Table 7. Cost, applicability, and other benefits of improvements.

Improvement	Cost	Applicability	Other[a]
One-way street[b]			
New installation	High	Very limited	Very positive
Existing installation	Low	Limited	Positive
Coordinated signals[c]	Low	Limited	Neutral
Stop sign removal	Low	Moderate	Positive
School pedestrian crossing[d]	Very high	Limited	Very positive
Right-turn lane	Medium	Moderate	Positive
Two-way-left-turn lane[e]	Medium	Moderate	Very positive
Curb radius			
New installation	Low	Limited	Neutral
Reconstruction	Medium	Extensive	Positive
Flashing signal operation[f]	Low	Moderate	Uncertain
Speed limit[g]	Low	Moderate	Positive
Neighborhood diverter	Medium	Limited	Positive

[a]Other benefits include travel time savings, increased capacity, improved operation, and safety.
[b]Assume 3.2 km long, good signal coordination.
[c]For 0.8-km section, one-direction, with signing.
[d]Grade separation, crossings 3 h/day.
[e]One block long, replaces previous median barriers.
[f]Operation for 8 h/day versus isolated pretimed signal.
[g]Optimistic assumption of motorist compliance with 40-km/h limit.

The results presented in Tables 6 and 7 were used to develop a general hierarchy of low-cost traffic engineering improvements to promote fuel savings. The priorities, listed below and limited to the improvements studied in this project, must be considered general in nature. The ranking differs from one that would be established on the basis of other criteria, such as safety. As noted before, the application of a particular improvement at a specific location requires a study of sufficient detail at that location.

Priority	Improvement
High	Flashing signal operation
	Larger curb radii for new installation
	Progressive signal system signing
	Diversion to existing one-way streets
	Stop sign evaluations
	Lengthening existing curb radii
	Exclusive right-turn lanes
	Installation of two-way left-turn lane
	Installation of new one-way streets
	Change urban speed limits to optimal values
	Grade separations at school crossings
Low	Neighborhood traffic diverters.

Despite these limitations, the findings summarized above warrant some consideration in the development of a traffic engineering improvement program for energy conservation.

SUMMARY

This study has found that there are modest but discernible fuel benefits associated with traffic engineering improvements. The savings are small in comparison with other programs to cut fuel consumption such as improved vehicles, vanpools, and reduced travel. However, the traffic improvements are often low in cost and have the potential for providing benefits on a daily basis for an extended time period.

The study has a deficiency that is worth noting. The time and financial constraints on the project, coupled with the nature of traffic improvements made in Albuquerque during the study period, limited the types of improvements that were evaluated. There are clearly other TSM improvements that should be evaluated in a more comprehensive evaluation of this subject.

REFERENCES

1. Energy Effects, Efficiences, and Prospects for Various Modes of Transportation. National Cooperative Highway Research Program, Synthesis of Highway Practice No. 43, 1977, 57 pp.
2. W.E. Fraize and others. Energy and Environmental Aspects of U.S. Transportation. MITRE Corp., McLean, VA, Rept. No. MTP-391, 1974.
3. A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements. American Association of State Highway and Transportation Officials, Washington, DC, 1977.
4. Handbook. Society of Automotive Engineers, Warrendale, PA, 1976.
5. Energy: Conservation in Transportation and Construction. Conference Rept., Federal Highway Administration, Dec. 1975.
6. R. Winfrey. Economic Analysis for Highways. International Textbook Co., Scranton, PA, 1969.
7. P.D. Christopherson and G.G. Olafson. Effects of Urban Traffic Control Strategies on Fuel Consumption. ITE Annual Meeting, Aug. 1978.
8. L. Evans and R. Herman. A Simplified Approach to Calculations of Fuel Consumption in Urban Traffic Systems. Traffic Engineering and Control, Aug.-Sept. 1976.
9. M. Chang and others. Gasoline Consumption in Urban Traffic. TRB, Transportation Research Record 599, 1976, pp. 25-30.
10. J.W. Hall. Traffic Engineering Improvement Priorities for Energy Conservation. New Mexico Energy and Minerals Department, Santa Fe, Final Rept. EMD-78-1128, April 1979.

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Assessment of Neighborhood Parking Permit Programs as Traffic Restraint Measures

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Residential parking permit programs have become an important component of traffic restraint schemes designed to improve the social and environmental characteristics of neighborhood areas. By restricting nonresident and commercial vehicle parking, such programs are effective in controlling the use of the

neighborhood street network; however, these programs could also have many other effects that were never anticipated. This paper assesses the impact of neighborhood parking permit programs on economic, system efficiency, mobility, equity, environmental, and amenity objectives. Experiences with recently implemented permit programs are used to illustrate these impacts. A conceptual perspective on how such programs fit into a regional transportation system is also provided. This paper concludes that residential parking permit programs are generally beneficial to the neighborhoods in which they are implemented and have no discernible impact at the regional level, if their implementation considers that the result might be a simple redistribution of unwanted traffic rather than its absolute reduction. Finally, long-term evaluations of permit programs is recommended to discern those impacts that can only be identified over longer periods of time.

When the Federal Highway Administration (FHWA) and the Urban Mass Transportation Administration (UMTA) issued joint planning regulations on transportation system management (TSM) in 1975, a major step was taken to encourage, on a more formal basis, many new types of transportation actions and programs (1). Initial descriptions of the TSM program emphasized its orientation toward efficiency: The aim was to expand service without the use of significant levels of resources. However, another set of objectives related to amenity considerations soon became important to many program constituents. This amenity orientation was expressed in one form as a desire to reduce (2) "the impacts on neighborhoods from traffic dangers and pollution, and to encourage designed environments requiring restraint of traffic."

The purpose of this paper is to examine one type of TSM action, neighborhood parking permit strategies, that has objectives that fit more closely within this latter category. Such strategies are designed to improve the social and environmental characteristics of neighborhood areas by restricting nonresident and commercial vehicle parking, by providing adequate parking for residents, and by discouraging high volumes and high speeds. Until recently, however, the development of a coordinated approach to parking management has been either nonexistent or has focused solely on the objective of congestion relief, not yet totally accepted in principle by agencies that are traditionally associated with provision, management, and regulation of parking supply. What has been lacking is the perspective that parking strategies, no matter at what geographic level they are implemented, have the potential of affecting more than one urban objective (3). To illustrate this relation, the impacts of neighborhood parking management strategies are examined from a multiobjective perspective.

RECENT EXPERIENCE WITH NEIGHBORHOOD PARKING STRATEGIES

Urban transportation planning in the United States has traditionally focused on such relatively large-scale concerns as accessibility, trip generation, network configuration, and changing land use patterns. Only recently has there been any effort to examine in a systematic fashion the social, economic, and environmental impact of vehicular traffic at the local or neighborhood level (4). One of the first major policy statements concerning transportation impacts at this level is found in Buchanan's Traffic in Towns, an English report published in 1963 that advocated the creation of environmental areas in cities (5). In fact, this report went so far as to propose environmental standards that relate to levels of safety, air pollution, noise, visual effect, and pedestrian conditions.

As illustrated by the Buchanan report, European cities experimented with traffic restraint strategies long before North American planners even considered such strategies to be feasible transportation actions or demand restraint to be a relevant objective. A recent study on TSM in Europe made the same conclusion about parking policies and further stated that strategies to manage the parking supply were often adopted in European cities in lieu of more dramatic demand-restraint approaches because (6) "(i) where charges are involved, they are net earners of income for the administering locality, (ii) they are easy to implement, (iii) they are effective in holding down excessive car use in the controlled zone, and (iv) they are usually more politically expedient than more radical restraint measures."

A leading example of neighborhood parking policies and how they relate to a traffic-restraint program is found in London. The London parking policy consists of several measures aimed almost exclusively at influencing the supply of parking. The most important measures include the following (7,8):

1. Controlled parking zones (CPZs) for on-street parking,
2. Controls on the building of new public parking facilities,
3. Controls on the operation of existing temporary and permanent public parking facilities, and
4. Controls on the building of new private parking facilities.

In 1966, the Greater London Council (the transportation planning and policy agency for the metropolitan area) designated a 100-km² area of London as an inner London parking area, where on-street parking was to be stringently regulated through the use of CPZs. Parking meters were used to limit the duration of the use of parking space, and special areas were set aside for residents who had purchased and displayed a permit. Parking surveys of two CPZs in 1966 and 1969 showed that in the three-year period the number of on-street parked vehicles fell by two-thirds, and long-term parking was reduced by 80 percent and short-term parking was reduced by 44 percent. At the same time, however, London's on-street parking controls have not resulted in a reduction in street traffic comparable to the on-street parking reduction, because (9):

1. Many of the displaced on-street parkers merely switched to off-street parking facilities; in some cases (for all-day parkers) the incremental cost has been subsidized by employers;
2. Although the number of on-street spaces has declined dramatically, the numbers of public for-hire off-street spaces and, in particular, the number of private nonresidential spaces, appears to have increased, possibly in part due to the pressures created by on-street demand restraint; and
3. Through traffic has grown sharply, to replace vehicles that have downtown destinations now discouraged from parking.

In North America, a concern for neighborhood transportation problems and the subsequent planning of comprehensive neighborhood-level transportation programs did not begin until the early 1970s. For example, transportation planners in Ottawa, Ontario, initiated a series of neighborhood traffic studies in 1973 that have resulted in several changes in the provision of transportation services (10). In two of these studies, residents were only slightly concerned with parking issues; the most important issue was the provision of off-street parking to meet the demand of those who lived, worked, and shopped in the study area (11,12). In another study, however, parking problems were of consider-

ably more concern among neighborhood residents and stimulated lengthy discussion on a number of alternative solution strategies (13):

1. Residential zoning that permitted parking for commercial uses,
2. Permit parking in commercial and mixed land use zones,
3. Metered parking along a busy residential-commercial street to increase space turnover,
4. New off-street parking areas, and
5. Strong enforcement of parking restrictions.

In the United States, comprehensive neighborhood transportation strategies were little known outside of a few cities (Berkeley, Seattle, and Madison) until the mid-1970s. The most common strategy consisted of traffic restraint schemes that employed a combination of such measures as diverters, barriers, street closures, and one-way street configurations (14). Only in recent years have parking controls become a major element of these neighborhood schemes, due to the increased concern with parking problems expressed by local residents.

The parking problem in residential neighborhoods is based on three principal issues (15):

1. Retention or restoration of on-street parking as a means of restricting the volume and speed of travel,
2. Provision of adequate and convenient parking for residents, and
3. Restriction of nonresident and commercial vehicle parking to preserve the residential character of the neighborhood.

A recent survey of 20 U.S. communities showed that the most widespread form of on-street parking strategy applied to address these issues was the residential parking permit program (RPPP) (16). The characteristics of an RPPP usually reflect perceived specific needs of the community in which it is applied. The primary characteristic that denotes RPPPs is the assignment of parking privileges within a neighborhood area, usually through some sort of permit or sticker displayed directly on the vehicle windshield or bumper. In Cambridge, Massachusetts, for example, the principal elements of the current program include the following (17):

1. Any Cambridge resident who has a valid Massachusetts registration is allowed a citywide resident parking sticker;
2. Visitors receive passes, valid for only 1 of the 13 designated neighborhoods in the city;
3. Resident parking areas include all city streets except for areas in front of commercial establishments; and
4. All permits are reissued January 1 of each year to control the use of permits by previous residents.

In San Francisco, RPPPs have been established around some Bay Area Rapid Transit (BART) stations as well as in the more densely populated downtown area. In Washington, D.C., the RPPP has been extended to 24 areas of the city to protect local residential parking space from automobile commuters attracted by universities, hospitals, transit garages, transit transfer points, and proximity to the central business district (CBD).

As can be seen from the above discussion, the RPPP concept has been used mainly to protect local residents from the encroachment of nonresident automobiles. One suspects, however, that not only do RPPPs affect the level of congestion on residential streets and provide a higher quality residential character, but they can also affect measures of accessibility, fuel consumption, air pollutant emissions, and economic development both in the neighborhood and at a much larger, regional scale (18). This comprehensive assessment of RPPPs has been lacking in the transportation literature to date.

URBAN GOALS AND RPPPS

A recent effort to place parking management within the broader context of management tools for the supply of urban transportation defined a slate of general urban goals and traced the traditional relation of each of these goals to urban transportation, in general, and parking availability and control, in particular (19). As shown in the list of urban goals related to parking strategy applications, these goal categories tend to embrace most, if not all, of the specific objectives proposed by municipalities as reason for embarking on particular transportation policies. As such, they provide a useful means of gauging the potential range of impacts of RPPPs (19):

1. Healthy economic climate, and a business community able to support local employment needs, which means the ability to attract and keep desired kinds of development and industry, a healthy retail sales climate, and a stable or growing municipal revenue base;
2. Most efficient use of existing transportation, land, and other public resources;
3. Ease of mobility and accessibility of resources for vehicles and pedestrians;
4. Equity of resource distribution and preferential allocation of some resources;
5. Environmental goals, especially reduced air pollution and the related goal of minimized energy consumption; and
6. Enhanced amenity and cultural attractiveness, preservation of a city's unique character.

Healthy Economic Climate and a Business Community Able to Support Local Employment Needs

One of the most important concerns to city officials in the consideration of parking management schemes is the possible impact on the economic climate of the area. Some preferential access strategies have the potential to alter the kinds of new development proposed for the area of control, which results in an increase in activities that serve the favored groups and a decline in other kinds of development. When favored groups are explicitly identified and provided for, the result may be an increasing homogeneity of the area, and a consequent increase in demand for parking, even among those who meet the requirement for preferential treatment.

Major office or business development is not likely to be discouraged by programs designed to give special access rights to local residents as long as (a) their own short-term customer or client parking needs are adequately provided for, (b) street access for service and delivery vehicles is not restricted, and (c) some form of alternative access (or preferential parking for carpooling commuters) exists to allow employees to get to work. In the long term, the existence of parking controls may alter land values faced by potential builders to reflect the increased desirability of locations served by reasonable transit service or within easy reach of unrestricted parking. For this reason, the extent of the area across which parking controls apply (and the perceived permanence of such

controls) may be important in the locational decisions made by developers.

In addition to development-related issues, local officials are likely to be concerned about the impact of parking-restraint measures on a continuing high level of retail activity. The relation between the availability of parking and retail success has not as yet been defined adequately, although important attempts were made to formulate such a relation during the 1960s (20). However, customer parking is still regarded as an absolute necessity by most retailers. In most cases, RPPPs have been implemented to give special consideration to customers of local businesses (e.g., permitted 2-h parking in areas otherwise restricted to residents). Consequently, there is very little evidence to suggest that RPPPs have a detrimental impact on retail activity. A survey of business leaders in Alexandria, Virginia, for example, found that most business people did not perceive the RPPP as an inconvenience but reported the sentiment that more off-street parking facilities should be built (21). This suggests that, to some degree, RPPPs may crystallize merchant demands for increased public parking designed exclusively to serve retailer needs. In other cases, where the primary target group of parking controls was clearly seen to be all-day commuter parkers, the congestion-relief characteristic of strategies such as RPPPs are reported to have resulted in the attraction of more business activities to the area (22). In Washington, D.C., recent meetings between representatives of businesses located near the capitol and local transportation officials have shown near unanimous support from the business community for the local RPPP (16). The business representatives, especially those from small establishments, claim that the parking restrictions have resulted in larger numbers of customers and a healthier business climate.

In sum, where RPPPs have been implemented with special considerations given to the requirements of business establishments, there is little empirical evidence to suggest that such programs have had negative effects on development and retail concerns thus far. Of course, these sorts of impacts tend to require long gestation periods before they become manifest, so that definitive conclusions regarding a strategy that has only become popular in this country in the last 5-10 years cannot yet be reached. It seems likely, however, that as long as sufficient provision is made for customer access, such impacts will be small. Indeed, the reaction of many business people in RPPP areas seems to indicate that such parking restrictions increase business activity by providing potential customers with an increased probability of finding a parking space.

Most Efficient Use of Existing Transportation, Land, and Other Public Resources

This goal can be restated in terms of deriving the maximum level of productivity from resources, where productivity is defined according to the functions that the resource is expected to serve. The imposition of specific parking management techniques is likely to be most directly relevant to efficient or optimal use of existing transportation and land resources. With respect to a limited number of parking spaces to serve a particular area, efficient allocation of parking resources may be interpreted as the reserving of sufficient quantities of parking for users who have no reasonable alternatives, and discouraging the use of the limited parking supply by patrons who could reasonably use other modes, transit in particular. By thus reserving space for residents, RPPPs serve to enhance the accessory value of parking that is not in itself designed to be profit-making but which provides access to particular adjacent land uses.

Limited findings have been reported concerning the impact of residential parking programs on the use of street space and on changes in travel behavior adopted by restricted parkers. In Alexandria, Virginia, 12 percent of a commuter sample indicated that they had changed travel mode (to bus and carpool) as a result of the RPPP restriction. Close to 30 percent of the respondents had shifted to off-street parking facilities. In Baltimore, a previously underused parking garage in the RPPP area has become a more desirable parking location for displaced commuters. In San Francisco and Washington, D.C., parking programs resulted in dramatic decreases in on-street commuter parking (16).

Thus, to the extent that residential permit programs encourage greater use of existing off-street parking facilities or the diversion to transit of trips that can readily be served by existing services, they can be said to contribute, to some degree, to more efficient use of existing resources. This is so if, in fact, existing transit is capable of handling the diverted demand, and if control can then be maintained over the size, operation, and location of any new additions to the parking stock designed to accommodate overflow from existing facilities.

Ease of Mobility and Accessibility of Resources

In urban areas, vehicles and pedestrians compete for limited space; each in a sense impedes the other's mobility. To the extent that parking policies have been used in the past to achieve ease of mobility, a primarily vehicle-based mobility has been encouraged. The primary motivation of agencies charged with the management of street traffic has generally been the reduction of vehicle congestion and the facilitation of traffic movement on city streets. However, parking policy may be related to pedestrian mobility in two ways. First, in that pedestrian safety and directness of access are enhanced when traffic volumes are reduced or removed altogether from certain rights-of-way. A parking policy that discourages vehicular traffic from certain areas may work toward these ends. Second, a relation may be established between the amount and distribution of parking and the activity densities and lengths of walking trip of parkers and nonparkers in urban areas.

RPPPs act both to decrease mobility by adding to the perceived cost of parking for commuters and to increase ease of mobility for residents by reducing traffic levels on residential streets and by providing easier means of parking. In particular, such programs may have the following consequences.

They raise the perceived cost of parking, measured in both dollar cost and time spent searching or walking, for some or all parkers. In effect, RPPPs decrease their mobility and trip-making ease. Some parkers may be unaffected or aided by particular strategies: Employees of firms that control their own parking, for example, will benefit from the increased value of their reserved spaces. Most nonresident parkers will be mobility-disadvantaged by strategies that make parking more difficult or more expensive.

Residential parking strategies may serve to reduce traffic on residential streets and thus allow enhanced movement by remaining vehicles and pedestrians. However, this effect will result only if (a) additional through traffic is not generated to replace diverted terminating traffic, and (b) the area across which parking is limited is wide enough

so that traffic diversion to the area's periphery in search of replacement parking is minimized.

If parkers displaced by these strategies are largely commuters, they will be likely to seek alternative methods of making the same trips. In addition, it may be relatively easy to offer reasonable travel alternatives to such trip makers. If, instead, displaced parkers tend to be short-term visitors or shoppers, they are likely to seek alternative destinations or to eliminate the trip altogether. The latter eventually may be regarded as a more severe mobility loss, in terms of both individual and community impacts.

As a neighborhood traffic restraint method, RPPPs are designed to serve the first purpose mentioned above (i.e., decrease the utility of parking in the residential area for nonresidents). The evidence to date indicates that the parking programs are most successful in doing this. A sample study of two neighborhoods in Cambridge, Massachusetts, showed that, one year after RPPP implementation, the number of cars parked on the street decreased by 31 percent. In San Francisco, a before-and-after study of one RPPP area indicated that the parking program had significantly reduced nonresident parking. In Washington, D.C., the decrease in the number of nonresident vehicles parked in two residential areas was 62 percent and 42 percent, respectively (23).

Equity of Resource Distribution and Preferential Allocation of Some Resources

The difficulty of establishing transportation policy intended to achieve some measure of equity in the distribution of scarce resources lies in determining what is equitable, given a host of varying affected constituencies. Equity implies fairness, which can be translated into a number of principles, not all of them consistent with one another.

Equity Implies Providing Just Compensation for Injuries Sustained or Hardship Borne

Thus, for example, residents of a town that is transversed by a new freeway should, in principle, receive some priority in terms of access to that facility, prices charged for tolls, and parking compared with residents of other unaffected towns. However, this principle does not hold to the extent that access to a regional facility should be prohibited de facto by parking restrictions or other means to persons not residents of the town in which the facility is located.

Equity Involves Nondiscrimination in the Provision of Services

If it can be demonstrated that public transportation resources are allocated in a manner that grossly favors certain neighborhoods, social classes, or sets of interests over others, a legitimate equity case can be made. This is not to say, however, that it is necessary to provide equivalent levels of service in all parts of an area for the sake of equity. Such an approach would itself represent a misallocation of resources.

Equity Requires a Fair Distribution of the Costs of Resources Consumed

This is an argument frequently advanced by proponents of congestion pricing: Such pricing represents a mechanism by which users of public resources can be charged directly for the indirect societal costs they generate. This principle is applied to some extent in differential transit fare structures that charge more for travel in peak periods than in the off-peak. However, other direct applications of congestion-pricing, including price structures for parking that follow this same model, have been rare in this country, although they have been adopted elsewhere, most notably in Singapore.

Equity issues arise with RPPPs in that they involve the establishment of hierarchies of preferred users, such as shoppers over commuters, or carpoolers over lone drivers, or residents over nonresidents, in areas where demand for parking greatly exceeds supply. Some applications are intended to reserve certain scarce privileges or resources for residents, explicitly excluding outsiders. No behavioral change is desired of outsiders, other than keeping away from the prized resource, but the privilege in question is not denied to members of the insider group who derive all the benefit from such actions. Usually, a valid case can be made for at least partial restrictions of the parking rights of outsiders on equity grounds, when such neighborhoods are genuinely threatened. In other areas, however, local autonomy over the creation of such programs may create the equivalent of snob zoning, especially when there is a valid reason for making some local parking available for outsiders (e.g., shoppers in neighborhoods that border downtowns or commuters at a park-and-ride transit or carpool facility).

Several court cases have upheld the legality of the residential parking programs and have dismissed charges that such programs are inequitable to nonresidents (24). The court concluded in a case that challenged the Arlington ordinance that local objectives of reducing air pollution and other adverse environmental effects are legitimate goals and that a "community reasonably may restrict on-street parking available to commuters, thus encouraging reliance on carpools and mass transit." In 1975, a nonresident of Cambridge, Massachusetts, brought suit against the city, arguing that the parking regulation discriminated against him in violation of his right to equal protection of the laws. The court disagreed and upheld the legality of the permit program.

Thus, residential parking programs have different levels of impact on various groups. The groups affected by RPPPs are listed below.

1. Neighborhood--residents, store owners, students, parking lot owners, and schools and churches;
2. Community, private sector--developers, employers, business people, and parking lot owners;
3. Community, public sector--police; hospitals, schools, and other attractors of high traffic; traffic engineering department; chamber of commerce; parking authority; and planning department;
4. Regional, private sector--commuters and developers' organizations; and
5. Regional, public sector--transit provider, metropolitan planning organization, air quality agency, and cities and towns that adjoin RPPPs.

The most affected group is the commuters who previously used the parking space. However, this incidence of impacts has been found acceptable by several courts throughout the country. Nevertheless, such programs should be viewed with a broad perspective on their ultimate consequences. In those cases, for example, where designated commuter parking that serves regional facilities is restricted out of concern for local amenity and yet alternative means of access to the station are likewise unacceptable to local constituencies, the access rights of legitimate customers of such

facilities are very likely being abrogated. At present, no right-of-review authority exists to overrule excessively exclusionary local demands.

Environmental Goals, Especially Reduced Air Pollution and Related Goal of Minimized Energy Consumption

The idea of reducing air pollution levels through the application of parking constraints was one of the major thrusts of the U.S. Environmental Protection Agency's (EPA) transportation control plan regulations as applied to certain urban areas. That this idea failed in most applications was due largely to the political opposition generated by these constraints, which rendered them unenforceable and therefore ineffectual. Several residential parking programs, however, have been successfully advocated as means of reducing the levels of air and noise pollution. As mentioned before, the Arlington, Virginia, RPPP had been justified on the grounds of protecting the residential areas from polluted air and excessive noise. The evaluation of the London parking program concluded that it was not possible to identify any environmental effects of parking controls, although there had been a significant improvement in the street scene as a result of the reduction in on-street parking.

An environmental assessment of RPPPs must occur at two levels, the impact in the residential restricted area and the spin-off effect of displaced automobiles on the surrounding areas of the region. In both cases, the environmental impact depends to a great extent on what happens to those drivers who previously parked in the restricted area.

Within the residential area, the impact on air quality and noise levels should be favorable if large numbers of automobiles are deterred from entering the area. This seems to have been the result in San Francisco and Washington, D.C. However, as found in Arlington and to some extent in Baltimore, many of the automobiles displaced by the RPPP were diverted to nearby off-street facilities, so that areawide traffic and air pollution levels were not really reduced; they may have even been aggravated. If, in the longer term, the on-street restrictions created pressure to increase the number of off-street parking facilities in order to satisfy this new demand, the overall air quality situation could become worse than in the no-restriction case.

In addition, restricted entry for commuter parkers (who make only one trip per day per space into and out of a neighborhood) may create additional space for retail customers or people on personal business. This may mean that a single on-street space will now serve three, four, or more trips per day--an outcome regarded as beneficial by local businesses but certainly more detrimental environmentally than if primarily commuter parking is served.

From the viewpoint of regional environmental quality, another important consideration may be the displacement of previous automobile parkers to parking sites outside the zone of restriction. If a large percentage of these drivers switch to other, more efficient modes of transportation, such as carpooling or transit, then a net environmental benefit to the region would be expected. If, on the other hand, a large percentage of these drivers simply switch parking locations to areas that border the restricted zone, thereby creating congestion in these areas and increasing the amount of driver time and vehicle miles of travel spent searching for parking space, then the impact on air quality and other neighborhood environmental characteristics in the nonrestricted zone would be negative.

There are few data to support either one of these possible outcomes. However, a study for the Washington Metropolitan Council of Governments indicated that a nonresident restriction would reduce emissions by about 1 percent. This reduction corresponds to an estimated 1 percent reduction of automobile trips (12 100 trips) daily and a corresponding 1 percent increase (3900 trips) in transit trips (25).

In Cambridge, Massachusetts, a preliminary evaluation of the citywide RPPP has shown that, since the program was implemented, there has been an 18 percent decrease in the amount of traffic that enters the city on an average day. However, local officials are uncertain about how much of this decrease can be attributed to the RPPP. Both of these examples indicate that the RPPP by itself will most likely not provide significant regional improvements in air quality. However, if combined with other tactics, it could be one of the most influential components of an air quality-transportation strategy.

Enhanced Amenity and Cultural Attractiveness: Preservation of an Area's Unique Character

The influence that transportation exerts on land use can be directed toward ends that are not explicitly economic in nature, but which are more closely related to urban design and amenity objectives. Residential parking programs are perceived by many affected residents as a way of maintaining neighborhood character by limiting the intrusion of nonresidents. Polls taken of residents in restricted areas show that they overwhelmingly support the implemented programs. In San Francisco, for example, 74 percent of those who responded to a questionnaire favored the continuance of that city's permit program because they perceived that it was successfully maintaining the fabric of the neighborhood.

The specific manner in which residential parking management strategies can be applied to achieve the amenity and attractiveness goal does not lend itself to generalization as readily as do methods of structuring parking controls to achieve other ends. Moreover, parking management strategies alone will not serve as a motivational force to stimulate major changes in how urban space is used. Such changes must be motivated by social and economic forces that can be taken advantage of, rather than controlled by, parking policy.

SUMMARY AND CONCLUSIONS

Although neighborhood parking programs have been in existence in some cities for several years, few attempts have been made to analyze their impact. This is not surprising. The evaluation of such programs would be a complicated undertaking because establishment of the cause-effect relation between RPPP implementation in a complex urban environment and ensuring marginal changes in observed travel behavior is likely to be very difficult. Further, many of the impact measures that would be essential in a comprehensive analysis (e.g., impact on retail sales or development location decisions) do not evidence change immediately but require several years before the effect is noticeable. However, the data that are available and the experiences of those RPPPs already implemented provide some indication of how such a program will impact a community. A summary of these impacts is shown in Table 1.

Thus, rather than conclusions per se, this paper lends itself more appropriately to a set of summary observations regarding the interrelation of residential neighborhood parking controls and broader goals of the neighborhood itself and the urban area as a whole.

Table 1. Impact assessment of RPPPs.

RPPP	Neighborhood Impact	Regional Impact	Evidence
Healthy economic climate	+	0	Members of the local business community support of RPPPs in Washington, D.C., and Cambridge due to higher parking space turnover rate
Efficient use of public resources	+	0	Increased use of off-street parking spaces in Baltimore, Alexandria, and London
Ease of mobility	++	-	31 percent decrease in cars parked in two Cambridge neighborhoods; 62 and 42 percent decrease in nonresident parked vehicles in two Washington, D.C., neighborhoods
Equity of resource distribution	+	0	Arlington, Cambridge, and Washington, D.C., court cases
Environmental goals	+	?	Depends on behavior of displaced automobiles; preliminary finding of 18 percent decrease in automobiles entering Cambridge since RPPP implementation
Neighborhood amenities	++	0	Response of officials and residents in those communities that have RPPPs

Notes: ++ = significant positive impact, + = slight positive impact, 0 = no discernible impact, - = slight negative impact, and ? = unknown.

The efficacy of particular types of controls with respect to certain goals depends, to a large degree, on what types of parking consumers are disfavored by such controls and what alternative access modes are available or acceptable to them. Parking controls that are limited in scope may achieve only the redistribution of unwanted traffic rather than its absolute reduction. This may be regarded as acceptable or unacceptable, depending on the goals of the implementing jurisdiction, but it must be recognized that such redistribution is likely to create new problems in adjacent zones.

Reports on the limited experience thus far with RPPPs suggest that such programs probably do not create development obstacles or difficulties for existing local business establishments if designed with these considerations in mind. Also, existing programs are generally reported to have modest beneficial impacts with respect to environmental indicators and in terms of increasing use of alternative transportation facilities. These are not general or definitive conclusions, however. The direction of the effect of an RPPP on many of these objectives depends very much on the specific situation in which it is applied, and on the degree to which individual programs are tailored to fit specific needs.

With respect to other, less tangible, objectives, a set of criteria is needed for evaluating impacts of RPPPs. Also, since many of these effects tend to require a long time to develop, continued observation of and reporting on programs now firmly established for several years are called for.

As a traffic restraint measure (that is, as a method of discouraging or rerouting traffic away from specified neighborhood areas), the RPPP is a particularly effective strategy. However, such programs will also most likely affect other important aspects of neighborhood and regional life. Because of this, a closer look at existing RPPPs and, most importantly, extensive evaluation studies of future neighborhood parking programs as they are implemented are needed.

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REFERENCES

1. Federal Highway Administration and Urban Mass Transportation Administration. Transportation Improvement Program. Federal Register, Vol. 40, No. 181, Sept. 17, 1975.
2. R. Gakenheimer and M. Meyer. Urban Transportation Planning In Transition: The Sources and Prospects of TSM. Journal of the American Planning Association, Jan. 1979.
3. M. McShane and M. Meyer. Links Between Parking Policy and Urban Goals: Key Issues. Center for Transportation Studies, Massachusetts Institute of Technology, Cambridge, Sept. 1979.
4. D. Appleyard and others. Liveable Urban Streets: Managing Auto Traffic in Neighborhoods. Federal Highway Administration, Jan. 1976.
5. C. Buchanan. Traffic in Towns. Her Majesty's Stationery Office, London, 1963.
6. F. Britton. Transportation Systems Management in Europe--The Research Results. U.S. Department of Transportation, Rept. I-FN-06-0004, Sept. 15, 1978.
7. Bayliss and others. Traffic Policies for the Improvement of the Urban Environment: Case Study on London. Organization For Economic Cooperation and Development, Paris, Dec. 1, 1976.
8. F. Britton and C.E. Feibel. Transportation Systems Management in London: A Case Study. U.S. Department of Transportation, May 1978.
9. A.D. May. Parking Control: Experience and Problems in London. Traffic Engineering and Control, Vol. 16, No. 5, May 1975.
10. J.A. Bonsall and others. Traffic Policies for the Improvement of the Urban Environment: Case Study On Ottawa-Carleton. Organization For Economic Cooperation and Development, Paris, May 1977.
11. Churchill-Richmond Road Area Traffic Study. Transportation Department, Regional Municipality of Ottawa-Carleton, Ottawa, Canada, Dec. 1976.
12. Lowertown West Area Transportation Study. Transportation Department, Regional Municipality of Ottawa-Carleton, Ottawa, Canada, Dec. 1976.
13. Dalhousie Area Transportation Study. Transportation Department Regional Municipality of Ottawa-Carleton, Ottawa, Canada, Aug. 1975.
14. Public Technology, Inc. Neighborhood Traffic Controls. Washington, D.C., 1977.
15. Public Technology, Inc. Parking Management. Washington, DC, 1978.
16. J. DiRenzo and others. Study of Parking Management Tactics, Volume 1: Overview. Federal Highway Administration, Rept. FHWA-PL-79-020, Dec. 1979.
17. M.D. Meyer and J. Sheldon-Dean. The Role of Enforcement Agencies in Transportation Planning: The Boston Case. Center for Transportation Studies, Massachusetts Institute of Technology, Cambridge, June 1980.
18. R.S. Beebe. Parking and the CBD in the Future. Parking, Oct. 1979.
19. M. McShane and M.D. Meyer. Applicability of Types of Parking Management Techniques to Urban Goals. Center for Transportation Studies, Massachusetts Institute of Technology, Cambridge, Nov. 1979.

20. Parking As A Factor In Business. HRB, Special Rept. 11, 1953.
21. M.L. Olsson and G.K. Miller. The Impact on Commuters of a Residential Parking Permit Program. Urban Institute, Washington, DC, Dec. 1979.
22. V.R. Vuchic and M. Suleiman Hessami. Parking Policy as a Transportation System Management Measure. Univ. of Pennsylvania, Philadelphia, Final Rept., Aug. 1978.
23. B.S. Moulton. Analysis of Residential Permit Parking in Washington, DC. Catholic Univ., M.S. thesis, Nov. 13, 1978.
24. H. Simkowitz and others. Parking Permit Programs to Restrain the Automobile in Residential Neighborhoods. Proc., Transportation Research Forum, 1979.
25. R.H. Pratt and Associates, Inc. Transportation Controls for Air Quality Improvement in the National Capitol Region. Metropolitan Washington Council of Governments, Washington, DC, Oct. 1976.

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South African Parking Standards

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Certain minimum desirable parking standards were developed in the Urban Transport Branch of the South African Department of Transport during 1979-1980. This was done to provide guidance and requirements for uniform parking standards. This paper conveys these standards and some of the background to the development of the standards. The subject is dealt with in two parts: standards for parking dimension and requirements for parking provision. In the first section, the establishment of a South African design vehicle is discussed—motor cars in South Africa are generally smaller than those in the United States and slightly larger than the European cars. From the design vehicle, at present proposed to be 4.8 m in length and 1.8-m wide, the dimensions of parking bays and aisle widths are derived and certain standards proposed. For 90° parking a basic standard module width is 17.5-m wide aisles. Dimensions for angle parking and for on-street parking are also proposed as well as dimensions for certain parking garages. In the second section, the background to the development of requirements for provision of off-street parking is discussed. A questionnaire on current parking provision requirements was sent to all local authorities in the five declared metropolitan areas in South Africa. The results of this survey were compared with findings of parking demand surveys and South African and overseas proposed standards. A summary of the recommended minimum desirable standards for parking provision is then given.

Parking is a very important and integral part of the total transportation system in any metropolitan area. Because of the ever-increasing cost of land and construction of parking facilities and also because of the influence of on-street and off-street parking on traffic flow, it is necessary for all authorities to ensure compliance with adequate, realistic, and effective parking requirements and standards. The Urban Transport Branch of the Department of Transport therefore compiled a report on parking standards (1), of which this paper is a summary. The object of the report was to propose (a) standards for parking dimension and (b) requirements for parking provision to provide national guidance and requirements for uniform parking standards and also to assist the National Transport Commission in evaluating requests for subsidies for parking facilities.

The National Transport Commission accepted, in principle, the parking-dimension standards and parking-provision requirements, as laid down in the report, as the minimum desirable standards for the urban areas of South Africa. The commission further agreed that the report be distributed to all local authorities in the declared metropolitan transport areas, that it should be recommended to the core cities for possible acceptance and application in their respective transport plans, and that all local authorities should consider inclusion of the parking provision requirements in their town planning schemes, with the understanding that deviations would be possible if adequate motivation proves it necessary.

The purpose of the report was to cover only those aspects of parking that may differ from available overseas standards and requirements. The use of other literature on parking in conjunction with this report is thus recommended [e.g., (2)].

STANDARDS FOR PARKING DIMENSIONS

South African Design Vehicle

Minimum standards and desirable standards for dimensions of parking bays can be laid down. For the purpose of this report, we decided to propose only one desirable standard that will be applicable to most circumstances. Good judgment is necessary, however, in the application of these standards, and certain deviations may be necessary. These standards apply only to ordinary private vehicles such as motor cars, minibuses, and light delivery vehicles but not to trucks and buses. South African motor cars are generally smaller than those in the United States and probably slightly larger than European cars; therefore, it was necessary to develop a South African design vehicle from which dimensions of parking bays can be derived.

A number of people, including the city engineer's department of Durban (3), Olivier (4), Uys and Van der Merwe (5), and the Division of Highway Traffic Engineering of the South African Institute of Civil Engineers (6), did some work on the dimensions of a South African design vehicle. Most of the above-mentioned studies based the design vehicle on the 95 percentile value of the different dimensions. This represents a conservative working value that covers the overall majority of vehicles. Cumulative frequency diagrams were plotted for such factors as the length, width, turning circle, and height of vehicles from which the 95 percentile values can easily be determined.

Uys and Van der Merwe (5) found a definite trend toward smaller cars in South Africa. Volkswagen South Africa (7) confirmed this after studying the change in buying habits of the South African motoring public. They found an increase of 15 percent in