FIRE PROTECTION ALTERNATIVES FOR RURAL AREAS*

M. B. Badenhop and T. Morris Jones

INTRODUCTION

Studies show that populations of 10-12 thousand and more are needed before maximum savings in providing fire protection services to rural areas can be achieved [4, 7]. Yet, many rural areas have smaller, widely scattered populations, lax building codes and inadequate water supplies. Fire damage to rural property is three to six times greater per occurrence than for city property [5, p. 36]. Also, insurance costs are about six times greater on unprotected farm property than on protected [8]. Data published for 1974 conditions indicate that all rural Tennessee counties and 45 percent of its municipalities were assigned Class 10, the lowest possible fire protection rating, denoting little or no fire fighting capability [1].[1]

Previous research reveals little information on fire protection services to assist decision-makers of local jurisdictions [4]. Hirsch [2] and Will [9] found only slight economies of scale for systems serving populations of up to 100 and 300 thousand, respectively. Neither study accounted for variations in fire-control quality, and neither included private fire protection costs, water supply costs or value of volunteer effort. Both Hitzhusen [4] and Lederer [7], studying fire protection services for rural areas, found that size economies leveled off at population levels of 10 to 12 thousand. Moreover, Lederer's analysis indicated that population density per square mile seemed to have little influence on the total cost of providing fire protection to the rural areas of Tennessee. Greater variations of densities than found in the Tennessee data would likely alter this conclusion, as more densely populated areas probably lead to lower cost fire protection, *ceteris paribus*.

Some things can be done, however, to improve fire protection in rural areas; for example: (1) design fire protection systems especially adapted to rural areas—smaller equipment, using volunteers—and/or (2) pool resources with adjacent counties to save costs and reduce travel times. In addressing these possibilities, local decision-makers also face the question of how far to upgrade protection systems within limitations imposed by budget constraints and tax bases. Therefore, this study was undertaken to evaluate net benefits generated by different fire protection systems (alternatives) that provided different levels of fire protection in rural areas.

PROCEDURES

Alternatives

Three alternative systems for providing fire protection services to rural areas were selected for analysis based on present technologies that have been used by rural Tennessee fire departments and on an

M. B. Badenhop is Professor of Agricultural Economics, The University of Tennessee, Knoxville and T. Morris Jones is Assistant Professor of Economics, Mobile College, Mobile, Alabama.

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[1] A fire protection classification rating is one that has been assigned to a municipality by the Insurance Services Office (ISO) of Tennessee. ISO is a private organization supported by insurance companies and regulated by the Tennessee Department of Insurance. ISO evaluates the water supply, fire department, fire service communications and fire safety control components of a municipality's fire defenses, and assigns deficiency points when components do not meet required standards. Based on inspection, a rating from Class 1 to Class 10 is assigned with 1 as the best rating and 10 the poorest. (If there has been no inspection, a Class 10 rating is automatically assigned.) Class 10 indicates very limited or no fire fighting capability.

evaluation by local leaders of their range of effectiveness. These alternatives were specified using the following criteria:

(1) *Minimum Service Alternative* (MSA): Under the MSA, the primary consideration was to identify a set of limited improvements in fire protection for rural property owners which would not incur expenditures of the magnitude required to upgrade the fire rating above the lowest possible rating of Class 10 [1]. The Class 10 rating was assigned because these rural areas had very limited or no organized fire fighting capability.

(2) *Insurance Reduction Alternative* (IRA): Under the IRA, delivery systems were developed to upgrade the fire classification rating to a Class B Rural Fire Department (RFD) or to a Class 9 Public Fire Department (PFD) without altering existing road and water systems.[2]

(3) *Full Service Alternative* (FSA): The FSA was designed to enable a subunit of a county, such as a utility district or a fire protection district, to achieve a Class 8 fire protection rating. This rating was considered an acceptable goal by community leaders and was consistent with the county's financial resources.[3]

Options

Six different options, each sufficient to provide fire protection services in the study area, were delineated for the MSA and IRA (Table 1). To determine these options, fire chiefs serving rural areas were surveyed to determine the extent of volunteer versus full-time, or a combination of volunteer and full-time firemen employed; types of equipment used to suppress fires in rural areas; and the average distance in miles traveled by the fire-fighting equipment to reach the scene of a fire. These MSA and IRA alternatives assumed that present water and road systems would remain essentially unchanged. The FSA encompassed changes in the water system and, in this study, was evaluated for only one option for a limited area of one county.[4]

TABLE 1. FIRE PROTECTION DELIVERY SYSTEMS (OPTIONS) USED IN TENNESSEE RURAL AREAS BY TYPE OF FIRE DEPARTMENT AND PERSONNEL AND BY TYPE OF EQUIPMENT AND AVERAGE TRAVEL DISTANCE

Type of fire department (option) and personnel[a]	Type equipment used: Pumper capacity (gpm)	Type equipment used: Water tank capacity (gallons)	Average distance to the fire[b] (miles)
Option I municipal volunteers	500	250[c]	5.0
Option II municipal volunteers	250	1,000	7.0
Option III municipal volunteers	500	750	6.5
Option IV civil defense volunteers	250	1,000	13.5
Option V civil defense volunteers	250	700	17.0
Option VI full-time municipal personnel	500	750	6.5

[a]For the options, the number of fire stations, pumpers and firemen would vary between alternatives while other types of equipment and personnel would remain the same.

[b]Distance in miles was used as a proxy for response time—the time for fire equipment to arrive at a fire after leaving the fire station.

[c]The fire department using a pumper with a 250-gallon water tank capacity responded to fires no farther than five miles from the fire station.

Options I, II and III are municipal fire departments manned by volunteer firemen. Options IV and V are rural fire departments manned by civil defense workers, and Option VI is a municipal fire department manned by full-time personnel. These options were used as a reasonable base for constructing and comparing alternative fire protection systems.

This approach seems to be a realistic way to analyze alternative fire protection delivery systems because the technology is lumpy and factor proportions are fixed. Moreover, it has the advantage of drawing on the informed judgment of professionals in the field who are faced with day-to-day decisions about what system to adopt.

Putnam and White counties, Tennessee, were used to provide empirical content to the alternatives. These counties are located on the Highland Rim of

[2]For rural fire protection systems, ISO may assign either a Class A or Class B Rural Fire Department (RFD) fire protection rating, or may assign a Class 1 to Class 10 Public Fire Department (PFD) fire protection rating. With a Class A or Class B RFD rating, rural property owners can receive fire insurance premium credit only on farm property; with a Class 1 to Class 10 PFD rating, fire insurance premium credit can be received on all types of property.

[3]To obtain a Class 8 fire protection rating, a municipality, utility district or county must have a water system fire department facility adequate to meet ISO standards. A rating better than Class 8 (Class 1 to Class 7) can be achieved only by having full-time firemen, a full-time fire prevention inspector, apparatus and other fire department resources. Consideration of a better fire protection rating was dropped since estimated additional costs necessary to obtain these ratings were greater than estimated additional benefits for communities in this study.

[4]The reason for selecting only one particular utility district rather than the entire county was because of the difficulty of obtaining maps and other necessary data for existing utility districts and the difficulty of estimating water system costs for areas of the county without a water distribution system.

the Upper Cumberland Area of North Central Tennessee. About 55 thousand persons live in the two-county area with slightly more than half in unincorporated places. Major and connector roads within the counties provide good access to most parts of the study area.

Benefits and costs associated with the alternatives and options were estimated using survey data from a sample of rural property owners (rural residents, businesses and institutions) in the area and from representatives of agencies providing fire protection services. The analysis was for each county separately, and for the two counties combined.

Benefits

Improved fire protection systems benefit both rural property owners and insurance companies. Benefits to property owners are comprised of savings from reduced fire losses and savings in fire insurance premiums resulting from improved fire protection service.

The only potential benefits to rural property owners from the various options under the MSA would be reduced fire losses. Since new or improved fire protection options do not alter the Class 10 fire rating, no savings would accrue from reduced insurance premiums which vary only by fire classification ratings.

Benefits to owners under the IRA and FSA would include both savings from reduced fire losses and savings in fire insurance premiums. Savings in premiums would be realized because the new or improved systems of protection would result in upgrading fire classification ratings to Class 9 under the IRA and Class 8 under the FSA. Insurance companies would benefit because payments for fire losses would be less if one of the fire protection options were implemented [6].

Reduced Fire Losses to Property Owners. Benefits from reduced fire losses can be estimated by determining the difference between the annual value of property lost to fires with no fire protection and the value lost with the use of the improved system.

To approximate the average fire loss for different property types by county, the state-wide fire loss ratio was used. This fire loss ratio was calculated from annual reports of the Tennessee Department of Insurance. Direct premiums earned and losses incurred were summed for 1958, 1960, 1962 and 1965-1972 on the fire insurance portion of the homeowners, commercial and institutional policies. Direct losses were divided by direct premiums earned to yield the state-wide fire loss ratio. For the categories of residential, and for commercial and institutional properties, these ratios were .597 and .531, respectively. Data were then aggregated for the study area by multiplying the average fire loss for the different type properties by the number of properties in each category.

Reduced fire losses were calculated based on no fire protection, and assuming 100 percent of the property destroyed where fires occurred. These losses were compared with projected losses that would have occurred under the different options for providing fire protection developed in the study. These estimated values were obtained from fire chiefs. It is realized that the assumption of 100 percent property loss may overstate actual losses in some cases. Local fire chiefs, however, felt that this was a more realistic assumption in the absence of data to the contrary. Estimated fire loss savings were then claimed as benefits for the alternatives.

Premium Savings to Property Owners. Data on annual premium savings to property owners were estimated by aggregating the amount of insurance on farm, nonfarm, commercial and institutional properties. Premium rate savings that would be allowed if fire protection services were upgraded to meet ISO specifications under the IRA to Class 9 and under the FSA to Class 8 were then applied. Premium savings were added to fire loss savings and claimed as benefits to property owners under the IRA and FSA.

Savings to Insurance Companies. Premiums paid to insurance companies and payments to rural property owners were obtained from the survey of rural property owners. Changes in amount of premiums paid and compensation received could be estimated for each fire protection option. Incremental net payments (e.g. premiums paid minus compensation received) for each option were specified as benefits to insurance companies. These values were expanded to reflect insurance company benefits for the study area by applying the coverage ratio (i.e. percent of property owners in each category covered by insurance) to the number of units of property in each category.

Costs

Cost data for the three alternatives were obtained from fire chiefs, apparatus and equipment manufacturers and other persons associated with providing fire protection services. Budgets for each option were based on estimates of the number of fire stations, apparatus and ancillary equipment, personnel needed for each option, and estimates of costs associated with the facility, the apparatus and equipment, and personnel [6].

Initial outlays costs included costs of fire station(s), station fixtures, communication equipment, apparatus, land and equipment. These initial

outlays were simply entered into the first year's cost. This seems realistic since major investments such as these are often financed with revenue sharing funds or other state or federal grants. Obviously, long term debt (perhaps revenue bonds) would be used by local governments to finance the initial outlay.

Annual operating costs consisted of salaries, insurance and fringe benefits for fireman; utilities, office supplies and fuel; repairs and maintenance for apparatus, fire station(s), station fixtures and communication equipment; and insurance for fire station(s), apparatus and communication equipment. Operating costs were assumed to begin accruing during the first year of operation and were discounted over successive time periods.

In calculating present values of net benefits, a planning horizon of 20 years was used with the base year being 1973. This planning horizon was based on the technical life of the major investment item, the apparatus fully equipped. Salvage values and replacement costs were estimated. Land cost was assumed to remain the same during the time period and was added to benefits to be received during the last year of the planning horizon. A six percent discount rate was based on the local bond rates of the two counties in 1973. All benefits and costs were calculated in constant 1973 dollars.

RESULTS

The investment decision that local government officials must make in providing public services to rural areas often depends on the nature of the budget constraint, relative size of the budget, time horizon and the lumpiness of investments. This situation faces local governing bodies responsible for providing fire protection in the study area. One objective might be to maximize the present value of net benefits derived from the investment. Hirschleifer [3, p. 48] points out that the "present value" rule is the criterion most often used by economic theorists when faced with investment decisions. Therefore, an appropriate criterion for selecting the fire protection service best suited for the study area would be to compare the present value of net benefits for each option under alternatives studied.[5]

The present value of net benefits for each option is detailed in Table 2. Results show that the present value of net benefits for all options using volunteer firemen was higher for the two counties operating as one unit than for each county operating separately, suggesting potential gain to rural residents of inter-county cooperation for service delivery.

Assuming fire protection services for the two counties can be pooled, and using the net benefits criterion, decision-makers should select Option I of Class 9 PFD under the IRA. Under this option, the fire classification rating would be upgraded from 10 to 9. The present value of net benefits would be $2,958 thousand, which is more than the present value of net benefits when the two counties were considered as separate units. Option I provides for a fire delivery system manned by a volunteer fire-fighting force operating out of a central two-bay and

TABLE 2. PRESENT VALUES OF NET BENEFITS FOR SIX FIRE PROTECTION OPTIONS FOR PUTNAM COUNTY, WHITE COUNTY AND PUTNAM AND WHITE COUNTIES COMBINED, BY ALTERNATIVE, TENNESSEE, 1973[a]

Alternative and option	Present value of net benefits		
	White County	Putnam County	White and Putnam counties combined
	Dollars (000)		
Minimum Service Alternative			
Option I	1,006	1,525	2,607
Option II	833	1,277	2,215
Option III	667	1,106	1,808
Option IV	772	1,102	1,909
Option V	682	775	1,492
Option VI	-859	29	-812
Insurance Reduction Alternative			
Class B RFD			
Option I	1,017	1,566	2,659
Option II	844	1,308	2,267
Option III	678	1,147	1,860
Option IV	782	1,143	1,960
Option V	692	799	1,526
Option VI	-848	70	-760
Class 9 RFD			
Option I	1,117	1,770	2,958
Option II	907	1,455	2,498
Option III	748	1,298	2,075
Option IV	800	1,200	2,065
Option V	701	838	1,603
Option VI	-1,112	-115	-1,220
Full Service Alternative[b]			
Class 8 RFD	--	-590	--

[a]Computed at six percent discount rate.

[b]The FSA was considered under Option I only, and only for a utility district in Putnam County.

[5]The present value of net benefits for each option can be expressed as:

$$\text{Net benefits} = \sum_{t=1}^{T} \frac{B}{(1+i)^t} - \left[\sum_{t=1}^{T} \frac{OMR}{(1+i)^t} + K \right]$$

where B = annual benefits (fire loss and fire insurance premium savings)
OMR = annual operating, maintenance and repair costs
K = initial investment or capital costs
i = discount or interest rate and
T = planning or time horizon.

six one-bay stations each equipped with a 500 gallon per minute pumper authorized to travel a maximum distance of five miles to fight a fire [6, table 5-2, p. 129].

Estimated annual savings on fire insurance premiums for all options were small compared to estimated fire loss savings (Table 3). For instance, when all requirements were met and the fire classification for a department was upgraded from Class 10 to 9, a premium rate savings of three cents per $100 insurance would be allowed by the ISO. Thus, if fire protection was provided under Option I, fire insurance premium savings for rural property owners would have been $39,000 in 1973 compared to a fire loss savings of $274,000.

Annual net benefits to rural property owners served by fire departments operated by volunteer firemen (Options I-V) are inversely related to distances traveled to answer fire calls (Tables 1 and 4). When both counties are served jointly by Class 9 fire protection service under the IRA, annual net benefits would be $313 thousand for Option I, which has a response distance of five miles from any one fire

TABLE 3. ESTIMATED ANNUAL BENEFITS (FIRE LOSS AND FIRE INSURANCE PREMIUM SAVINGS) ACCRUING TO RURAL PROPERTY OWNERS AND INSURANCE COMPANIES IN PUTNAM AND WHITE COUNTIES, BY ALTERNATIVE AND OPTION, TENNESSEE, 1973

County, group benefiting, type of benefit and alternative	Option I	II	III	IV	V	VI
	Dollars (000)					
Putnam and White counties						
Rural property owners savings						
Fire loss savings	274	215	193	179	139	238
Fire insurance premium savings						
Farm property	5	5	5	5	3	5
Other property	34	25	27	13	11	27
Annual benefits for MSA[a]	274	215	193	179	139	238
Annual benefits for IRA						
Class B RFD[b]	279	220	198	184	141	243
Class 9 PFD[c]	313	245	225	196	153	270
Insurance company savings	184	131	99	102	96	142

[a]Fire loss savings exclusive of insurance company savings.

[b]Fire loss savings exclusive of insurance company savings and fire insurance premium savings on farm property.

[c]Fire loss savings exclusive of insurance company savings and fire insurance premium savings on farm and other property.

TABLE 4. ESTIMATED ANNUAL BENEFITS FOR RURAL PROPERTY OWNERS AND ESTIMATED INITIAL OUTLAY COST AND ANNUAL OPERATING COST FOR SIX FIRE PROTECTION OPTIONS FOR PUTNAM COUNTY, WHITE COUNTY AND PUTNAM AND WHITE COUNTIES COMBINED, BY ALTERNATIVE, TENNESSEE, 1973[a]

Alternative and option	Putnam County			White County			Putnam and White Counties		
	Annual benefits	Initial outlay cost	Annual operating cost	Annual benefits	Initial outlay cost	Annual operating cost	Annual benefits	Initial outlay cost	Annual operating cost
	Dollars (nearest thousand)								
Minimum Service Alternative									
Option I	161	221	9	112	193	8	274	362	15
Option II	127	118	5	88	118	5	215	166	7
Option III	114	136	6	79	165	7	193	277	12
Option IV	105	71	3	73	47	2	179	95	4
Option V	74	47	2	66	47	2	139	71	3
Option VI	141	160	125	98	196	156	238	342	281
Insurance Reduction Alternative									
Class B RFD									
Option I	165	221	9	113	193	8	279	362	15
Option II	131	118	5	89	118	5	220	166	7
Option III	118	136	6	80	165	7	98	277	12
Option IV	109	71	3	74	47	2	184	95	4
Option V	76	47	2	67	47	2	143	71	3
Option VI	145	160	125	99	196	156	243	342	281
Class 9 PFD									
Option I	188	240	10	126	212	9	313	404	17
Option II	147	137	6	98	137	6	245	185	8
Option III	135	155	7	90	184	8	225	319	13
Option IV	117	90	4	79	66	3	196	114	5
Option V	83	66	3	70	66	3	153	90	4
Option VI	162	179	155	108	215	186	270	390	341
Full Service Alternative[b]									
Class 8 PFD									
Option I	23	712	14	--	--	--	--	--	--

[a]Computed from survey data. For the MSA, estimates include only fire loss savings. For the other alternatives, estimates include fire loss savings and fire insurance premium savings.

[b]The FSA was considered only under Option I in Putnam County.

department. In contrast, for Option V, when each county is treated independently, an average response distance of 17 miles is entailed and annual net benefits would be only $153 thousand.

Annual net benefits would be greater for rural property owners served by fire departments with a full-time instead of a volunteer force when response distance is the same. However, total annual costs of providing a full-time force of firemen and essential related facilities are also greater.

The FSA is not an acceptable alternative. Costs to be incurred by rural residents in developing an adequate water system for implementation of this alternative are high, and the stream of net benefits derived is negative.

SUMMARY

Three alternative systems with a range of options for delivering fire protection services to rural areas were examined. Analysis shows that substantial net benefits can be realized by establishing minimum fire protection services in rural areas and by combining resources across county jurisdictions to realize economies of scale. However, potential "size" economies in fire department operation and capital costs may be quite limited without improving the water supply and components of the fire protection system.

Reductions in annual fire losses represent the major gains to rural areas. Savings in fire insurance premiums would be relatively small because of the difficulty of improving fire protection classification ratings, unless substantial investments are undertaken by local governments.

Greatest net benefits from a fire delivery system in rural areas of Tennessee would be achieved by selecting a system that would upgrade the fire classification rating from 10 to 9 without altering the water system. In this study where resources for two rural counties were pooled, such a system would be manned by a volunteer firefighting force operating out of a central two-bay and six one-bay stations each equipped with a 500 gallon per minute pumper authorized to travel a maximum distance of five miles to fight a fire. This would be Option I of the Class 9 PFD under the IRA.

These findings are specific to population density, rating system and institutional structure of rural Tennessee. Yet, the approach taken in this research may be generalized and seems to have potentially high yields for applied research in providing answers for local decision-makers. Estimates of benefits and costs should be based on available technologies and realistic factor proportions.

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