ECONOMIC COSTS AND BENEFITS OF RURAL ROAD IMPROVEMENT IN THE EASTERN KENTUCKY COAL FIELDS

— An Illustrative Case Analysis —

By

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FOREWORD

In this research we analyze one aspect of a problem which potentially involves millions of dollars of expenditures and one which touches directly the lives of several thousand people. However, we are acutely aware of the fact that knowledge of a single aspect, even if that knowledge specifically pertained to each individual community, would not be a sufficient basis for decisions by the public officials or citizens who have the responsibility for making them. We have attempted only to show how the decisions to build or not to build roads to communities like those in our sample affect the financial position of the residents and the public agencies which represent the public at large. When benefits are less than costs, this does not necessarily mean that the project is not justified. It means only that, on the average, the residents of the area would be better off financially if they were to be given the money it would cost to improve and maintain the roads than to have it spent for that purpose, and even then only if the relationship of benefits and costs which were calculated is valid for many years to come, which is always problematical.

Where benefits are low in relation to costs, we have suggested some possible alternatives to building roads. However, we emphasize that these are only possibilities to be considered along with many others. These possibilities themselves would require careful investigation. Their merits would have to be evaluated after specific, detailed plans were worked out. We do not intend by any of the factual statements that we make or by calling attention to the solutions which were used to solve somewhat similar problems elsewhere to indicate that we advocate similar solutions. Programs which have worked well in some areas have frequently worked badly in others with different political, social, or economic conditions. Our purposes are solely those of (a) stimulating thinking by responsible officials and voters about alternative solutions to an important problem, and (b) providing some factual information which will indicate the types and general orders of magnitude of a few key decision variables.

At various places in this publication it is noted that the data upon which the report is based are relatively old and that both costs and benefits will have changed as a result of changing economic conditions since the data were collected. While this would be a serious shortcoming if we were evaluating a specific project, this is not our purpose. The purpose here is to illustrate the relationships that must be evaluated by direct consideration of a particular project, and to provide some insight into how important each of these factors is in determining the economic merits of various projects. In addition, as prices and costs change, usually primarily as a result of general price movements in the economy, they tend to move in similar directions, although not precisely so. Therefore, in general, the age of the data does not greatly affect the value of it for our purposes.

SUMMARY

A companion study [3] indicates that the effects of having access to only unimproved roads, a common condition of families in many of the coves and hollows of Appalachia, are largely economic. There is no direct or indirect evidence that this situation limits educational attainment, or that it impairs mobility of the labor force of such areas, although both they and their neighbors living on paved roads receive limited education, medical and dental service and probably other public services as compared with more affluent areas. Therefore, this study analyzes the economic costs and benefits that would result if the large mileage of presently unimproved roads were improved to minimum all-weather standards.

Benefits under conditions in the survey area were mainly in the form of reduced travel costs and reductions in absenteeism from work in periods of bad weather. With existing average population densities of 9.7 families per mile and moderate 6.0% interest on investment, benefits exceeded estimated added maintenance and interest costs on traffic-bound rock surfaced roads. However, the ratio of benefits to costs was significantly lowered if trends in population decline are projected over the 40-year planning horizon assumed here, especially if discount rates are higher. If population densities were one-half the average level found in the communities studied, costs would exceed benefits even with continued constant population. Therefore, the economic merits of each road improvement project should be separately evaluated on the basis of comparisons of economic costs and benefits under existing population densities, trends in population, travel patterns and applicable interest rates.

If considerations of equity or political considerations dictate that all residents must be provided with all-weather roads to their homes, consideration should be given to alternative means in the event that costs exceed benefits by a large margin. Costs will likely exceed benefits in severely depopulated areas. Subsidies to induce remaining residents to move to areas which are more accessible, possibly in combination with zoning against further residential use, are among the possibilities which should be carefully examined by local policy makers with due regard for local social and economic conditions.

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Introduction

Road construction and maintenance are extremely expensive in relation to the quality of the raod system in the Appalachian region. Rugged terrain and rocky geologic features increase costs per mile. The limited numbers of sites suitable for concentrations of population, in effect, "force" population to disperse out in the narrow valleys and increase mileage per capita, and increase average mileages between origin and destination points for travelers. In addition, per capita incomes are low, public revenues are scarce, and the needs of the resident population for improved public services are great. These are among the reasons that a high proportion of the roads in Appalachia is unimproved.

There is, of course, continuous political pressure to have these roads improved. In part it comes, understandably, from that large segment of the population which has to endure the inconvenience, discomfort, and added cost associated with having to travel these unimproved roads to reach places of employment, recreational sites, and sources of public and private services which they require or desire. With a limited revenue base with which to meet these and other demands for public services, an improved factual basis for deciding under what circumstances road improvements should be and when they should not be undertaken is obviously needed.

While economic costs and benefits are important considerations, it is obvious that a much broader array of considerations is relevant to such decisions. In a companion study [3] an analysis is presented of the manner and extent to which families living on unimproved roads are affected with regard to their social, recreational, and business interactions with the broader community and the effects of this on their mobility and on the educational achievement of their children. In this companion study, statistical comparisons of patterns of travel for recreational, shopping and school-related functions, medical and dental service are made. These comparisons suggest that people of comparable income and other characteristics living in an area accessible only by unimproved road shop somewhat less frequently, have somewhat lower frequencies of participation in school-related activities, and go on fewer recreational trips. However, children reared in such areas are not

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significantly different in educational attainment and mobility from children of families living in communities with bituminous-surfaced roads. Moreover, while the area was once very isolated from the rest of the state and nation, this is no longer true. There is a great deal of travel to areas outside the immediate neighborhood, and a high proportion of families have traveled to, or actually lived in areas outside the mountain region. Therefore, it was concluded that there was no strong evidence that residents of areas without accessibility by improved road were significantly disadvantaged educationally or socially by this factor alone.

The primary disadvantage of those located on unimproved roads results from their extremely low relative levels of income, almost $1,400 per year less than those living on paved roads ($3,282 as compared with $4,660 per year inclusive of the value of home produced foods as of 1966). Moreover, 24% of the income they received was from transfer payments such as Unemployment Compensation, and Social Security benefits and other retirement income. As many received transfer payment income in the previous year as received employment income. Thus the group living on the unimproved roads was living very near to what we now euphemistically call the "poverty line," and small savings which might result from road improvements are likely to be proportionately quite important in determining their economic well-being.

Sources of Data

This study draws upon data from a 1966 survey in Pike County, Kentucky, plus a variety of sources of secondary data provided from tabulations by the Kentucky Highway Department, the Kentucky Department of Education, published reports relating to Rural Electrification Administration borrowers, the United States Census of Population and United States Census of State and Local Governments. Data for the companion study are largely from the survey.

The survey data from Pike County were collected from two samples of nonfarm households. One lived on bituminous-surfaced roads in a band 10 to 15 road miles from Pikeville (93 useable questionnaires) and the other lived at least one-half mile from any improved road in a band between 5 and 15 road miles from Pikeville (87 useable questionnaires). A proportional stratified random sampling scheme w as followed in which sample segments were laid out on a highway map showing residential structures. Stratification was according to the number of residential units per sample segment. Three families were excluded as being atypical of this predominantly nonfarm rural area because they had sufficient income from farming to classify them as part-time or full-time farmers.

Methods of Analysis

The primary method of analysis upon which the remainder of this report is based is benefit-cost analysis, a technique which is applied to the economic evaluation of many other types of public investments, notably multipurpose dams and flood control projects.[1] Both increased income and reduced costs or savings are counted as benefits after deduction of added annual variable costs such as increased road maintenance. Since the remaining net benefits are received over an extremely long (but somewhat uncertain) period of time, while the investments in road

[1]For a brief analysis of the procedures of benefit-cost analysis see Howe's recent monograph [1].

improvements necessarily take place before any benefits are received, the future benefits must be discounted and summed to see how they would compare with a normal return on a secure investment of the same amount. The precise procedure by which this is done in this study is shown in Appendix I. Basically, each year's net benefit is divided by the cumulated value of $1.00 at compound interest for the stated time period. At 6.0% this becomes $3.207 after 20 years. Thus the discounted value is less than one-third the original net benefit 20 years later. If the sum of these discounted values for the selected planning time horizon exceeds the original investment, a "favorable" benefit-cost ratio is said to result.

For ease of exposition, the procedures for estimating the components of annual benefits under conditions existing in the sampled Pike County communities and under alternative situations which are assumed to exist in the future are explained in connection with the estimation of each component.

Savings and Increased Earnings Resulting from Road Improvement

Reduced Costs of Travel

In the analysis which follows estimates are made of the economic effects of living in areas without direct access to improved roads by comparing frequencies of travel and distances traveled. Since the amount of travel is affected by (a) income, (b) distance to sources of supplies, services, and employment, (c) the proportion of food supplied produced at home, (d) family size, and (e) whether the family owns an automobile or shares the transportation of others—regression equations including these independent variables were computed for travel frequencies of the residents living on paved roads and those living on unimproved ones. The results are shown in Table 1.

There are two possible approaches to comparing the groups located on unimproved roads with those on paved roads. One, in effect, asks the question, "How frequently would the paved road residents travel as compared with the residents living on unimproved roads if they had the same family size, value of food production, distance per trip, net income and frequency of ownership of automobiles as the unimproved road residents?" The other, in effect, inquires, "How would the frequency of travel of the population of the area with only unimproved roads compare with the frequency of the ones on paved roads if family income and other factors were equal to theirs?"

If the paved road group equation is used to estimate the trips per year of a population with the characteristics of those living on unpaved roads, we estimate that they would make about 272 trips per year as compared with an actual frequency of 225. If the equation for the unimproved road residents is used to estimate the number of trips per household for a population identical to the non-isolated area, we estimate (by coincidence) 272 trips, compared with an actual 323.

From this analysis of aggregate travel frequencies, we may infer that personal travel was between 16 and 17% less for residents of isolated areas than for comparable rural-nonfarm residents who lived on bituminous-surfaced roads.[1] Clearly, this reaffirms our conclusion that generally the residents without access to improved roads are *not* seriously deprived of access to the social, cultural, and economic opportunities of the community by the locational factor

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[1] 225 ÷ 272 = 0.83; 272 ÷ 323 = 0.84.

Table 1. Regression Analysis of Factors Affecting Frequency of Travel for All Business, Social, and Recreational Purposes

	Variable	Isolated Areas Mean Value[a]	Isolated Areas Regression Coeff. (Standard Error)	Non-Isolated Areas Mean Value	Non-Isolated Areas Regression Coeff. (Standard Error)
Y	No. trips per year	224.95	---	322.52	---
X_1	Av. value food production for home consumption	\$246.78	- 0.072 (0.035)	\$127.10	- 0.154 (0.067)
X_2	Av. distance per trip (mi.)	11.75	- 6.096 (1.245)	9.69	- 6.338 (2.191)
X_3	Family size (members)	3.71	+13.639 (5.879)	3.75	+ 7.551[b] (6.280)
X_4	Net income	\$2,909.75	+ 0.015 (0.007)	\$4,346.11	+ 0.010[b] (0.006)
X_5	Ownership of auto or truck (1=own; 2=not own)	1.36	-65.619 (25.607)	1.15	-83.499 (37.196)
a	Constant term	---	308.943	---	427.844
R^2		---	0.45	---	0.23
n		---	87	---	93

[a]All differences in mean values significant at P = 0.05.

[b]Not significant at P = 0.05; all other significant.

alone. According to our regression estimates, differences in income and the closely associated differences in automobile ownership, accounted for about two-thirds as much of the difference in travel frequencies as did the locational factor. However, both regression equations leave a majority of the variance in travel frequencies unexplained, indicating that unidentified factors not included in this analysis importantly affect travel frequencies.

While the frequencies of travel apparently are somewhat reduced by inferior roads, a factor of importance in determination of cost is the proportion of that travel on unimproved roads. This was demonstrated directly to the staff of the project by the fact that several tires were ruined by sharp rocks and other hazards during the course of the field enumeration. Nevertheless, it is quite difficult to determine precisely actual increases in travel costs resulting from bad road conditions. Travel over unimproved roads inflates fuel consumption, and repair and depreciation costs. Informal estimates from several public officials and automotive service people in the area indicate that the life expectancy of a vehicle traveling primarily in these areas is less than half that for cars traveling mainly on hard-surfaced roads. Tire life expectancy was reported to be from 5,000 to 10,000 miles as compared with about 20,000 for original equipment tires under highway conditions. On the other hand, new cars are rare among the less affluent, and obsolescence depreciation costs are, accordingly, lower.

Vehicle operating cost estimates derived from cost component estimates supplied by sample respondents averaged only 6.2 cents per mile, including travel over unimproved roads.[1] Reports from local business firms indicate that this estimate is much too low, especially for travel over bad roads. Therefore, we will assume a very conservative 7.0 cents per mile for travel on improved roads and 14.0 cents per mile for travel on unimproved roads.

As noted earlier (p. 8), we have estimated from our regression equation that a population comparable in income and other characteristics to the population living on unimproved roads would travel significantly more if located on an improved road—about 272 trips of 11.7 miles round-trip distance, as compared with a present frequency of 225 per year. An average of about 3.6 miles per trip was estimated to be over unimproved roads. Therefore, with a cost saving of $0.07 per mile to the traveler, it appears that the average family would experience automobile travel cost savings of about $69 per year (272 X 3.6 X $0.07) if previously unimproved roads were improved.[2]

Avoided Losses of Work Time Resulting from Impassable Roads

The 47 employed respondent heads of households in areas without improved roads lost an average of 4.8 work days owing to bad roads during the preceding year. If one

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[1] This compares with mileage charges of 7.0 cents per mile on University of Kentucky College of Agriculture vehicles (as of this writing), which are purchased at fleet rates and are driven over high-speed, paved roads most of the time and without payment of gasoline taxes or personal property taxes.

[2] Note that the total distance traveled per trip is irrelevant since it is assumed that the places to which they would travel would remain the same if roads were improved.

considers the total of all 87 isolated area households, this is equal to an average of 2.6 days per family. The residents living on paved roads also experienced some loss of work time for the same reason, an average of 1.3 days per year per employed resident and 0.9 for all non-isolated families. Thus, if the isolated area residents were also provided with improved roads their loss in employment might be reduced to about 1.7 days per year per family. The estimated difference of income per family resulting from the bad roads was $34 per year.

Savings on Travel of Commercial Sales and Service and Public Official Visitation

The residents living on paved roads reported receiving an average of about 45 visits from deliverymen, salesmen, and school or public officials (exclusive of mail service), combined. If residents living in areas with unimproved roads were to receive the same number of visits, and each visit involved an average of 3.6 miles of unimproved road per round trip, this would add an estimated annual cost of $5.70 per family for the services provided by the external agents.[1]

Other Benefits from Road Improvement

In addition to the foregoing private resident travel costs and costs for public and private service deliveries, especially school bus service, other services such as mail deliveries, and utility services require some travel on the unimproved roads. Since some of the roads are frequently impassable, not all such neighborhoods are directly served by mail deliveries. Instead, mail deliveries are sometimes made at the junction with the nearest "good" road, especially if the distance to the most remote residences is short. However, for those that are served, if added costs are 7.0 cents per milt, and 305 deliveries are made annually, the saving is about $21 per road mile or $2.20 per family.[2] Comparable estimates of utility service cost additions are not available, but would unquestionably be much smaller.

Costs of Road Improvements

That residents of neighborhoods without improved roads are somewhat economically disadvantaged by lack of good roads is obvious. Therefore, consideration will be given to the alternative possibilities of removing this disadvantage. We consider in this section the costs of road improvements and their maintenance, specifically, improvement to the level of minimum all-weather construction. This will here be defined as equivalent to Kentucky Highway Department specifications for traffic bound, rock-surfaced road 16 feet wide. Costs include necessary grading, draining, structures, base and surface.

Costs of road construction and maintenance vary with terrain, and geologic conditions, the number of bridges and culverts that must be installed and the type of base and surface required. For projects of traffic bound rock surface type in Appalachian counties, the original capital outlay was about $9,000 per mile for those

[1] In actuality, their lower incomes would probably result in a smaller number of visits. But the total cost is low and the probably error small. "Cost per family" does not imply that the families who receive the visits bear the cost. It means only that the cost is borne by someone. Average distance per call for families living on unimproved road was only 1.8 miles, indicating that delivery, sales, and service calls were mainly from neighborhood locations, largely sales or deliverymen from local stores. (1.8 X 45.2 X $0.07 = $5.70)

[2] Based on a population density of 9.7 families per road mile.

constructed in the years 1964-66.[1]

Maintenance costs are somewhat deferrable and variable depending upon maintenance policy. Moreover, in the case of structures such as bridges, the distinction between maintenance and capital improvements becomes blurred, since old structures are often replaced with superior ones. Nevertheless, a crude idea of such costs is provided by costs and mileage reported for state maintained roads of roughly comparable specifications. These costs averaged about $242 per mile annually during the period 1962-63 through 1964-65.

While the so-called "primitive roads" (usually not much more than wagon trails or worse) get little or no maintenance, counties usually attempt to maintain the "unimproved" or graded and drained classes of roads in passable condition for the greater part of the year. While there is no source of data which segregates the maintenance costs on various classes of unsurfaced roads, the county responsibility is almost entirely for traffic-bound-rock-surfaced roads and lower classes. Therefore, an estimate is possible by calculations based on Census of Governments data.[2] We can subtract from the total county road maintenance bill an estimate of the cost of maintaining the improved portions. The latter estimate can be made by multiplying the mileage of improved roads by $242, the state cost per mile for maintenance of traffic-bound roads. When this is done, and the 1967 Census data for the 14 coal field counties are adjusted for changes in the level of prices, the average estimated maintenance expenditure per mile for unimproved roads is approximately $70. Since this cost must be borne for unimproved roads, the added maintenance cost is $242 less the $70, or $172 per mile when roads are improved.

If alternative uses of money invested in the original improvement would yield 6% ("interest cost"), the estimated combined maintenance and interest cost would be roughly $712 per mile.

Aggregate Annual Costs and Benefits from Road Improvement Compared

Costs of road construction and maintenance as well as costs of automobile travel have increased since the period for which data were collected. Estimates for the period under study are only approximate. Equally apparent is that each road improvement project cannot be adequately evaluated except by direct examination of the particular case. This involves its terrain, present level of development, structures required and population density, to name a few of the cost-determinants. Nevertheless, it may be useful to illustrate the process of evaluating a particular project by using the data available.

If the added costs of providing on-site services from external agencies are combined with the added private travel costs of residents, and loss of earnings resulting from work absences, the average added cost associated with lack of improved roads is approximately $109 annually per family in the survey area (Table 2).

According to a count of residential and farmstead structures shown on the county highway maps, in the areas with only unimproved roads there was an average of about 9.7 residences per mile of unimproved road. The estimated saving from reduced travel costs and reduced work absenses would be $1,057 per road mile (9.7 X $109). If maintenance and construction costs were comparable to those noted in the preceding section, this would mean that annual net

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[1]Source: Kentucky Department of Highways, Special Tabulation completed in 1967.

[2]Source: 1967 *Census of Governments*, Vol. 17, Kentucky.

Table 2. Summary of Estimated Annual Benefits and Costs On Road Improvement Exclusive of Depreciation

	(1) Per Household[1]	(2) Per Mile Improved[4]
Benefits		
Reduced private travel costs	69	$ 669
Reduced losses of earnings due to impassible roads	34	330
Reduced costs of travel by commercial and government personnel[2]	6	58
Total benefits	109	1057
Costs		
Interest on original improvement cost ($9,000 @ 6.0%)[3]	---	540
Increase in maintenance cost[5]	---	172
Total annual costs	---	712
Net return above annual costs		+$ 345

[1]Rounded to nearest dollar, 1966 basis.

[2]Excludes postal delivery and school bus transportation savings.

[3]Sixteen foot traffic bound rock surface

[4]Benefits based on a population of 9.7 families per mile of road.

[5]Traffic bound road maintenance cost less cost of maintenance on unimproved roads.

returns above costs from this type of road improvement would be about $345 per mile. Note that this makes no allowance for several omitted items such as savings on school bus transportation, nor does it include the intangible benefits of increased comfort and convenience to the residents. Moreover, the estimated savings per mile of travel are probably conservative.

Should More Roads Be Improved?

To repeat, there is no important evidence from this or other studies of which we are aware, that the inaccessibility of mountain neighborhoods by improved roads influences mobility, attitudes or educational attainment. While annual benefits in these illustrative estimates exceed annual costs, this does not necessarily mean that road improvements should be undertaken. Persons who receive the benefits from such investments are not the ones who bear the costs. On the other hand, present residents of these areas who pay property and gasoline taxes contribute to the public revenues which finance the construction and amintenance of road facilities for others within the community and elsewhere. Therefore, considerations of equity may be pertinent.

Another consideration in such decisions is the specific characteristics of the neighborhood which would be served by the improved road. Population densities vary considerably among existing communities, and the population of these areas varies in age, proportion gainfully employed, and other characteristics which would affect the costs associated with living in areas served by poor roads.

The computations of benefits resulting from savings in transportation costs and increased earnings owing to reduced absenteeism implicitly assume a constant population. This is a very questionable assumption, since population declined in some counties of the coal field area by more than 47% during the 1950-70 period and in no instance less than 19% (Table 3). If this continues for many more years, there will be areas which are very sparsely populated. Thus, as a minimum, benefits must be adjusted downward to compensate for the anticipated population loss, preferably on a neighborhood-by-neighborhood basis.

In addition to declining population, future income is less valuable than present income. Therefore, the declining yearly benefits must be discounted and summed to determine whether they compare favorably with the cost of the road construction project. The summary of discounted net benefits of road improvement over 20-year and 40-year periods under various degrees of population concentration, rates of population decline and discount (interest) rates are shown in Table 4. These show the importance of all of these factors in determining the present value of future net benefits.

Since some small additions to the present value of future benefits continue indefinitely if the population remains stable, for comparative purposes, it is conventional to establish a time horizon beyond which benefits will not be counted. For most investments for which benefit-cost ratios are computed, the time horizon is 40 years or above.[1] On that assumption, the computed values for constant or slowly declining projected population levels are fairly favorable. For those declining rapidly benefits are only slightly above the estimated cost

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[1] Raising the time horizon to 60 or even 100 years would have a relatively small effect on the benefit-cost ratio. At the fiftieth year present values of future benefits are 5% and 2%, of the undiscounted values for 6.0% and 8.0% discount rates, respectively.

Table 3. Population Change in Appalachian Coal Field Counties, 1950-70

County	1950	1960	1970[1]	Percent Change 1950-70
Bell	47,602	35,336	31,087	-34.7
Breathitt	19,964	15,490	14,221	-28.8
Floyd	53,500	41,642	35,889	-32.9
Harlan	71,751	51,107	37,370	-47.9
Johnson	23,846	19,748	17,539	-26.4
Knott	20,320	17,362	14,698	-27.7
Knox	30,409	25,258	23,689	-22.1
Leslie	15,537	10,941	11,623	-25.2
Letcher	39,522	30,102	23,165	-41.4
McCreary	16,660	12,463	12,548	-24.7
Martin	11,677	10,201	9,377	-19.7
Perry	46,566	34,961	25,714	-44.8
Pike	81,854	68,264	61,059	-25.4
Whitley	31,940	25,815	24,145	-24.4
Total	510,448	398,690	342,124	-33.0

[1] Preliminary estimates.

Source: U.S. Census of Population

Table 4. Summary Benefit-Cost Analysis of Road Improvements By Levels of Original Population, Rates of Population Change, and Discount Rates

Benefits Per Mile With 9.7 Families Original Population[1]

Planning Horizon	Constant Population (Discount Rate @ 6.0%)	Annual Population Loss of 1.0% of Base Population[1] (Discount Rate @ 6.0%)	Annual Population Loss of 2.0% of Base Population[1]	
			Discount Rate @ 6.0%	Discount Rate @ 8.0%
20 Years	$10,151	$ 9,167	8,309	7,222
40 Years	13,931	12,219	9,311	7,840
Benefit-cost ratio @ $9,000 original cost/mile and 40-year horizon	1.55:1	1.36:1	1.03:1	0.87:1

Benefits Per Mile With 4.85 Families Original Population

Planning Horizon	Constant Population (Discount Rate @ 6.0%)	Annual Population Loss of 1.0% of Base Population (Discount Rate @ 6.0%)	Annual Population Loss of 2.0% of Base Population	
			Discount Rate @ 6.0%	Discount Rate @ 8.0%
20 Years	5,076	4,584	4,154	3.611
40 Years	6,966	6,110	4,656	3.92
Benefit-cost ratio @ $9,000 original cost/mile and 40-year horizon	0.78:1	0.68:1	0.52:1	0.44:1

[1] 9.7 families per road mile = estimated density in sample area, while 4.85 is half the estimated density.

level of $9,000 per mile at discount rates of 6.0% and less than this at a rate of 8.0%. If population densities were initially lower by one-half, none of the benefit-cost ratios would be favorable.[1]

It becomes apparent from this analysis that usual benefit-cost criteria provide no justification for road improvement investments in many communities which now have unimproved roads. Evidently, other solutions must be sought, other justifications must be employed, or the situation of these areas with unimproved roads must be accepted.

Policy Alternatives to Road Improvement - Zoning and Relocation

Very large amounts of investment would be required to improve all of the presently unimproved roads. For Pike County, alone, capital outlays of more than $5,400,000 at 1965-66 prices, about 80 times the county road budget for Pike County in 1967 would be required to improve its 600 miles of unimproved roads to the assumed minimum, all-weather level. If the benefits accruing from road improvements are insufficient to justify the cost, or if higher priority claims on public revenue exist, what options are available?

In a few other areas of the country which were initially thinly populated and/or have experienced severe depopulation, this problem has been approached by a combination of (a) zoning thinly populated areas against further residential construction, and (b) public purchase of remaining dwelling units and public assistance in relocation to areas in which it is feasible to provide roads and other public services. In some areas where these problems have been directly attracked by state and/or local government, sound home structures have actually been moved to more accessible sites. Most such efforts have been in areas with little agricultural potential and most were several decades ago.[2]

We re-emphasize that our purpose here is only to draw attention to alternatives and their possible consequences! Responsible public officials, not research personnel, must take the choices among the alternatives and this normally involves considerations of political feasibility, possible social dislocations to those families which are directly affected and other factors. *We do not advocate either the continuance of present policies or any of the alternatives mentioned* and would encourage careful study of all relevant aspects of each. However, we now have compulsory education to age 16, the mandatory provision of school bus transportation for pupils and the fairly general provision of telephone and electrical service in rural areas. Therefore, there are now even stronger economic reasons than before to consider the applicability of these and substitute measures. Moreover, it is anticipated by some that solid waste collection and disposal, sanitary water supplies, and possibly

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[1] It is obvious that the assumption that road maintenance costs are unrelated to population density is somewhat questionable. However, available county road maintenance costs per mile when regressed on population density per road mile do not result in a significant regression coefficient for this factor. However, aggregate county data are not entirely adequate for this purpose. Therefore, since maintenance is a relatively small factor compared with both gross benefits and interest on capital outlay, and a substantial part of maintenance such as brush and weed control, repair of washouts and general weathering is independent of level of use, the assumption probably does not seriously affect the results of the benefit-cost analysis. The ratio would still be unfavorable with one-half present densities if net benefits were reduced proportionally with population.

[2] For a discussion of the experience in zoning and related measures in the cutover areas of Wisconsin, see Raymond J. Penn's article [3].

other services, all of which are more costly if population is thinly dispersed, may be required in many rural areas in the relatively near future. Hence, more economic pressure for systematic public guidance of residential and other land uses may become apparent.

From an analysis of the distribution costs of 19 rural electric cooperatives in the Appalachian region of Kentucky and other states, it appears that an additional mile of electric power line adds approximately $372 to annual distribution costs if consumer numbers are constant.[1]

Although below usually accepted standards of reliability, our best estimate of the added school bus transportation costs associated with additional mileage of unimproved roads suggests that on the average for a comparable number of pupils the reduction of one mile total unimproved road in the county would save the school system $38 in bus transportation, while reducing the mileage of traffic-bound road would save about $49 per mile.[2] This seemingly unreasonable result could possibly be explained by the fact that virtually all surfaced roads are covered by school bus routes, while many of the unimproved roads are not. Many students living on unimproved roads walk or are transported by their parents to the nearest all-weather road, if within approximately one mile, the maximum under state law.[3]

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[1] A regression equation which included as independent variables the number of residential and farm consumers, number of kilowatt hours of small commercial and industrial service, number of kilowatt hours of large commercial and residential service and miles of energized line, and "operating deduction" less "cost of purchased power," plus 5 percent interest on value of plant investment as the dependent variable, was computed. Data were from *1964 Annual Statistical Report of Borrowers*, Rural Electrification Administration, USDA, Washington. Irrational negative coefficients were obtained for number of residential and farm consumers and small commercial and industrial services. Therefore, we have resorted to use of a simple regression and deducted from the coefficient for miles of energized line an estimate of costs associated with the individual service facilities. REA officials privately estimated the cost of the individual installation to be $380 as of 1966. We, therefore, charge a flat 10% annual rate to cover interest (5%), depreciation (5%) plus $5.00 customer service per installation. The fitted equation is: $Y = \$34{,}400 + 415X$ where; Y = distribution costs as defined above, and X = miles of energized line. $R^2 = 0.76$ and S.E. of $X = \pm 53$. From $415 we deduct ($380 X 0.10) + $5 for an estimated cost per mile of line of $372.

[2] Fitted to data for Eastern Kentucky counties. The equation was:

$$Y = 16{,}628 + 37.6X_1 + 49.5X_2 + 20.9X_3 + 23.4X_4$$

Standard error = (33.8) (25.3) (49.5) (2.42)

$R^2 = 0.87$ Total $F = 71.49$

X_1 and X_3 not significant at $P = 0.10$

X_2 significant at slightly above $P = 0.05$

X_4 significant at $P = 0.01$

Where: Y = School bus transportation costs, inclusive of depreciation

X_1 = miles unimproved road (not primitive)

X_2 = miles traffic bound road

X_3 = miles paved road

X_4 = students in average daily attendance transported

Data sources: (a) Highway mileages from special 1966 tabulation, Kentucky Department of Highways, for the latest reconnaissance survey available. (b) Cost and average daily attendance from "Tentative Calculation of the Districts Formula Adjusted Cost for Pupil Transportation Under Kentucky's Minimum Foundation Program, 1964-65 School Year," Kentucky Department of Education, Basis for Allotments Circular, Vol. XIV, Number 1, August 1964.

[3] Kentucky law KRS 157–370 required that transportation must be provided within approximately one mile of the place of residence.

Again, costs have increased since the mid-1960's making the absolute values of these estimates obsolete. In addition, some of the estimates are relatively unreliable, will vary from one situation to another, and can properly be used for illustrative purposes only. We use them here only to show the calculations which would be appropriate in an economic evaluation of the alternative of zoning and relocation of remaining residents. In evaluating a specific case, computation of actual savings in mileage valued at estimated average costs per mile would be a more realistic estimating procedure. The calculations will be based on two assumptions: (a) that it is not economically feasible to improve the road to all-weather quality, and (b) that it is judged to be legally, politically, or morally necessary to improve the road if any residual population remains (Table 5). That is, road improvement or relocation are assumed to be the only available choices.[1]

The savings which might accrue to the public as a result of a program to relocate families living in areas served by unimproved roads, depend on the cost of relocating the families and on the cost savings that result from relocating *all* families living in such neighborhoods. The public cost savings are largely independent of the number of families per mile of road. Road must be maintained, electric power supplied and school buses must be provided whether there are few or many families per mile or road. The direct costs associated with the individual family such as transformers and service installations for electric power, and school bus capacity, are mainly the same irrespective of the location of the family. Therefore, the "public" cost items shown in Table 5 remain the same irrespective of population density. The only way that they may be avoided is to completely depopulate the neighborhood.

We include electric power distribution as a "public" cost here because most rural areas are served by rural electric cooperatives which attempt to provide service to consumers at minimum average cost for entire systems. Even where private utility companies serve the area, rates are presumably adjusted to provide a reasonable return on investment, and savings would be passed back to patrons of the system, not residents of particular neighborhoods.

The savings which accrue depend upon what options are allowed. If it is necessary to service eventually each area which has any population with an all-weather road, cost savings (costs avoided) are considerably greater than if this is not true, as indicated in comparisons of Columns 1 and 2 of Table 5.

If the problem were strictly viewed from the standpoint of the economic benefits and costs to the public at large and to the consumers of electric power what would be the result? If the total residual population in an area served by a mile of unimproved road could be induced to relocate by payments equal to $480 per year or less, it would be advantageous under these assumptions to undertake such a program. This would be true even if the alternative was for the roads to remain unimproved. At 6% interest, this $480, if continued for 10 years, would be equivalent to a lump sum payment to induce the relocation of approximately $3,569.[2] If

[1] We again emphasize that a continuation of the present situation is an alternative if road improvements are too expensive and relocation too disruptive to the lives of those who have developed strong preferences for the features of remote areas. However, the value of improved sewage and water services which are frequently provided in more concentrated population centers is an intangible advantage not included in cost comparisons.

[2] Values per year discounted at 6%.

Table 5. Illustrative Summary Estimates of Long-Run "Public" and Private Cost Savings From Relocation of Residents of Isolated Neighborhoods[1]

	Annual Savings Per Mile (1) No Road Improvement	Annual Savings Per Mile (2) All-Weather Road Construction Assumed
"Public" Cost Savings		
Road maintenance	$ 70	$ 242
Interest on road improvement investment @ 6%	---	540
School bus costs	38	38
Power distribution cost	372	372
Telephone	Not Included	Not Included
Total public cost savings	$ 480	$ 1092[1]
Private Cost Savings		
Transportation costs and loss of earnings from absenteeism[2]	$ 1057	$ 1057
Less increased cost of housing	Not Included	Not Included
Less loss in value of home food production and net farm income	-1096	-1096
Total private cost savings	$- 39	$- 39
Total Net Savings	$ 441	$ 1053

[1]Assumes residents relocated in the same county tax jurisdiction.

[2]Assumes population density of 9.7 residential units per mile.

[3]Difference in net value of home food production after deduction of direct costs in isolated and non-isolated communities.

[4]Excludes depreciation on improvements.

the alternative to relocation were the construction of all-weather rock-surfaced roads, the figure would be much higher. Annual costs per mile for road and utility services would be $1,092 exclusive of depreciation of the road, itself. If the original cost of $9,000 per mile of road improved plus the discounted annual costs for a 10-year period were considered, the public would "break even" with a lump sum payment to the residents of $10,801.

Whether these amounts would be sufficient to adequately compensate residents for relocation would depend on several factors including both economic and non-economic considerations. From an economic standpoint the total amount of compensation that would be required depends on the number of residents, the amount that they would save in transportation costs, the increases in earnings that would result if they missed fewer work days resulting from impassible roads, the losses in farm income and value of home-produced foods, and the comparative cost of housing accommodations.

With the average situation of 9.7 families per mile, the economic gains which result from the fact that there are fewer work days lost and lowered costs of transportation are slightly less ($39 per mile or $4.00 per family) than the losses from decreased home food production and net farm income.[1] The result is a small net loss to relocated families even disregarding housing costs. Thus the primary economic consideration is the cost of providing housing, and the cost of moving to accommodations which are equal to or better than the homes they occupy.

Obviously, the savings which would result from relocating families living on unimproved roads would not be very large if it was not necessary to improve the roads. The public could only "break even" if each family were paid $49 per year as an inducement to relocate, which would not be very attractive if the move required renting or buying another home. If the offer were a lump sum payment equivalent in value to the $49 subsidy for a 10-year period, it would amount to only $355 approximately.[2] If the alternative to relocation were construction of an all-weather road, the annual cost savings to the public would be somewhat higher even ignoring depreciation allowances on the road itself, about $1,092 per year per mile, or $113 per family. However, if the original cost of road construction plus annual (non-interest) costs for a 10-year period were offered as a lump sum payment this would amount to $13,799 per mile or $1,422 per family if there were 9.7 households per mile. To repeat, this payment would allow the public at large to "break even." That is, from a fiscal standpoint with this amount of compensation it would be a matter of indifference whether the roads were improved or the subsidies were used to induce residents to relocate. Obviously, the compensation would not be sufficient to provide even the most modest housing in other areas. However, at lower population densities the situation is quite different.

If the population were reduced to one family per mile which is already true of many neighborhoods in Appalachia, the "break even" point would be the entire cost per mile either in lump sum or in annual installments.

[1] It is assumed that if they moved to all-weather roads their losses in work time and changes in farm income and home food production would make them comparable to the present residents living on the paved roads. Note that private gains from relocation are less than those for road improvement because losses in cash farm income and production of food for home use are large comparatively.

[2] Discounted at 6.0%.

Obviously, compared with the typically modest housing of most mountain area communities, a $13,000 structure would be relatively luxurious. In the 1960 Census of Housing, 46% of all rural non-farm houses were classified as dilapidated or deteriorating. Only 30% had complete indoor plumbing facilities. Moreover, about 6.8% of the housing units were vacant but habitable (classified as "sound" or "deteriorating," the latter meaning that more than normal maintenance was needed but major renovation was not required). Thus, it seems highly probably that some of the families not located in remote areas or ones which are very thinly populated per road mile could be accommodated in housing of equal or better quality which is now vacant owing to the outmigration which has occurred in the past two decades. Moreover, in these cases the added cost may be quite low. Thus, as an alternative to road construction it may be entirely feasible to provide equal or better housing in more centrally located areas for residents of neighborhoods where there are only two or three families per mile of road.

Obviously, when population is sparse, and especially where road improvements are "required," from a pure economic standpoint quite large amounts can be justifiably spent to relocate families so that heavy public service costs can be avoided.

CONCLUSIONS

We presume that there are many other rural areas which are generally similar to the Pike County area which was surveyed in this study. Its population is predominantly non-agricultural, very poor and in a very high proportion of cases no member of the family is employed. Loss of income from additional days of work absence, plus added travel costs amount to about $109 annually per family living in the neighborhoods which do not have access to improved roads, or about $1,057 per mile of unimproved road.

In some of the more densely populated neighborhoods with relatively stable population, a strong case could be made for investments in road improvement to bring them up to all-weather standard. However, in thinly populated communities, or ones in which rapid declines can be expected, such expenditures are not justified on economic grounds. For these, the alternative of legal steps to zone the areas against further residential development, and, when severely depopulated, the relocation of remaining residents to areas which already have improved roads should be investigated. Local governments, including school districts, as well as utility companies, have joint financial interests in assisting the remaining families in those areas with only very sparse and/or declining populations to relocate to areas where it will be feasible to supply a full complement of services at reasonable cost.

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Appendix I

Computation of Present Value of Estimated Average Road Improvement Benefits Under
Various Population Change and Discount Rates, For 20- and 40-Year Periods

Appendix I

Computation of Present Value of Estimated Average Road Improvement Benefits Under Various Population Change and Discount Rates, For 20- and 40-Year Periods

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		POPULATION LOSS 1.0% PER YEAR[1]			CONSTANT POP.	POP. LOSS @ 2.0% PER YEAR[1]	
Years After Con-struction	Discount Factor[2] @ 6.0%	Gross Annual Benefits	Gross Benefits Less Added Maintenance @ $172[4]	Discounted Net Benefits @ 6.0% (4) ÷ (2)	Discounted Net Benefits @ 6.0%	Discounted Net Benefits @ 6.0%	Discounted Net Benefits @ 8.0%
1	1.060	$1,057.00[3]	$885.00	834.91	834.91	834.91	819.44
2	1.124	1,046.43	874.43	777.96	787.37	768.56	740.87
3	1.191	1,035.86	863.86	725.32	743.07	707.57	668.83
4	1.262	1,025.29	853.29	676.14	701.27	651.01	604.10
5	1.338	1,014.72	842.72	629.84	661.43	598.24	544.62
6	1.418	1,004.15	832.15	586.85	624.12	549.58	491.05
7	1.504	993.58	821.58	546.26	588.43	504.10	442.33
8	1.594	972.44	800.44	502.16	555.21	462.37	398.17
9	1.689	961.87	789.87	467.66	523.98	423.85	358.12
10	1.791	951.30	779.30	435.12	494.14	387.91	321.79
11	1.898	940.73	768.73	405.02	466.28	354.90	288.85
12	2.012	930.16	758.16	376.82	439.86	324.28	253.09
13	2.133	919.59	747.59	350.49	414.91	295.98	232.19
14	2.261	909.02	737.02	325.97	391.42	269.87	207.76
15	2.397	898.45	726.45	303.07	369.21	245.74	185.70
16	2.540	887.88	715.88	281.84	348.43	223.58	165.76
17	2.693	877.31	705.31	261.90	328.63	203.03	147.77
18	2.854	866.74	694.74	243.43	310.09	184.17	131.54
19	3.025	856.17	684.17	226.17	292.56	166.77	116.91
20	3.207	845.60	673.60	210.04	275.96	150.71	103.72
TOTAL:	20 Years	--	--	9166.97	10151.28	8309.13	7222.61
TOTAL:	40 Years	--	--	11218.93	13931.44	9311.49	7839.43

[1] Percent of base population in year no. 1, i.e., 9.7 families per mile.

[2] $(1.0 + r)^n$ where: r = rate of interest and n = years after construction.

[3] From Table 2 "Total Benefits"

[4] Net annual maintenance cost per mile of traffic bound roads less maintenance cost per mile of unimproved roads.