The Economics of Reducing the Size of the Local Rural Road System

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The large number of miles of local rural roads in the United States originated in the Ordinance of 1785, which was passed by Congress to open new lands to settlement. Most of today's local rural roads were built in the late 1800s and early 1900s, when overland transportation was limited to horse and wagon and newly built railroad lines. From that time until World War II, each of these roads served dozens of farms. Since 1950, the number of farms has declined sharply and is expected to continue to decline in the future. The type of traffic on rural roads has changed from small vehicles serving many households and farms to large vehicles serving fewer households and farms. Many of the vehicles now traveling on these roads are heavy or wide farm tractors, trucks, and harvesting combines that impose major weight or width stress on the roads and bridges. However, the financial ability to maintain and rebuild the system is not keeping up with its rate of deterioration. Local officials have insufficient money to properly maintain the existing system for the types of vehicles that are traveling on it. Reducing the size of the local rural road and bridge system through the abandonment of road segments that contain no property accesses results in cost savings from discontinued maintaining, reconstructing, and resurfacing the roads and bridges that exceed the additional costs imposed on the traveling public when they are rerouted around the abandoned roads.

The local rural road system contains 71 percent of the 3.2 million mi of rural roads in the United States *(1)*. Local rural roads are defined as those roads that are under the jurisdiction of county and township governments. The large number of miles and the rectangular regularity of the local rural road system originated in the Ordinance of 1785, which established townships and 1-mile survey grids. The objective of Congress was to open the land for settlement.

Many of today's local rural roads and bridges were built in the late 1800s and early 1900s when overland transportation for both passengers and freight was limited to horse and wagon or recently built railroad lines. Farmers living on small farms needed road access to homes, schools, churches, and markets.

During the 1920s and 1930s, local rural roads were surfaced, mainly with gravel, and bridges were replaced to carry 6- to 7-ton loads. Since then, the number of farms has declined, farm size has increased, and the number of heavy vehicles traveling on these roads has increased.

In most instances, a farmer obtains more land by buying or leasing land from other farmers, frequently on nonadjoining farms. The increasing scatter of tracts of land operated by one farmer increases travel distances and size of farm equipment on the roads. Large tandem-axle and semitrailer trucks, farm tractor-wagon combinations, and harvesting combines now travel from homesteads to fields and back. Farm supply and marketing firms use large tandem-axle and semitrailer trucks for pickups and deliveries. The declining rural population causes school districts to use larger school buses to transport fewer children longer distances to consolidated schools. These school buses, which weigh up to 15 tons when fully loaded, cannot cross bridges that are posted at less than their gross loaded weights.

Precise data on the condition of the local rural road system are not available. However, there is ample evidence that the system is deteriorating rapidly. In a recent Illinois survey, farmers and agribusiness representatives rated about one-half of the Illinois local rural roads as needing more than regular maintenance, and over 20 percent were rated as needing major repair *(2)*. Common complaints about the local rural roads in many states include the following:

1. Overweight vehicles are breaking up road surfaces.
2. Lack of hard surfaces results in dust and rideability problems.
3. Road widths and other design characteristics are inadequate for today's large farm equipment and heavy trucks.
4. Narrow lanes create safety problems.

The condition of local bridges is also of great concern. On January 1, 1985, 184,977 (61 percent) of all the off-federal-aid bridges that had been inventoried were deficient *(3)*. In addition, 118,390 (39 percent) of the 306,388 off-federal-aid system bridges were posted, or should have been posted, at less than legal weight limits. However, even this deficiency understates the magnitude of the problem. Thousands of bridges under 20 ft long not included in the inventory needed replacement or repair.

Data for the distribution of deficient bridges among states indicate that the local bridge problem is national in scope *(3)*. States with the largest numbers of deficient bridges are Arkansas, Illinois, Indiana, Iowa, Kansas, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, Tennessee, and Texas. Other states in the northeast, midwest, southeast, and southwest regions are included in the group with a high percent or a large total number of deficient bridges.

The county road system faces many of the same problems that the railroad system encountered in the late 1960s and early

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1970s. The physical condition of the county road system is deteriorating. The heavy vehicles traveling on the system are causing damage; however, the financial ability to maintain and rebuild the system is not keeping up with the rate of deterioration. Although federal and state motor vehicle fuel taxes have increased sharply in recent years, there is increasing pressure to reallocate a larger share of these taxes to roads that are under city and state rather than rural jurisdiction. Moreover, a substantial share of the funds to maintain local rural roads originates in property taxes. The recent decline in rural property values is decreasing the amount of funds from this source. In short, money is lacking to properly maintain the existing system for the types of vehicles that are traveling on the roads.

Public debate about the county roads has focused mainly on the deteriorating condition of the system. The implicit assumption behind much of this debate is that the system should be maintained as it is. However, an increasing number of observers believe that the number of miles of local rural roads could be reduced, either by abandonment or by conversion to private drives. A 1976 editorial in the *Des Moines Register* states the following:

> County roads that served dozens of farms forty years ago may be serving only two or three farms today. Many roads that were once vital to a county's well-being have become, in effect, private roads, although the county is responsible for their upkeep. Such roads no longer belong in a county road system. *(1)*

Residents on the roads argue that abandoning these roads or converting them to private drives will force farmers and rural residents to travel longer distances and that the additional travel and maintenance costs on these longer roads will exceed the cost savings of removing the shorter roads from the public system.

Numerous analysts have discussed the deteriorating conditions of the local rural road and bridge system *(4)*. However, in only a small number of studies have alternative solutions been identified *(1, 2, 5, 6)*. In fewer studies yet have the impacts of the deteriorating roads and bridges on all travel costs or the impacts of alternative solutions on travel costs and local government costs been quantified. The Pennsylvania Department of Transportation identified those roads in two Pennsylvania counties that are most important to the rural agricultural areas for the transport of agricultural products to market and of supplies to the farm *(7)*. Tucker and Johnson examined the impact of alternative rural road development and maintenance policies on grain marketing costs in southeastern Michigan *(8)*. Their results indicate that grain marketing costs decrease as the road system is improved, but the savings in grain transport costs were far less than the costs of the road improvement. Nyamaah and Hitzhusen used a circuity model to estimate the rerouting costs to road users when 15 rural bridges in Ohio were posted or closed *(9)*. The model indicated substantially greater benefits from bridge repair or replacement than the county engineers estimated. Chicoine and Walzar surveyed farmers, township officials, and agricultural and rural business officials to identify their opinions and attitudes on a wide range of rural road and bridge questions and issues *(5)*.

No previous analyses quantitatively evaluated the impacts of alternative road and bridge investment strategies on all the traffic traveling on the rural road and bridge system. The purpose of this paper is to present estimates of the impacts on all traffic on the system from reducing the size of the public rural road system by abandoning selected roads.

METHOD OF ANALYSIS

Study Areas

The county roads in three 100-mi^2 areas in Iowa were included in the analysis. The three study areas were selected for their differences in terrain, quality of roads and bridges, and level and type of economic activity. Area 1, located in east central Iowa just north of Cedar Rapids, has a large nonfarm population, a productive cash grain agriculture, a high percentage of paved roads, and level terrain. Area 2, located in southwest Iowa, has a small population of farm and nonfarm residents; a large but declining livestock industry; a high percentage of gravel, oiled, and earth-surfaced county road system; and hilly terrain with many bridges. Area 3, located in north central Iowa, has a small farm and nonfarm population, high cash grain agriculture, a well-developed paved road system, and level terrain.

Benefit-Cost Analysis

A benefit-cost analysis is used to evaluate the economics of reducing the size of the county road system in the three study areas. The benefits derived from keeping up the roads that were evaluated for abandonment are defined as the additional travel costs incurred by the traveling public when the roads are removed from the system. The traveling public incurs additional travel costs when roads are abandoned because some traffic must travel longer distances to reach the intended destination or must travel on lower quality road surfaces. The cost portion of the benefit-cost analysis is the expense of keeping up the roads that were considered for abandonment. These costs include variable and fixed road maintenance, road resurfacing and reconstruction, and bridge maintenance and reconstruction costs on the abandoned roads, minus the variable maintenance, resurfacing, and reconstruction costs transferred to the roads inheriting the traffic from the abandoned roads. The costs also include the rental value foregone by having the land in roads rather than in production, minus the cost of converting the land from road to agricultural use.

The following benefit-cost ratio is used to evaluate whether a road segment, group of road segments, or bridge should remain in the county road system:

$$\frac{B}{C_{j_A}} = (TC_j - TC_{j-1})[(MC_{j-1} - MC_j) + (REC_{j-1} - REC_j) + (RES_{j-1} - RES_j) + (BREC_{j-1} - BREC_j) + (BMC_{j-1} - BMC_j) + (VL_j - ROW_j)]^{-1} \quad (1)$$

where

$\frac{B}{C_{j_A}}$ = the abandonment benefit-cost ratio of the jth set of road segments;

MC_{j-1} = the total annual road maintenance cost before the jth set of road segments is abandoned;

MC_j = the total annual road maintenance cost after the jth set of road segments is abandoned;
REC_{j-1} = the total annualized life cycle roadbed reconstruction cost before the jth set of road segments is abandoned;
REC_j = the total annualized life cycle roadbed reconstruction cost after the jth set of road segments is abandoned;
RES_{j-1} = the total annualized life cycle road resurfacing cost before the jth set of road segments is abandoned;
RES_j = the total annualized life cycle road resurfacing cost after the jth set of road segments is abandoned;
$BREC_{j-1}$ = the total annualized life cycle bridge reconstruction cost before the jth set of road segments is abandoned;
$BREC_j$ = the total annualized life cycle bridge reconstruction cost after the jth set of road segments is abandoned;
BMC_{j-1} = the total annual bridge maintenance cost before the jth set of road segments is abandoned;
BMC_j = the total annual bridge maintenance cost after the jth set of road segments is abandoned;
VL_j = the annual value of the land if the jth set of road segments is not maintained;
ROW_j = the annualized cost of converting the right-of-way of the jth set of road segments to agricultural production;
TC_j = the total annual vehicle transportation cost after the jth set of segments is abandoned; and
TC_{j-1} = the total annual vehicle transportation cost before the jth set of road segments is abandoned.

If the value of the ratio in Equation 1 is less than 1.0, the net benefits to the traveling public of keeping the road segment in the system are less than the cost of keeping the road segment in the system. If the ratio is greater than 1.0, the benefits to the traveling public of keeping the road are greater than the cost of keeping the road.

Benefit-Cost Estimation

Except for school bus and post office travel costs, the benefits accruing to the traveling public were estimated in two steps. First, a network model was used to estimate the minimum cost traffic flows for all 1982 traffic within each study area. The network model for each study area included all roads by type of surface; all bridges by load bearing capacity; all property and field tract access points; and all trips by origin, destination, and vehicle type. Travel costs were defined as the variable vehicle cost per mile by type of road surface times the number of miles traveled by each vehicle type on each type of road surface. Dijkstra's algorithm was chosen to estimate the minimum cost routing of traveling from each origin to each destination for each vehicle type because it preserves the origin-destination relationship and requires relatively few operations to find an optimal solution *(10)*. The actual estimation of the benefit to the traveling public of keeping a road or group of roads in the system was calculated as follows:

1. The computerized algorithm was run to route the trips through the study area road system to obtain the total miles traveled and cost of this travel.
2. The computerized road network was altered by removing a set of road segments.
3. The algorithm was run again to reroute trips through the altered road network to obtain the total miles traveled and cost of the travel on the "adjusted" network.
4. The change in travel costs between the two solutions is the estimated benefit from having the set of roads considered for abandonment in the system.

The basic assumptions behind the network model used in this analysis are the following:

1. Travel costs are a linear function of distance traveled for each vehicle type.
2. The number of trips from each origin to each destination in each time period by each vehicle type is independent of changes in the road system.
3. Vehicle purchase decisions are not affected by the relatively small changes in distance between an origin and a destination resulting from a change in the road system.
4. Travel routes are selected to minimize travel costs.
5. Vehicles with gross weight greater than the posted carrying capacity of a bridge cannot cross that bridge.

Detailed specifications of the network model are presented in Pautsch et al. *(10)*.

School bus and post office travel costs could not be estimated by the network model because much of the routing of these vehicles depends on the route structure outside the study areas. Existing school bus routes were used to estimate travel costs for Step 1. Then the school buses were rerouted manually after selected roads were removed from the system to obtain the change in school bus travel costs resulting from road abandonment. Postal service travel routes and costs before and after the selected roads were eliminated from the system were estimated by officials from the U.S. Post Office.

Maintenance Costs

Total maintenance costs for paved, gravel and dirt roads consist of fixed and variable maintenance costs. The fixed portion of maintenance cost is independent of the traffic level and composition and is associated with signing, slope erosion, ditching, and snow removal. The variable portion of maintenance cost for gravel and dirt roads is expressed as a function of the average daily traffic level of the road, whereas the variable portion of maintenance cost for paved roads is expressed as a function of kip loadings.

The basic assumption underlying the variable maintenance cost of paved roads is that a portion of the cost varies directly with the number of standardized (18-kip) axle loads passing on the road. Each type of pavement is designed to withstand a projected number of 18-kip loadings during the expected life of the road. An increase in the number of axle loadings in the form of more trips or heavier vehicles increases the maintenance cost of the road surface. Variable maintenance costs for paved roads were estimated as follows:

$$VMC = \frac{TK}{AK} \cdot AVMC \cdot D \quad (2)$$

where

VMC = variable maintenance cost;
TK = total number of standardized (18-kip) loadings applied in 1982;
AK = average annual standardized (18-kip) axle loadings embodied in the pavement;
$AVMC$ = average annual variable maintenance cost per mile of paved road; and
D = length of the road segment in miles.

Equation 2 adjusts the average annual variable maintenance cost per mile of paved road for changes in the number of trips as well as for changes in vehicle size and weight.

The periodic reconstruction and resurfacing costs were annualized over a 45-year life cycle. The opportunity cost of keeping the land in roads rather than in alternative uses was assumed to be the annual rental value of nearby land in agricultural production minus the annualized cost of converting the right-of-way to agricultural production.

THE DATA

Travel Patterns

Data on 1982 personal and farm travel were obtained by a traffic survey of households and farms in the three study areas *(11)*. Data were obtained on the exact location of each respondent's home and land tracts within and outside the study areas as well as the location of home and field driveways. In addition, the number of trips was gathered by vehicle type for the following:

1. Origin of deliveries to each home and field tract;
2. Origin and destination of pickup truck and farm equipment trips;
3. Intra- and off-farm product hauling by type of product, origin, and destination;
4. Personal trips by origin, destination, and purpose; and
5. Origin of visits to each household.

Of the 753 farms that were interviewed, 727 completed questionnaires for a response rate of 96.5 percent. Of the 1,205 households that were interviewed, 1,146 completed questionnaires for a response rate of 95.1 percent. Neighbors were questioned about the characteristics of farms and households for the refused interviews. Questionnaires from respondents with similar traits were then substituted for the refusing respondents.

The questionnaire did not include data on school bus, post office, and overhead traffic that did not originate and terminate within the study area. School bus routes were obtained from the school districts operating buses in the study areas. The U.S. Post Office provided data on postal routes and costs. A "stop and go" traffic survey was conducted in Study Area 1 to obtain data on overhead traffic traveling through but not originating and terminating in the study area. Study Areas 2 and 3 were judged to have an insignificant amount of overhead traffic on county roads.

Vehicle Travel Costs

More than 100 different types of vehicles traveled over the county roads in the three study areas. The large number of vehicles made it necessary to group several different types of vehicles together and to then estimate costs for a typical vehicle in each group. The major vehicle groups for which travel costs were estimated were automobiles; pickup trucks; school buses; commercially owned vans and trucks; garbage trucks; farmer-owned single-axle, tandem-axle, and semitrailer trucks; and three farm combine sizes and four farm tractor sizes, each pulling seven sizes of grain wagons or farm tillage equipment.

Variable operating costs per mile were estimated for each of these vehicle groups operating on paved, gravel, and earth-surfaced roads where variable operating costs include fuel, oil, tires, maintenance, and travel time. Variable costs are assumed to be a linear function of the number of miles traveled on each surface type. Therefore, all estimated costs are estimated in cents per mile. The costs are based on 1982 prices and representative vehicles. In cases where 1982 prices were not available, the available prices were adjusted to 1982 price levels. The cost per mile estimates and the estimation procedure are described in Hansen et al. *(12)*.

A travel time penalty was added to the travel cost of the time-critical farming operations of planting and harvesting if changes in the road system required additional travel distances for these operations. The travel time penalty was estimated by calculating the cost of increasing machine capacity to permit the farmer to drive the additional distance and complete the time-critical farming operation in the same total time required before the change in the road system. A description of this procedure is presented in Baumel et al. *(11)*.

Maintenance and resurfacing costs for paved roads and reconstruction costs for all roads and bridges were obtained from the Iowa Department of Transportation *(13)*. Maintenance costs for bridges and gravel, earth, and oil-surfaced roads as well as the costs of converting abandoned road right-of-way were obtained from county engineers.

RESULTS

The base solution in each study area provided estimates of total miles and variable travel costs with the full 1982 road network

TABLE 1 NUMBER OF MILES OF ROAD ABANDONED AND CONVERTED TO PRIVATE DRIVES BY STUDY AREA SOLUTION

Study Area	Solution	Miles Abandoned
1	1	5.25
1	2	3.75
2	1	9.25
2	2	6.75
2	3	5.25
3	1	17.75

in the model. Then, low-traffic-volume road segments with no property access points were removed from the computerized road network, and the network model was rerun to obtain total miles and variable travel costs for the reduced network.

Table 1 gives the number of miles of roads abandoned by study area solution. Multiple solutions were run in Areas 1 and 2. In the multiple solutions, roads abandoned in the previous solutions remained abandoned in subsequent solutions.

Table 2 gives the base solution estimates of total miles of travel, cost of travel, and percentage distribution of the miles and cost by type of travel for the three study areas. The total number of miles of travel was more than four times larger in Area 1 than in Areas 2 or 3. The principal reason for this large number of miles of travel in Area 1 is that it contains a substantial number of housing developments. In addition, overhead traffic accounted for 25 percent of the total miles of travel in Area 1. No overhead traffic surveys were conducted in Areas 2 and 3.

Approximately two-thirds of all travel in all three areas was for household purposes, mostly by automobile. Travel for farming purposes accounted for less than 5 percent of total travel in Area 1 but about one-third of the travel in Areas 2 and 3. However, farm travel costs were 8 percent of travel costs in Area 1, 40 percent in Area 2, and almost 50 percent in Area 3. Thus, although farm travel miles is a relatively small portion of total travel miles in Area 1, it is a major share of total variable travel costs.

Table 3 gives the estimated change in travel costs resulting from road abandonment. The large computer cost to run these models limited the number of alternative solutions that could be run. Several major observations can be made from Table 3. First, none of the Area 1 overhead traffic traveled on the roads abandoned in the first solution, and only a small amount traveled on the roads abandoned in the second solution, so overhead traffic had little impact on this analysis. The fact that Area 1 has a large amount of overhead traffic and only a small amount of overhead traffic affected by road abandonment suggests that overhead traffic can be ignored in abandonment analyses if the study area size is approximately 100 mi^2. Second, additional travel costs per mile of abandoned road increase at an increasing rate as additional miles are taken out in multiple solutions in Area 2. Third, farm travel incurs the largest percentage of additional travel costs. If the travel time penalty cost is added to the change in farm travel costs, farm costs are about one-half or more of the total change in travel costs. Fourth, school bus and post office costs range from 2.8 to 26.7 percent of total additional travel costs depending on which roads are abandoned. Therefore, these costs should be included when evaluating road abandonment.

Table 4 gives the estimated annual savings from abandoning the roads in the three study areas. The average savings ranged from $4,205/mi to $10,887/mi of road abandoned. The major reason for the $10,887 savings in the first solution of Area 2 is the large number of bridges on the roads abandoned in this solution. Nearly 58 percent of the cost savings were from bridge maintenance and reconstruction cost savings. The other major sources of cost savings were fixed maintenance and reconstruction cost savings.

In several solutions, variable maintenance and paved resurfacing costs increased. These higher costs occur on roads that inherit the traffic from the abandoned roads. Thus, nearby roads incur increasing variable maintenance, reconstruction, and re-

TABLE 2 ESTIMATED TOTAL MILES OF TRAVEL AND COST OF TRAVEL IN THE BASE SOLUTION AND THE PERCENTAGE DISTRIBUTION OF TRAVEL MILES AND COST BY TYPE OF TRAVEL AND STUDY AREA, 1982

	Area 1		Area 2		Area 3	
Total and Percent of Miles and Cost by Type of Travel	Total Miles	Total Cost	Total Miles	Total Cost	Total Miles	Total Cost
Total travel (mi)	28,213,628		6,212,210		5,075,169	
Total cost ($)		6,864,943		1,857,246		1,515,083
Percent of miles and cost by:						
Household (%)	69.7	66.0	68.5	55.0	63.3	47.3
Overhead (%)	25.0	24.6	—[a]	—[a]	—[a]	—[a]
Farm (%)						
Automobile (%)	0.1	0.1	0.6	0.5	1.0	0.8
Pickup (%)	3.4	4.1	23.3	23.4	26.9	25.6
Trucks (%)	0.7	1.2	2.9	3.9	2.7	3.5
Tractor-wagon (%)	0.1	0.5	0.7	3.0	1.0	4.7
Tractor-equipment and combines (%)	0.4	2.1	2.2	9.8	3.1	13.6
School buses (%)	0.3	0.5	0.8	1.2	0.9	1.2
Post Office (%)	0.3	0.9	1.0	3.2	1.1	3.3

[a]Overhead traffic was not estimated in these areas.

TABLE 3 ESTIMATED 1982 CHANGE IN TRAVEL COSTS RESULTING FROM ROAD ABANDONMENT, THE DISTRIBUTION OF ADDITIONAL COSTS BY TYPE OF TRAVEL, AND THE MILES OF ROAD ABANDONED

	Area 1		Area 2			Area 3
	Solution 1	Solution 2	Solution 1	Solution 2	Solution 3	Solution 1
Miles abandoned	5.25	3.75	9.25	6.75	5.25	17.75
Change in travel costs from previous solution ($)	29,822	25,698	39,179	78,436	76,668	58,146
Percentage distribution of additional costs by—						
Households	28.4	34.4	14.2	15.6	40.1	7.0
Overhead traffic	0	1.5	—[a]	—[a]	—[a]	—[a]
Farm travel	38.4	56.3	74.1	69.7	45.2	60.3
Farm timeliness penalty	6.5	5.0	5.6	4.3	4.7	9.8
School buses and post office	26.7	2.8	6.1	10.4	10.0	22.9

[a]Overhead traffic was not estimated in these areas.

surfacing costs from the higher traffic levels. The increase in variable maintenance costs on roads inheriting the traffic from the abandoned roads exceeds the variable maintenance cost savings on the abandoned roads in four of the seven solutions. Fixed road maintenance and net land rental values are a function of miles of road abandoned, while the bridge maintenance savings are a function of the number and size of abandoned bridges and not of traffic levels.

Table 5 gives the estimated benefit-cost ratios of the five abandonment solutions. In urbanized Area 1, the benefit-cost ratio for the first abandonment solution was 0.88; that is, the traveling public spends $0.88 in additional travel costs for each $1.00 saved in maintenance and investment costs when the 5.25 mi of road were abandoned. In the second abandonment solution in the urbanized area, the benefit-cost ratio was 1.01. The additional roads abandoned in this solution had higher traffic levels than those abandoned in the first solution. The abandonment of the roads in the second solution would force the traveling public to incur additional travel costs approximately equal to the maintenance and investment cost savings from abandoning these roads.

In the largely rural Area 2, the benefit-cost ratio of abandoning the first set of 9.25 mi was 0.39, but the ratio climbed to 1.73 and 3.47 for the next 6.75 and 5.25 mi of abandoned roads, respectively. The major reasons for the low ratio in the first solution were the low traffic levels and the high cost of rebuilding and maintaining the bridges on these roads. The benefit-cost ratios increased as additional sets of roads were abandoned because each additional set of roads considered for abandonment had more traffic than the previous set of roads. Moreover, only 11.5 percent of the roads in Area 2 were paved roads. Thus, the traffic from the abandoned roads was rerouted onto gravel or oiled roads that have high vehicle travel costs and high variable maintenance costs.

TABLE 5 BENEFIT-COST RATIOS FOR SIX SOLUTIONS

Area	Solution	Benefit-Cost Ratio
1	1	0.88
1	2	1.01
2	1	0.39
2	2	1.73
2	3	3.47
3	1	0.61

TABLE 4 ESTIMATED ANNUAL MAINTENANCE AND INVESTMENT COST SAVINGS FROM ABANDONING SELECTED ROADS BY STUDY AREA

	Area 1		Area 2			Area 3
	Solution 1 ($)	Solution 2 ($)	Solution 1 ($)	Solution 2 ($)	Solution 3 ($)	Solution 1 ($)
Road costs						
Variable maintenance	−1,275	3,952	−1,036	−2,727	−4,727	1,647
Fixed maintenance	12,258	8,471	20,957	17,001	14,516	42,174
Resurfacing	26	−176	−41	−50	29	0
Reconstruction	6,141	7,019	10,194	14,819	−8,900	8,893
Bridge costs						
Maintenance	1,284	583	10,159	1,781	2,529	3,120
Reconstruction	8,441	4,191	57,807	12,516	17,115	19,618
Net land rental value minus land reconstruction costs	7,184	1,437	2,663	1,943	1,512	19,313
Total	34,059	25,477	100,703	45,283	22,074	94,765
Average savings per mile of abandoned road	6,487	6,794	10,887	6,709	4,205	5,339

In Area 3, the benefit-cost ratio for the abandoned roads was 0.61. Area 3 has lower traffic levels and a relatively high percent of paved roads. Thus, the traffic rerouted from the abandoned gravel roads to paved roads had lower vehicle operating costs, and the paved roads inheriting the additional traffic had relatively low maintenance costs.

The benefit-cost ratios reported in this paper are lower than the benefit-cost ratios for the same set of abandoned roads that were reported in Baumel et al. *(11)*. The reasons for the lower ratios are the following:

1. Road reconstruction and paved resurfacing costs in this analysis are estimated on a 45-year life cycle. In the earlier report, these costs were estimated on a one-time investment basis.
2. In this paper, bridges are reconstructed every 45 years. No bridge reconstruction costs were included in the earlier analysis.
3. In this analysis, no resurfacing costs were charged to gravel roads. Annual maintenance costs include sufficient gravel to maintain an adequate gravel surface. In the earlier analysis, gravel roads were resurfaced every 20 years in addition to the resurfacing contained in annual maintenance costs.

SUMMARY AND CONCLUSIONS

The basic purpose of the study was to develop guidelines for local supervisors and engineers in evaluating local rural road investment or disinvestment proposals and to provide information to state legislatures in developing local rural road and bridge policies.

Three case study areas of 100 mi^2 each were selected in Iowa for this analysis. Study Area 1 has a high agricultural tax base, a high percentage of paved roads, and a large number of nonfarm households with commuters to Cedar Rapids and Waterloo. Study Area 2 has a low agricultural tax base, hilly terrain, a low percentage of paved roads, and a large number of bridges. Study Area 3 has a high agricultural tax base, a high percentage of paved roads, and few bridges. The major conclusions from the study were as follows:

- The major sources of vehicle miles on county roads are automobiles used for household purposes and pickup truck travel for farm purposes.
- Farm-related travel represents a small percentage of total travel miles but a high percentage of total travel costs.
- In areas with a large nonfarm population, a small number of low-traffic roads on which the increased vehicle travel costs of the rerouted traffic will be less than the maintenance and investment cost savings can be abandoned.
- In areas with a small rural population and a large percentage of gravel roads, abandonment of roads with no property accesses and high bridge maintenance and reconstruction costs will result in additional travel costs that are sharply lower than savings in maintenance and investment costs. However, if the bridge maintenance and reconstruction costs are relatively low, the additional travel costs incurred from rerouting the traffic over gravel roads tend to be greater than the maintenance and reconstruction savings from abandonment.
- In areas with a small rural population and a high percentage of paved roads, a relatively large number of miles of county roads with no property accesses can be abandoned on which the savings from abandoning the roads will exceed the additional travel costs.

The public policy implications of these results are as follows:

- There are limited potential cost savings from abandonment of local rural roads with no property accesses in areas with a large nonfarm population.
- There are high potential cost savings from abandonment of roads with no property accesses in areas with a small rural population and a core network of paved roads.
- There are potential savings from abandonment of roads with no property accesses that have high bridge costs in areas with a small rural population and a large share of gravel roads. However, more roads might be abandonment candidates if some gravel roads are resurfaced to create a core paved network. This alternative was not explored in this analysis.
- There can be substantial legal costs and damage awards associated with road abandonment. The possibility and extent of such costs depend on the state laws in effect in the various states. Because these costs vary widely from case to case, it was not possible to include these costs in the benefit-cost ratios in this study.

Present laws in some states may preclude any possibility of road abandonment even though all costs considered, including the shifting of road costs from the public to private sector, indicate a net benefit from such abandonments. In fact, it may require changes in state laws, along with a major change in public policy and acceptance, before any of these changes could and would be implemented and accepted. Some of the areas that need to be addressed are the following:

1. Adequate methods of compensation for those adversely affected by road abandonment.
2. Exemption of local government authority from legal action upon completion of established guidelines.
3. Legislative consideration to strengthen existing laws regarding road abandonment.
4. A method of educating the public of the benefits and costs of alternative road system changes to enhance the quality of the public input into the policy-making process.

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