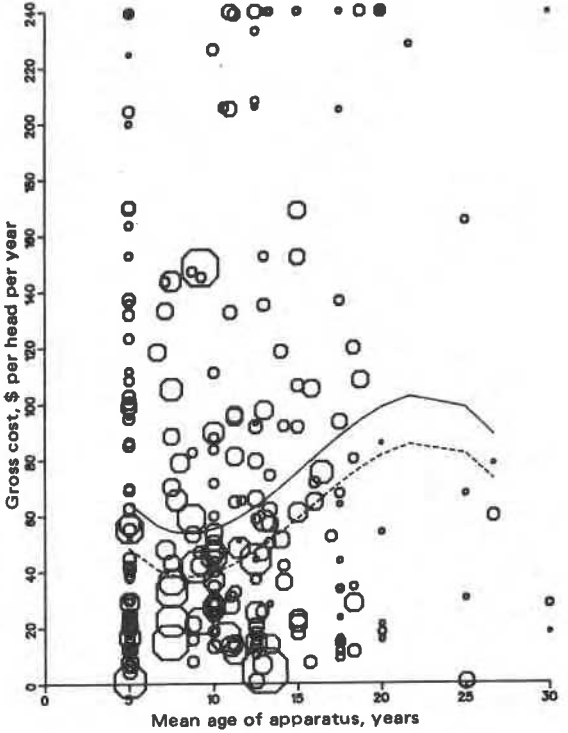

FIGURE 11. Costs in relation to age of apparatus used by *dense volunteer* FDs

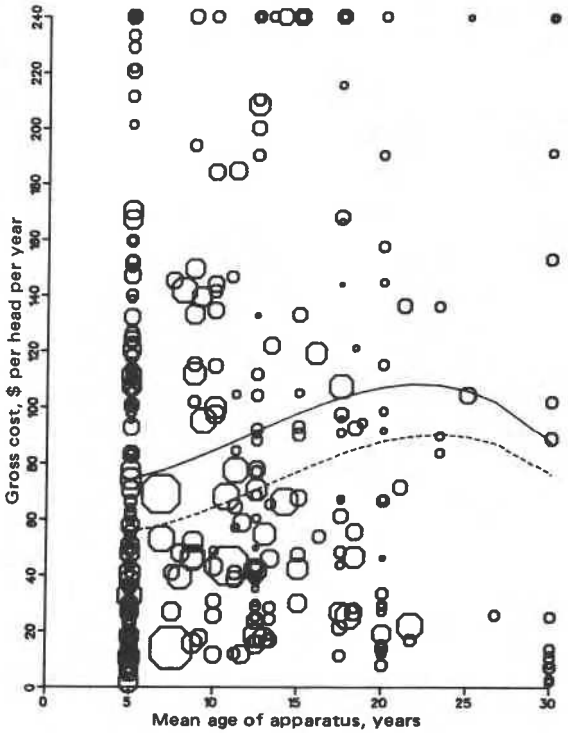

FIGURE 12. Costs in relation to age of apparatus used by *sparse volunteer* FDs.

e) increasing the ratio of inventory to number of apparatus in full-time, composite and sparse volunteer FD's (Figures 13, 14 and 15),

f) giving fire prevention inspectors more training in composite FD's Figure 16),

g) giving officers more administrative training in composite and volunteer FD's (Figures 17, 18 and 19), and

h) paying a higher rate in sparse volunteer FD's (Figure 20).

When studying the graph of FD budget per apparatus in fulltime FD's (Figure 8), note that for all the FD's serving larger populations, the budget exceeds $400,000 per apparatus, while most of those serving smaller populations spend less. This invites the speculation that it is not

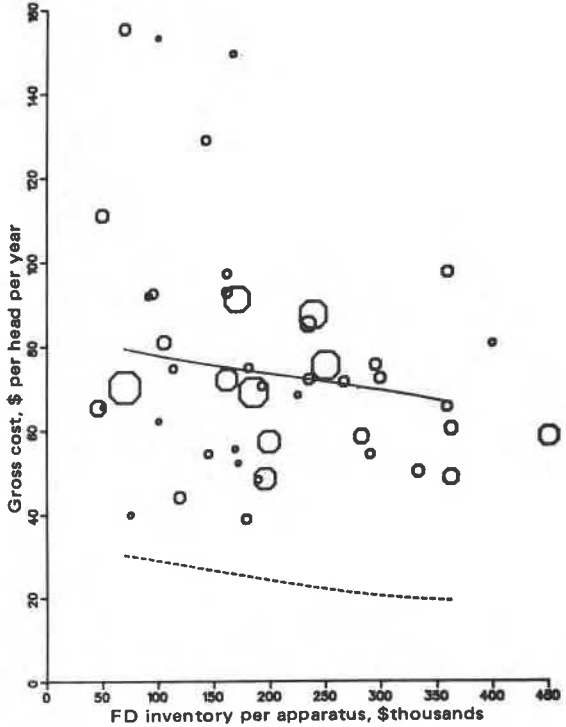

FIGURE 13. Costs in relation to ratios of *fulltime* FD inventories to numbers of apparatus

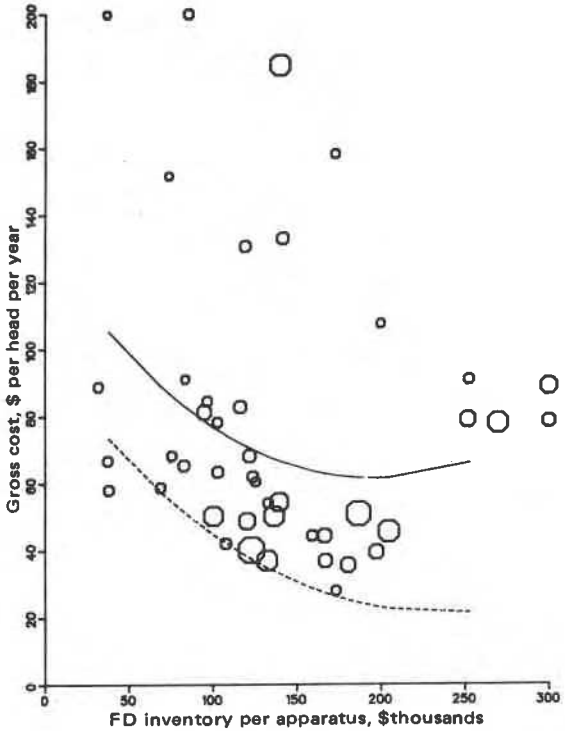

FIGURE 14. Costs in relation to ratios of *composite* FD inventories to numbers of apparatus

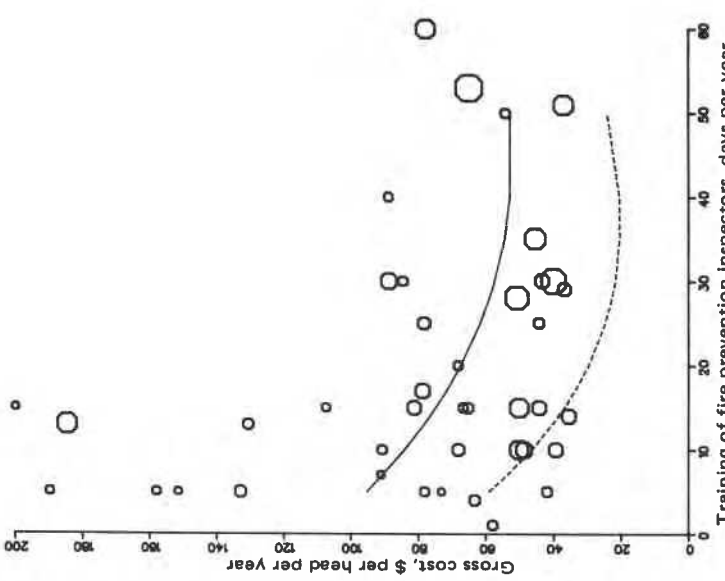

FIGURE 16. Costs in relation to training given to fire prevention inspectors in *composite* FDs

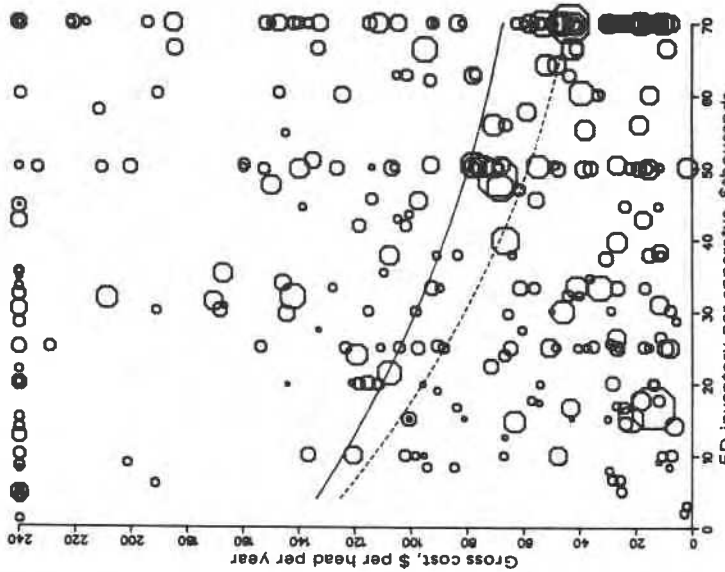

FIGURE 15. Costs in relation to ratios of *sparse volunteer* FD inventories to numbers of apparatus

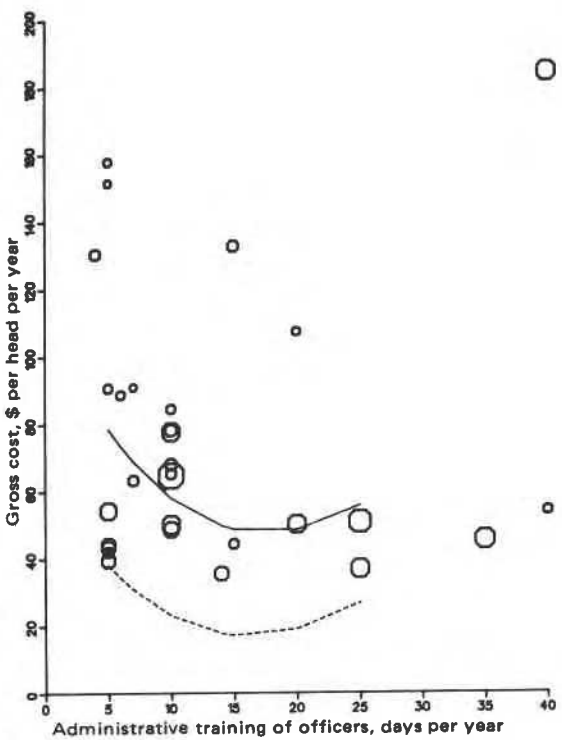

FIGURE 17. Costs in relation to training given to officers in *composite* FDs

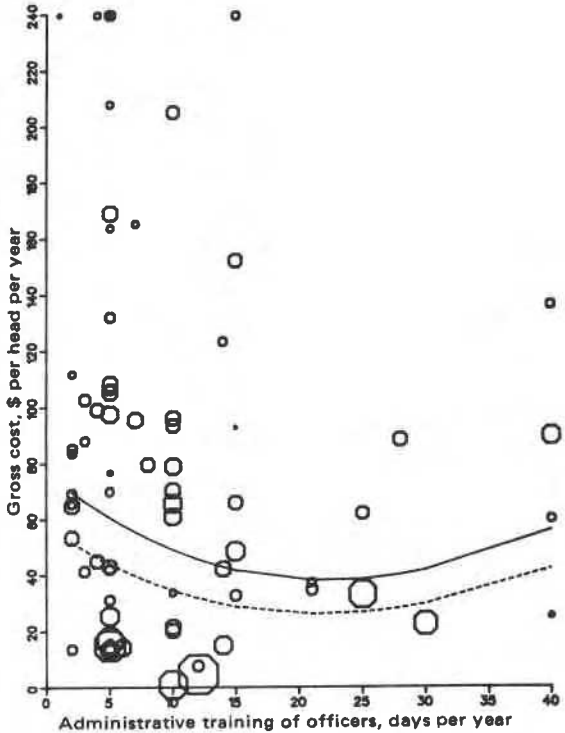

FIGURE 18. Costs in relation to training given to officers in *dense volunteer* FDs

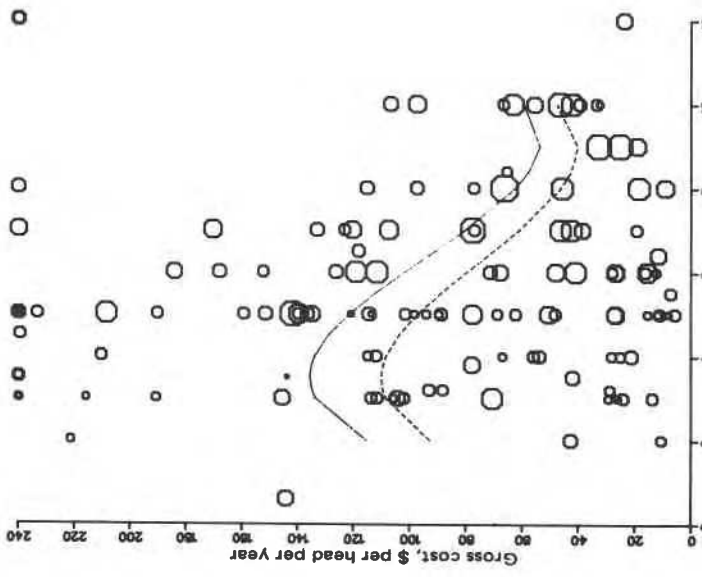

FIGURE 20. Costs in relation to pay rates in *sparse volunteer* FDs

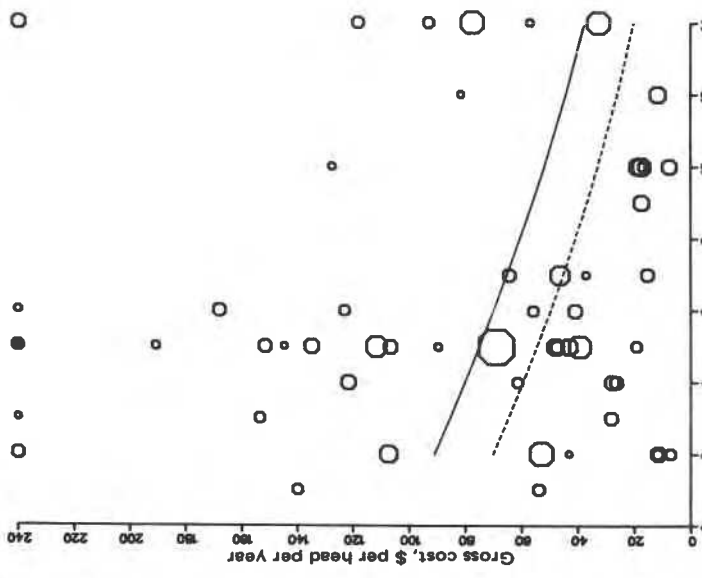

FIGURE 19. Costs in relation to training given to officers in *sparse volunteer* FDs

heavy expenditure, but rather urbanization, that is connected with the better results.

Superficially, (c), (d) and (e) suggest that a FD's performance would be improved by scrapping obsolete equipment. More precisely, the inference is that relatively high losses and elderly equipment in reserve tend to be found in the same FDs.

Where the broken line trends down as the solid line goes up, as in Figure 21, the inference is that a judgment has to be made. This will be illustrated for the case of FD expenditure in sparsely populated volunteer FD areas:

Increasing expenditure from say zero to $25 per head of population per year appears to be associated with a reduction of losses from around $75 to $60. The judgment required is whether the community wishes to spend $25 in order to save $15. The argument for the negative reply is obviously that this course results in a net extra cost of $10. It might, however, be reasonably argued for the positive reply that we would rather spend $25 on hiring firefighters, who might otherwise be unemployed and dependent on the community, than spend $15 on replacing losses and compensating the victims of fire.

Similar but weaker indications apply in two cases:

a) FD expenditure in composite FD's (Figure 22).

b) Municipal building inspection budget in fulltime FD's (Figure 23).

"STATUS QUO"

As remarked earlier, many of the graphs do not fall in the "Redeploy?" category. Either the curves are too level to support any inference, or they have an upward trend, for example Figure 24.

The inference that can be drawn in this case and in similar ones is that, apparently, the FD's and those who regulate them have, on the average, distributed their resources, not necessarily in the best way possible, but at least so that, wherever the needs are greater, the resources applied are also greater. If changes need to be made this analysis fails to reveal them. The evidence thus justifies the "Status Quo."

This being the case, there is little need to present the upward-trending graphs in this report, and thus encourage complacency. All 14 analyses have, however, been carried out for each of the four categories of FD,

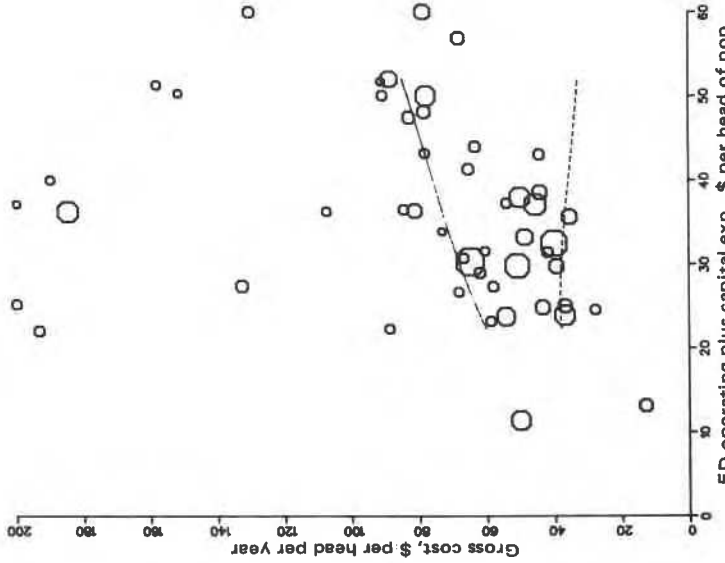

FIGURE 22. Costs in relation to budgets of *composite* FDs

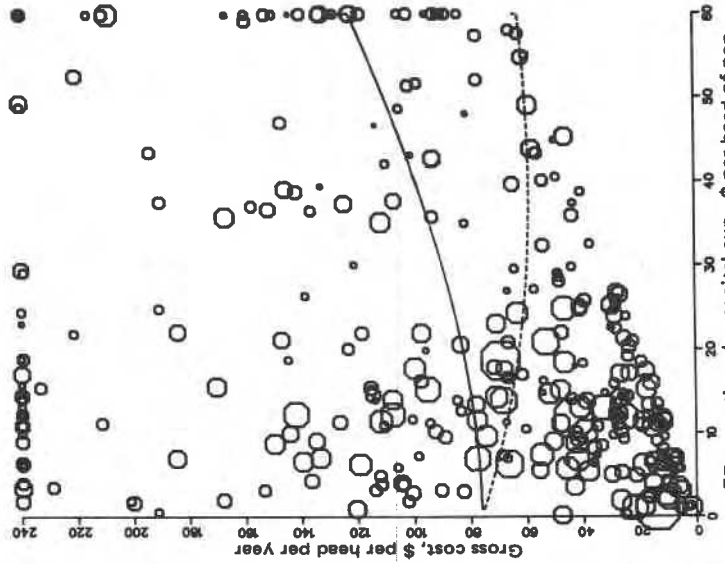

FIGURE 21. Costs in relation to budgets of *sparse volunteer* FDs

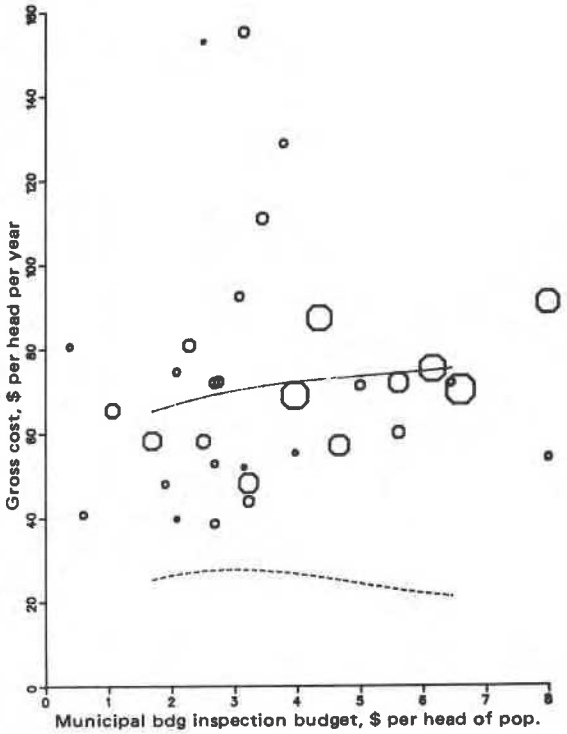

FIGURE 23. Costs in relation to building inspection budgets in *fulltime* FD areas

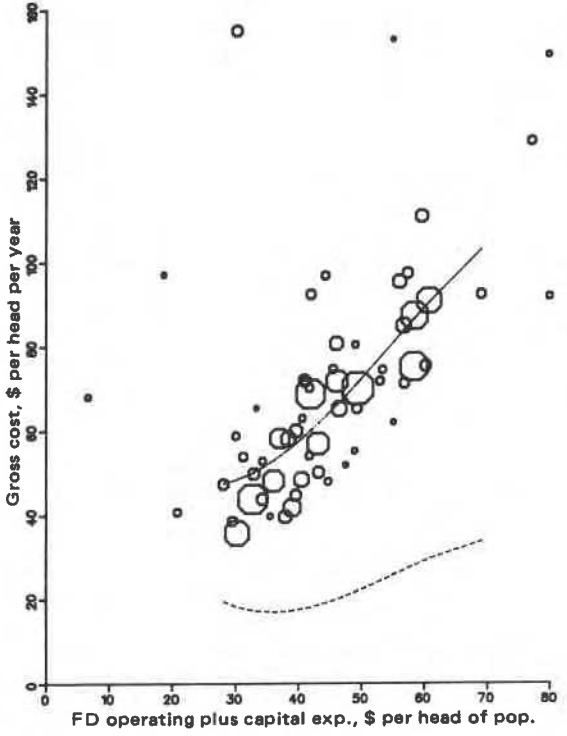

FIGURE 24. Costs in relation to budgets of *fulltime* FDs

and if the result is not presented among the "Redeploy?" figures, it may be taken that the message is "Status Quo." As mentioned, Figure 24 provides an example of the latter category.

The following parameters were found to lie in the "Status Quo" category for all four types of FD, and consequently are not represented among the graphs chosen for publication:

Fire dept. strength per head of population,

Number of stations per head of population,

Number of apparatus per head of population,

Fire prevention budget per head of population,

and Volunteer training, hours per month.

RELIABILITY OF FIGURES 6-25

Some comment is needed on the reliability of the curves presented, which represent weighted polynomial regressions. The author has decided not to present statistical statements on this subject, on the grounds that for most readers of this report there is another approach that will be more convincing. Each reader should examine the plots, and assess for himself to what extent the solid curves are supported by the points, bearing in mind that the size of the symbol centered on each point is proportional to the population served by each FD, and that the points to which the dashed curve relates are not shown.

It will be seen that:

a) where there is a clear trend in the center of each graph, the solid line follows it.

b) on the extreme left and right of each graph, there are often only a few small points, and these may cause the line to wander. For this reason, the line is not continued to the edge of the graph.

A small proportion of the information received must be assumed to be in error and it is sometimes hard to distinguish these cases from random variations. Consequently it would be unwise to place reliance on trends that are strongly influenced by a small number of points, e.g., in

Figure 17, where a single composite department that gives its officers 50 days' administrative training per year was unlucky and reported high losses. The upward tendency at the right hand end of the curve in Figure 17 should, therefore, be disregarded.

SEPARATING THE EFFECTS

In the five preceding sections, the effect of a number of variables on losses and costs is studied individually, without regard for the effect on other variables. It is possible that where an apparent effect is observed, it is actually due to another variable that is correlated with the first. It would be desirable to separate the effects and distinguish which variables are the best predictors, but to do so demands more sophisticated statistical methods, which inevitably are more sensitive to accuracy of the data.

Multiple regression analysis depends on the correct choice of models, which it may or may not be possible to validate. The model that has been tried was:

$$y = c_0 + c_1x_1 + c_2x_2 + \ldots + c_1x_{16}$$

where y is the logarithm of gross cost per head, and x_1 through x_{16} are the logarithms of each of the first sixteen parameters listed in Table II.

This model has had limited success. There are indications that, collectively, volunteer FDs need extra firefighters more than they need extra apparatus; but in general the results of this approach have done little more than support the judgment of the councils and fire chiefs who have determined policy; they tend to justify the status quo, in the sense in which this phrase has been used in previous sections. It appears that differences in the allocation of resources to fire protection are the result rather than the cause of variations in the loss rate.

FIRE DEPARTMENT COMMUNICATIONS

On pages 18 and 19 of the questionnaire (see Appendix A) there is a series of questions dealing with how FD's are called to a fire. The answers to questions 221 to 223, 226 and 227 to 234 are analyzed in Table IV, which should be studied in conjunction with the following explanations.

The first line of numbers, "TOTALS," includes the populations and losses per head for each of four classes of FD and for all together. The top right corner, for instance, tells us that the 12 million people covered by the table had an over-all loss per head of $31 for the year. In each line after the first, the pairs of numbers comprise a percentage of the population, as stated at the head of the column, and a loss per head for the category, which may be compared with the figure at the top. Where the number in the tenth column would be less than 0.3 per cent, the entire line is omitted.

The principal message of the first 8 numbered lines, representing questions 221 to 223, is that 71 per cent of the population are linked to their FD's by telephone *and* by alarm systems in buildings but *not* by street boxes, and that this sector has a loss rate of $26, i.e., $5 below the over-all average. The pattern is not very different for the four groups of FD's; but for sparse volunteer FD's, 67 per cent of 994,000 people served are linked only by telephone and their losses are very slightly greater than those of the rest of the group.

Passing to lines 9 and 10 of the table (question 226), we find that 82 per cent in all groups live in areas where sprinkler alarms, etc., are transmitted direct to the FD's; their losses are $4 below the over-all average. Again it is only the sparse volunteer areas that depart radically from this pattern; 77 per cent are not so protected and their losses are $72, compared with $47 for those that are.

The analysis of questions 227 to 234, on legal requirements for residential detection, in lines 11 to 26 of Table IV is similar.

Line 21 of the table shows that of 12 million, 22 per cent are required to have automatic detection if they live in new buildings, whether large or small, and their loss rate is $34, slightly over the general average. A further 21 per cent are so required if they live in new 1 or 2 family dwellings or any larger building ($32). In line 11, 15 per cent are exempt from such requirements, and their losses are $36. In sparse volunteer fire departments, the exempt proportion rises to 51 per cent and the losses to $61, but otherwise the findings are not very different for the various types of FD.

Table V, whose format is similar to that of Table IV, shows that fire calls are received predominantly at a fire station and that, where this is so, the losses are $5 less than generally. An exception is in volunteer FD's, especially sparsely populated ones, where, for 47 per cent of the population, calls are received at firefighters' homes. Where this is so

TABLE IV

Fire Department Communications

FD Type:	Full-Time		Composite		Dense Vol		Sparse Vol		All	
	Thous.	$	Thous.	$	Thous.	$	Thous.	$	Thous.	$
Totals:	7777.3	21.71	1644.6	36.47	1723.1	46.98	994.4	66.50	12139.4	30.96
Means of Alarm Available to Public: Q. 221-3										
	%	$	%	$	%	$	%	$	%	$
1	3.5	3.65	0.0	0.00	0.3	8.50	4.2	97.79	2.6	16.10
2	1.4	98.69	1.5	25.30	3.3	48.51	2.2	35.71	1.8	70.29
3	8.4	22.68	0.0	0.00	44.7	45.94	66.6	66.61	17.2	45.22
4	76.7	19.42	93.9	34.46	48.5	46.26	22.7	62.91	70.6	25.89
6	5.2	30.24	0.9	35.76	0.1	338.62	0.2	5.01	3.5	31.30
7	0.0	0.00	0.0	0.00	0.7	47.95	3.0	49.70	0.4	49.17
8	4.7	38.12	3.7	91.70	2.1	73.92	0.5	229.46	3.9	49.91
Automatic Alarm Service: Q. 226										
9	8.6	11.52	0.0	0.00	42.4	52.56	77.2	72.14	17.8	46.89
10	91.4	22.66	100.0	36.47	57.6	42.88	22.8	47.41	82.2	27.51
Residential Detection Bylaws: Q. 227-234										
11	9.9	20.55	7.9	30.59	26.3	38.14	50.8	60.70	15.3	36.44
12	0.9	40.85	0.9	35.76	0.3	19.95	0.7	79.20	0.8	41.54
13	1.2	31.43	11.4	31.62	13.0	65.83	13.6	45.45	5.3	46.43
14	11.3	23.49	10.1	33.28	14.7	63.79	6.6	48.78	11.2	33.39
19	12.5	8.98	0.0	0.00	0.7	24.81	2.6	69.08	8.3	10.70
21	17.7	25.12	33.3	38.21	33.0	40.81	15.6	74.24	21.8	34.08
22	24.3	24.56	28.5	44.50	8.7	47.13	5.7	155.86	21.1	32.42
25	11.9	21.03	2.0	5.89	0.7	2.69	0.8	140.09	8.1	21.21
26	10.3	21.60	5.9	21.27	1.2	56.41	1.7	108.45	7.7	23.92

KEY

Q. 221-3. What means are available to the public for calling the Fire Department?

1. None
2. Alarm systems in buildings connected to Fire Department.
3. Public telephone
4. 2 + 3
5. Street Alarm box system
6. 5 + 2
7. 5 + 3
8. 5 + 3 + 2

Q. 226. Are sprinkler alarms, etc., automatically transmitted to the Fire Department?

9. No
10. Yes

Q. 227-234. In which buildings is fire detection mandatory under local bylaws?

11. None
12. In existing larger buildings
13. In new larger buildings
14. In all larger buildings
15. In existing 1-2 family dwellings
16. 15 + 12
17. 15 + 13
18. 15 + 14
19. In new 1-2 family dwellings
20. 19 + 12
21. 19 + 13
22. 19 + 14
23. In all 1-2 family dwellings
24. 23 + 12
25. 23 + 13
26. 23 + 14

N.B. A missing line means "less than 0.3 per cent of total population."

TABLE V

Fire Department Communications

FD Type:	Full-Time		Composite		Dense Vol		Sparse Vol		All	
	Thous.	$	Thous.	$	Thous.	$	Thous.	$	Thous.	$
Totals:	7503.7	22.36	1644.6	36.47	1721.8	47.00	987.4	65.90	11857.5	31.52
Q. 224: Where are Fire Alarms Received?										
	%	$	%	$	%	$	%	$	%	$
1	84.1	22.09	97.3	37.16	27.7	47.91	15.1	49.12	72.0	26.83
2	0.0	0.00	1.6	11.48	11.0	33.41	5.5	50.09	2.3	34.67
3	15.1	23.06	1.1	10.72	7.0	53.37	1.6	45.84	10.9	26.01
4	0.0	0.00	0.0	0.00	7.5	63.37	15.6	54.50	2.4	58.54
5	0.7	39.02	0.0	0.00	14.5	37.29	4.6	45.95	3.0	38.69
6	0.0	0.00	0.0	0.00	9.0	44.08	4.9	64.99	1.7	49.09
7	0.0	0.00	0.0	0.00	19.2	52.32	47.3	80.68	6.7	68.94
8	0.0	0.00	0.0	0.00	4.1	52.51	5.3	56.01	1.0	54.01

KEY

1. At own fire station
2. At another Fire Department
3. At a municipal communications center
4. At a 24-hour industry or institution
5. At a police station
6. Through a telephone answering service
7. At homes of firefighters
8. At other locations

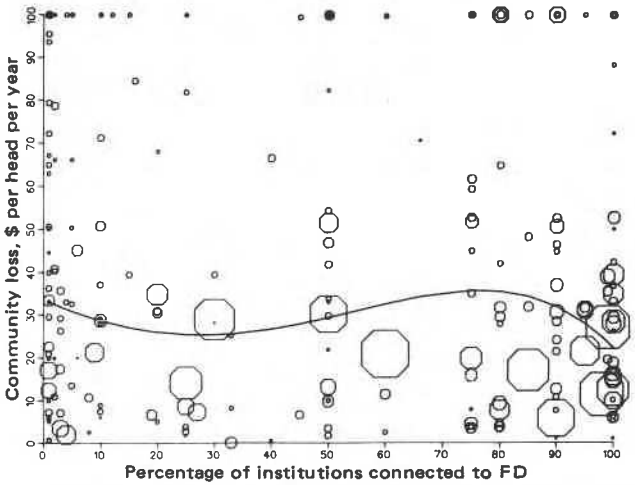

FIGURE 25. Losses in *all* classes of FD in relation to proportion of institutional buildings with alarm systems connected direct to FDs

losses rise to $81 compared with $66 generally, and $49 where they are received at the station.

The responses to question 225 are presented in Figure 25. This shows the propostion of institutions whose fire alarm systems are directly connected to the FD, and the related losses. The area of the symbol is, again, proportional to the population served by each FD. The larger populations have from 25 to 100 per cent connected, and the smaller populations are well represented at both ends of the scale 1 to 100 per cent. The associated losses where the proportion is low are a little less than those where it is high.

PAY RATES OF VOLUNTEER FIREFIGHTERS (VFF's)

a) *Method of Payment*	*Number of VFF's*
By the hour	9,039
Per call	1,709
Annually	1,757
On points	1,860
In other ways	763
Unpaid	4,153
Total	19,281

b) The rates received by those who are paid are shown in Figure 26.

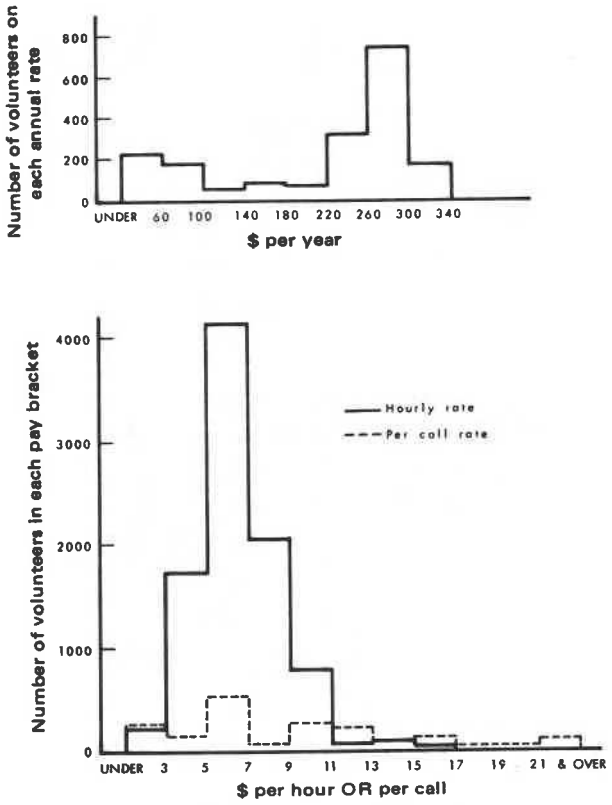

FIGURE 26. Pay rates of volunteer firefighters

CONCLUSION

Only a part of the Questionnaire has been analyzed here for information; there is undoubtedly much more to be found. Readers with an interest in special aspects not covered here are invited to send their questions to the author at the address given on the Title page.

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REFERENCE

Switzer, R. A. W. and D. M. Baird. Report of study on fire prevention and control systems in Canada, Ottawa, National Research Council, 1980 (NRCC 18586).

APPENDIX A

D. COMMUNICATIONS

1. Means Available for Transmission of Alarms to Fire Department by the public (check any applicable)
   - 221 Street Alarm Box System ( )
   - 222 Public Telephone System ( )
   - 223 Alarm Systems in Buildings Direct-Connected to Fire Department or Security Central Station Service ( )

2. Main Location of Receipt of Alarms of Fire (check one)
   - 224 Own Fire Station or Center ( )
   - Another Fire Department ( )
   - Municipal Communications Cener ( )
   - 24-hr. Industry or Institution ( )
   - Police Station ( )
   - Telephone Answering Service ( )
   - Homes of Firefighters ( )
   - Other (specify) _____

3. Institution Alarms (if "none" enter "0")
   - 225 Percentage of Institutional Buildings in Your Community that have an Alarm System Direct-Connected to the Fire Department or A Security Central Station (%)

4. Automatic Alarm Service
   - 226 Is There a Service Available for Automatic Transmission of Alarms from Sprinkler and other Automatic Systems Direct to the Fire Department or a Security Central Station Yes ( ) No ( )

5. Residential Detection

   For which of the following types of Residential Buildings is there a Legal Requirement that they be Protected by Automatic Detection or Extinguishing Devices (check any applicable)

	New Buildings	Existing Buildings
No Requirement	227 ( )	228 ( )
All Residential Occupancies	229 ( )	230 ( )
One-and Two-Family Dwellings Only	231 ( )	232 ( )
Limited to Larger Buildings	233 ( )	234 ( )