Activity Centers

Activity Centers

Introduction

In considering and implementing "programs and ordinances to facilitate nonautomobile travel, ... utilization of mass transit" and reducing "the need for single-occupant vehicle travel, as part of transportation planning and development efforts of a locality, including programs and ordinances applicable to ... centers of vehicle activity," citizens, elected officials and their staff are giving renewed attention to the relationships among site-specific design considerations, transportation services, and local and regional traffic and air quality conditions. This chapter focuses on the effects of site-specific urban design measures, including density, scale, location and mix of activities, on travel behavior and thus on air quality. Growing interest in this subject is the result of a recognition that an emphasis on the augmentation of transportation infrastructure (supply) and management of transportation demand together may be insufficient to encompass the range of policy options required in order to modify travel behavior and reduce mobile source emissions.

The relationship between land use activities and travel traditionally has been based on the Trip Generation Manual, published by the Institute of Transportation Engineers, now in its fifth edition (9). The manual has been expanded steadily in its more recent editions to encompass an ever wider set of activities, as well as a growing body of data on travel characteristics. At the same time it is recognized that the types of land uses identified in the ITE Manual vary substantially in their urban design characteristics. These variations account for the disparity in observed travel behavior exhibited in the data found in that source.

Table 1 identifies characteristics of activity centers or other concentrations of development which have been shown to affect travel behavior, and thus vehicular emissions. These characteristics can be divided into those affecting the micro-level environment (such as the specific location of activities and the characteristics of amenities available to pedestrians) and those which affect the macro-level environment in which the activity or activities are located (such as the characteristics of land uses abutting the activity center or the overall size of the center itself).

The characteristics identified in Table 1 result from urban design and land use standards (either mandatory or negotiated), that can be established by units of government. While the private sector is excellent at adopting innovations in design which will enhance the value or the marketability of the products they produce, the urban design measures required to bring about reduced vehicular emissions are not typically in great demand by either developers or consumers, who may not readily appreciate the enhanced convenience and personal freedoms associated with having alternatives to single occupant vehicles.

Table 1. Activity Center Characteristics Which Affect Travel Behavior and Air Quality

Macro-Level Characteristics

- Location of the center
- Size of the center
  - Square footage, by use
- Density of the center
- Mix of uses within the center

Micro-Level Characteristics

- Variations in density within the center
- Location of activities with respect to parking
- Accessibility to transit and shuttle services
- Distances between uses within the center
- Availability of services within the center
  - food services
  - shopping
  - day care
  - personnel services
- Pedestrian and bicycle amenities
  - sidewalks
  - landscaping
  - weather protection
  - bicycle parking and storage
  - bicycle access and circulation

Description of Measures

Desirable urban design measures can be incorporated into the fabric of cities, towns, activity centers, and metropolitan areas by utilizing measures such as the following:

- **Transit Friendly Design Regulations.** At least three excellent examples of transit-oriented design regulations are available. In its source book entitled "Building Better Communities: Coordinating Land Use and Transit Planning," the American Public Transit Association has published a variety of strategies, agreements and policies which further the integration of transit into the fabric of the built environment (1). The Urban Mass Transportation Administration has published "A Guide to Land Use and Public Transportation," available through the National Technical Information Service (20). Several local and regional transit agencies have published compendia of standards for ensuring that new developments are supportive of public transportation (14). These publications focus on the diverse set of design issues shown in Table 1 and are directed at the development of activity centers that will support the efficient operation and utilization of transit.

- **Vehicle Pooling Design Considerations.** Though carpools and vanpools have the same access and parking requirements as single occupant vehicles, ridesharing can be made more attractive by providing preferential parking in desirable locations supported by pedestrian walkways or other amenities. (For more on this subject, reference the Chapters on Employer-Based Transportation Management Programs and Parking Management.)

- **Pedestrian and Bicycling Design Considerations.** Separate circulation systems for pedestrians or bicyclists are an important element to enhancing the attractive of walking or bicycling including the provision for secure bicycle parking and storage. Attractive networks or paths, grade separated crossings, adequate lighting and assorted amenities all play an important role. An excellent set of pedestrian-oriented design guidelines has been prepared for Sacramento County, California. Bicycle and pedestrian programs is the subject of a separate section in this series and the reader is referred to it for more information on this subject.

- **Parking Regulations and Standards.** As described in the chapter on Parking Management, the provision and cost of parking play an important role in affecting travel behavior.

- **Mixed-Use Development Ordinances and Zones.** Single use restrictions are too often still in place for large areas of suburbia. In order to permit the kinds of mixed-use developments which reduce tripmaking by single occupant vehicles, local regulations can allow for mixed-use developments under single ownership.

- **Site Plan Review Ordinances.** A carefully articulated set of standards and procedures by which site plans for developments and activity centers should be reviewed is essential. The process of reviewing development plans and negotiating

appropriate modifications in the public interest can be time consuming but is important to the successful incorporation of enhanced urban design measures.

These types of measures are illustrative of the kinds of actions which local governments have taken to affect their built environment. Among the many benefits which residents, employees, and travelers experience as a result of the implementation of these measures are reduced travel in single-occupant vehicles, reduced automobile tripmaking, and increases in the use of transit, bicycles and pedestrian travel.

Of the local governments which either are considering or already have adopted or revised ordinances of the kinds described, Sacramento County, California stands out as a jurisdiction which is undertaking perhaps the most comprehensive revision in its design and development guidelines with these goals in mind (4). As part of an update to that area's comprehensive plan, officials in Sacramento County have identified a variety of strategies to accommodate the rapid growth projected for the county while maintaining its present quality of life and continued economic vitality. In the introduction to their design guidelines, the authors state that "these strategies seek to address the county's most pressing problems: urban sprawl, escalating traffic congestion, nonattainment of regional air quality standards, and growing demand for housing opportunities... " The principles and guidelines explicitly recognize that new forms of urban development are needed to resolve these problems. Thus the Land Use Element of their General Plan established the following principles:

- Maximizing the use of existing urban areas,
- Reducing consumption of land in nonurbanized areas,
- Linking new land development with transit,
- Reducing the number of auto trips and vehicle miles traveled, and
- Reducing air pollution.

To achieve these principles, officials and citizens are in the process of preparing a new development concept for their county. Known as a "transit-oriented development", this concept would consist of mixed-use neighborhoods between 20 and 160 acres in size developed around a transit stop and a core commercial area. Secondary areas of lower density would surround these TOD's for up to one mile. Planners intend the design of the TOD's to provide an "alternative to traditional suburban development by emphasizing a pedestrian-oriented environment and reinforcing the use of public transportation." These ends would be achieved by mixing residential, retail, office and other development within walking distance, and by providing options for employees and residents to travel by means other than the automobile. The residential densities and

building intensities specified by these guidelines are designed to support a public transit system running at frequent headways to important destinations in the region.[1]

Sacramento County's proposed design guidelines consist of 13 broad topics, covering a variety of specific guidelines and recommendations. The outline of these guidelines is shown in Table 2. The overall structure and content of the guidelines exemplifies state-of-the-art knowledge concerning the effects of the design of activity centers on travel behavior and air quality.

The key principles underlying these guidelines can be summarized as follows:

- Transit-oriented design guidelines can apply both to underdeveloped sites within an existing urban area and to undeveloped sites.

- The sites should be located within 2,000 feet of a transit stop. Development of these sites must be governed by a comprehensive plan or review process.

- Transit-oriented designs should incorporate a mix of uses. Residential uses should include a variety of densities, patterns, costs and buildings types. Retail and service space should be incorporated in each such development.

- The developments should be denser than frequently occurs today, varying from 7 to 30 dwelling units per gross residential acre. Office and commercial intensities should also be subject to both minimum and maximum floor area ratios defined in the guidelines.

- Areas outside of the TOD's should be carefully planned to afford easy access to the more densely developed centers, easy entry to buildings from bikeways and walkways, and be accompanied by substantial public amenities supportive of the goals of the plan.

- Access to residential and commercial structures should be oriented toward streets rather than interior blocks or parking lots. Setbacks from the street should be minimized. Overall development plans should seek a balance between automobile safety and accessibility and pedestrian convenience.

- Street patterns within TOD's should be interconnected. Cul-de-sac and dead-end streets should be avoided. The street system should provide multiple and parallel routes between the core area and surrounding areas. Streets should be designed with vistas to the core area of commercial space and related public amenities. Street

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1/ The study of record in this subject for over 10 years has been Public Transportation and Land Use Policy, published in 1977 (16). The authors of this book document, among other things, the clear relationship between the density of development, both residential and nonresidential, and travel behavior. Density, defined as the measure of concentration of either households or employees per unit of space, continues to be recognized today as a key determinant of mode split and tripmaking, thus determining the extent of the utilization of transit.

Table 2. Transit-Oriented Development Design Guidelines: A Taxonomy

Location Criteria	• Relationship to Transit • Urban Policy Area • Urban Growth Area Sites • Infill and Revitalization Sites • Commercial and Industrial Reuse Sites
Site Characteristics	• Amount of Existing On-Site Development • Site Size: Urban Growth Areas • Site Size: Infill and Revitalization Sites • Distance From Transit Stops • Single Site Plan • Phasing
Mix of Uses	• Proportion of Uses • Core Commercial Area • Housing • Ancillary Units • Day Care • Public Uses
Residential Densities and Commercial Intensities	• Residential Densities • Office Intensities • Core Commercial Intensities • Upper Story Uses on Retail Sites • Building Heights
Secondary Areas	• Type and Proximity of Uses • Residential Densities in Secondary Areas • Roadway Connections to TODS • Bikeways in Secondary Areas • Public Amenities in Secondary Areas
Building Siting and Design	• Core Commercial Area Configuration • Commercial Building Entries • Residential Building Entries • Similar Uses Adjacent to Streets • Building Setbacks • Building Facades

Table 2. Transit-Oriented Development Design Guidelines: A Taxonomy (continued)

Street and Circulation System	• Arterial Streets and Thoroughfares • Street Patterns • Multiple Routes • Street Vistas • Street Trees • On-Street Parking • Street Dimensions • Alleys • Intersection Design
Pedestrian and Bicycle System	• Pedestrian Routes • Connections to the Core Area and the Transit Stop • Sidewalks • Bikeways • Bike Parking
Transit Stops	• Site Relationship to Transit Stop • Transit Stop Facilities • Street Crossings to Transit Stops
Parking Requirements and Configuration	• Locations of Parking Lots • Size of Surface Parking Lots • Joint Use Parking • Parking Requirements in Office Areas • Surface Parking Redevelopment • Retail in Structured Parking Lots • Peak Parking Lots • On-Street Parking Requirements • Parking Lot Landscaping • Park and Ride Lots
Open Space, Parks, and Public Spaces	• Location of Parks and Plazas • Park and Plaza Design • Park and Plaza Landscaping • Monument Trees • On-Site Creeks and Riparian Habitat • Schools and Community Parks
Relationship to Surrounding Land Uses	• Integrating Existing Viable Uses • Condition and Density of Existing Uses • Redesigning Street and Pedestrian Systems • Proximity of Competing Retail

Source: Calthorpe & Associates (4).

design should facilitate pedestrian movement and minimize inconvenience to pedestrians.

- A well-developed system of pedestrian and bicycle paths should be incorporated into the development, focusing on the core area and its transit stop. Adequate parking for bicycles should be provided.

- Core area transit stops should be made as accessible as possible by means of visible paths, streets and sidewalks, with adequate attention to pedestrian and bicycle amenities.

- Parking should be carefully planned, shared whenever possible between uses, adequately landscaped, and enclosed whenever possible.

- Parks and public spaces should be the focus of the development. They should be designed for both active and passive uses, with ample landscaping and adequate pedestrian and bicycle connections.

- In general, transit-oriented developments should be the locus of major land uses, including employment and retail uses. Surrounding land uses should be lower in density and less varied in use than the transit-oriented developments which are the heart of the development plan.

Together this set of guidelines exemplifies the kind of comprehensive, integrated urban design and planning which is capable of influencing local travel behavior and thus air quality. Elements of many of these principles have long been incorporated in developments, both planned and unplanned, both in this country and overseas. As their effects on travel have become better understood, the principles are being formalized and combined in Sacramento and elsewhere in a manner designed to bring about a reduction in automobile travel and the associated improvement in local and regional air quality.

The identified principles complement other needed programs, such as demand management and parking management. They also complement programs, ordinances and by-laws which focus on regional issues related to the location of jobs and housing, level-of-service standards, the timing of new development, the provision of adequate infrastructure, and the urban form of metropolitan areas. The focus here however is on community-scale or local design issues, within the control of individual jurisdictions.

Application Examples

Of the many developments planned and built in the United States since the advent of the automobile, several can be selected which illustrate to varying degrees the implementation of many of the elements of the design guidelines which are being codified by Sacramento County in the 1990's. These developments are atypical in that they stand in contrast to the patterns of development which predominate in the automobile age. Characteristics of the auto dominant development include:

- Segregation of employment from residential development,
- Orientation toward the automobile rather than pedestrians or transit,
- Steadily lower densities which consume more land and road surface per resident or employee than prevails in pre-automobile age development.

In contrast, the developments summarized in this section are the result of a unified vision of the design and characteristics suitable for a particular community, as articulated by an individual architect or design team. Since the late 1920's and continuing to the present day, a number of such developments have been constructed. For the most part they distinguish themselves from the kind of development which will result from the Sacramento County TOD guidelines in that they typically incorporate an extensive network of cul-de-sac and dead-end roads for residential developments. In this respect they conflict with the "neo-traditional" approach taken by Sacramento County involving the use of a highly interlocked grid system of streets. However, in other respects, these "planned" communities have been constructed using a variety of characteristics which are quite consistent with reduced automobile use and improved air quality. These include the separation of vehicular traffic from pedestrian and bicycle traffic, with each using a separate network of paths and streets, special attention to the quality of the natural and built environment, including the use of a variety of amenities, and the integration of retail and employment uses into the community in conjunction with residential uses (although the residential and nonresidential uses are usually not allowed to be mingled in a specific building or site).

Planned Communities, 1930-1970

During the 1930's, planned communities appeared in several locations in the eastern United States. Two examples are Greenbelt, Maryland and Radburn, New Jersey. In both of these communities, designers developed an activity center which consisted principally of residential development, with supportable retail and service development centrally located. Residential units included both renter- and owner-occupied units, with Greenbelt following the cooperative model and Radburn the owner-occupied

model.[2] Both Greenbelt and Radburn include a network of pedestrian and bicycle paths, fully separated (including grade separations) from the community street network. In both communities, there is a central park area adjacent to which is located the community school and certain retail activities.

Both of these communities retain their original appearance and character today, although the area surrounding them has developed in more traditional suburban fashion.

During the 1960's several planned communities were built, the most famous of which are Columbia, Maryland and Reston, Virginia. Both of these communities were built at a scale which is substantially larger than either Greenbelt or Radburn. Densities were lower in these communities than in those of the previous generation. In both cases, extensive industrial and office development was incorporated in the community to a degree not found in the planned communities of the 1930's.

Both Reston and Columbia represent developments which have a distinctly suburban character, in contrast to other planned communities built during the same period in central cities. The Urban Renewal program underwrote the redevelopment of residential and commercial areas of many United States' cities during this period. Among the many new housing and commercial developments built during the 1960's were the development of Southwest Washington D.C., a largely residential development quite close to Capitol Hill and major Federal agencies, and Lafayette-Elmwood, Michigan, containing two contiguous urban renewal projects near the center of Detroit. These projects featured higher levels of residential density than those found in the more suburban environments of Columbia and Reston. Townhouses and apartments were proportionally far more common. However, the planned nature of these developments allowed for the inclusion of a variety of pedestrian and bicycle amenities. Furthermore the developments were usually well integrated into the existing urban environment, including its street system, although the design of the streets in both developments tended to minimize thru-traffic in residential areas.

These six residential communities built between the 1930's and the 1960's, represent a cross-section of the types of "planned" communities which, it was hoped, would correct many of the perceived weaknesses of traditional urban and suburban development patterns. Among these was an ever-growing dependence on automobile use. The typical suburban shopping center, inaccessible except by automobile and isolated from other land uses, exhibits this dependence. So do typical suburban "activity centers," which consist of a large quantity of low density office developments, separated from one another with little attention paid by designers to pedestrians or to feasible servicing by public transportation. Even those "centers" which contain residential development typically site the residents in a manner which isolates them from other uses on the site, thus obliging automobile use for virtually all trip purposes.

2/ "Co-operative" refers to a means of ownership in which individuals purchase a proportional interest in the entire community, whose size is commensurate with the size of the unit they occupy. They thereby have an undivided interest, rather than a divided interest which would be the case in traditional home ownership.

"Neo-Traditional" Developments

During the 1980's there was a growing trend to reject the approach to planning and development which has come to typify the automobile age. For example, rather than emphasizing an extensive network of cul-de-sac and dead-end roads on which most residential units are placed, "neo-traditional" planners emphasize the introduction of the kind of street grid which prevailed in pre-automobile age development, a system which brings structures close to the sidewalk, provides a density of development somewhat higher than that which is typical in suburbia today, and an environment which affords pedestrians enhanced opportunities to make trips by other means than the automobile. Projects which illustrate the application of these principles include the following:

- **Seaside, Florida.** This development is the first of the neo-traditional planned communities. Special attention has been paid to the location of retail and service establishments and to pedestrian amenities. Because of its location on Florida's Atlantic coast, the kinds of residents and the mix of employment opportunities available within the community may not be considered typical of those which prevail in most other parts of the United States. The principles which govern the design, however, have been widely publicized and acclaimed.

- **Laguna West, Sacramento, California.** This development, by the architect who prepared the transit-oriented guidelines for that county, is the first such development of its kind being implemented in the western United States. Although it is located at some distance from the developed urban area, it is on the right-of-way of a proposed extension of light-rail transit service from downtown Sacramento. The plan makes full provision for the presence of such service, in anticipation of its extension.

- **Kentlands, Gaithersburg, Maryland.** This development, like the others, is oriented towards pedestrians, with neighborhood streets to discourage speeding, and with schools, shopping and parks within walking distance.

- **Alexandria 2020, Alexandria, Virginia.** This large-scale urban redevelopment is proposed to occur on the site of a railroad freight yard adjacent to the Potomac River. The proposal features the careful integration of development with future transit service connecting it to the Washington D.C. area. There will be five walking scale neighborhoods with ground floor retail and on-site employment opportunities.

One opportunity for cleaner air is the promotion of transit-oriented activity centers. Such activity centers are being, and can be, built in redeveloping urban areas which are conveniently located on a metropolitan area's public transit system. Transit can play a role in providing mobility for both new residents and workers in these areas. Where the redevelopment site is convenient to transit which connects to major downtown business centers, new residents will move there so they may use transit for their commuter to work. Where the office sites are well connected by transit to external labor force markets, high transit mode splits are possible on the journey-to-work trips to the redevelopment area.

A good example of a redeveloping activity area is the Hudson River Waterfront in northeastern New Jersey, to the west of Manhattan. This shoreline area, comprised mostly of the cities of Jersey City, Hoboken, Weehawken and West New York, was once filled with railroad, distribution and maritime uses. These activities became obsolete after World War II. After years of lying fallow, the land has been rezoned for mixed-use commercial developments. The area's developers have planned 32 million square feet of office space and 25,000 residential units, as well as shopping centers, other retail amenities and marinas. Already some 5 million square feet of office space and 3,500 residential units have been built.

Public transit is the principal means of travel in the journey to work for the residents and workers of this emerging "linear city." Some 70 to 80% of the early residents work in Manhattan. The development sites are well-served for Manhattan trips by the PATH rapid transit system and two separate ferry operations. Virtually all of the new residents use public transit for this Manhattan-bound trip. For the area's new workers, most of their job sites are conveniently located near PATH stations, the NJ Transit commuter rail terminal at Hoboken and local bus lines. Auto travel to the area is constricted by heavy cross-Hudson congestion backed up from the Lincoln and Holland Tunnels. For these work sites close to transit lines, between 55 and 60% of the workers are arriving by public transit. A north-south fixed guideway system and other lower cost transit improvements are expected to extend this high reliance on transit more uniformly among work sites on the Waterfront and to raise it further where it's already high.

The benefits from this kind of mixed use appear to outweigh techniques for mitigating auto use at development sites that are essentially auto oriented. For example a comparison of the Jersey City Downtown with one of New Jersey's major auto-oriented corridor development areas indicates that the number of peak period journey-to-work auto trips per 1,000 square feet of office space in the highway corridor will be nearly four times as high as it is expected to be in Jersey City; mitigation is unlikely to close this large gap.

Sites like the Hudson River Waterfront can be found in the disinvested areas surrounding many older metropolitan central business districts. State or local development policies that promote the identification of targets of opportunity with incentives for private investment would not only produce less auto-reliant development but strengthen the public transit systems that pass near these underdeveloped sites but derive less than optimum ridership from them today.

These developments, incorporating the principles identified in the Sacramento design guidelines, all show promise for improving the air quality consequences of alternative urban designs in activity centers. Until these developments are fully completed, and appropriate studies are conducted, however, one must rely upon other existing studies which have been conducted in recent years in order to infer the type and magnitude of transportation benefits which can be expected to result from the kinds of activity center design characteristics just described.

■ Transportation Impacts

Available literature on transportation activity center impacts can be divided into two groups.[3] The first consists of studies containing empirical data on tripmaking behavior for individual buildings and communities. These studies include, in addition to the ITE manual, the following sources:

- "Travel Characteristics at Large-Scale Suburban Activity Centers", a study of six suburban activity centers containing 81 buildings, at which tripmaking was observed (8);

- "America's Suburban Centers: A Study of the Land Use Transportation Link" (5), a study of the influences of density, size, scale and location of activities on traffic conditions, with accompanying statistical analyses for 57 activity centers;

- "Montgomery County Trip Generation Rate Study" (6), a compendium of observations of travel behavior from a total of 162 sites in Montgomery County, Maryland, including commercial office buildings, residential developments, shopping centers and fast food restaurants;

- "Trip Generation From Mixed-Use Developments" (11), observations made of a number of mixed-use centers in the State of Colorado;

- "Houston's Major Activity Centers and Worker Travel Behavior" (18), an examination of travel characteristics associated with the Houston CBD and three suburban centers in the same metropolitan area; and

- "Planned Residential Environments" (12), an analysis of ten planned communities in the United States and the travel behavior observed there.

These studies constitute the principal sources currently being used to draw conclusions on the effects of the arrangement of activity center activities and the specific attributes of these activities on tripmaking.

A second set of studies focuses on forecasts of travel behavior attributable to variation in the location, intensity and amenities of activity centers within a region. Among the more important of these studies are the following:

- "The Impact of Various Land Use Strategies on Suburban Mobility" (9), an assessment of regional travel consequences associated with different locations and intensities of residential and employment activity in the three-county region around Princeton, New Jersey;

3/ "Activity Centers" refers to concentrations of employment and/or households at one location, at a density or scale sufficient to distinguish it from surrounding areas.

- "Vision 2020: A Growth Strategy and Transportation Plan for the Central Puget Sound Region" (16), a draft environmental impact statement prepared for a long range regional land use and transportation plan for the four-county, Seattle metropolitan area;

- "Increasing Transit Ridership and the Efficiency of Land Use While Maximizing Economic Potential" (2), a similar simulation undertaken for the Bay Area (San Francisco) in California; and

- "Transportation Demand Impacts of Alternative Land Use Scenarios" (13), a simulation of the effects of the rearrangement of employment concentrations and households in the metropolitan Washington, D.C. area.

From the studies enumerated above, several of the mostly highly regarded have been selected for summarization. Three are analyses of existing empirical data and two are forecast and simulation studies.

Planned Residential Environments

This 1970 study, prepared for the U.S. Department of Transportation, had as one of its two objectives, "an investigation of the transportation requirements of people living in planned residential environments and a comparison with similar demands of people living in more typical residential surroundings" (p. iii). The ten communities were selected for the diversity they exhibited in the extent of community planning which preceded their construction. The study affords an opportunity to compare the travel behavior of residents of five highly planned communities (urban and suburban) with behavior in five "moderately" or "less" planned communities.

The five "highly planned" communities include:

- Columbia, Maryland,

- Reston, Virginia,

- Lafayette-Elmwood, Michigan,

- Southwest Washington, D.C., and

- Radburn, New Jersey.

These communities offer fifteen characteristics which distinguish them from less planned developments. The most relevant of these are:

- Protection of residential areas from industrial or other undesirable uses,
- Provision of a mix of housing types and prices,
- Homogeneous residential neighborhoods,
- Easily accessible community facilities and services,
- Separation of pedestrian and vehicular traffic,
- Provision of transportation alternatives to the automobile,
- Attention to landscaping and aesthetics, and
- Planned growth patterns.

Most of these characteristics are recognized today as supporting reduced automobile tripmaking and thus improved air quality.

Relevant study results include the following:

- Multiple car ownership is 20% higher in the least planned communities than in the most planned, despite the fact that residents in the highly planned communities have a much higher level of educational attainment (and, presumably, income).
- The presence of an exclusive system of pedestrian paths in the more planned communities corresponds to a 20% higher proportion of "frequent walkers" than in the less planned communities.
- Density of residential development did not adversely affect resident's satisfaction with their neighborhood.
- The degree of planning made little or no difference in vehicle miles traveled per household among the suburban planned communities such as Reston and Columbia. However, VMT clearly varied across all communities in relation to their distance from inner city areas, with close-in planned communities exhibiting lower VMT per household than suburban communities.
- A high level of commuter bus service in Reston corresponded with a higher than average bus mode share for that suburban community. In Southwest Washington and other urban communities with well developed transit service, transit mode share also was higher.
- Despite their communities' goal of providing employment opportunities within the community, residents' journey to work trip lengths in planned communities lengthened as distance from the inner city increased.

- The number of trips per household varied much more within communities than between them. The authors found no evidence that the total number of vehicle trips "is appreciably influenced by the level of community planning".

Thus, this cross-sectional study provides evidence that the design of activity centers affect travel behavior. The study illustrates the complexity of the issues at hand. It suggests that both macro- and micro-scale design characteristics, of the kind identified in Table 1, are at work in these communities with some micro-scale characteristics, such as the presence of sidewalks and convenient neighborhood shopping, inducing non-auto travel. In addition, it makes clear the role which density and centrality play in influencing mode choice and vehicle miles traveled.

"Travel Characteristics at Large-Scale Suburban Activity Centers"

A 1989 study completed for the National Cooperative Highway Research Program, entitled "Travel Characteristics at Large-Scale Suburban Activity Centers," focused on observed tripmaking behavior in six major suburban activity centers, with varying combinations of office, residential and retail development. The study, which represents a substantial advancement in the understanding of tripmaking behavior in the kinds of activity centers which are increasingly prevalent in U.S. cities and suburbs today, includes conclusions regarding tripmaking behavior at office, residential and retail establishments in the following six centers:

- Bellevue, Washington;
- Southcoast Metro, California;
- Parkway Center, Texas;
- Perimeter Center, Georgia;
- Tysons Corner, Virginia; and
- Southdale, Minnesota.

Of these centers, most can be considered to exacerbate rather than mitigate the dependence on automobile use in general and single-occupant vehicle use in particular. The main purpose of the study was to quantify trip generation rates in a manner consistent with the approach used by ITE in its trip generation manual. In the course of doing this, however, the authors identified a number of results which illustrate the effects of urban design on travel behavior.

These observation result from the fact that several of the centers studied had unusual or atypical features. In the case of Bellevue, Washington, the activity center is characterized by a well-developed system of pedestrian walkways. Overall levels of density at the activity center are somewhat higher that those in most of the other centers studied. Bellevue also has an extremely well-developed demand management program.

Parkway Center in Dallas, Texas features a large shopping center connected by enclosed and climate-controlled walkways to a number of the adjacent office buildings. Its

proximity and the characteristics of the connections between it and the office buildings result in noticeable changes in midday tripmaking.

Important findings from this NCHRP study with respect to office developments and residential tripmaking are as follows:

Office Developments

The tendency of drivers to make increasing number of trips on a daily basis has been documented in numerous publications and studies (e.g., Pisarski (15)). The NCHRP study contains varied data which point out the ability of any area or activity center to accommodate these trips by means other than the automobile. For example, as indicated in Table 3, there appears to be a positive relationship between the midday non-automobile mode share and the proximity of office space. The highest percentage of walking mode share found for midday trips in the activity centers studied was at Parkway Center whose office employment is connected by enclosed walkways with approximately 1 million square feet of retail space. The number of midday patrons visiting the attached retail development amounted to approximately 20% of all office tower employees.

Table 3 also indicates that the availability of transit plays a key role in capturing midday tripmaking. Bellevue's extensive radial bus service affords employees easy access by transit to many popular midday destinations. Bellevue's well-developed pedestrian pathway system appears to account for its high walking mode split as well.

Table 4, also taken from NCHRP report, indicates the magnitude of internal tripmaking behavior at each of the activity centers. Table 5 describes the distribution of trip purposes prevailing at each of the times during which observations were made. Together, these tables furnish the conclusion that there exists the opportunity to reduce the number of trips made at both AM and PM peak, as well as at midday, through the incorporation of a better mix of activities within activity centers themselves.

Residential Tripmaking

The proportion of employed residents who both live and work within the activity centers analyzed in the NCHRP study ranged from 13% to 50%. Disaggregating these observations by the size of activity center, the authors concluded that the proportion of employed residents increases as a function of activity center size, although the differences are not great. Thirty-three percent of the residents in large activity centers work within the center; 27% of the employed residents in smaller activity centers work within the center. This suggests the potential for reduced work trip length, and/or reduced use of automobiles for the journey to work, in centers with more housing on site. While intra-center tripmaking by means other than automobile averaged only 7%, the largest activity centers, Bellevue and Southcoast Metro, displayed walk mode shares of 17%. The authors concluded that "the shorter potential walk distances (coupled with the Bellevue pedestrian pathway system) contribute directly to an increased walk mode share" at that center (p. 39).

Table 3. Midday Non-Auto Mode Share by Size of Office Development on Site

Regional Center	Transit (%)	Walk (%)	Office GSF Within 2,000 Ft. (millions)
Galleria (Parkway Center)	1	17	2.1
Bellevue Square	5	6	2.1
Perimeter Mall	0	7	2.8
Southdale Mall	1	5	0.7
South Coast Plaza	0	4	1.6
Tysons Corner	0	4	1.5
Prestonwood Town Center (Parkway Center)	0	2	0.7

Source: Hooper (NCHRP) (8).

Table 4. Characteristics of Trips Made by Suburban Activity Center Employees

	Bellevue	South Coast Metro	Parkway Center	Perimeter Center	Tysons Corner	Southdale
Trip to Work						
- Proportion of employees who stop outside SAC	34%	23%	21%	17%	17%	17%
- Proportion who stop within SAC	15%	8%	9%	12%	9%	7%
- Average number of stops per trip	1.4	1.2	1.2	1.2	1.2	1.2
Midday Trips						
- Proportion of employees who make a midday trip	55%	59%	45%	46%	55%	42%
- Proportion who make a midday trip within the SAC	29%	22%	20%	33%	32%	23%
- Average number of stops per trip	1.7	1.9	1.6	1.6	1.6	1.6
Trip From Work						
- Proportion of employees who stop	66%	40%	37%	35%	36%	36%
- Proportion who stop within SAC	14%	6%	9%	16%	10%	13%
- Average number of stops per trip	1.7	1.0	1.1	1.2	1.5	1.5

Source: Hooper, (NCHRP) (8).

Table 5. Intermediate Stop Trip Purposes at Large Activity Centers

Trip Purpose	Distribution of Trip Purposes by Time Period		
	Along Trip To Work	Midday Trips	Along Trip Home
Work Related	21%	25%	6%
Meal/Snack	10	35	4
Shopping	3	13	21
Childcare/School	34	*	14
Pick Up/Drop Off Passenger	5	1	3
Education	*[1]	*	2
Social/Recreation[2]	3	3	15
Home	*	4	0[3]
Banking	7	9	6
Medical	2	2	3
Dry Cleaners	9	1	7
Gas Station	0*	1	0*
Grocery Store	2	1	13
Other	3	3	6
	100	100	100

1 * indicates less than 1 percent.

2 Health club trips have been included under the Social/Recreation category.

3 By definition, trips to home from work cannot have an intermediate stop at home.

* Intermediate steps at gas stations along the way either to work or from work have been excluded in this distribution. During the trip to work, the survey indicates that roughly 11 percent of all intermediate stops are at a gas station. Along the trip home, roughly 9 percent of all intermediate stops are at gas stations.

Source: Hooper (NCHRP) (8).

In all, the NCHRP study contributes hitherto unavailable information on the travel behavior of workers and residents in suburban activity centers. While the study confirms the auto-dependence of these centers, worker's and resident's behavior within the center is varied, with centers which afford higher levels of pedestrian amenities (i.e., Bellevue, Washington) displaying a larger pedestrian and transit mode split. Furthermore, the study clearly indicates that the larger activity centers generate a higher proportion of internal trips at all key times of the day. The proportion of these trips made by other than single occupant vehicles depends on the pedestrian amenities at each of the sites. Lastly, the study implies that there exists an opportunity, through additional improvements to amenities as well as the spatial arrangement of activities within a site, to affect mode split and tripmaking behavior in ways greater than that actually observed at any of the sites.

"America's Suburban Centers: A Study of the Land Use-Transportation Link"

This study, completed prior to the NCHRP project, developed several statistically significant quantitative conclusions on the relationship between activity center characteristics and travel behavior. The study's author, Robert Cervero, developed a typology of six kinds of suburban employment centers (SEC's). These are:

- Office parks,
- Office centers and concentrations;
- Large-scale, mixed-use developments;
- Moderate sized, mixed-use developments;
- Sub-cities; and
- Large-scale office growth corridors.

For a set of 57 of the largest such suburban employment centers in the nation, data were gathered on the density, site design, employment, land use and travel characteristics prevailing in each center. A combination of statistical models and case study analyses were used to test several hypotheses concerning the relationships between activity center characteristics and travel behavior. The conclusion is that there are a variety of land use and work site factors which influence travel behavior in the employment centers studied. Some of his more relevant conclusions are the following:

- As employment centers become more office oriented, the observed share of single occupant vehicle commuting trips rises. All else equal, an employment center with a share of floor space in office use that is 20% greater than another center can be expected to have a 2.4% higher share of work trips made by single-occupant vehicles.

- As the share of floor space in the activity center devoted to retail activities increases, the proportion of walking and bicycling trips increases. For each 20% increase in floor space devoted to retail, a 1% increase in the percentage of work trips by walking or bicycling modes was observed.

- Workers in employment centers with far more jobs on site than housing units can generally expect a commute at relatively slower average speeds. For each 10% increase in the employees per on-site housing unit, a one mile per hour decrease in average commuting speed was observed.

- Density of employment in the centers, as expected, affects nearby traffic conditions. If a given employment center were to double in size and the FAR (floor area ratio) were to increase from one to five, then all else equal, peak hour level-of-service on adjacent arterials could be expected to fall from Level C to Level D.

- The probability of shared ride commuting to and from work increases as a function of the number of employees at the activity center. As displayed visually in Figure 1, the author's analysis of ridesharing in Pleasanton, California indicated a strong relationship between ridesharing and the size of the SEC's in the community.

- The probability of travel outside of the AM and PM peak hours was shown to decline as a function of the number of employees at a given center (Figure 2).

Cervero's conclusions, which were implicitly tested in the NCHRP study, can be summarized by noting that four characteristics of activity centers were shown to affect travel behavior. These are density, land use composition or mix, the scale or size of the activity center and the balance of employment and households on the site.

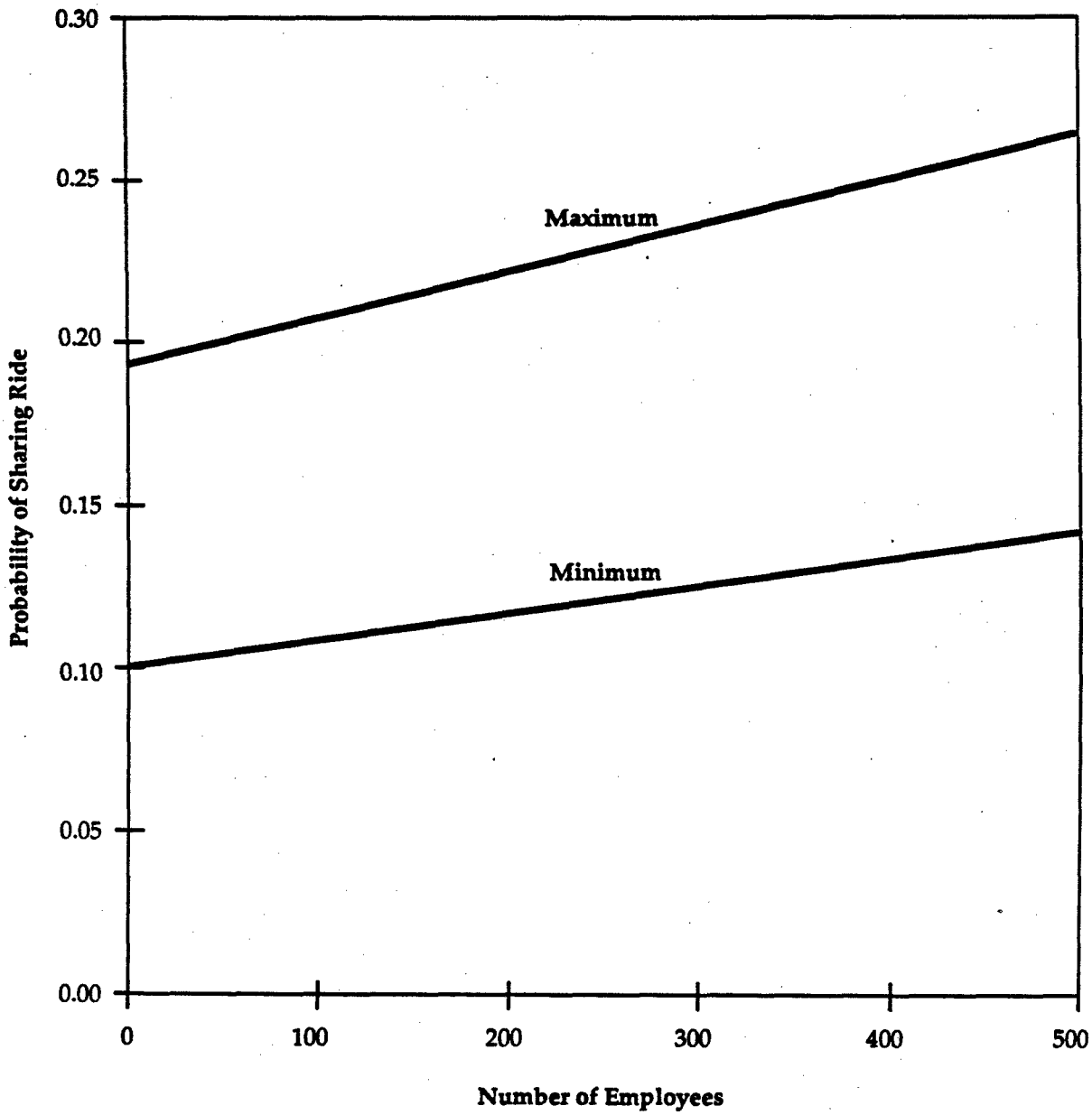
Regarding density, Cervero observed that "high densities appear to work in favor of commute alternatives to the drive along automobile," (p. 133), a conclusion consistent with that found from rideshare program coordinators nationally in both urban and suburban jurisdictions. This outcome, however, is also partly a result of the high levels of congestion and longer commute times associated with travel to and from these larger centers.

The conclusions regarding the role of land use mix in affecting travel behavior emphasize the adverse effects which single use office developments have on non-SOV commuting. Cervero concludes that on-site retail services induce ridesharing, presumably by affording employees the opportunity to obtain needed products and services during their lunch hours and thus obviating the need for personal trips to these services as part of their work trip.

While reconfirming the intuitive conclusion that large-scale employment centers afford the poorest levels of service on adjacent freeways and arterials, Cervero concludes that large developments tend to display greater peaking of employee arrivals and departures. Furthermore, "suburban work environments with a critical mass of employees appear to be an important prerequisite for successful ridesharing programs," (p. 133), clearly indicating the role which density plays in affecting travel behavior.

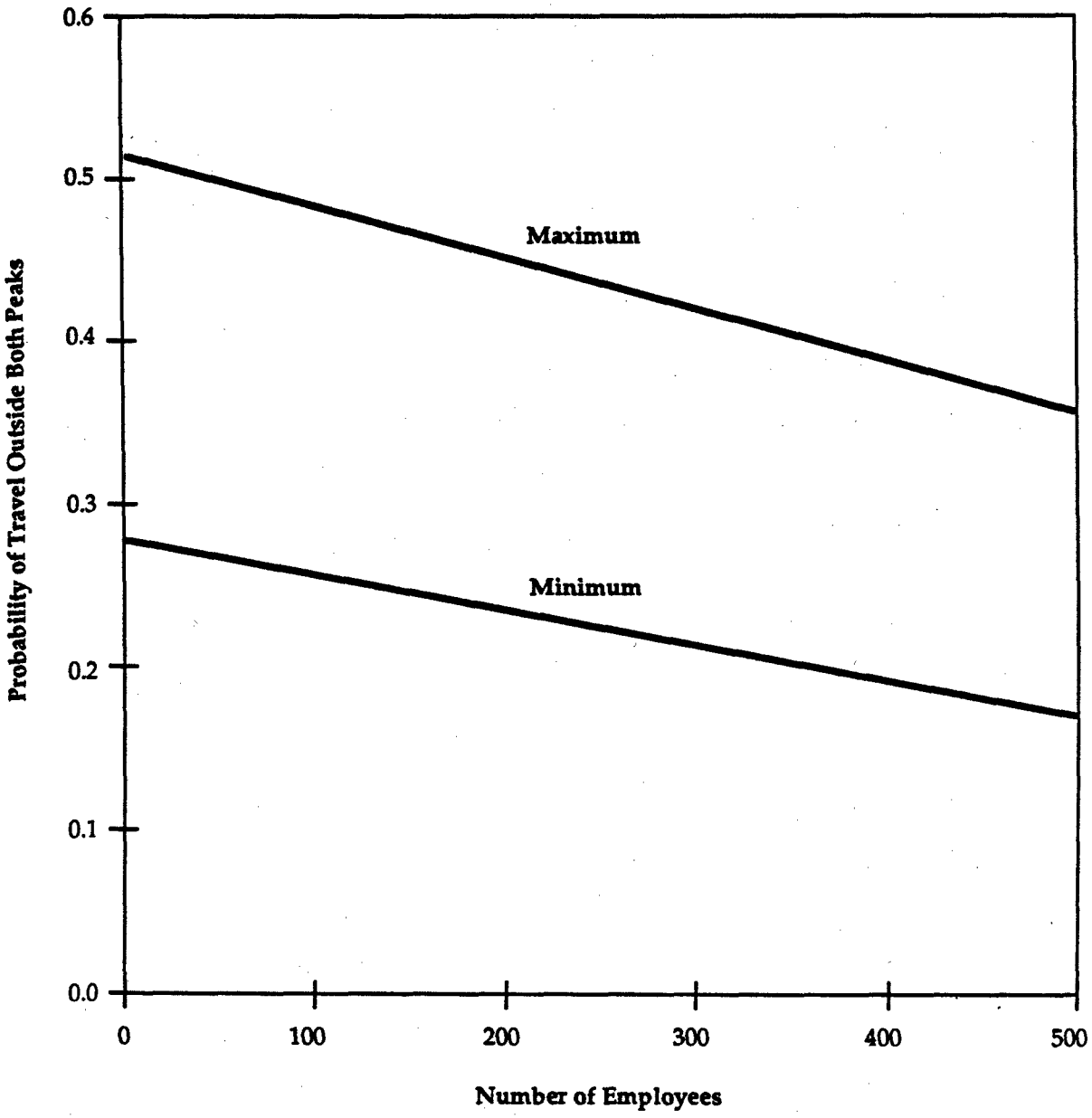
Finally, employment centers with a higher number of housing units on-site tend to display a higher proportion of walking and cycling to work, though they also display lower than average percentages of ridesharing. "These more balanced environments also tend to have less congestion on connecting roadways, possibly because the conflicts

Figure 1. Probability of Shared Ride Commute by Number of Employees at Work Sites in Pleasanton, California



Source: Cervero (5)

Figure 2. Probability of Travel Outside of AM and PM Peak Hours by Number of Employees at Work Sites in Pleasanton, California



Source: Cervero (5)

between SEC oriented trips and other through travel are reduced." (p. 133.) Elsewhere, Cervero observes that the "subcity" category of employment center tends to display more peak spreading, a fact which is attributed to the relatively more diverse mix of uses which more traditional cities display in comparison to suburban employment centers.

"The Impact of Various Land Use Strategies on Suburban Mobility"

A fourth significant research effort builds upon the work of Cervero and the NCHRP authors. The project, undertaken by the Middlesex-Somerset-Mercer Regional Council in New Jersey, is part of that organization's efforts to educate area residents on the relationships between urban design and transportation. The report combines empirical data from other sources with careful use of expert judgement. The authors infer and estimate a set of trip reduction factors which they believe might occur through the systematic and careful implementation of a variety of urban design principles. These trip reduction factors were then applied to a sketch plan version of the region's highway network, estimating the regional consequences of site-specific urban design improvements on vehicle miles traveled, travel speed, travel time and total trips in the multi-county area.

Three basic "constructs" were developed consisting of different combinations of urban design and land use planning features. The intention was to determine the most likely effects of combining these sets of features on overall rates of trip generation. The Transit Construct, the Short Drive Construct, and the Walking Construct represent three types of activity centers with different land use mixes, levels of activity, and transportation infrastructure. The Transit Construct is a higher density mixed-use center with a high level of employment intended to maximize the use of transit (Figure 3). It includes significant pedestrian amenities. The Short Drive Construct is similar to the Transit Construct except for the absence of major investments in transit service. The Walking Construct emphasizes a high level of residential development with minimal employment on-site, laid out in a compact pattern. Table 6 summarizes the character of each of these constructs.

Since the goal was to estimate levels of reduction in automobile usage possible through the implementation of these Constructs, the study team developed a series of linked assumptions which built upon the data contained in the NCHRP suburban activity center study. That study formed a "base indicator of trip reductions which can be achieved through mixing land uses and increasing density." However, the authors note that "the case study averages provide the benchmark values, tied to reality, which can be the starting point for the regional testing" conducted in the MSM project. Since the NCHRP data displayed substantial variation in key travel behavior indicators, the study team set out to estimate "added reductions which can be attributed to the particular features" assumed in their constructs (p. 29). The goal was to estimate trip reductions which would result from the combination of factors including:

Figure 3. Transit Construct City Diagram

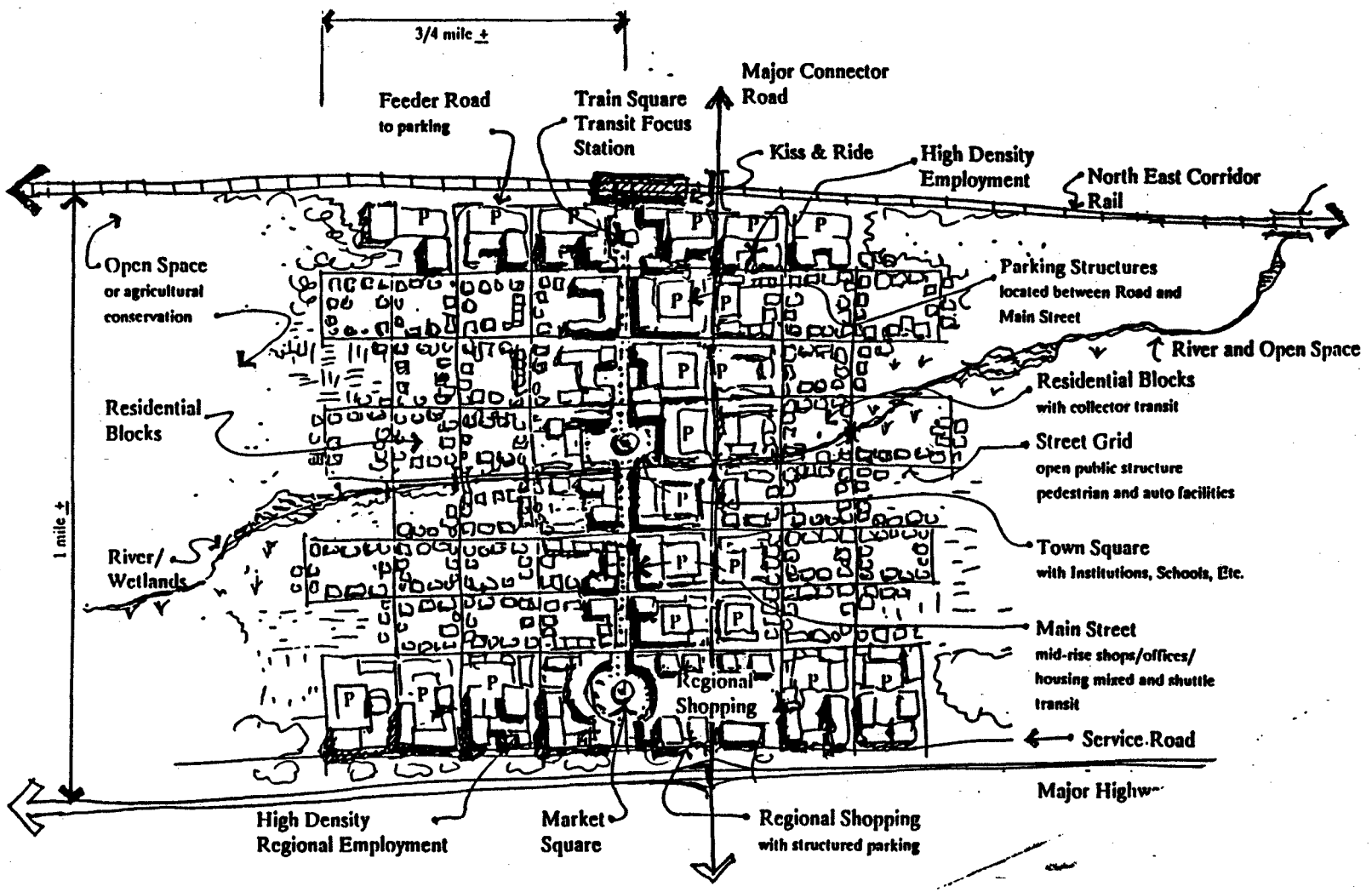


Table 6. MSM Land Use Construct Comparison

Characteristic	Transit Construct "TC"	Short Drive Construct "SD"	Walking Construct "W"
Commercial Components:			
Comm. Floor Area (SF)	4,000,000	3,000,000	10,000
Comm. Employment	12,000	9,000	30
Commercial FAR	2.0	1.1	0.4
Comm. Net Acres	45.9	62.6	0.6
Retail Components:			
Retail Floor Area (SF)	550,000	250,000	50,000
Retail Employment	1,100	500	200
Retail FAR	1.00	0.40	0.23
Retail Net Acres	12.6	14.3	5.0
Non-Resident Totals:			
Total Employment	13,100	9,500	230
Total Net Non-Res. Areas	58.5	77.0	5.6
Residential Components:			
Population	12,000	6,700	4,500
People per D.U.	2.0	2.4	2.8
Dwelling Units	6,000	2,800	1,600
D.U. per Net Res. Acre	15	10	10
Net Residential Acres	400.0	280.0	160.0
Total Construction Factors:			
Jobs per D.U.	2.18	3.39	0.14
Workers per D.U.	1.0	1.5	1.5
Reserve Areas:			
Open Space	15%	15%	15%
Roads/Utilities	25%	28%	28%
Public Buildings, etc.	10%	10%	10%
Gross Dimensions:			
Area in Acres	917	759	352
Area in Sq. Mi.	1.43	1.19	0.55
Radius if Circular (FT)	3,566	3,245	2,210

Source: Howard/Stein-Hudson (MSM) (9).

- Overall activity mix;
- Jobs/housing ratio;
- Total employment;
- Design integration;
- Proximity to transit, radial bus service, and internal bus services;
- Increased residential density; and
- Constrained commercial parking.

The MSM project built upon Cervero's conclusion that such factors in combination can bring about reduction in single occupant vehicle usage due to internalization of external trips and the reduction of external trips through mode shifts to transit or other modes.

Table 7 displays the summary of vehicle trip reduction factors applied to the sets of conditions hypothesized for each of the constructs being studied. Proportional reductions in automobile trips varied from 18 to 41% at different times of day under the transit construct, 16 to 31% under the short drive construct, and 14 to 23% under the walking construct. Trip generation at commercial establishments was forecast to be reduced by 29 to 33% under the transit construct assumptions, 25 to 29% under the short drive assumptions, and 10 to 25% under the walking construct assumptions. Trip-making at retail and restaurant establishments was expected to be reduced by 17 to 33% under the transit construct, 15 to 30% under the short drive construct, and 14 to 23% under the walking construct. The report provides complete documentation of the assumptions used to reach these trip reduction conclusions.

Potential locations for each of the three types of activity centers ("constructs") were then identified and projected levels of employment and households were assigned to specific locations in the three-county region. Three transit constructs, eight short drive constructs and eight walking constructs were assigned to specific locations so that these three alternative development scenarios could be analyzed using a sketch plan version of the regional transportation network. Appropriate shares of forecast levels of regional growth were assigned to each of the constructs. The network effects of the three land use alternatives were then compared with the travel behavior forecast for a continuation of existing trends through the year 2010.

Graphic results of the network simulations are shown in Figures 4 and 5. The simulation suggests that a continuation of existing trends would result in a growth of 43% in daily vehicle trips by the year 2010 in the nonurbanized portions of the region. By comparison, the growth in vehicle trips if all growth were kept in suburban constructs was 29%.

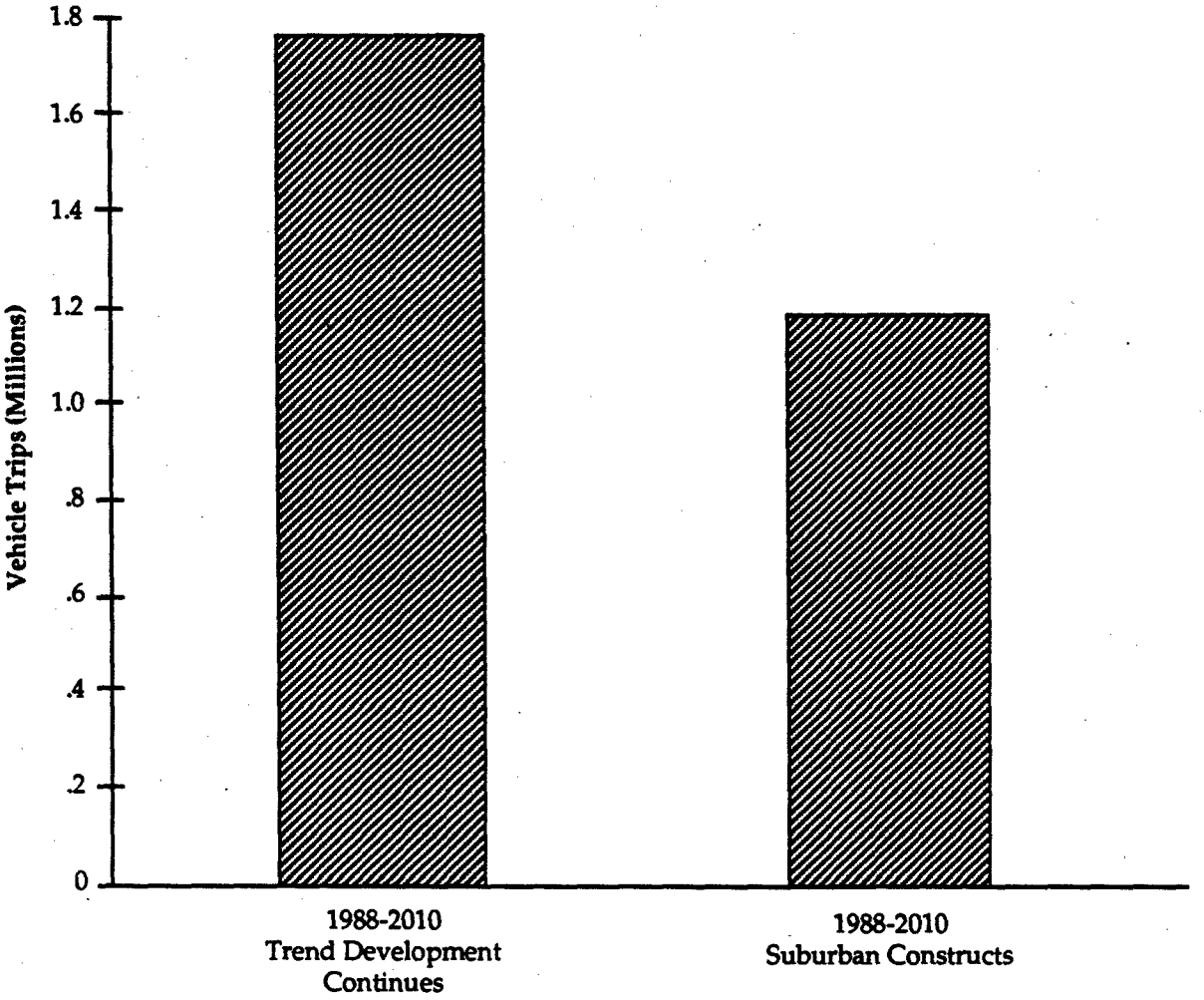
Table 7. Summary of Vehicle Trip Reduction Factors MSM Study

	Summary of Vehicle Trip Reduction Factors			
	Trend	**Transit**	**Short Drive**	**Walking**
Commercial:				
Average Daily	1.00	0.69	0.73	0.81
AM Peak Hour	1.00	0.71	0.75	0.90
PM Peak Hour	1.00	0.71	0.75	0.90
Off Peak Periods	1.00	0.67	0.71	0.75
Retail/Restaurant:				
Average Daily	1.00	0.73	0.76	0.81
AM Peak Hour	1.00	0.83	0.85	0.86
PM Peak Hour	1.00	0.83	0.85	0.86
Off Peak Periods	1.00	0.67	0.70	0.77
Residential:				
Average Daily	1.00	0.73	0.78	0.82
AM Peak Hour	1.00	0.59	0.69	0.77
PM Peak Hour	1.00	0.59	0.69	0.77
Off Peak Periods	1.00	0.82	0.84	0.86

Note: Compared to the development pattern expected to occur in the MSM region by the Year 2010 if trend conditions continue, constructs would produce fewer vehicle trips that would use the regional highway network. As this chart shows, if the Trend represents the expected level of vehicle tripmaking, then the constructs produce daily trip levels which are between 0.59 and 0.90 of what would be expected to occur, depending upon trip types and construct types.

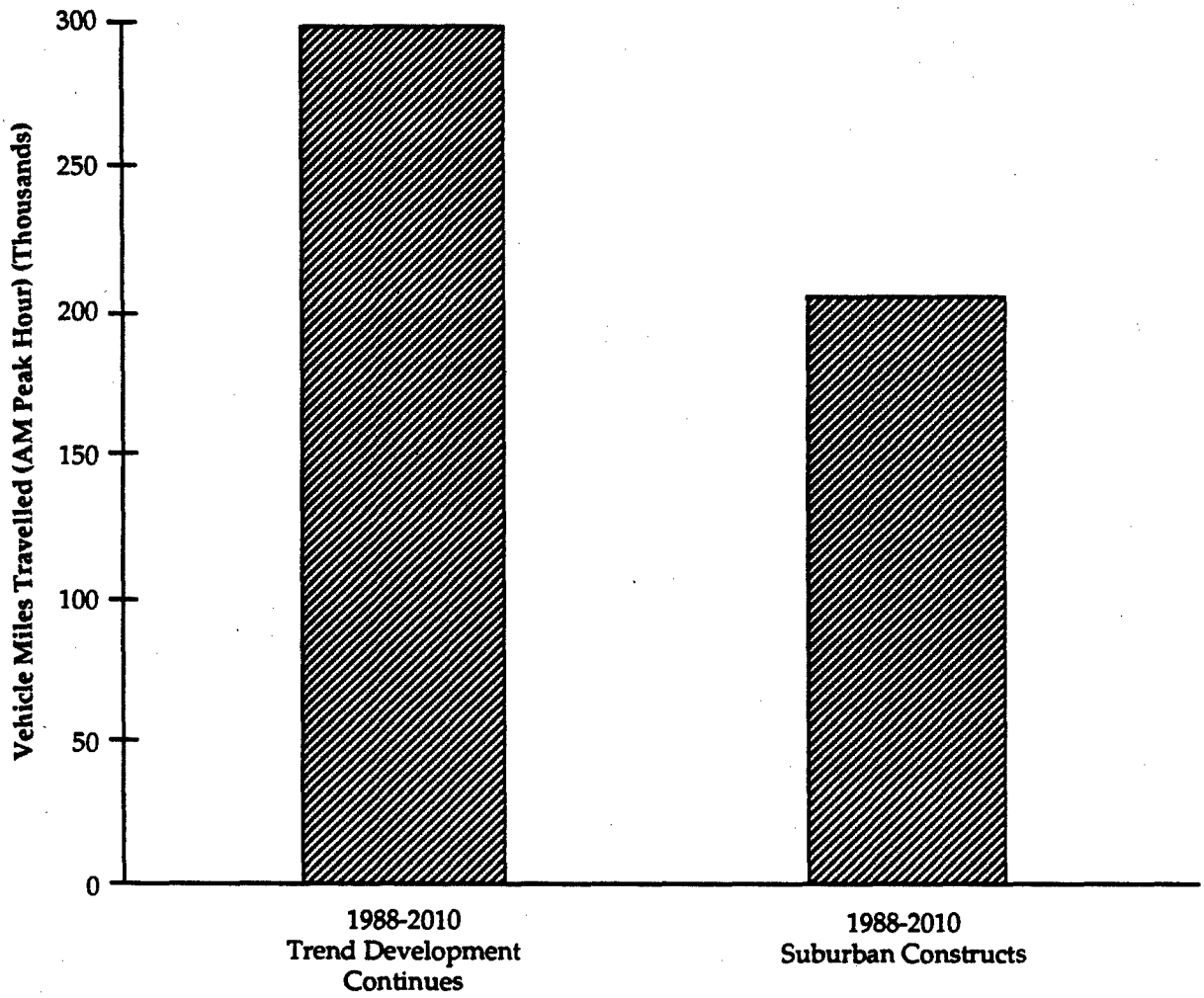
Source: Howard/Stein-Hudson (MSM) (9).

Figure 4. Growth in Daily Vehicle Trip Ends: 1988-2010 MSM Construct Study Area: Trend Versus Alternative Development Scenarios



Source: Howard/Stein-Hudson (MSM) (9)

Figure 5. Growth in AM Peak Hour Vehicle Mile of Travel: 1988-2010 MSM Construct Study Area: Trend Versus Alternative Development Scenarios



Source: Howard/Stein-Hudson (MSM) (9)

Equally significant effects on vehicle miles traveled are shown in Figure 5. The control forecast indicates a growth of 38% in VMT between 1988 and 2010. By comparison, the construct scenario indicated growth of 26%.

Three basic conclusions were reached as a result of these simulations and related analyses:

- First, "mixed-use centers can produce significant regional transportation benefits" (p. 61). Significant effects on slowing the growth of trips, VMT and a deterioration of highway speeds were documented. Incremental impacts of 30% on forecast growth in trips and 33% in forecast growth of vehicle mile traveled were shown to result from the implementation of urban design measures in the context of suburban activity centers.

- Benefits of implementing urban design measures in each of the constructs include a reduction of tripmaking both within and outside the activity centers.

- Further concentrating growth in existing urban areas, in combination with the urban design measures proposed for suburban mixed-use centers, gave the most dramatic regional transportation benefits.

The authors acknowledge that "the benefits cited above are premised on the channelling of all new development either into an urban area or a higher density, mixed use, carefully planned construct," and that "achieving this level of success in planning and implementing new development patterns by the year 2010 is unlikely because of the number of new developments that already have planning permits," (p. 63). Thus, the results of the MSM study must be considered to be at the high end of the range of benefits which might be achieved through the rearrangement of activity into and within suburban activity centers. Nevertheless, the MSM work represents a useful estimation of both specific trip reduction factors and their effects on regional transportation demand.

"Vision 2020: Growth Strategy and Transportation Plan for the Central Puget Sound Region"

A final set of findings worthy of mention results from the development of a long range regional land use and transportation plan in the four-county Puget Sound (Seattle) Metropolitan Area. This effort, like that of the MSM Regional Council, is a forecasting and simulation project rather than a study of empirical behavior. Furthermore, it resembles MSM in that project staff estimated the regional travel demand consequences of assigning growth in households and employment to specific traffic analysis zones. However, unlike the MSM study, no trip reduction factors were introduced. The differences between the alternatives examined are the result of changes in mode choice and trip length, rather than assumptions concerning changes in trip frequency.

At the heart of the Council's study were three major alternatives for regional growth. The "major centers" alternative concentrated employment growth in six major downtowns that could be efficiently served by transit. It postulated a heavy level of investment in transit including 140 miles of light rail and commuter rail and 300 miles of HOV lanes. The "multiple centers" alternative concentrated employment growth in 36 centers, all of which could also be served by transit. A regional balance was sought between the location of jobs and housing to shorten commutes (work trip length). A somewhat lower level of investment in transit was combined with a higher level of investment in highway construction. The "dispersed growth" alternative involved the dispersion of growth to suburban and rural areas and a near exclusive emphasis on highway improvements.

Using an interactive transportation and land use modeling system, simulations were conducted which estimated the change in transportation system performance associated with each of the alternatives (Table 8). Of the alternatives examined, the major centers alternative attracted the greatest transit mode split and the lowest vehicle miles traveled. However it also resulted in the largest number of hours of delay, most likely because of the effects of concentrating employment in already congested centers. The dispersed growth alternative generated the highest VMT. The multiple centers alternative generated high transit use, combined with low delays on regional highways and intermediate levels of VMT. A fourth alternative, combining desirable elements of the major centers and multipliers alternatives, was eventually developed and selected. As shown in Table 8, the performance of this preferred alternative on key transportation measures is strong.

The results of the Puget Sound study show less substantial changes to travel behavior than suggested by the MSM report, but results which are consistent with the smaller, but still statistically significant travel behavior effects shown by Cervero to be attributable to urban design in activity centers.

Summary

In summary, the five studies reviewed indicate that urban design characteristics of activity centers affect virtually all kinds of travel behavior. Cross-sectional studies and simulations indicate that the mode split and trip length of work trips varies as a function of density and size of the activity center and/or its proximity to other major centers of employment, and its overall location within the region. The larger and more dense the center, the more likely that work trips will be made by means other than the drive alone automobile. The closer a planned residential community is to the region's major employment center, the shorter its residents' work trips will likely be and the more likely it is that these trips will be made on transit.

Midday tripmaking behavior is also affected by the characteristics of activity centers. The provision of appropriate retail facilities and services within an activity center promotes the retention of trips within the center. This further affords the opportunity through appropriate urban design measures to modify the midday trip mode choice.

Table 8. Puget Sound Transportation Systems Performance by Alternative

Criteria	Alternative					
	No Action	Existing Plans	Major Centers	Multiple Centers	Dispersed Growth	Preferred Alternative
Vehicles Miles Travelled	99	98	94	97	101	95
Vehicle Speed During Peak Period (mph)	10	15	14	15	15	16
Hours of Delay (Millions)	1.76	.83	.96	.81	.82	.83
% of Increase in Hours of Delay Over 1990	926	437	505	426	432	440
% of Increase in Transit Ridership Over 1990	20	185	241	168	39	218
% of Transit During Peak Period (Mode Split)	5.6	12.8	14.8	12.2	6.9	14.1
% of Network that is Congested (Over Capacity):						
Freeways	75	46	50	45	49	45
Regional Arterials	26	17	19	16	17	17
Overall	30	21	23	19	20	20

Source: PSCOG (16).

Connecting a well-located retail shopping facility to office buildings with enclosed, weather-protected pedestrian walkways has been shown to substantially decrease the use of automobiles for midday trip making.

In addition, the inclusion of necessary services such as child care, ancillary retail activity and services within an activities center, be it principally residential or employment based in character, has been shown to reduce both the length of these work-based trips and to afford means for making these trips by means other than the automobile.

The magnitude of the transportation impacts associated with the urban design measures shown in Table 1 has been shown to vary substantially. Since no one place has been observed to contain all of the attributes which have a positive impact on travel behavior, it is difficult to quantify precisely the benefits associated with these measures. The best examples of activity centers which incorporate these measures are in the locations which are currently under construction and/or which have not yet been the subject of special studies. In all, however, the positive contribution which urban design can make to facilitating nonautomobile travel, the use of mass transit, pedestrian and bicycle modes, and to reducing the need for single-occupant vehicle travel has now been established.

■ Other Impacts

Air Quality Impacts

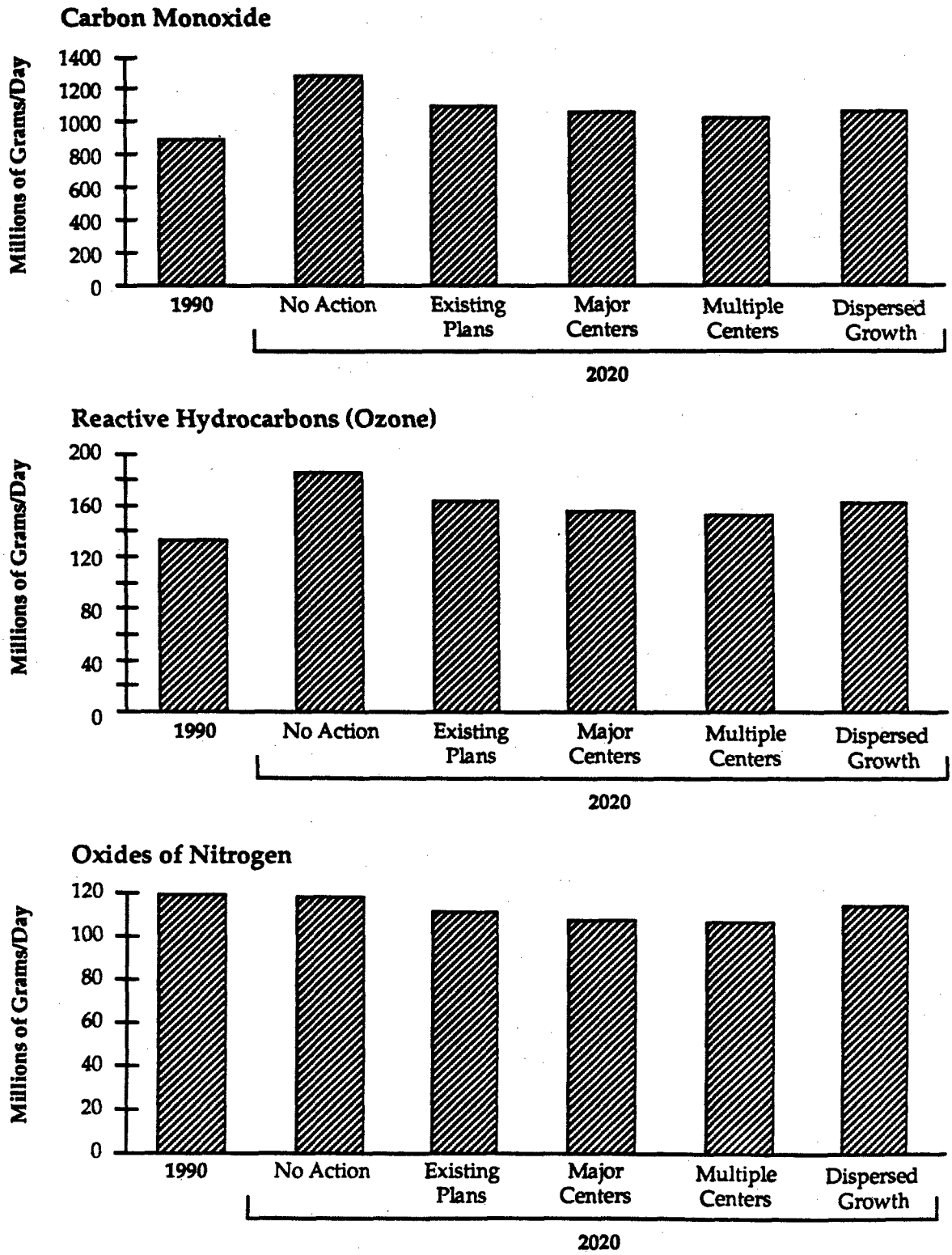
The Puget Sound study is the only transportation/urban design project evaluated here which explicitly estimated the air quality effects of alternative distributions of households and employment. The results are summarized in Figure 6.[4]

The staff concluded that a no-action alternative is clearly worse than others for key mobile source pollutants. Levels of carbon monoxide, reactive hydrocarbons and oxides of nitrogen were all found to be lower under any of the scenarios analyzed than would be the case under the no-action alternative. On the other hand, pollution levels under all the scenarios were found to somewhat higher overall in the 2020 simulations than current (1990) levels. While zonal pollutant levels were shown to vary, regional levels of pollution associated with each of the alternatives studied were shown to be somewhat comparable. Levels of regional emissions varied among alternatives in a range of approximately 3% to 7%.

The alternative which generated the least adverse air quality impacts for all three kinds of air quality studied was the multiple centers alternative. This was closely followed by

4/ Other studies, from Central and Southern California, on the connection between regional development patterns and air quality include studies by the Southern California Association of Governments and the South Coast Air Quality Management District (19).

Figure 6. Air Quality Impacts of Puget Sound Alternatives



Source: PSCOG (16)

the major centers alternative. The dispersed growth alternative generated higher levels of pollution than either the multiple or major centers scenarios.

Capital and Operating Costs

The implementation of urban design measures involve costs to both public and private sectors. To the public sector there are costs in the form of developing, adopting and managing the ordinances or programs which govern the design of activity centers. Since units of local government already have in place departments to manage issues related to the location and characteristics of development within their jurisdiction, the implementation of modifications to their programs or ordinances should involve manageable one-time costs for program development and minimal ongoing costs for program administration.

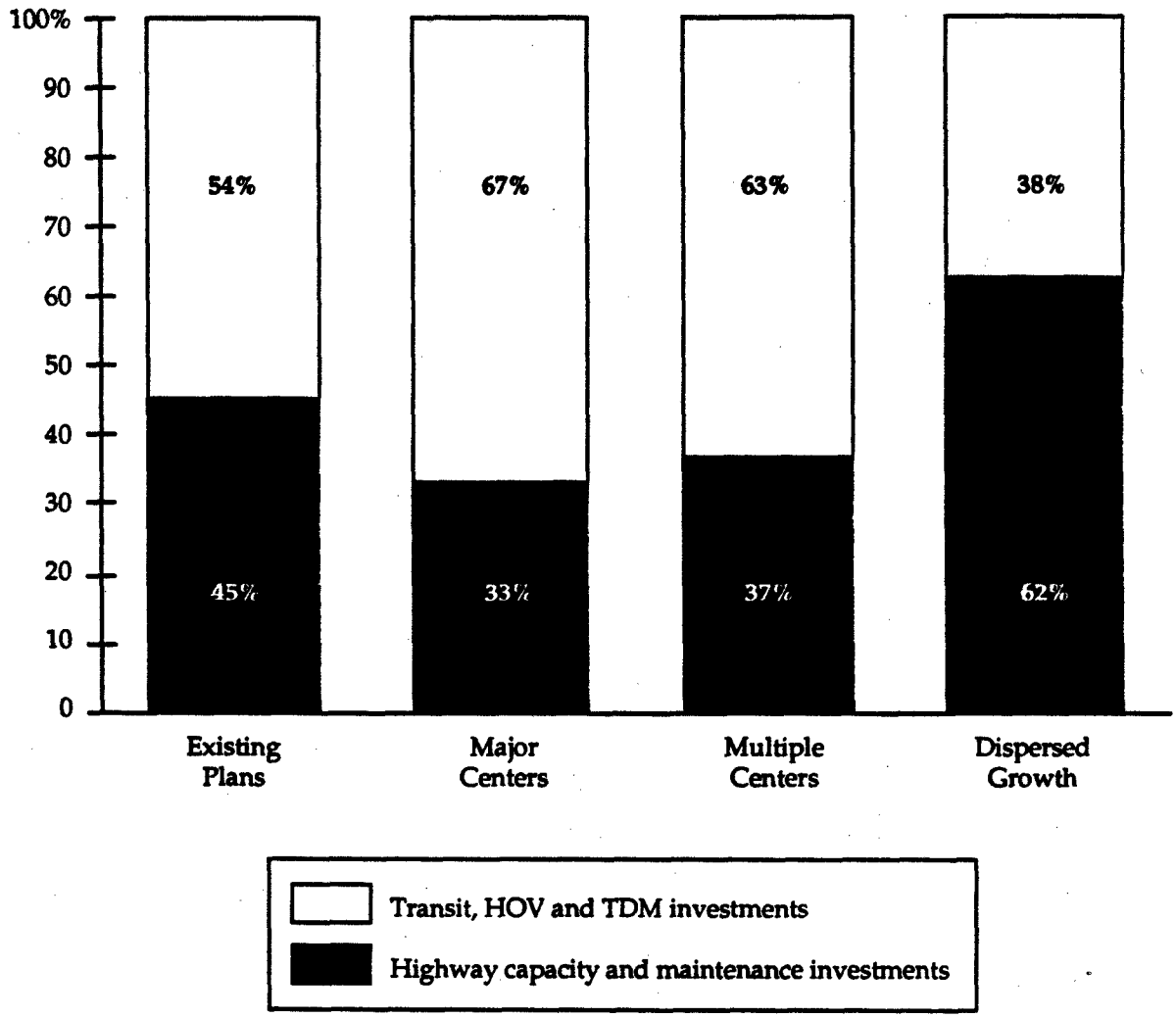
The nature of capital costs associated with the implementation of urban design codes or programs is highly variable. There will be some situations in which expenditures of public funds will be required for the construction of pedestrian or transit oriented amenities at specific sites. Furthermore, there may be costs associated with new transportation infrastructure, either for highways, buses or transit. To the degree that public funds are required for capital improvements, the types of measures envisioned here will tend to generate lower costs per capita than the types of infrastructure required for the less dense forms of settlement which might otherwise prevail.[5]

The Puget Sound Council of Governments project team estimated the total public investment required to implement the transportation element of each of their alternatives. The Council staff concluded that the capital and operating costs of the transportation component of the plan would be essentially the same under each of the alternatives; however, the mix of expenditures would differ. As shown in Figure 7, the alternatives distinguish themselves in terms of the mix of highway versus non-highway related transportation expenditures which would be required.

In addition, the PSCOG team studied the effects of the alternatives on the costs of other public services, both capital and operating (see Battelle HARC (3)). The results of the analysis suggest that while density of development affects government cost in statistically significant ways, the absolute value of these cost differences was rather small. In more dense areas, per capita public service costs tended to be higher for operating cost and lower for capital costs than in lower density areas. However, the authors concluded that in communities with denser patterns of settlement, governments tended to provide higher levels of services than were provided in lower density suburban and rural communities. Thus, the per capita efficiencies associated with more compact settlement are counterbalanced by higher levels of service, resulting in relatively similar levels of overall expenditure.

5/ For a review of the literature on this subject, see Frank (7).

Figure 7. Transportation Investment Emphasis: Puget Sound Alternatives



Source: PSCOG (16)

The provision of amenities for pedestrians and bicyclists, as well as area residents and employees, may impose costs upon the private sector as well as the public sector. Since the provision of some amenities is often the subject of negotiation between developers and local officials, it is necessary to recognize that the implementation of urban design criteria can impose additional development costs. On the other hand, one of the most crucial urban design variables, higher density, is a clear benefit to the private sector because it allows for cost saving and increased profits resulting from more intensive development. Thus, there often is an opportunity for trading-off increased density with the provision of additional amenities at a given activity center. This trade-off may afford both the community and the developer additional, desirable benefits while at the same time providing mutually reinforcing, positive impacts on travel behavior and air quality.

Travel Markets Affected

The urban design measures which are the subject of this chapter potentially affect all forms of vehicular travel. To the degree that any activity center contains employment uses at the expense of residential uses, the benefits of better site design will accrue principally in the form of reductions in VMT and/or trips during peak hours, including the noon-day peak. However, as activity centers become more developed and incorporate a broader mix of land uses, better site design can affect non-work related trips (home-based trips) as well.

Time Frame for Implementation

The array of measures presented in this document vary in the time frame required for their implementation. Typically, new ordinances and guidelines of the kind in progress in Sacramento tend to be developed and implemented within a few years. On the other hand, retrofitting pedestrian- or transit-oriented amenities into the existing urban and regional infrastructure may require up to 10 years, depending upon the magnitude of the expenditure, the complexity of the construction process, and the capital budgeting process in the affected jurisdictions.

A third set of measures may require in excess of 10 years for implementation. These include the kinds of measures which are designed to affect long-term regional growth patterns in a jurisdiction. Examples of these measures include urban growth boundaries, jobs/housing balance strategies and urban revitalization plans. These measures not only take several years to develop and adopt; they also must be in place, without substantial modification, for a long enough period of time to affect new development. Since a large number of developments are typically approved but not yet constructed in almost all jurisdictions, there may be a long lag time before new regulations can affect the urban design characteristics of activity centers. Furthermore, in a jurisdiction with a slow rate of population and employment growth, the ability of these regulations to affect overall levels of travel and air quality is substantially diminished. On the other hand, in rapidly growing regions in the United States, jurisdictions which act promptly

and effectively to modify their ordinances affecting urban design can expect to see measurable results of the kind indicated in the MSM (New Jersey) study within a shorter period of time.

Areas of Uncertainty

Several areas of uncertainty affect the magnitude of the impacts which can be achieved by urban design measures. The first is that there remains a scarcity of empirical data on their travel behavior consequences. Both the Cervero and the NCHRP study, while representing major contributions, are only the first steps in a process of validating by observation at individual sites what careful cross-sectional analysis has suggested should be the case. The NCHRP study provides empirical data, but its finding are handicapped by the lack of data on the urban design characteristics of the areas studied. It is expected that future research will underwrite much needed data collection in this area.

A second major area of uncertainty is the ability of currently available techniques to analyze and simulate the effects of urban design on travel behavior. In large part because of the scarcity of actual data, existing urban transportation and land use models, (such as those used in Seattle and Princeton) rely upon a series of exogenous assumptions in order to reach conclusions on key issues. These exogenous assumptions include, for example, the ways in which urban design can affect mode split, trip frequency and trip length.

However, even as data of this kind improves in quality and quantity, there is a need to enhance the state of the practice in transportation and land use modeling. Models which allow for interaction between transportation investments and land use decisions are essential in order to understand the effects of alternative distributions of employment and households. Interactive transportation and land use models are in use in fewer than ten major jurisdiction in the United States today. As their cost, reliability and ease of calibration improves, so will their use. As a result, the ability of planners and decision-makers to understand the systemwide effects of urban design improvements on travel behavior will also increase.

■ Implementation and Transferability

Implementation

The implementation of the kinds of ordinances and urban design standards discussed in this chapter is well within the authority of local government. Working with enabling legislation of their respective states, local government officials can develop and approve

ordinances and regulations which establish urban design standards for new development. The ability of local governments to regulate land uses within their boundaries has been well established for 75 years.

The process of implementing the kinds of measures previously described, however, requires several factors. First, strong leadership by local elected officials is imperative. Those officials, elected or appointed, responsible for development review within their communities must be prepared to organize the effort to adopt modifications to existing codes. Secondly, a public education effort is required to inform interested constituencies about the issues and benefits of better urban design measures, and involve these same constituencies in the development of the contents of the measures themselves.

As the results of the NCHRP study indicate, there typically is a coincidence of factors which combine with the urban design characteristics of activity centers to affect overall travel behavior and air quality. Thus, in modifying or adopting new ordinances or regulations, public officials must recognize that urban design measures in and of themselves cannot be as effective as these same measures can be in combination with other transportation control measures such as demand management, parking policy, parking pricing and others.

Since the private sector has shown the willingness and ability to develop new activity centers along the lines described here, officials must turn to these groups for information which can be used to educate and inform the public about alternatives to more prevalent design practices. Land use advocacy organizations, transit agencies and others concerned with the urban environment are already publicizing these projects.

Lastly, officials must recognize that the effectiveness of urban design measures also depends upon the practices of adjacent jurisdictions. The coordination of transportation and land use plans across jurisdictional lines is crucial to maximizing the benefits which better urban design measures can bring. The 1990 amendments to the Clean Air Act establish standards for such coordination and interaction between and among transportation planning agencies and others responsible for these issues at the state and local level. Only through the coordination of both planning and development reviews can the maximum benefits be achieved.

Transferability

The potential for urban design improvements to affect travel behavior and air quality in any given jurisdiction depends, among other things, on the degree to which undeveloped land remains available. Clearly once an urban design infrastructure is in place, the difficulty of retrofitting sufficient pedestrian and transit-oriented amenities to provide an inducement to alter travel behavior is severely constrained. Thus suburbs, more frequently than cities, and rural areas more frequently than suburbs, are in a position to make use of urban design measures.

On the other hand, even casual observation of recent events in our country's most densely developed urban employment centers indicates the degree to which urban development is a dynamic process, constantly renewing and modifying the urban design fabric of cities and regions. At every step of this process there are opportunities to affect the scale, density, mix of activities and amenities associated with urban development projects. Thus, opportunities for improving air quality through urban design can be considered as numerous as the development projects constantly requiring the approval of local elected officials today.

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