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FOREST ROAD STANDARDS AS RELATED TO ECONOMICS AND THE ENVIRONMENT

R. B. Gardner[1]

ABSTRACT

Planning a truly optimum forest road system is not possible at this time primarily because data needed as input for such an analysis is either inadequately defined or nonexistent. However, it is appropriate to use whatever rational means are available to give greater weight to protecting the quality of the environment. This paper discusses the problem in a general way and recommends a procedure that might be used to help decide on appropriate standards until better methods are available.

Today, widespread concern for the environment necessitates reorientation of the economic analyses and methods that are being used to determine forest road standards. Most of the design standards and techniques for forest road location were borrowed from methods that evolved from values associated with major freeways and highways. This former approach emphasized the cost to the user assessed over a predetermined economic life of the structure. In regard to forest roads, present-day thinking definitely minimizes this direct-cost-to-user concept and also tends to outmode related concepts or standards regarding the economic life of the road.

If we accept this present-day thinking, then it does not seem reasonable to assign a relatively short economic life of 15 to 20 years to any road that will be added to the permanent system of forest roads. Such short terms have been considered appropriate for many modern highways because of the rapid evolution of faster vehicles and greater volumes of traffic. In the relatively flat and less scenic locations of most modern highways, it may be reasonable to continually upgrade alinements, grades, and widths (even this process must someday slow down); but for the environment-conscious public, which now insists upon protection from over-development, this approach is no longer acceptable for most forested areas.

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[1]Engineer in charge, Forest Engineering Research, stationed in Bozeman, Montana, at Forestry Sciences Laboratory, maintained in cooperation with Montana State University.

The thought of building a forest road and assuming a relatively long life of 50 to 100 years would probably be considered unrealistic by many engineers and economists; however, this may be more realistic than using a short period of 15 to 20 years if we decide that protection of the environment should be given major consideration. This approach will force us to sacrifice some economic values, mostly short-term ones. Such sacrifices are always necessary when environmental protection decisions take priority over purely economic ones. Economic values related to speed of travel and vehicle maintenance are examples of values that many users would consider giving up in favor of environmental protection.

Construction, maintenance, and vehicle-use costs of highways or roads are considered when economic analyses are made; then these costs are compared with the benefits accruing to the users. Road priorities are usually decided upon either a benefit-cost or rate-of-return basis. Construction costs are amortized over an assumed design life, using some appropriate interest rate. Maintenance costs for the road standards being considered are derived from past maintenance cost records. Vehicle-use costs include maintenance, operation, depreciation, and cost of the *time* of the driver and passengers. How these costs affect total annual costs for an average forest road are shown in table 1, assuming an annual traffic volume of 10,000 vehicles. Annual traffic volumes rather than daily volumes are generally used for forest roads because of the seasonal nature of the traffic and relatively low volumes during some periods.

As the traffic volumes increase, there is justification for higher levels of road standards, as would be expected. Comparison of costs for traffic volumes of 20,000 and 40,000 vehicles per annum (VPA) are shown in table 2.

Vehicle use costs for increased vehicles per annum play an increasing role in the total costs, as would be expected--the difference is more pronounced for a very low standard road carrying high traffic volumes. The appropriate standard of road, if vehicle use is considered to be the predominant criteria, for the traffic volumes of 10,000 to 20,000 and 40,000 VPA is a 1-lane gravel, 2-lane chip-seal, and 2-lane paved road, respectively. It should be noted in this example that a change in the amortization period from 20 to 50 or 100 years has no effect on the most economical road standard when this criteria is used. This is because vehicle use costs for 50- and 100-year depreciation periods are greater than the depreciation costs for all road standards; thus, the higher standard road is always favored. It should also be noted that we have not yet considered the impact of these various standards on the environment, the social and economic impacts of safety, or the indirect benefits from recreation and other uses.

At this point in the analysis we have some of the inputs, but other required inputs are either not well established or nonexistent. For example, possible damages to the environment are either not well established or unknown quantitatively. Here, we refer to instances where there may be appreciable damages to the environment because of the influence of a road on the hydrology of a watershed that in turn may result in accelerated erosion or undesirable flood peaks in a stream.

If we used our analysis at this point (where some inputs are lacking) in a direct comparison of benefits versus damages (negative benefits) these quantities that are difficult to calculate would have to be reduced to an annual dollars-per-mile basis. To do this, it would be necessary to assume some useful or ultimate life for the road and/or some end point (or termination of the positive and negative benefits) that are quantifiable. It should also be noted that many negative benefits, such as those chargeable to esthetics, changes in streamflow rates, etc., continue beyond any known assumed economic road life.

Table 1.--*Comparison of annual road costs per mile, 10,000 vehicles per annum (VPA)*

Cost distribution	Road standard					
	2-lane paved	2-lane chip-seal	2-lane gravel	1-lane gravel	1-lane spot stabilization	1-lane primitive
	Dollars per mile					
Initial construction	50,000	40,000	30,000	20,000	15,000	10,000
	Annual dollars per mile (20-year period)					
[1]Depreciation	4,360	3,490	2,610	1,740	1,310	870
Maintenance	200	400	600	800	1,100	500
Vehicle use	2,200	2,300	2,700	3,000	4,400	8,500
Total annual	6,760	6,190	5,910	[2]5,540	6,810	9,870

[1]20 years at 6% using capital recovery.
[2]Lowest annual cost.

Table 2.--*Comparison of annual road costs per mile for 20,000 and 40,000 vehicles per annum (VPA)*

Cost distribution	Road standard					
	2-lane paved	2-lane chip-seal	2-lane gravel	1-lane gravel	1-lane spot stabilization	1-lane primitive
	Dollars per mile					
Initial construction	50,000	40,000	30,000	20,000	15,000	10,000
	(20,000 VPA)					
[1]Depreciation	4,360	3,490	2,610	1,740	1,310	870
Maintenance	400	800	1,200	1,600	2,200	1,000
Vehicle use	4,400	4,600	5,400	6,000	8,800	17,000
Total annual	9,160	[2]8,890	9,210	9,340	12,310	18,870
	(40,000 VPA)					
Depreciation	4,360	3,490	2,610	1,740	1,310	870
Maintenance	800	1,600	2,400	3,200	4,400	2,000
Vehicle use	8,800	9,200	10,800	12,000	17,600	34,000
Total annual	[2]13,960	14,290	15,810	16,940	23,310	36,870

[1]20 years' depreciation at 6% using capital recovery.
[2]Lowest annual cost.

Table 3.--*Comparison of single-lane versus double-lane costs for three different vehicle-per-annum (VPA) categories*

VPA	Total annual cost per mile		Difference
	1-lane gravel	2-lane paved	
	Dollars		
10,000	5,540	6,760	-1,220
20,000	9,340	9,160	+ 180
40,000	16,940	13,960	+2,880

Since we lack much of the data needed for accomplishing this total analysis now, we must try to use the information at hand and make a subjective, but hopefully rational, approach to a solution. It is almost certain that most of the negative benefits will be minimized using a lower standard road (lower standard because of reduced width and alinement, primarily). The lower standard road should produce less impact on the total environment--hydrology, soils, esthetics, etc. From the point of view of user cost (the *time* portion of this cost is questionable for most forest roads that serve significant recreation traffic because speed of travel is not of primary concern), what is given up in dollars for the 3 VPA's looked at earlier (10 to 20 to 40,000) for a single-lane gravel road versus a 2-lane paved road? See table 3.

The differences in cost per mile for the two standards of road reveal that for the estimated traffic over a 20-year amortization period, the single-lane road would be preferred. Admittedly, making predictions about the future is risky business. However, if increased anticipated (or allowed) use was extended on the basis of past trends, 40,000 VPA would probably be near the maximum for 50 years or more. Increased use, of course, could be controlled significantly by limiting recreation facilities, timber harvesting, and other uses; it is likely that some limitations may be required sometime in the near future. At the 40,000 VPA level, about $2,900 annually per mile would be "charged the users," in a manner of speaking, for anticipated preservation of environmental values. This would amount to 25¢ or 30¢ per user per mile annually.

Since the likelihood of limiting use of roads at some time in the near future is probably quite good (this is already being done in some Federal and State parks), and the direct, rather easily calculated cost of such roads to the users is relatively small, it seems reasonable to consider single-lane roads adequate for about 50 years.

Past studies of accident records for single-lane roads (mostly rural county roads) show only a slight increase in accident frequency between low standard 2-lane and single-lane roads. These figures are for average daily traffic (ADT) totals of 100 to 200 vehicles (20,000 to 40,000 VPA)--traffic volumes of the same general magnitude as most typical forest access roads. The critical period for accident potential, of course, would be the maximum expected peak hourly traffic. For these few critical periods during the year, some form of traffic control could be used. These same accident rate studies referred to above also show that fewer accidents occurred on curves than on tangents, and also that widening or adding extra lanes cannot be *economically* justified to prevent accidents. If loss of life from accidents were to be considered of primary concern, then there would be no limit to the money that could be justifiably spent for traffic control by adding features such as extra lanes, land dividers and surveillance.

We realize that every road is unique and requires a separate analysis. When potential traffic volumes may be high for a through road, and environmental impacts may be obviously low for a high standard road, then user costs could be heavily weighted. Although we may not be able to assign values to some uses with great confidence and in a manner agreeable to everyone, it is possible to subjectively give weight to some of these values. For example, economists are divided in their opinions about assigning values to some recreation experiences. Many feel that attempting to do so is an exercise in futility--others will attempt to do it. In either case, the weight of public opinion cannot be ignored. It is clear that these experiences have value to the general public and must be weighted in some fashion. New and better methods for accomplishing this are currently being studied and, hopefully, better solutions will be forthcoming.

In the meantime, it would seem clear that analyses to determine forest road standards cannot end when the direct cost to the user has been determined, as has been the general practice in the past. This too often results in many indirect costs to environment quality. Greater emphasis must be given to other values in some rational manner.