

Cost-Effectiveness of Park-and-Ride Lots in the Seattle Metropolitan Area

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ABSTRACT

A cost-effectiveness evaluation and a cost-benefit analysis were performed on a park-and-ride system consisting of 26 lots in the Seattle metropolitan area. Costs and benefits of the system were examined with respect to the user, the community at large, and the public agencies responsible for providing for the community's transportation needs. A user survey was conducted at the 26 lots. With the survey data and other data as input, a model was developed to calculate the total incurred trip costs with and without the park-and-ride lot. These trip costs were compared in a before-and-after analysis. In addition, the park-and-ride system was analyzed for its effect on the following transportation system measures of effectiveness: travel time, person miles traveled (PMT), vehicle miles traveled (VMT), traffic volumes, vehicle emissions, accidents, and energy consumption. General results indicated that the park-and-ride system in the Seattle area is cost-effective. The average park-and-ride trip was estimated to be 11.6 percent less expensive than the corresponding average previous trip by another mode. Results also indicated that the lots have had a slightly negative impact on travel time and PMT (i.e., these measures have increased), but VMT, traffic volumes, accidents, vehicle emissions, and energy consumption have all been reduced.

Park-and-ride lots are parking facilities, typically located some distance from the central business district (CBD), where the commuter changes from an automobile to some form of public transportation or ridesharing. In major urban areas throughout the United States such lots have been established to provide more efficient transportation and to assist in the conservation of energy. As such, they have become an integral part of the nation's urban transportation system framework. Nowhere is this more true than in the Seattle metropolitan area.

The agency responsible for providing transit service in the Seattle/King County area is the Municipality of Metropolitan Seattle (METRO). The first park-and-ride lot in the Seattle area was established in 1970 by METRO's predecessor, Seattle Transit, in the Northgate vicinity. Encouraged by the high utilization of this lot, the Washington State Department of Transportation (WSDOT) coordinated planning efforts with METRO to provide additional park-and-ride lots in the Seattle metropolitan area. Under a memorandum of understanding between the two agencies, WSDOT was to construct the lots using appropriate funds (Interstate, UMTA, state motor vehicle funds, and some METRO matching dollars), and METRO was to maintain them.

As of March 1984 the Seattle/King County area had 26 permanent, 8 semipermanent, and 16 interim park-and-ride lots. Lots are classified on the basis of their funding and long-range planning considerations. These 50 lots in total represented 12,520 automobile parking spaces. To date, WSDOT has spent approxi-

mately \$47 million for construction of the 26 permanent lots.

Planned additions to the existing park-and-ride system are extensive. Both METRO and the Puget Sound Council of Governments (PSCOG), the regional planning agency, recommend plans that would double the number of park-and-ride lots in the Seattle/King County region (1,2).

Despite the substantial sums of money that have been invested and are planned for investment in park-and-ride lots, little has been done to evaluate their total effectiveness. The initial goal of park-and-ride lots was to entice automobile commuters into express buses to alleviate freeway traffic congestion. Energy conservation became an additional objective with the advent of the Arab oil embargo in the early 1970s. To lure commuters from their cars to transit, the benefit to them had to be clearly outlined. Consequently, previous analyses of this topic have focused on benefits to the users through economic savings and energy conservation. However, a need exists to take a more comprehensive and detailed look at the costs and benefits of park-and-ride lots, not only with respect to the user, but with respect to the community at large and to the public agencies responsible for providing for the community's transportation needs. In short, do the benefits provided by park-and-ride lots sufficiently justify their expense? This study was undertaken to answer that question for the Seattle area.

The basic goal of this study was to determine the cost-effectiveness of existing park-and-ride lots with respect to the total transportation system in the Seattle metropolitan area. Results from this study may also be of use in the development of guidelines and tools for assessing the effectiveness of proposed park-and-ride facilities.

In meeting this goal, the basic objective was to provide a total cost-effectiveness evaluation of the

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existing park-and-ride lot system, which included looking at costs, benefits, and other measures of effectiveness as they related to each of the following groups:

- The community at large,
- The public agencies involved, and
- The park-and-ride lot user.

In the development of this study, the question arose whether highway capital costs, being "sunk" costs (i.e., the investment in them has already been made), should be included in the cost analysis. Depending on the purpose of the study and the application of its results, arguments can be made both for and against including these costs in the analysis. Because all the capital costs considered in this analysis--including those for both freeways and park-and-ride lots--have been sunk costs, it is legitimate to include them, including those for freeways, in the cost analysis.

Another strong argument for the inclusion of highway capital costs is that, with respect to the park-and-ride system, WSDOT's "participation with gas tax money is based on the premise that the construction of the park-and-ride lot system will relieve the need for the construction of additional highway lanes" (3). Still another argument is that the transportation system of the given area is in its infancy. In other words, the construction of either freeway lanes or a park-and-ride system is a valid alternative (neither are sunk costs in this case). In this instance, the trading off of the cost of freeway capacity with that of the park-and-ride system is an appropriate strategy.

However, there are also scenarios in which including highway capital costs is not necessarily appropriate. One such case involves analyzing the cost-effectiveness of a single proposed park-and-ride lot. For this case, highway capital costs are sunk but the cost of the lot is not. Given a situation in which it is highly unlikely that many additional freeway lanes will be built (which is the case for most major urban areas in the United States, including Seattle), the trade-off would not be between the cost of the park-and-ride lot and the cost of additional freeway construction, but rather the cost associated with the increased freeway congestion that would result if the lot were not built, the cost of implementing an alternative transportation system management (TSM) tactic of equivalent effectiveness, or the cost of implementing some other form of mass transportation.

Because a sidelight of this study is to provide a base that may be used in developing general guidelines for evaluating the effectiveness of park-and-ride lots, the foregoing scenario was considered. For this, general estimates of congestion costs were developed for inclusion in the cost analysis. Because of limited resources, costs of alternative TSM tactics or mass transit options were not developed.

METHODOLOGY

A great deal of the data needed for this study was available through traditional sources. However, certain types of data regarding the park-and-ride lot user were not available and had to be obtained with a special survey. For this purpose, a windshield-placed mailback business-reply survey form was used. The study consisted of the 26 permanent park-and-ride lots in the Seattle metropolitan area sponsored by WSDOT. These lots were divided into four corridors, as shown in Figure 1. In the course of the survey,

6,138 forms were distributed among the 26 lots, and 2,402 were returned, for an overall return rate of 39.1 percent.

For the purposes of the cost-effectiveness evaluation, the primary information obtained from the survey dealt with what mode patrons used before using the park-and-ride lot. With this information, estimates of previous-mode trip costs could be made and compared with the costs of the corresponding trips involving park-and-ride lots in a before-and-after trip cost analysis. Trip costs as referred to here include much more than just out-of-pocket expenses. The full cost of a trip includes every identifiable cost incurred in the provision for that trip. Among those considered in this study are the user costs of time, vehicle operation, and parking; public agency costs of roadway provision and maintenance and transit service provision; roadway user costs due to traffic congestion; and other publicly incurred costs such as city planning, police services, and noise and air pollution. These cost components are outlined in Table 1.

In addition to the total public and private cost comparison, separate before-and-after analyses were made for user-incurred trip costs and for public-agency-incurred trip costs. Comparing costs from these three different perspectives enabled a clearer view as to how costs and benefits of park-and-ride lots were distributed among the respective groups concerned.

For the purposes of the before-and-after trip cost analysis, the study area was narrowed down to the north and southeast corridors, consisting of 11 lots in total, because they represented the relative extremes as far as park-and-ride lot utilization was concerned. The north corridor lots had the highest combined utilization rate and the southeast lots had the lowest. The north corridor is in a relatively mature stage, whereas the southeast corridor is still young and developing. Thus using these two corridors in the analysis covered both ends of the spectrum of park-and-ride lots in the Seattle area.

Park-and-ride lots in the Seattle area were designed primarily to serve the suburban commuter trip to downtown Seattle. This is reflected in the survey results showing that 95 percent of park-and-ride trips are work trips, and 70 percent of those from the north and southeast corridors go downtown. This study focuses on this primary park-and-ride trip--the work trip to downtown Seattle--in its before-and-after analysis.

For the north and southeast corridor cases analyzed, the percentage breakdown of previous-mode trip types was as follows:

<u>Trip Type</u>	<u>Percent</u>
Walk to transit	22.5
Drive to transit	32.1
Drive alone (automobile)	34.3
Carpool or vanpool	11.1

The corresponding park-and-ride trip breakdown was

<u>Trip Type</u>	<u>Percent</u>
Park-and-ride transit	96.8
Park-and-ride carpool/vanpool	3.2

TRIP COST MODEL

Given the basic analysis needs, a model was required that would reasonably estimate all identifiable costs of a commuter trip. The model needed to be theoretically consistent in estimating costs for each of the four previous-mode and the two park-and-ride trip types.

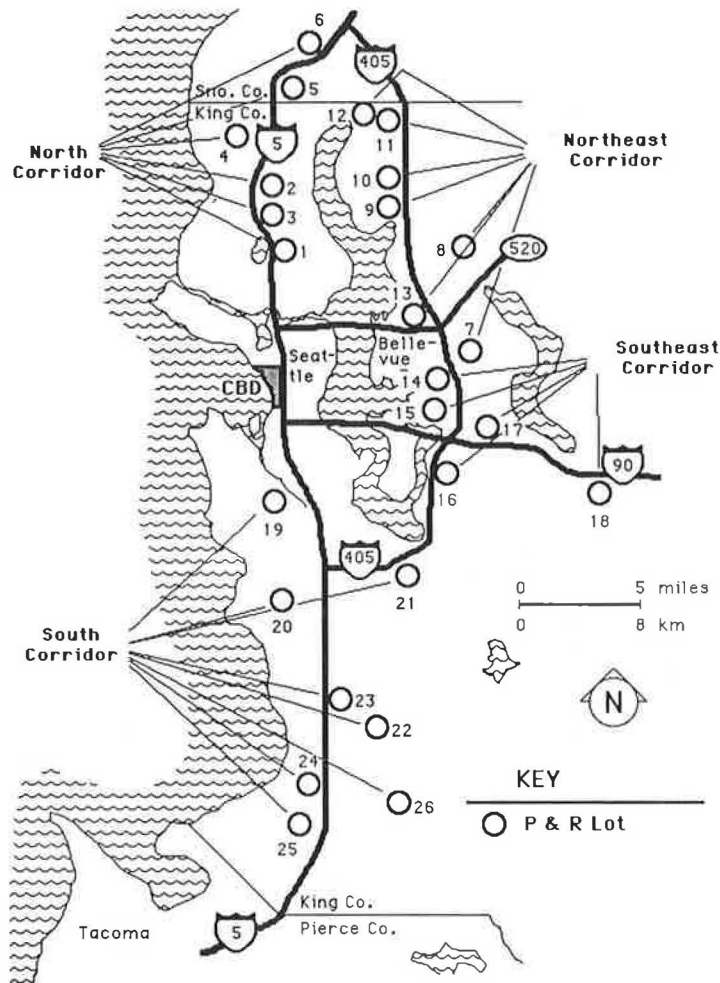


FIGURE 1 Park-and-ride lot study area.

Following a literature search and review, a study by Keeler, Small and Associates (4) was chosen as a base from which to develop the trip cost model. The Keeler-Small study was chosen primarily because (a) it encompassed all of the basic types of costs desired for this study and (b) it was a thorough and highly regarded study that remains today a principal work on the subject of urban transport costs.

The Keeler-Small study estimated trip costs for the major urban transportation modes--automobile, bus, and rail--in the San Francisco Bay area. With such inclusions as travel-time, public-service, pollution, and accident costs, it accounted for more costs than most previous studies.

To fulfill the needs of this study, some general modifications needed to be made to the Keeler-Small

TABLE 1 Total Public and Private Trip Cost Components

Component	Study Value	Reference
Time costs		
In vehicle	1/3 wage rate	(5-7)
Out of vehicle	2.5 x in-vehicle cost	(5-7)
Public costs		
Provision and maintenance of roadway	Peak period; bus 2.49 x automobile	(5,8)
Traffic congestion impact on road users	Time, fuel, maintenance	(5)
Other government-provided services (planning, police, etc.)	Keeler-Small	(4)
Environmental (noise and air pollution)	Keeler-Small	(4)
Automobile costs		
Ownership and operating (less fuel and accident)	FHWA, American Automobile Association, Hertz	(9-11)
Fuel	FHWA, American Automobile Association, Hertz	(9-11)
Accident	FHWA, American Automobile Association, Hertz	(9-11)
Parking costs		
Provision of park-and-ride lot parking	Actual construction and operating and maintenance costs	(12)
Parking at destination	Reported on survey	(5)
Transit costs		
All costs involved in providing transit service (less user fare)	METRO model	(13)
User fare	Actual fare	(5)

study. These modifications are described in detail elsewhere (5).

A review of studies on the value of travel time indicated a range of values (6,7). For the purposes of this study, a middle-range estimate of one-third of the commuter's hourly wage rate was used for the value of in-vehicle time. That value multiplied by 2.5 was used for the value of out-of-vehicle time. Although these values are generally accepted as representative, a sensitivity analysis was done to determine the impact of altering these assumptions.

RESULTS

Total Costs

The total cost comparison for the average previous-mode trip versus the average park-and-ride trip based on a total of 467 cases analyzed is presented in Figure 2, which also lists the component costs for each trip. It should be kept in mind that these costs are averages of individual observations for all trip types in each category; that is, the average previous-mode trip represents a combination of walk to transit, drive to transit, carpool or vanpool, and automobile trips, whereas the average park-and-ride trip incorporates both park-and-ride transit and park-and-ride carpool and vanpool trips.

The results show that on the average, the park-and-ride trip is 7 to 12 percent less expensive than the previous-mode trip, depending on how sunk costs are handled. The park-and-ride trip is more expensive with respect to time, transit, and parking costs. This may appear a little surprising until it is realized that there are no parking costs for the 55

percent of previous-mode trips involving transit. The only previous-mode trip with significant parking costs is the one in which the automobile is driven alone. Conversely, every park-and-ride trip incurs the cost of parking at the park-and-ride lot (this is an agency cost, not a user cost).

Figure 3 presents the trip cost for each type of previous-mode trip as compared with the average park-and-ride trip. The only previous-mode trip more expensive than the park-and-ride trip is the one in which the automobile is driven alone. The drive-alone trip represents a large enough portion of previous-mode trips and its cost is high enough for it to cause the combined average previous-mode trip cost to be greater than that of the park-and-ride trip.

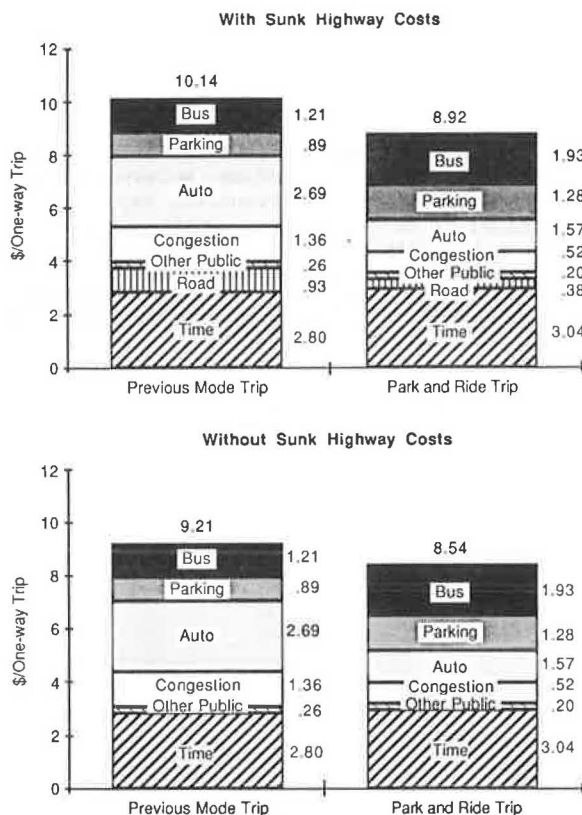


FIGURE 2 Total incurred cost comparison: combined average previous-mode trip versus combined average park-and-ride trip (highway costs included).

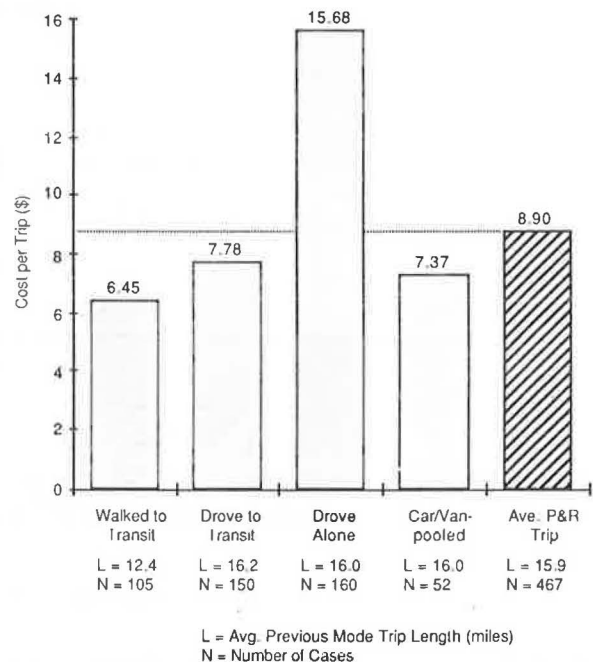


FIGURE 3 Previous-mode total trip cost by mode type versus average park-and-ride total trip cost (highway costs included).

Agency and User Costs

When total costs (i.e., those as they affect users, agencies, and the general community combined) are considered, results indicate park-and-ride lots to be cost-effective. But how do agencies and users fare when considered separately? Figure 4 shows before-and-after (previous mode versus park-and-ride mode) costs per person trip (including highway costs) as incurred by WSDOT, METRO, and the individual user. The agency "after" costs are shown for both existing lot use and 100 percent lot use levels. With respect to WSDOT, park-and-ride trips reduce roadway costs, but the added expense of providing the lot overrides these savings. The net result is that WSDOT spends \$0.61 per park-and-ride person trip. However, because WSDOT's primary function is to serve the transportation needs of the public, which in this case includes both the park-and-ride lot user and the general roadway user, net costs to WSDOT must be weighed against benefits both to the park-and-ride and general roadway user. The savings to the park-and-ride lot user as shown in Figure 4 is \$1.48, or 22.9 percent, per trip. This in itself more than makes up for WSDOT's expenses.

In considering costs incurred by METRO, previous-

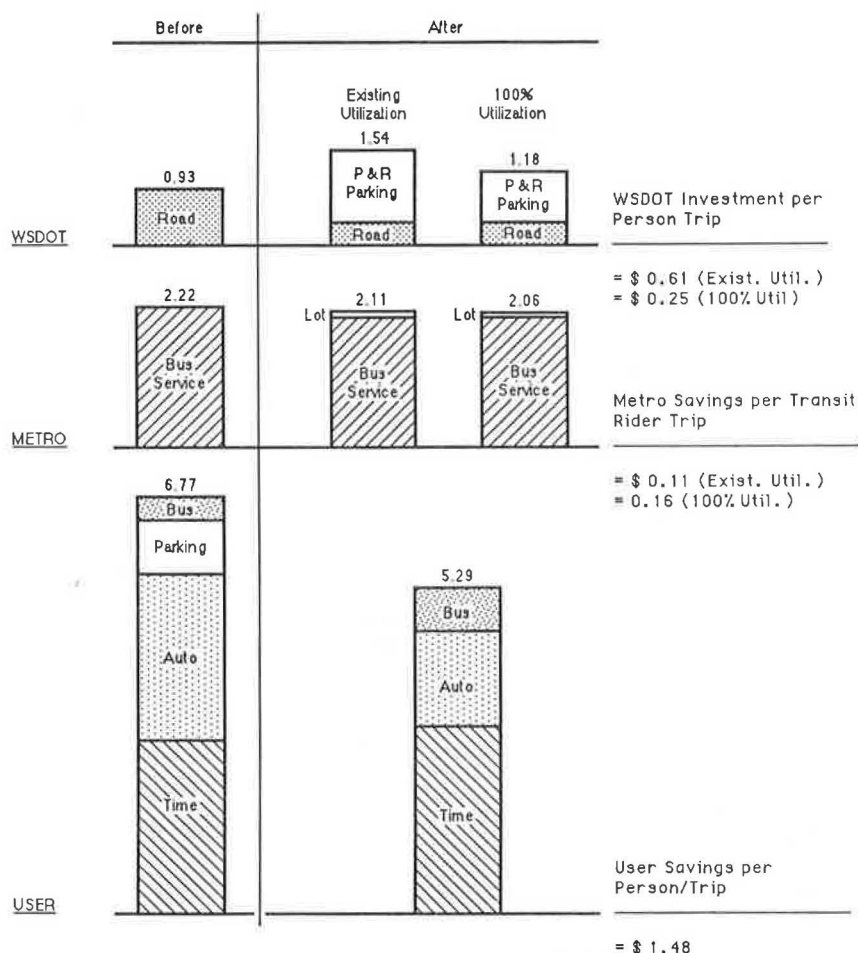


FIGURE 4 Agency and user incurred trip cost comparison (highway capital costs included, congestion costs excluded).

mode trips involving transit (55 percent of all previous mode trips) are compared with park-and-ride transit trips (96.8 percent of all park-and-ride trips). METRO's costs are reduced by \$0.11, or 5.0 percent, per transit rider trip when park-and-ride lots are involved (if the lots were 100 percent utilized this would rise to \$0.16, or 7.2 percent). In addition, among the data population analyzed, the introduction of park-and-ride lots contributed to a 77 percent increase in transit ridership.

Corridor Comparison

Figure 5 shows the percentage of savings due to park-and-ride lots along with utilization rates for each of the north and southeast corridors as well as for two individual lots, Northgate and Eastgate (3 and 17, Figure 1). These costs include highway capital costs. With respect to trip cost savings, park-and-ride lots are more effective in the southeast corridor than in the north. This is somewhat surprising in light of the fact that the southeast corridor has a much lower utilization rate (44.9 percent) than the north (79.2 percent). In fact, since its current utilization is so much lower, the southeast corridor has a higher potential for improvement. If the lots were fully utilized, the savings per park-and-ride trip would increase to 21.9 percent for the southeast corridor as opposed to 13.4 percent for the north. This contrast in cost-effectiveness is even more evident if the two se-

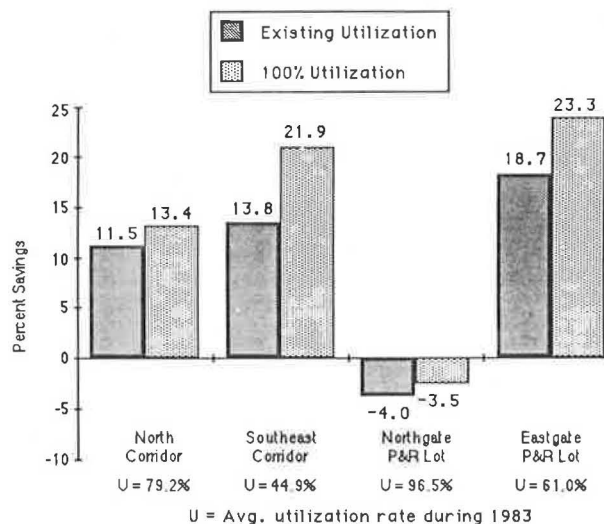


FIGURE 5 Total trip cost savings due to park-and-ride lots by corridor and by selected lots (highway capital costs included).

lected lots from each of the corridors are compared. The Northgate lot, even when fully utilized, experiences an average loss of 3.5 percent per trip, whereas Eastgate shows an impressive savings of 23.3 percent when fully utilized.

Several factors are involved in producing this

difference between the two corridors. One is that southeast corridor trips must follow I-90, which was a much more costly road to build than was I-5 in the north corridor. Hence, replacing automobile trips with transit trips results in greater savings in the southeast corridor than in the north.

Perhaps a more significant reason, however, is found by comparing the percentage breakdown of previous-mode trips between the two corridors (see Figure 6). Both corridors are fairly similar in their percentages of drive-to-transit and carpool and van-pool trips. However, a significant difference exists between their walk-to-transit and automobile-drive-alone trips. Park-and-ride lots in the southeast corridor drew a significantly greater proportion of automobile-drive-alone trips from the roadway than did those in the north. At the same time, fewer southeast park-and-riders had previously walked to transit. When compared with the park-and-ride trip, the automobile-drive-alone trip is much more costly and the walk-to-transit trip is less expensive (see Figure 3). Thus, the southeast corridor experiences a greater savings in overall trip costs than does the north corridor.

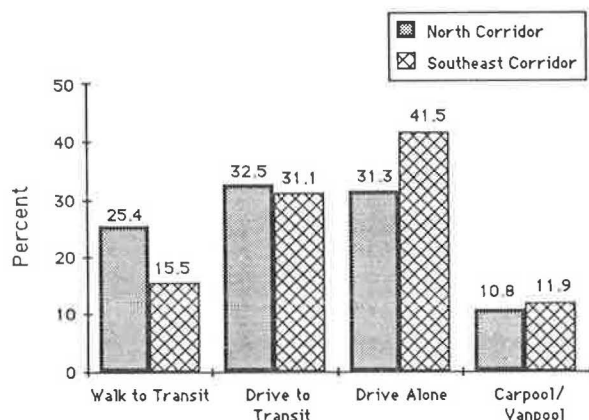


FIGURE 6 Previous-mode percentage breakdowns by corridor.

Figure 7 shows the general cost comparison results by corridor for the case in which highway capital costs are excluded from the cost analysis. In this case, the north corridor appears to fare better than the southeast (8.7 percent versus 4.3 percent savings). This is because estimated congestion costs are higher in the north corridor than in the southeast, whereas highway costs are much greater in the southeast than in the north corridor. Thus, excluding highway costs from the analysis causes a greater reduction in park-and-ride trip savings in the southeast than it does in the north corridor.

An interesting note here is that for both situations discussed (with and without the inclusion of highway capital costs) the southeast corridor fares better than the north corridor when the lots are 100 percent utilized.

Sensitivity Analysis for Various Input Parameter Values

In determining the values for various input parameters, the researchers considered several values based on varying assumptions and sources. Most significant among these were those used for the value of time, highway costs, congestion costs, and automobile owning and operating costs. Several values

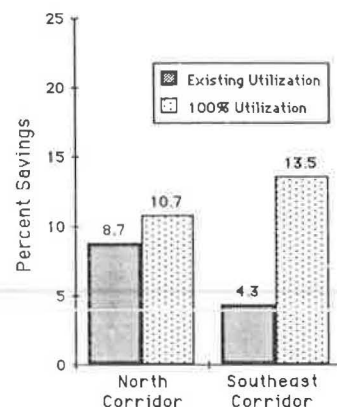


FIGURE 7 Trip cost savings due to park-and-ride lots by corridor (highway costs excluded).

could be used for each of these parameters. Those used in the cost analysis just presented were those determined most reasonable for use in this study. However, for comparison purposes it was desirable to see how the cost analysis might change if different values were used for these parameters. In the course of the study, the general results of the model were found to be relatively insensitive to changes in estimates used for the value of time; however, they were sensitive to changes in highway, congestion, and automobile costs.

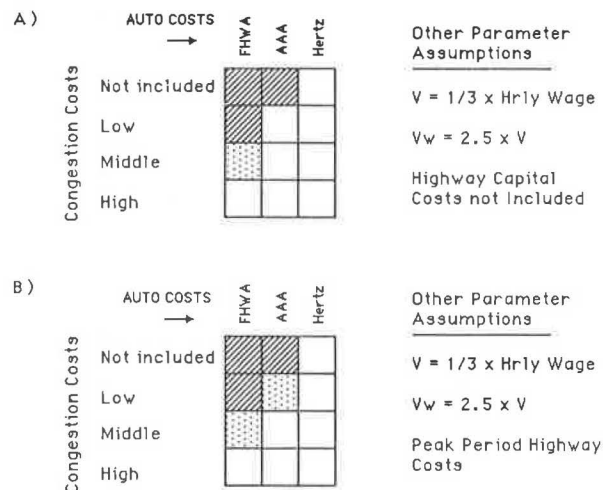
General results of trip cost model runs for cases representing several different combinations of three primary input parameters (highway costs, congestion costs, and automobile costs) are presented in Figure 8. In this sensitivity analysis, peak-period highway costs were either included or not included and congestion costs were varied among low, medium, and high estimates. Automobile costs were varied among those estimated by FHWA (the most conservative), AAA (middle range), and Hertz (the highest). When these varying input combinations were considered, park-and-ride lots proved to be cost-effective for all but the most conservative situations (i.e., when highway capital costs were excluded, either congestion costs were excluded or the lowest estimate for them was used, and the lower-range automobile cost estimates were used).

In a further sensitivity analysis, the trip cost comparison was conducted based on the most extreme sets of parameter-value combinations. Of all the parameter values identified, those that would be most favorable to the previous-mode trip (i.e., would lower the cost of the previous-mode trip more than that of the park-and-ride trip) were outlined as follows as extreme case 1:

- Highway capital costs excluded,
- Congestion costs excluded,
- Automobile costs based on FHWA and park-and-ride second-car values [the park-and-ride second-car concept and the Keeler-Small highway cost method are explained in detail elsewhere (5)],
- In-vehicle time one-half the hourly wage rate, and
- Out-of-vehicle time 3.33 times in-vehicle time.

Extreme case 2, that which was most favorable to the park-and-ride trip, was identified by the following parameter values:

- Highway costs based on the Keeler-Small method,



KEY

- a. System is cost effective with this set of parameter values (i.e., the park-and-ride trip is less expensive than the previous mode trip).
- b. Cost comparison breaks even (i.e., cost of the park-and-ride trip equals that of the previous mode trip).
- c. System is not cost effective (i.e., the park-and-ride trip is more expensive than the previous mode trip).

V = Value of In-Vehicle Time

V_w = Value of Out-of-Vehicle Time (Excess Time)

FIGURE 8 Trip cost comparison sensitivity analysis for various input parameter values.

- Congestion costs based on the high estimates,
- Automobile costs based on Hertz estimates,
- In-vehicle time equal to one-fourth the hourly wage rate, and
- Out-of-vehicle time 1.5 times in-vehicle time.

The results of the first extreme case show the previous-mode trip to be 7.2 percent less expensive than the park-and-ride trip (\$8.50 versus \$9.16). The results of the other extreme case, however, indicated the previous-mode trip to be 35.4 percent less expensive than the park-and-ride trip (\$12.33 versus \$9.17). These extremes encompass a broad

range of possibilities as far as the trip cost analysis is concerned and indicate that park-and-ride lots are highly likely to be cost-effective for the situation analyzed in the preceding cost analysis.

Measures of Effectiveness

In order to provide a more comprehensive analysis, it was desirable to evaluate several measures of effectiveness independently and as much as possible in terms of their own units rather than in dollars. This was done for the following measures: travel time, person miles traveled, vehicle miles traveled (VMT), traffic volumes, vehicle emissions, accidents, and energy consumption. Table 2 presents a general summary of the evaluation of these individual measures of effectiveness.

For the most part, park-and-ride lots have had a small yet positive impact with regard to individual measures of effectiveness. Although travel time and person miles traveled have increased slightly, the other measures--VMT, traffic volumes, accidents, vehicle emissions, and energy consumption--have experienced reductions. In other words, the negative impact of slightly longer trip lengths and travel times for the commuter is offset by the positive effects of a more efficient transportation system (fewer VMT), fewer vehicle accidents, better air quality, and more efficient use of energy.

CONCLUSIONS

The basic conclusion of this study is that park-and-ride lots in the Seattle metropolitan area, as a system, are cost-effective. The benefits they provide to the general community justify their expense. Park-and-ride lots provide considerable savings to the user with respect to automobile and parking expenses and they also prove beneficial to both WSDOT and METRO, the agencies directly involved. The user savings from the park-and-ride system have significantly outweighed WSDOT's investment. With respect to METRO, park-and-ride trips have proven less costly to provide than other transit trips, and, in addition, the lots have contributed to an increase in transit ridership.

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TABLE 2 Measure-of-Effectiveness Evaluation Summary

Measure of Effectiveness	Unit	Estimated Percent Change	
		Park-and-Ride Trip Versus Previous-Mode Trip	Park-and-Ride Lots Versus Total Regional Values
Travel time	Minutes/person trip	+13.3	—
Person miles traveled	Miles/person trip	+3.9	—
Accidents	Dollar equivalent/person trip	-35.5	—
Energy consumption	Gallon of gas/person trip	-21.3	—
VMT	Miles/day	—	-0.5 ^a
Traffic volumes	Vehicle trips/day	—	-1.3 ^b
Vehicle emissions	Grams/day	—	—
Carbon monoxide		—	-0.09 ^c
Hydrocarbons		—	-0.12 ^c
Nitrogen oxide		—	-0.16 ^c
Total suspended particles		—	+0.08 ^c

^aRepresents percent change with respect to total VMT on Interstate and principal arterials in King County.

^bIndicates percent change due to park-and-ride lots on the I-5 segment immediately north of downtown Seattle.

^cRepresents percent change with respect to total air pollutants in King County.

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Proposed Warrants for High-Occupancy-Vehicle Treatments in New York State

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ABSTRACT

At present the New York State Department of Transportation has informal guidelines for evaluating proposals for high-occupancy-vehicle (HOV) lanes. As attention to this particular treatment increases, it is important that many worthy projects be evaluated similarly. This report examines before-and-after conditions for approximately 25 HOV treatments nationwide and proposes warrants for the preliminary analysis of HOV projects. Particular attention is given to existing traffic volumes, person movement, and potential travel-time savings. These proposed warrants can help determine whether to advance a proposed HOV project beyond the general first-stage analysis to a detailed consideration of alternatives.

The New York State Department of Transportation (NYSDOT) is beginning to see proposals from upstate areas for high-occupancy-vehicle (HOV) lanes, and the emphasis on "rebuilding New York" will create opportunities for temporary HOV treatments, which may be advanced to permanent status once reconstruction has been completed. Because of the unique nature of HOV treatments, guidelines or warrants are needed

to help in making sound judgments concerning the relative merits of HOV proposals.

The literature generally advises against use of warrants for HOV projects (1,2). Reasons for this position include the unique nature of each project, difficulties caused by the involvement of several agencies with conflicting philosophies, the essentially political nature of any decision on HOV treatments, and the emphasis on creating new demand for high-occupancy vehicles as opposed to accommodating existing bus riders and carpoolers. FHWA recommends against uniform engineering-type warrants and suggests instead the identification of charac-