TRANSIT COOPERATIVE RESEARCH PROGRAM

SPONSORED BY

The Federal Transit Administration

TCRP Report 16

Transit and Urban Form

Volume 2

PART III A Guidebook for Practitioners

PART IV Public Policy and Transit-Oriented Development: Six International Case Studies

Transportation Research Board
National Research Council

TRANSIT COOPERATIVE RESEARCH PROGRAM

Report 16

Transit and Urban Form

Volume 2

PART III A Guidebook for Practitioners

PART IV Public Policy and Transit-Oriented Development: Six International Case Studies

PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.
Portland, OR

Subject Area
Public Transit
Planning and Administration

Research Sponsored by the Federal Transit Administration in Cooperation with the Transit Development Corporation

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY PRESS
Washington, D.C. 1996

TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transit Association (APTA), *Transportation 2000,* also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academy of Sciences, acting through the Transportation Research Board (TRB), and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

TCRP REPORT 16

Project H-1 FY'92
ISSN 1073-4872
ISBN 0-309-05722-1
Library of Congress Catalog Card No. 96-61356

Price $65.00

NOTICE

The project that is the subject of this report was a part of the Transit Cooperative Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the project concerned is appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, the Transit Development Corporation, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

Special Notice

The Transportation Research Board, the National Research Council, the Transit Development Corporation, and the Federal Transit Administration (Sponsor of the Transit Cooperative Research Program) do not endorse products or manufacturers. Trade of manufacturers' names appear herein solely because they are considered essential to the clarity and completeness of the project reporting.

Published reports of the

TRANSIT COOPERATIVE RESEARCH PROGRAM

are available from:

Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Printed in the United States of America

FOREWORD

By Staff
Transportation Research Board

TCRP Report 16 will be of interest to a broad cross section of individuals involved in transportation and land use planning and development. The research addressed many facets of the relationships between land use and public transportation. These relationships are reexamined, explained, evaluated, and documented to facilitate cost-effective multimodal public transportation investment decisions.

TCRP Report 16 presents the results from Project H-1, *An Evaluation of the Relationships Between Transit and Urban Form*. The research team was under the direction of Parsons Brinckerhoff Quade & Douglas, Inc., and included Dr. Robert Cervero, Howard/Stein-Hudson Associates, Inc., and Jeffery Zupan. Six reports were produced by the research team; a decision was made by the project panel to publish four of the six reports as a two-volume set, in the regular TCRP series. Report 16 consists of these two volumes, each containing two reports, as follows:

- **Volume 1.** Part I: *Transit, Urban Form, and the Built Environment: A Summary of Knowledge* and Part II: *Commuter and Light Rail Transit Corridors: The Land Use Connection*
- **Volume 2.** Part III: *A Guidebook for Practitioners* and Part IV: *Public Policy and Transit-Oriented Development: Six International Case Studies*.

The two reports that were prepared for this project but not published are available, on loan, from the TCRP. Their titles are 1) *Mode of Access and Catchment Areas for Rail Transit* and 2) *Influence of Land Use Mix and Neighborhood Design on Transit Demand*.

The six research reports prepared for TCRP Project H-1 by the Parsons Brinckerhoff research team are briefly described below.

Transit, Urban Form, and The Built Environment: A Summary of Knowledge (Volume 1, Part I)

This report synthesizes the overall findings and conclusions of TCRP Project H-1 and the existing body of literature on transit and urban form. The literature was summarized at the conclusion of Phase I of this research project in TCRP *Research Results Digest No. 7*. Empirical evidence from this project combines with previous research to demonstrate that transit and urban form relationships can be significant.

Commuter and Light Rail Transit Corridors: The Land Use Connection (Volume 1, Part II)

This report provides guidance on the land use characteristics that support new fixed-guideway transit services in a corridor. The work builds upon research conducted in the

1970s by Pushkarev and Zupan that established thresholds necessary to support transit in a cost-effective manner. That work is updated with data from current light rail and commuter rail cities and extended by considering the cost-efficiency (annual operating costs plus depreciation per vehicle mile) and effectiveness of service (daily passenger miles per line mile).

A Guidebook for Practitioners (Volume 2, Part III)

This report offers guidance to communities on patterns of development that encourage alternatives to the automobile for work and nonwork travel. It summarizes the key relationships between transit and urban form, outlines the role of transit in regional and corridor planning, and discusses the principles and tools for station-area planning and development.

Public Policy and Transit-Oriented Development: Six International Case Studies (Volume 2, Part IV)

This report uses case studies to determine the public policies and institutions necessary for transit-supportive development to occur. The case studies include three cities with rail systems and three with high-occupancy vehicle (HOV) lanes or exclusive busways. The six case study cities are Houston, Texas; Washington, D.C.; Portland, Oregon; Vancouver, British Columbia, Canada; Ottawa-Carleton, Ontario, Canada; and Curitiba, Brazil.

Mode of Access and Catchment Areas for Rail Transit

This unpublished report examines the influence of the built environment on two aspects of transit demand: 1) the mode of access to and from rail stations and 2) the sizes and shapes of catchment areas. Three rail systems were used as case studies: the Bay Area Rapid Transit System (BART), which provides heavy rail transit in the San Francisco Bay Area; Metra, which provides commuter rail service to Chicago; and the Chicago Transit Authority (CTA), which provides heavy rail service mainly within the city of Chicago.

Influence of Land Use Mix and Neighborhood Design on Transit Demand

This unpublished report examines the relationships of residential built environment on transit patronage. The emphasis is on the ways mixed land uses and urban design in residential neighborhoods affect travel choices, controlling for densities, household income, and transit service characteristics. The purpose is both to fill in the gaps in the state of current knowledge about the ways the built environment influences transit use and to confirm and validate several conclusions from the growing body of research on this subject. Multiple approaches are used to better understand the concept of mixed land use and its role in shaping travel choices.

CONTENTS

Part I Transit, Urban Form, and the Built Environment: A Summary of Knowledge

Part II Commuter and Light Rail Transit Corridors: The Land Use Connection

Part III A Guidebook for Practitioners

Part IV Public Policy and Transit-Oriented Development: Six International Case Studies

ACKNOWLEDGMENTS

Jane Howard of Howard/Stein-Hudson Associates, Inc., is the principal author of this guidebook. Arnold Bloch of Howard/Stein-Hudson Associates was responsible for Chapter 3.

Samuel Seskin of Parsons Brinckerhoff Quade & Douglas, Inc.; Robert Cervero of the University of California, Berkley; and Jeffrey Zupan, a transportation consultant, contributed to all sections of the guidebook, both directly and through their work on the H-1 Topic reports, *TCRP Research Results Digest 7*, and *Transit, Urban Form, and the Built Environment: A Summary of Knowledge,* which are summarized in the guidebook chapters.

Robyn Champion and Michelle M. Faith of Howard/Stein-Hudson Associates assisted with editing, production, and other phases of the work.

COOPERATIVE RESEARCH PROGRAMS STAFF

ROBERT J. REILLY, *Director, Cooperative Research Programs*
STEPHEN J. ANDRLE, *Manager, Transit Cooperative Research Program*
DIANNE S. SCHWAGER, *Senior Program Officer*
EILEEN P. DELANEY, *Editor*
KAMI CABRAL, *Assistant Editor*
HILARY FREER, *Assistant Editor*

PROJECT PANEL H-1

GEORGE T. (TERRY) LATHROP, *Charlotte DOT, Charlotte, NC (Chair)*
H. SCOTT BAKER, *KPMG-Peat Marwick, McLean, VA*
RICHARD G. BICKEL, JR., *SEPTA, Philadelphia, PA*
THOMAS BUICK, *Maricopa DOT, Phoenix, AZ*
SHARON GERACI, *TRI-MET, Portland, OR*
CHRISTOPHER LEINBERGER, *Robert Charles Lesser & Co., Santa Fe, NM*
EVA LERNER-LAM, *The Palisades Group, Tenafly, NJ*
WILLIAM LIEBERMAN, *Metropolitan Transit Dev. Board, San Diego, CA*
MARY K. MURPHY, *Louis Berger & Associates, East Orange, NJ*
ROY NAKADEGAWA, *SF Bay Area Rapid Transit Dist., Berkeley, CA*
C. KENNETH ORSKI, *Urban Mobility Corp., Washington, DC*
RICHARD TUSTIAN, *Lincoln Institute of Land Policy, Bethesda, MD*
RICHARD P. VOITH, *Federal Reserve Bank of Philadelphia, Philadelphia, PA*
BARRY WALLERSTEIN, *So. Coast Air Quality Mgmt. Dist. Planning & Technical Advancement Office, Diamond Bar, CA*
RICHARD STEINMAN, *FTA Liaison Representative*
EDWARD THOMAS, *FTA Liaison Representative*
PETER L. SHAW, *TRB Liaison Representative*

CHAPTER **1**

INTRODUCTION

As the 20th century nears an end, land use and transportation planners and decision makers are reexamining the relationship between transportation and urban form while keeping the following issues in mind:

- Rapidly growing metropolitan areas, faced with increasing traffic congestion and environmental degradation, are trying to manage growth so as to reduce automobile dependence and preserve open spaces and agricultural lands.
- Suburban activity centers, developed around convenient automobile access, are reaching levels of development and employment densities similar to many downtowns. Planners and decision makers are trying to integrate transit service and pedestrian improvements into these automobile-oriented areas.
- More and more suburban communities are turning to "neo-traditional" planning concepts to help restore pedestrian life and a sense of community to automobile-oriented, residential areas.
- Older cities, many of which were built up around transit lines, are losing population and employment to suburban areas. As suburbs develop and automobile ownership rates increase, transit ridership declines and costs per rider increase. This situation leads to a discouraging cycle of higher fares, service cuts, further ridership declines, and station closings. Reduction in accessibility and service quality accelerates the economic decline of city neighborhoods and business districts. Planners are thus seeking ways that transit investments and transitrelated development can be used to help revitalize downtowns and rebuild neighborhoods.

The common factor in these situations is the search for patterns of development that encourage alternatives to the automobile for work- and non-work-related travel.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) mandated the coordination of land use and transportation planning and resulted in new regional plans and visions that integrate land use and transportation, along with a focus on transit-oriented "Livable Communities." This integration represents a redirection for U.S. planners, who have always understood the connection but often seemed to act as if land use and transportation were independent of each other.

Numerous cities in Canada, Europe, and South America have developed successful, innovative transit-land use plans. Although U.S. planners often point to Toronto, Vancouver, Gotteborg, or Curitiba as examples of transit-land use planning that "could never work in the U.S.," several U.S. cities are trying to ensure that transit is used to its full potential in shaping urban form and directing growth. To do so, they are applying lessons learned and new techniques and initiatives to reduce the loss of jobs and housing to the suburbs and to reduce automobile dependence.

TCRP Project H-1, Transit and Urban Form, has focused on updating the state of knowledge about ever-changing land use-transit relationships in light of new demographics and urban form. The research was organized to look separately at the effects of urban form on transit ridership and cost-effectiveness and the effects of transit investment on shaping land use and urban form. Case studies of the social, political, and institutional contexts within which transit is planned, built, and operated were conducted in three U.S. and three foreign cities to develop an understanding of the relationships between transit and urban form. Exhibit 1 summarizes the research conducted for TCRP Project H-1.

Key questions addressed by the research are as follows:

- Can transit play an effective role in long-range regional planning?
- If so, what are the most important corridor characteristics and station area planning principles to ensure transit's effectiveness and efficiency?

The research findings are clear: transit-oriented regions must adopt policies that support more compact urban form and encourage land use mix and transit-friendly design. In addition, other institutional and financial supports must be in place to help provide dependable, high-quality transit services.

This guidebook, one product of the TCRP H-1 research, supplements additional research products, as follows:

- *Public Policy and Transit-Oriented Development: Six International Case Studies* (1996) (Volume 2, Part IV of this report);

SUMMARY OF RESEARCH CONDUCTED FOR TCRP H-1

How Urban Form Influences Transit Demand

How do characteristics of urban form (e.g., residential density and CBD employment size and density) influence the demand for light rail and commuter rail transit and the cost of providing such service?

Data used: Light rail boardings and transit information from 11 light rail cities with 19 lines. Commuter rail boardings and transit information from 6 commuter rail cities with 47 lines. Employment and population characteristics from the 1990 Census. Cost information from Federal Transit Administration reports, 1993 National Transit Database, and transit agencies.
Main findings: Residential densities have a significant influence on rail transit station boardings. Residential densities have more influence on light rail ridership and costs than on commuter rail. Both the size and the density of the CBD influence light rail ridership. CBD density is more important for supporting commuter rail ridership than light rail ridership. Other factors within the control of transit agencies, such as the availability of feeder bus service and park-and-ride lots, also influence ridership.
Product: *Commuter and Light Rail Transit Corridors: The Land Use Connection* (1996) Volume 1, Part II of this report

How does the built environment near rail transit stations affect the mode of access and the size of the catchment area?

Data used: Transit, regional land use, and 1990 Census data for Chicago (Metra commuter rail and CTA rapid rail) and San Francisco (BART).
Main findings: Residents of higher-density residential areas are more likely to walk to transit. Nearly all commuters walk to their destinations in CBDs, but 25 to 50 percent ride buses at other destinations. Use of feeder bus service depends mainly on the level of service and parking available, not on the built environment. Catchment areas are larger in more suburban areas and where parking is ample.
Product: *Mode of Access and Catchment Areas of Rail Transit* (1996) unpublished

Do neighborhood land use mix and urban design influence the demand for transit?

Data used: American Housing Survey for 1985. Transit and land use data for Chicago. Mail survey of residents and field observation of urban design in 12 East Bay census tracts in San Francisco area.
Main findings: The types and mix of land uses influence the demand for transit as well as the use of non-motorized modes. Residents of "traditional" neighborhoods are more likely to use non-automotive modes for non-work trips than residents of "suburban" neighborhoods. It is difficult to sort out the effects of land use mix and urban design because they are strongly correlated with density.
Product: *Influence of Land Use Mix and Neighborhood Design on Transit Demand* (1996) unpublished

How Transit Influences Land Uses

What public policies and institutions are needed for transit-supportive development to occur near transit stations?
Data used: Published reports, agency records, interviews, and site visits to six case study cities: Houston, Texas; Washington, D.C.; Portland, Oregon; Vancouver, B.C., Canada; Ottawa-Carleton, Ontario, Canada; and Curitiba, Brazil.
Main findings: Regions with successful transit-focused development have the following characteristics:

- Commitment to a regional vision of high-capacity transit connections between regional center or in development corridors;
- Strong, respected institutions that people trust to deliver services;
- Political cultures that value transit;
- High-quality transit service that attracts riders;
- Regional growth that provides the development to channel to station areas;
- Transit stations in areas where the market supports development;
- Regional policies that focus growth in transit corridors and limit it elsewhere;
- Station area policies and programs to support private-sector investments and transit-friendly development; and
- Long-term commitment.

Product: *Public Policy and Transit-Oriented Development: Six International Case Studies* (1996) Volume 2, Part IV of this report

Exhibit 1. Summary of research conducted for TCRP Project H-1.

- *Transit, Urban Form, and the Built Environment: A Summary of Knowledge* (1996) (Volume 1, Part I of this report).
- *Commuter and Light Rail Transit Corridors: The Land Use Connection* (1996) (Volume 1, Part II of this report);
- *Mode of Access and Catchment Areas of Rail Transit* (1996) (unpublished);
- *Influence of Land Use Mix and Neighborhood Design on Transit Demand* (1996) (unpublished); and
- "An Evaluation of the Relationships Between Transit and Urban Form," *TCRP Research Results Digest 7* (1995);

The guidebook summarizes the research findings and suggests applications at the regional, corridor, local, and site level. Intended for use during planning, approval, and design, this guidebook is designed to assist state and regional land use and transportation planners, developers, and decision makers with land use regulation, development program, and transit investment and service planning decisions.

The guidebook contains information on the following subjects:

- The basic relationships between urban form and public transportation;
- The role of transit in regional planning;
- The role of transit in corridor planning; and
- Station area planning and development.

CHAPTER **2**

BASIC RELATIONSHIPS BETWEEN URBAN FORM AND PUBLIC TRANSPORTATION

Transportation systems—highway, transit, and pedestrian—are indispensable to a region's economy. People need convenient, cost-effective means of access to places to live, work, and shop. Transit systems have served central business districts (CBDs) well, but employment and housing increasingly are located in suburban areas, which are more difficult to serve with transit.

The automobile—and its attendant highway and street network—is by far the most frequently used access mode for work- and non-work-related trips. Out of 31.6 billion urban area commuting trips in 1990, 92.2 percent were made using privately operated vehicles (Vincent, Keyes, and Reed, p. 4-3). Federal funding policy supports this dependence on the automobile—in 1995, federal spending on highways outpaced spending on transit almost 5 to 1.

Public transportation services—rapid transit, commuter rail, light rail, and bus—can and do provide extensive mobility and access, given land use patterns that ensure sufficient ridership to make the service cost-effective. Although transit accounted for less than 2 percent of all trips in urban areas nationwide, it accounted for 5.2 percent of all trips in large urban areas with rail transit service. In large urban areas with rail service, the proportion of walking trips (13.1 percent) was also highest. According to the *National Personal Transportation Survey*, "These mode choice findings reflect not only a wider variety of transportation services available in large rail urban areas, but also residential and urban densities that promote less reliance on private vehicle trip-making" (Vincent, Keyes, and Reed, p. 4-3). In some high-density corridors (e.g., Manhattan, downtown San Francisco, and Washington, D.C.) transit still carries 30 to 60 percent of workers—an indispensable means of transport. Supported by strong "transit-first" planning and policy, high-quality bus systems in Ottawa and Curitiba carry 70 to 75 percent of downtown workers.

The rest of this chapter discusses transportation-related attributes of urban form as follows:

- Density or compactness,
- CBD size,
- Land use mix, and
- Urban design.

Also discussed are how these attributes encourage transit use and reduce automobile use.

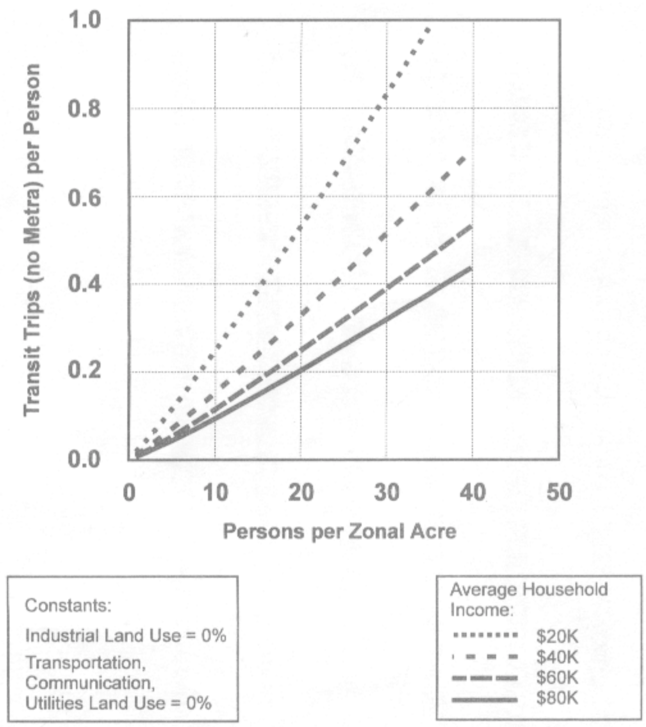
DENSITY OR COMPACTNESS

Density or compactness of employment and population is the single most important factor associated with transit use. (See Volume 1, Part I, Section 2.2, for a fuller discussion of this topic.) Residential density is measured in terms of dwelling units or persons per acre or square mi; employment density is measured in terms of jobs or commercial square ft per acre or square mi. As density increases, automobile ownership declines, and automobile travel—as measured by gasoline consumption or per capita vehicle miles of travel (VMT)—also decreases. Similarly, transit use increases with density.

The feasibility of providing various types of transit service and the cost of providing such service depends on the density of the area to be served. Without sufficient density, provision of transit-friendly features will not guarantee adequate ridership to ensure cost-effective service.

Residential densities influence commuter mode choices, transit trips per person, proportion of personal trips by transit, and rapid rail station boardings. Such densities are particularly important in determining light rail ridership. Station-area employment densities, on the other hand, influence the number of boardings at commuter rail stations.

In a sample of 11 large metropolitan areas (*Influence of Land Use Mix and Neighborhood Design on Transit Demand, Executive Summary* [unpublished]), the density of nearby housing strongly influenced commuter mode choices. Holding constant the mix of land uses, residents of higher-density areas were more likely to commute by transit, walking, bicycling, or combinations thereof and less likely to drive than people who live in lower-density areas. For example, the probability that a person in a one-car household commutes by transit is almost 30 percent if that household is in a mid- to high-rise multi-family neighborhood in a central city, but it is less than 10 percent if that person lives in a mostly single-family neighborhood in the city. In Chicago, a doubling of residential densities more than doubles transit use (Volume 1, Part I, Section 2.2 and Figure 1.) The difference in transit use between the residents of the two types of neighborhoods narrows, however, as the number of cars owned by the household increases. For the most conveniently located housing (i.e., within 0.25 mi of stations or bus stops), however, density matters less than the characteristics of the destination (i.e., whether jobs are near rail and whether commuters have to pay for parking).



Source: *Influence of Land Use Mix and Neighborhood Design on Transit Demand*

Figure 1. Chicago bus and heavy rail trips per person by residential density and average income.

CBD SIZE

Closely related to density is the size of the principal employment center (i.e., the CBD) in a region. (See Volume 1, Part II, for a more detailed discussion of this topic.) A minimum downtown size of 5 million square ft of commercial space is necessary to sustain very low levels of bus service; a downtown size of more than 20 million square ft of commercial space is necessary to sustain light rail service. In the 1970s, Pushkarev and Zupan showed how the feasibility and cost-effectiveness of providing various modes of transit varied by downtown size (Pushkarev and Zupan, 1977, p. 2 and Figure 2.) In the 1990s, activity center size has become a factor for a central downtown and for suburban activity centers in many urban areas. Planners must address how big activity centers should be to support transit service, how the growth of satellite centers affects the viability of transit service to other activity centers and to the CBD, and how the traffic effects of higher-density activity centers can be reduced.

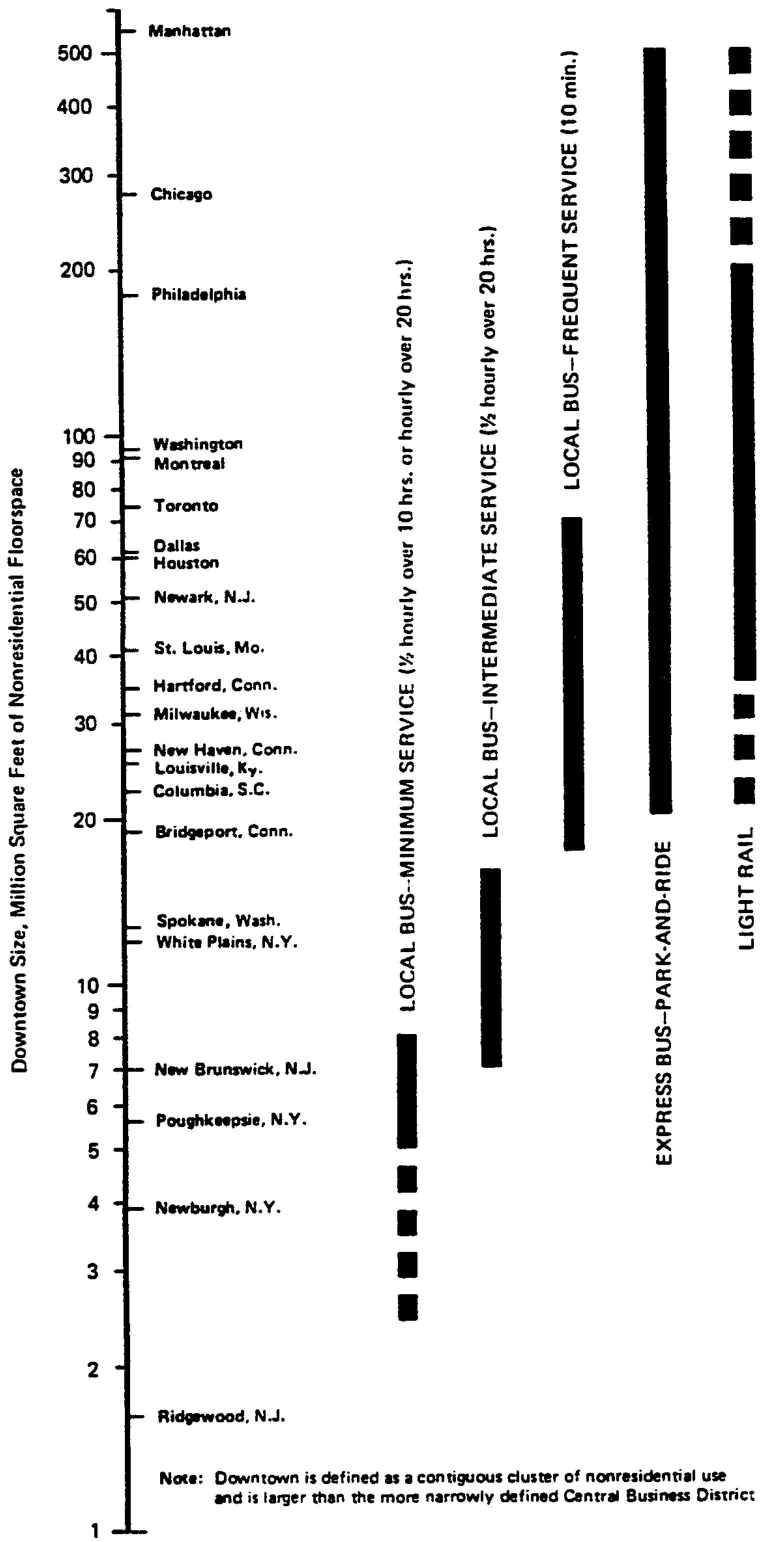
LAND USE MIX

Land use mix is related to density and CBD size in that the larger and denser the area, the more likely that various activities will be available. (See *Influence of Land Use Mix and Neighborhood Design on Transit Demand* [unpublished] for a more detailed discussion of this topic.) Cities traditionally have incorporated mixed uses into their neighborhoods and downtowns. Suburban zoning, on the other hand, has encouraged homogeneity of land use and separation of commercial, retail, and residential areas.

In general, land use mix shortens trips and encourages walking and transit use. At a regional level, a balance between the number of jobs and the number of dwelling units (i.e., jobs versus housing balance) helps to shorten work-related trips and reduce automobile use. Within employment centers, land use mix influences mid-day mode-choice decisions—enabling walk or transit trips to substitute for automobile trips. In neighborhoods, land use mix induces transit use for commuter trips, although it is less influential than density. In fact, density accounts for 10 to 20 times more transit use for commuting trips than land use mix. Table 1 shows how different station area land uses influence commuter rail and rapid rail boardings in Chicago. The Chicago Transit Authority (CTA) rapid rail stations, which are mainly in the city of Chicago, had higher boardings when more of the surrounding land uses were residential, commercial, institutional, or in transportation facilities. For example, if one station area had 10 percent more commercial activity (e.g., malls and office parks) nearby than another station area with similar land use densities, household incomes, and transit service then the station with more commercial activity had, on average, 30 percent more riders. Metra commuter rail boardings, however, are mainly influenced by the amount of undeveloped land near the stations, many of which are in relatively undeveloped suburban and exurban areas. If two Metra stations have similar transit service and residents but one has 10 percent more vacant land nearby, the station with the vacant land will have 27 percent fewer riders. (The unexpected positive relationship between the proportion of land in agriculture and the number of boardings probably results from the large parking lots at rural stations.)

In the 11-city survey conducted for the TCRP H-1 study, a resident's proximity to non-residential uses influenced mode choice for commuting trips. People who live in "mixed-use blocks" with non-residential uses within 300 ft of their residences are 1 to 2 percent more likely to commute by transit, 10 to 15 percent more likely to commute by walking or bicycling, and 3 to 4 percent less likely to commute by car than people who live in purely residential areas (holding income and density constant). As shown in Figure 3, the residents of mixed-use areas also own fewer cars and commute shorter distances (holding constant residential densities).

In terms of transit operations, land use mix at outlying stations or bus stops helps ensure balanced ridership and encourages transit use for non-work-related and off-peak trips; however, it is unclear whether adding retail activity to neighborhoods will result in more local shopping trips (made more often by foot or shuttle transit) that would otherwise be made by car to shops outside the neighborhood.



Source: Pushkarev and Zupan (1977)

Figure 2. *Transit modes suited to downtown size.*

TABLE 1 Changes in Metra and CTA boardings because of land use mix

(Note: A 10-percentage-point increase in the share of land in each use produces the following changes to boardings [controlling for residential densities, average household incomes, and transit service characteristics].)

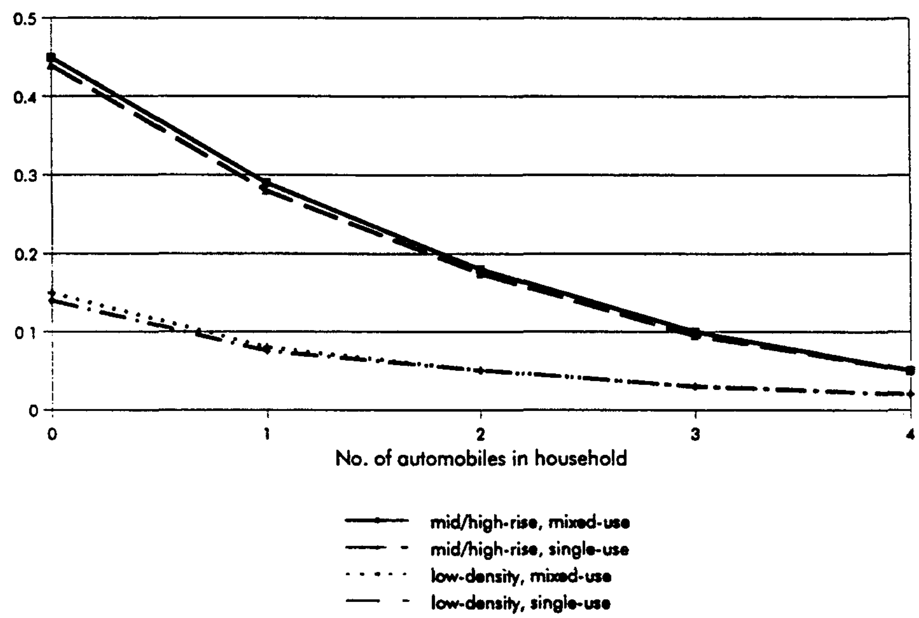
Variables	Metra Commuter Rail	CTA Rapid Rail
Proportion of station area land in:		
Single-family housing		10.6%
Multi-family housing		20.3%
Malls/office parks		30 7%
Institutional uses		33 8%
Transportation, communications		50 2%
Agriculture	24 4%	
Open spaces	-17 1%	
Vacant	-27.4%	

* See *Influence of Land Use Mix and Neighborhood Design on Transit Demand* for a complete explanation of the variables and their significance.

URBAN DESIGN

Pedestrian-friendly urban design supports transit use and travel by non-motorized modes. Urban design considerations can be used in selecting station sites and planning for land uses in station areas. Urban design can promote transit-oriented land use served by a mix of automobile and transit services. Overall, effective urban design makes higher densities acceptable to consumers. (See *Influence of Land Use Mix and Neighborhood Design on Transit Demand* [unpublished] for a more detailed discussion of this topic.)

Research conducted at several hundred California work sites, as shown in Table 2, indicates that land use mix and urban design features at work sites increase the number of work-related trips made using transit by 3 to 4 percentage points. For instance, the first line of Table 2 shows that transit



Source: American Housing Survey, presented in *Influence of Land Use Mix and Neighborhood Design on Transit Demand,* Section 3.2.

low density	=	**single-family detached and single-family attached/low-rise, multi-family units**
mid-/high-rise	=	**mid-rise and high-rise multi-family buildings**
mixed use	=	**residences with commercial and other non-residential buildings within 300 feet**
single use	=	**residential with no commercial or other non-residential buildings within 300 feet**

Source: *Influence of Land Use Mix and Neighborhood Design on Transit Demand,* pp. 10–11.

Figure 3. Probability of commute by transit for four land use scenarios.

TABLE 2 Transit shares at work sites with alternative land use characteristics and TDM programs

Land Use Characteristics	Transit with Land Use Characteristics Missing	Transit with Land Use Characteristics Present	Absolute Change	Increase
Mix of land use	2.9%	6.4%	+3.5%	120%
Accessibility to transit	3.4%	6.3%	+3.3%	85%
Availability of convenience services	3.4%	7.1%	+3.7%	108%
Perception of safety	3.6%	5 4%	+1.8%	50%
Aesthetic urban setting	4.2%	8.3%	+4.1%	102%

Source: Cambridge Systematics, 1994

is used on average for 2.9 percent of commuting trips at work sites without a mix of land uses, but transit use increases to 6.4 percent when land uses are mixed. Thus, land use mix boosts transit ridership to work sites by 120 percent. Transit use effectively doubled for all characteristics except safety, which contributed to a 50-percent increase. Of all of the factors analyzed, urban design factors (defined as "aesthetic urban settings") had the greatest influence on transit mode choice. The study showed that, although the presence or absence of shade trees, sidewalks, graffiti, and other factors affect mode choice, when the influences of land use were examined independently of the presence of various travel demand management programs at the work sites, only the aesthetic urban settings remained statistically significant (Cambridge Systematics, Inc., 1994). (See Volume 1, Part I, Section 2.3.)

These factors are interrelated and should not be considered separately. Although compact urban form is considered a far more powerful influence on transit use than is land use mix or design, these aspects of the built environment typically occur in more compact or densely developed places, so their influences are difficult to separate. In Portland, Oregon, researchers found that the combination of land use mix and urban design can reduce automobile trips by 7 percent (controlling for density and income) (1000 Friends of Oregon, 1995). The public policies and regulatory actions that influence each of these factors necessarily differ by scale.

CHAPTER **3**

ROLE OF TRANSIT IN REGIONAL PLANNING

In the late 19th and early 20th centuries, most regional development was characterized by a dense, mixed-use downtown surrounded by residential communities. Transit helped shape this pattern by providing radial access from downtowns to suburbs—first by streetcar, then by rapid transit and commuter rail. Today, many of the highest ridership bus routes operate on roads formerly served by trolley lines. In older metropolitan areas, neighborhoods developed in tandem with transit lines; many of these areas still reflect the high-density, mixed-use characteristics that continue to support transit use. Strong CBDs remain the most supportive of transit use, and transit lines reinforce the downtown as a development center.

In San Francisco, the "BART at 20" study showed that, in the downtown area, far more employment growth has occurred near to rather than away from BART stations. BART has anchored job growth, providing a "real but unmeasurable" benefit to the San Francisco CBD. Commercial rents are highest in locations served by BART, and more than 40 million square ft of office inventory was added within 0.25 mi of BART stations between 1975 and 1992. Non-residential densities have steadily risen near downtown BART stations, although they have stagnated or declined elsewhere on the system. Simultaneously, however, "BART has also played a role in the emergence of a multi-centered metropolitan form" (Cervero, 1995, p. 178).

Although the success of transit depends on downtowns, the share of total regional jobs in downtowns fell in every metropolitan area in the United States during the 1980s (Leinberger, 1993). In some regions, individual suburban centers actually exceed the downtowns' share in regional population and employment. Even cities served by rail transit (e.g., Atlanta and Chicago) saw more than 80 percent of employment growth occur outside of their CBDs during the 1980s. In San Francisco, changes in regional population and employment were greater in areas not served by BART than in BART-served corridors. If transit (whether rail, light rail, or bus) is to maintain or expand its market share, it must serve major subregional employment hubs and activity centers as well, or the share of jobs in CBDs must be either stabilized or increased. Regional planners are trying to determine how land use and transportation planning can be integrated to promote transit use within the desired land use pattern.

This study addresses the following key questions:

- Can transit still play an effective role in long-range regional planning?
- If so, what is the best way to ensure that cost-effective services and facilities are provided?

(See Volume 1, Part II, for a more detailed discussion of this topic.)

CAN TRANSIT STILL PLAY A KEY ROLE IN LONG-RANGE REGIONAL PLANNING?

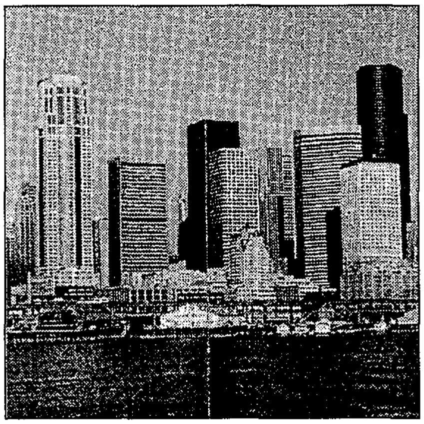
Regions can succeed in integrating transit into their land use planning. Key to this success is adoption of a strong regional vision of the desired settlement pattern. Land use regulations must also be developed to implement this vision. Transit can then be used for focusing growth.

Motivated both by ISTEA requirements for integrated land use and transportation plans and by success in Canada, Europe, and South America, many U.S. regions are in the midst of long-range transportation planning. In countries where the government plays a strong role in setting land use policy and cities have tended to be more homogeneous, it is easier to develop a common vision of what is in the public interest than it is in the United States

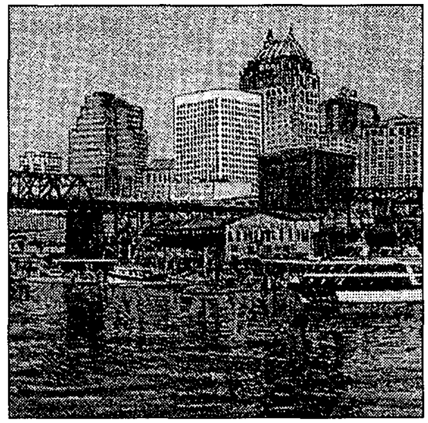
Many areas recognize that directing regional growth toward downtowns, where development can be served by transit and where automobiles are less necessary, will be beneficial. To this end, many areas are encouraging the development of a hierarchy of growth centers as an alternative to unplanned development in outlying areas. Figure 4 illustrates Seattle's hierarchy.

Regions that have succeeded in maximizing the influence of transit on urban form have integrated transit service into their land use and development plans. They put transit first, limit highway access, and implement regulations that ensure transit-friendly land use. These elements are necessary to achieve desired automobile trip reduction and land use management goals.

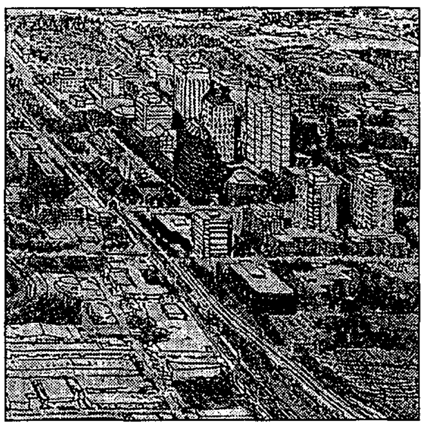
No single vision is more appropriate than another. A vision must suit the general wishes of residents and the topography. Various alternative models to a single CBD are discussed in the following sections.



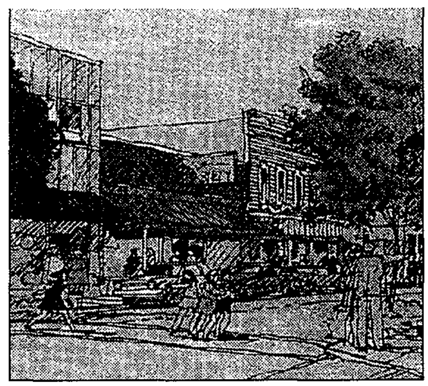
Downtown Seattle Skyline



Metropolitan Centers: Bellevue, Bremerton, Everett, Tacoma, Renton: linked to downtown by rail

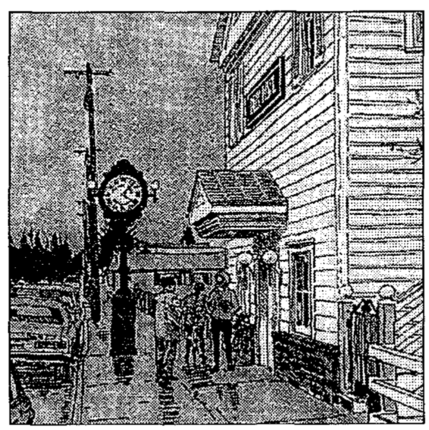


Subregional Centers: located along transit and bus routes



Pedestrian Pockets: "traditional" small towns inside suburbia

Activity Clusters: not necessarily served by transit



Small Towns: central places in both urban and rural areas

Source: Puget Sound Council of Governments, *Vision 2020*, October 1990

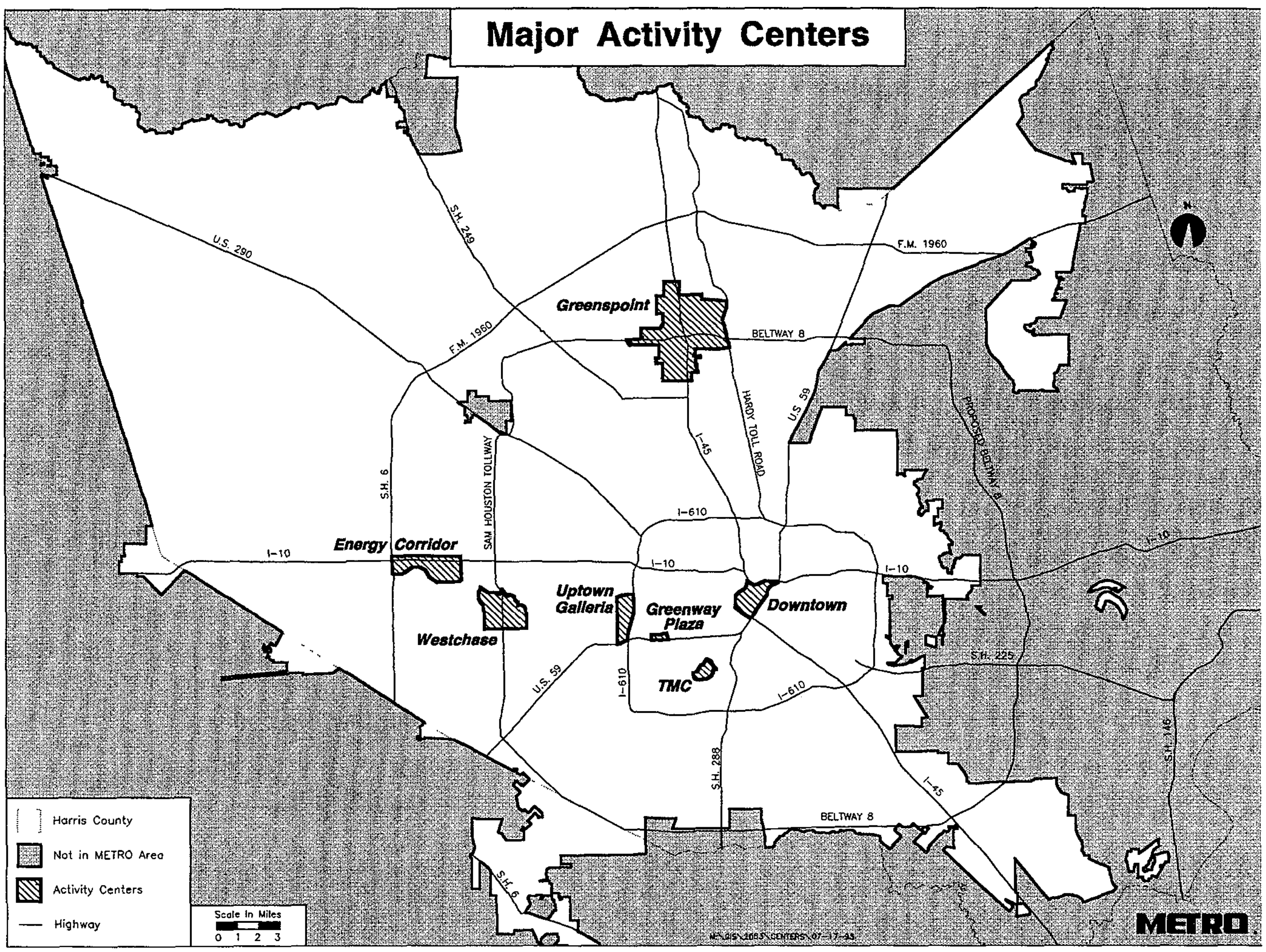
Figure 4. Seattle's hierarchy of centers.

Multi-Centers

Houston, Texas, adopted a low-density model with dispersed suburban activity centers (see Figure 5). The downtown accounts for only 9 percent of regional employment. Automobile access predominates, with strong local bus service to serve transit-dependent city residents, paired with express service, carpools, and vanpools on high-occupancy vehicle (HOV) lanes from suburban areas to downtown. Many activity centers have little transit service, but some major activity centers have "transit" shares (mainly company-sponsored vanpools and private buses) nearly as large as the downtown's. Transit use overall is relatively low. In Houston entrepreneurial van services have adapted to the low-density settlement pattern, with government helping by installing HOV lanes.

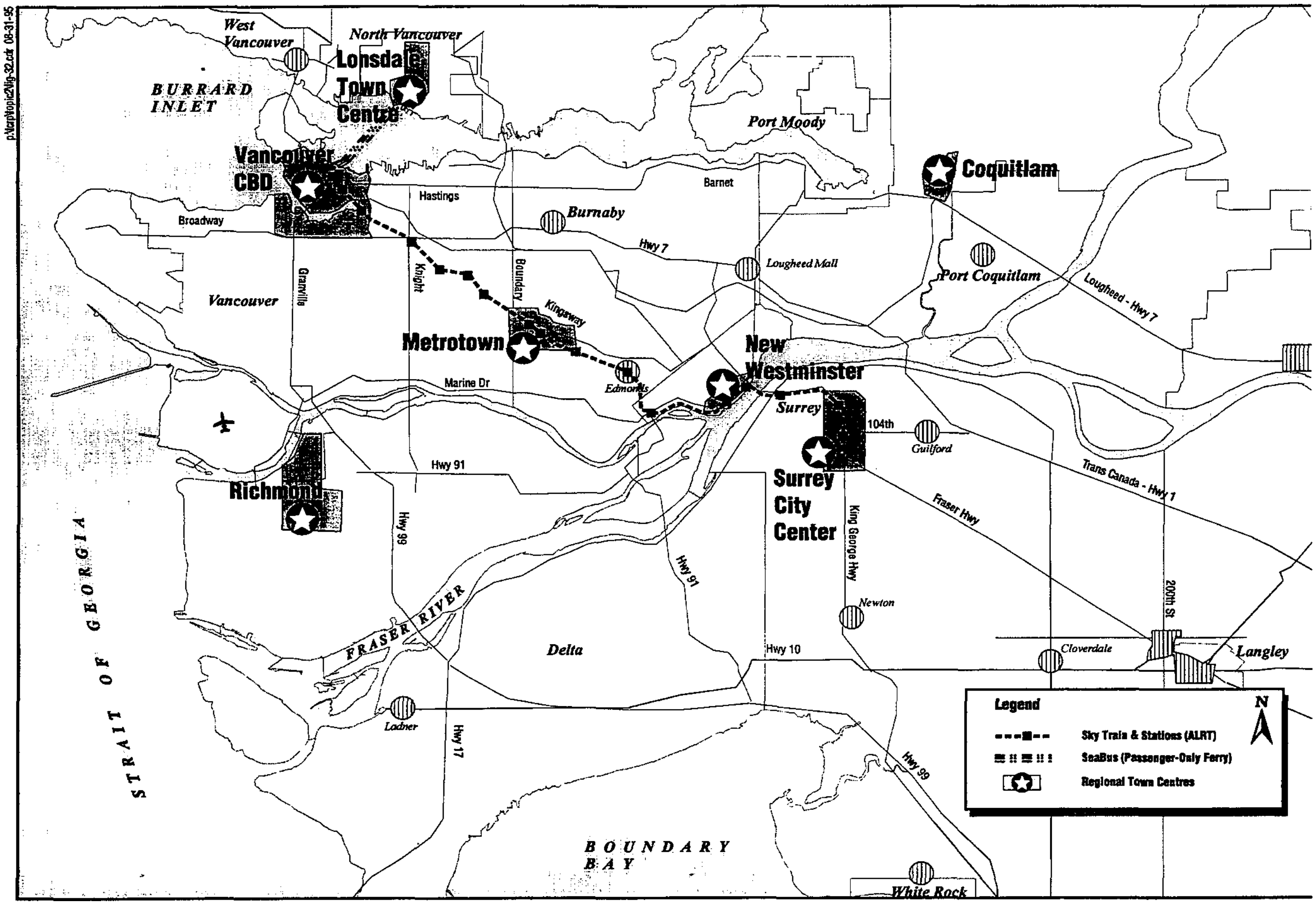
Vancouver, British Columbia, has used transit as the primary tool for implementing its vision of a multi-centered region (see Figure 6 and Tables 3, 4, and 5). To support a strong regional downtown accounting for 40 percent of regional employment, six Regional Town Centers serve as the downtowns of communities of between 100,000 and 200,000 people. Four of these are linked by the SkyTrain and SeaBus system; commuter rail and express bus transit are being considered as links to the remaining two. As the Vancouver region has grown, planners have used advanced light rail and passenger ferry services to channel development to underused properties in four designated regional centers. Multi-centered development has been encouraged by transit services and by supportive zoning, location of government agencies in station areas, and other initiatives. Strong parking management and moratoriums on highway construction also were used to shape growth.

In Ottawa, Ontario, decision makers and planners have developed a multi-centered regional structure for the area. Ottawa, the dominant center, is surrounded by primary and secondary employment centers. Under the Official Plan, downtown Ottawa is to remain the dominant employment



Source: *Public Policy and Transit-Oriented Development: Six International Case Studies*

Figure 5. Houston's major activity centers.



Source: *Public Policy and Transit-Oriented Development: Six International Case Studies*

Figure 6. Vancouver's Regional Town Centers.

center for the region. (Today, the downtown accounts for 28 percent of regional employment.) Nine primary employment centers will incorporate 5,000 or more jobs; each of these employment centers must be within 400 m of existing or future transitway stations. Secondary employment centers will provide 2,000 to 5,000 jobs. These centers can be off the transitway but must have access to efficient transit services (see Figure 7).

The cornerstone for achieving this vision is Ottawa's exclusive busway system—the most extensive in North America—which captures 70 percent of CBD work-related trips. The region has a "transit first" policy whereby rapid-

TABLE 3 Vancouver Regional Town Centers: primary land uses (acreage)

Town Centers	Metrotown	Coquitlam Town Center	Lonsdale Town Center	New Westminster	Richmond Town Center	Surrey City Center
Land Area (acres)						
All land uses	735	450	625	170	1,766	980
Commercial area	138	244	108	80	445	210
Residential area	206	49	250	41	956	685
Parks & open spaces	238	143	32	6	169	85
Regional Transit Link	SkyTrain		SeaBus	SkyTrain		SkyTrain

Source: Greater Vancouver Regional District, *Greater Vancouver Key Facts*

TABLE 4 Vancouver Regional Town Centers: development floor space (square ft)

Town Centers	Vancouver CBD *	Metrotown	Coquitlam Town Center	Town Center (N. Vanc. Quay)	New Westminster	Richmond Town Center	Surrey City Center
Building Floor Space (in millions of square feet)							
Office	22.800	2.400	0.170	1.200	0.930	1.500	0.040
Shopping center		1.800	1.100	.0300		1.400	1.100
Other retail	11.200	0.060	0.098	1.000	0.930	1.700	0.400
Total commercial	**34.000**	**4.800**	**1.400**	**2.200**	**0.190**	**4.500**	**1.800**

* Vancouver CBD values are for 1991; town center values are for 1993/4.
Source: Greater Vancouver Regional District Strategic Planning Department and *Greater Vancouver Key Facts*, 1994.

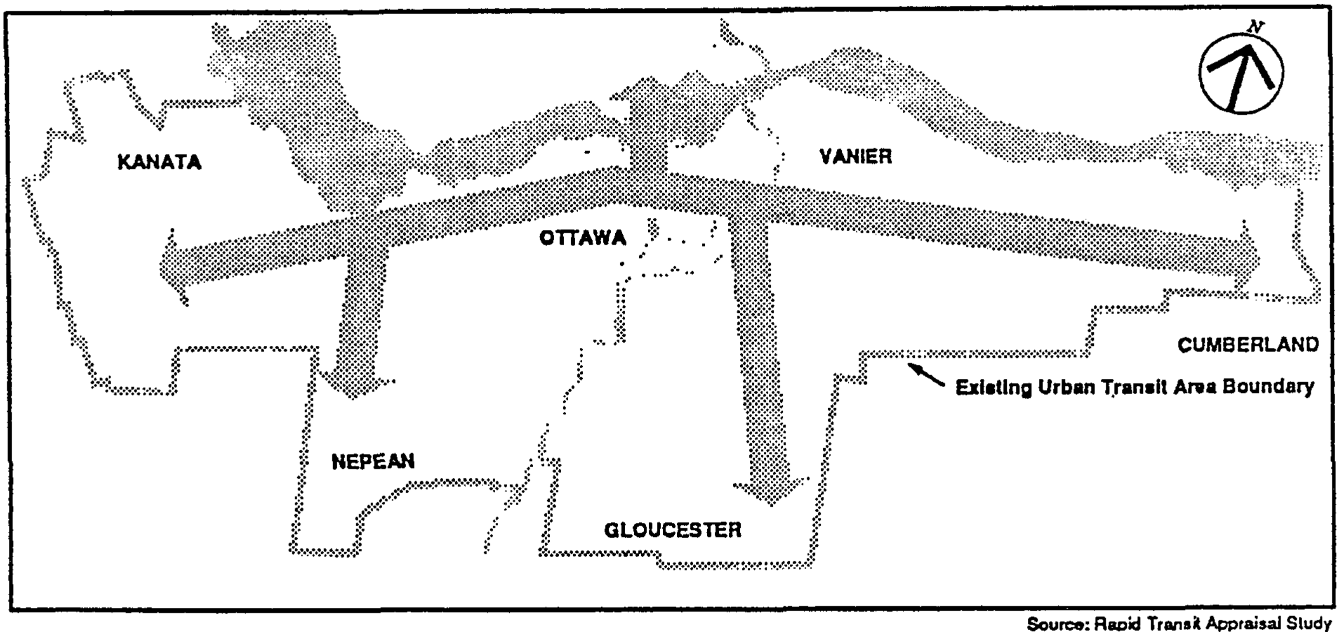
TABLE 5 Regional Town Centers: services provided

Services	Town Centers					
	Metrotown	Coquitlam	Lonsdale Quay	New Westminster	Richmond	Surrey City Ctr. (Whalley)
Cinema	●	●	●		●	
Library	●	●	●	●	●	●
Recreation Ctr.	●	●	●	●	●	●
College Campus/ Secondary Ed.		P	●		●	
Courthouse			●		●	
Municipal Hall		P	●	N	●	
Hospital			●	●	●	●
Art Gallery		P	●	●	●	●
Museum			●		●	
Theater	●	P	●		●	
Public Market			●			
Arena/Stadium	●		●	N	●	
Child Care Ctr.	●		●	●	●	●
Youth Ctr.	●	P	●	●		●
Senior Ctr.	●	P	●	●	●	●
Health Ctr.			●	●	●	●
Assisted Housing	●	N	●	●	●	●
Public Square	●	P	●	●	●	P
Ethnic Shopping District			●	P	●	
Regional Transit	SkyTrain		SeaBus	SkyTrain		SkyTrain

Source: Greater Vancouver Regional District, *Major Centers in Greater Vancouver: Current Status and Policy*

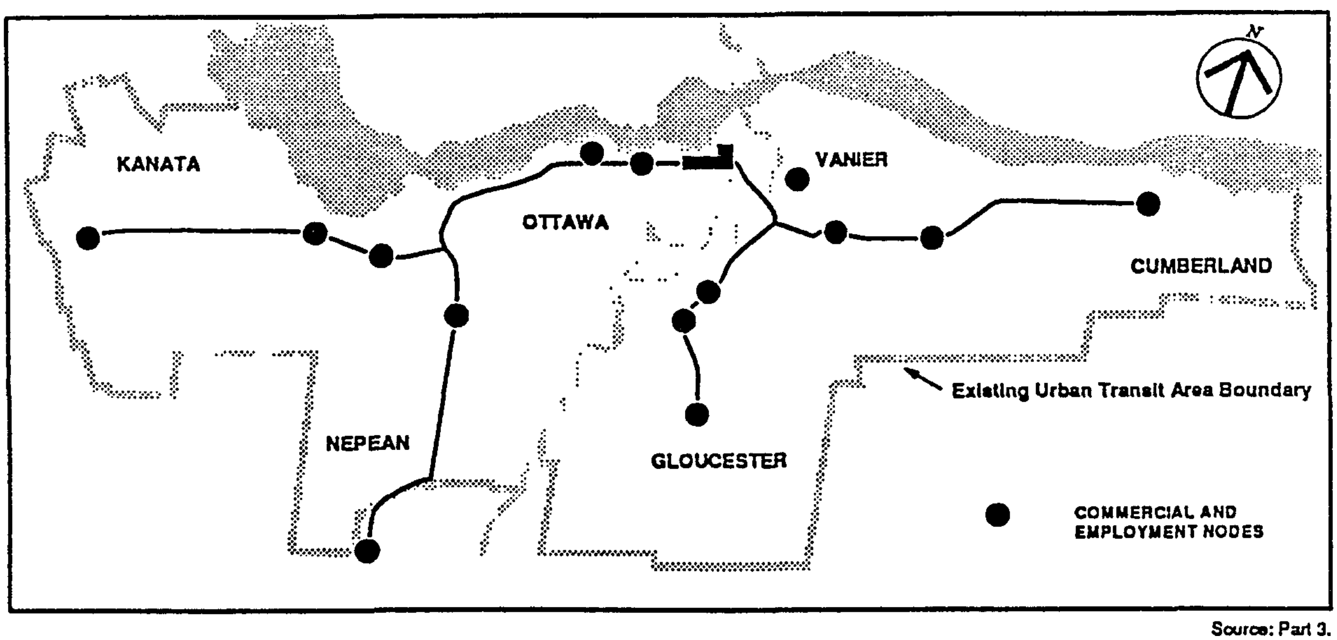
● Available
P Planned
N Nearby

Rapid Transit Concept in the 1974 Official Plan



Sources: Regional Municipality of Ottawa-Carleton, *Rapid Transit Appraisal Study,* 1976, and Bonsall and Stacey (1992).

Regional Growth Centers Strategy, 1998 Official Plan



Sources: Regional Municipality of Ottawa-Carleton, *Official Plan,* Schedule B, 1994, and Bonsall and Stacey (1992).

Source: *Public Policy and Transit-Oriented Development: Six International Case Studies*

Figure 7. Changes in Ottawa's regional growth strategies, 1974–1998.

transit investments have priority over road construction, parking is tightly managed, and transit is considered an essential neighborhood service like streets and water. High-quality bus services provide a level of accessibility as good as or better than that afforded by rail and can serve the low-density residential areas.

Linear Cities

Curitiba, Brazil, has used an all-bus system to serve its desired settlement pattern—a linear city. Higher-density housing and jobs are concentrated along transportation corridors. Exclusive busways are in the center of each corridor; higher-capacity streets for use by cars and express buses are on adjacent streets. Land uses are planned and located to encourage transit use and to balance ridership in each direction to increase the efficiency of the service (see Figure 8).

Wedges and Corridors

The Washington, D.C., area has used rapid transit services to carry out its regional "wedge and corridors" planning vision developed in the 1960s. Large counties, in combination with a development-sensitive transit agency, have instituted policies coordinating transit and land development and promoting station area development. Suburban activity centers, whose growth has been fostered by height limits in downtown Washington, have developed around transit stations. A long lead time in transit line planning has helped communities to develop regulations that ensure appropriate station area development (see Figure 9).

Growth Boundaries

The urban form of Portland, Oregon, was initially influenced by a streetcar system developed from 1889 to 1916, but highways and automobiles have shaped post-World War II development. In response to Oregon's 1973 statewide land use planning requirements, Portland adopted an urban growth boundary in 1979 that is shown in Figure 10. Within this boundary, a primary transit network includes light rail and express bus services. The plan for the region is to locate most new housing and jobs within a 5-min walk of this network. Station area planning, zoning, development guidelines, and a Transportation Planning Rule with targets for reduced VMT all reinforce the importance of the downtown and the transit corridors as development locations.

Ottawa, Seattle, and Vancouver have also employed urban growth boundaries to protect open space and rural areas and concentrate growth in urban and town centers.

ENSURING COST-EFFECTIVE SERVICES

For communities in which integrating transit and land use is a priority, the following commitments are required:

- Transit must be the primary link among activity centers;
- High-quality transit services (regardless of mode) must be provided; and
- Policies reinforcing transit use (and thus cost-effectiveness) must be implemented.

Make Transit the Primary Link

To make transit the primary link among activity centers, planners should adopt a Transit First policy; provide high-quality, coordinated transit service; and limit freeway construction.

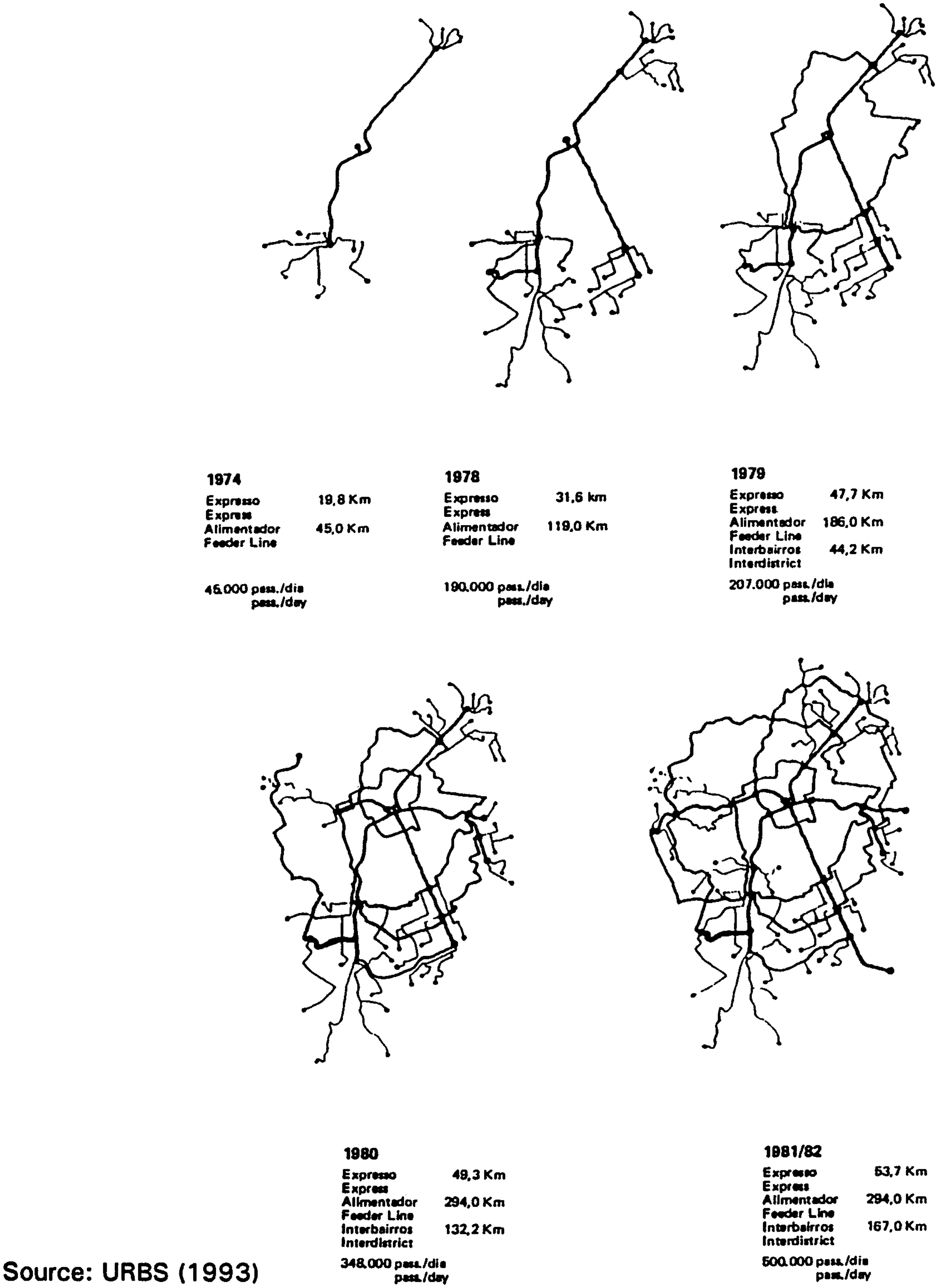
Adopt a Transit First Policy

In Ottawa, the moratorium on highway construction has been extended to give priority to transit in all transportation investment decisions. Ottawa's 1974 Official Plan embraced a Transit First philosophy, declaring that improvements to the existing transit system and the development of rapid transit should take precedence over all forms of road construction and widening. The effect of this policy is unmistakable. From 1975 to 1986, the transit system accommodated approximately one-third of the growth in total trips and virtually all of the increase in trips to downtown Ottawa. In 1986, fewer automobiles left the central area in the evening peak hour than in 1975.

In Curitiba, a 1965 Master Plan called for a reorientation in policy to meet the mobility needs of people rather than automobiles. The plan called for five linear transit-oriented corridors, or structural axes, that would function as high-density pathways for new growth. New growth was discouraged downtown and promoted along the linear corridors. Downtown was treated as a hub and terminus, partially closed to vehicle traffic, and given back to pedestrians. A trinary road system was developed to integrate mass transit, roadways, and land uses along each axis, with a high-capacity express bus corridor at its center. Two local one-way roads function as auxiliary lanes on each side of the busway. One block away on each side is a high-capacity, one-way street serving general traffic and local buses. Commercial and residential densities decrease with distance from the busway (see Figure 11).

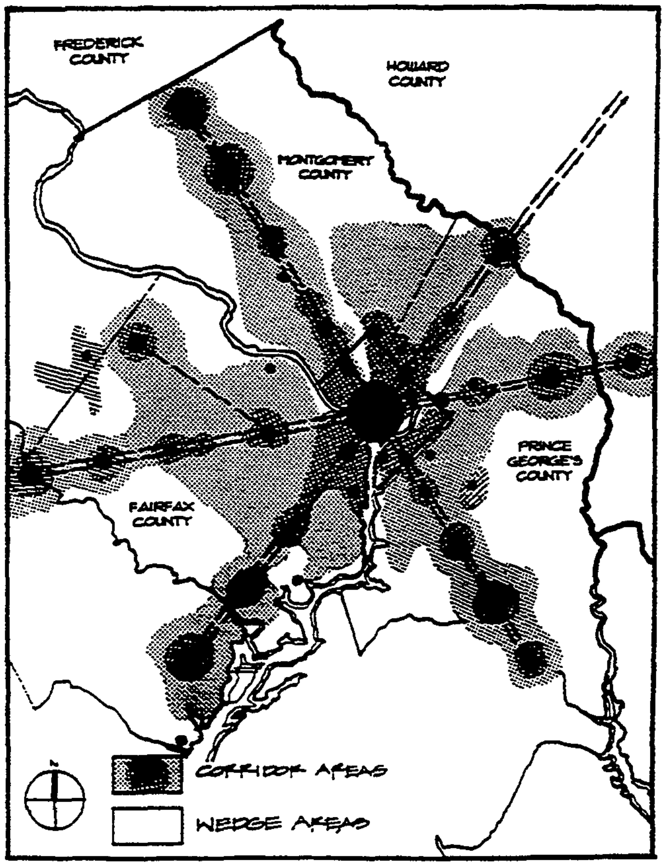
Provide High-Quality, Coordinated Service

Regardless of mode, a sustained commitment to high-quality, dependable, integrated transit service is necessary to



Source: *Public Policy and Transit-Oriented Development: Six International Case Studies*

Figure 8. Evolution of Curitiba's integrated transit network.



Source: *Public Policy and Transit-Oriented Development: Six International Case Studies*

Figure 9. Washington, D.C., Year 2000 wedges & corridors regional concept.

ensure continued support for a transit-based strategy over the long term. All of the case study cities offer these quality services.

In Curitiba and Ottawa, bus systems provide service that equals or exceeds that provided by rail transit. Curitiba's present Integrated Transit Network functions like a metropolitan subway. The bus system extends over 1,200 route km, with more than 1,300 buses, serving over 1.6 million daily trip segments. A single fare covers the entire system. Mainline express buses operate at 2-min peak headways. Crosstown circular routes interface at enclosed transfer stations. This system carries 75 percent of CBD work-related trips—the highest proportion of all the case study cities. Experiences in Germany—Munich and Hamburg—are even more impressive.

Ottawa's bus system also functions like a subway system. All stations have elevators, are protected from the weather, and provide seats and schedule information. Some stations are connected to surrounding areas by pedestrian skywalks. The government subsidizes the transitway routes to run almost twice as frequently as would be supported by demand (3 min during peak and 5 min during off-peak). Buses have signal priority at traffic lights, and most trips require no transfers. Seventy percent of CBD work-related trips are carried on the bus system—the second highest of the case study cities. Ottawa's busway carries 16,800 passengers per route mile—4 times the ridership of the Edmonton or Boston light rail systems. Pittsburgh's busway also carries 4,515 passengers per route mile—3.6 times the ridership of its light rail line see Figure 12).

Houston; Washington, D.C.; Portland; and Vancouver provide high levels of system maintenance and quality that enhance the ability of each system to attract riders and development.

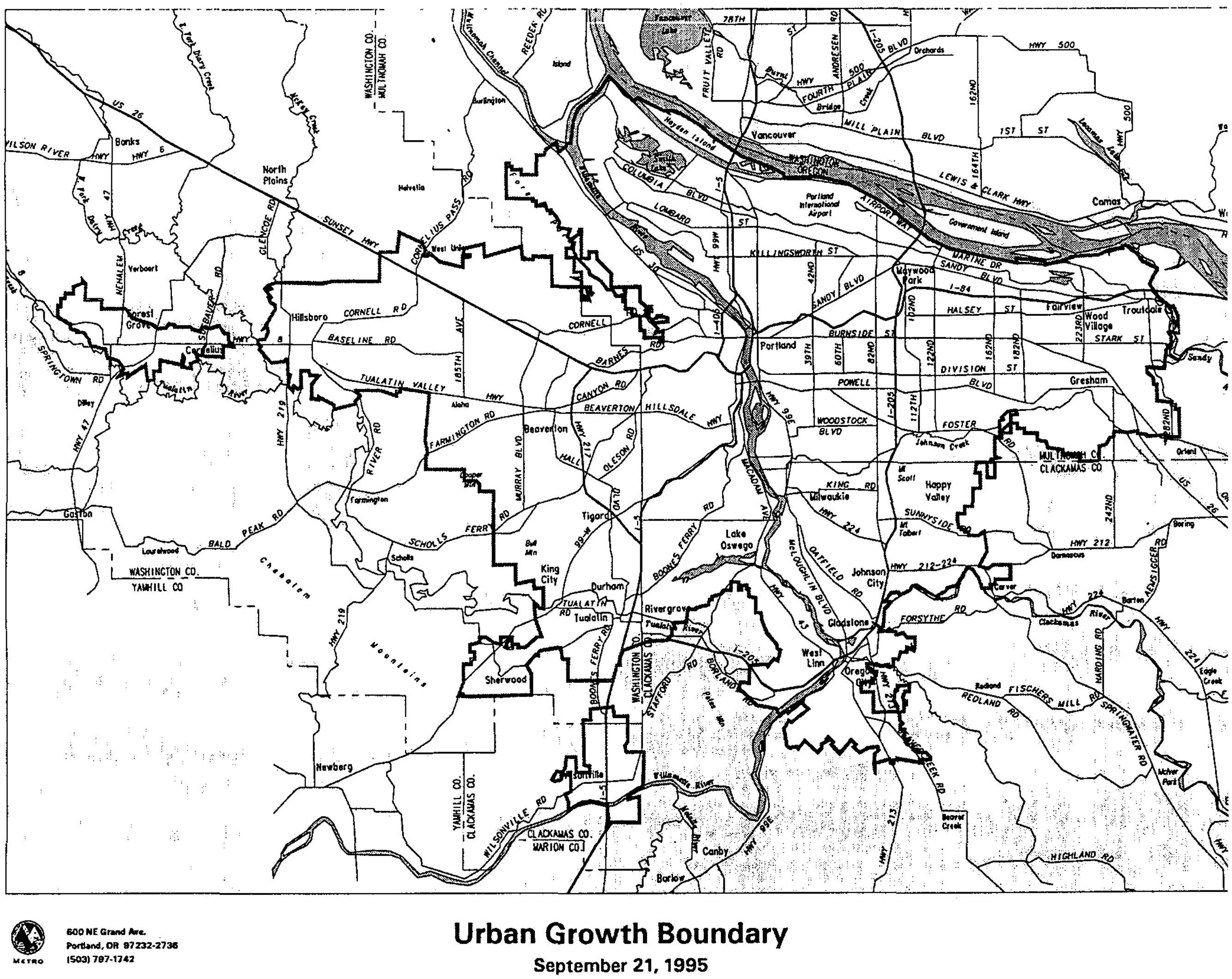
Limit Freeway Construction

One way to reinforce transit use, whatever the mode, is to limit new highway construction in the corridor. By so doing, regions can give the access advantage to developers who locate facilities along the transit lines. The more highways compete with the transit lines, the more development will locate facilities outside the designated transit corridors.

In Vancouver, new freeway construction has been prohibited as a matter of public policy since the early 1970s. The Greater Vancouver Regional District was set up to provide regional services, including planning. In 1975, a Livable Region Plan called for a regional planning framework of town centers linked to downtown and to each other by high-capacity transit. BC Transit was established in 1982 as an extension of the provisional government to run local and regional transit. The Livable Region Plan 1990 update upheld the freeway moratorium.

In Portland in the 1970s, a freeway-dominated transportation plan was replaced with a plan that balanced highways and transit. Light rail connecting the downtown with Gresham to the east opened in 1986, with a new line to the west under construction and a north-south line planned. During this time, no new highways have been built, although some (including the road parallel to the westside line) have been widened.

In Washington, D.C., on the other hand, the highway system has seen extensive improvement during the period of Metro planning, design, and construction. In the first phases of construction, several jurisdictions coordinated their efforts with Metro system planning to adopt zoning regulations that steered growth toward new stations. Jurisdictions scheduled for Metrorail service at a later time, however, have been less enthusiastic about transit-supportive development—and are even questioning the transit investment. Fairfax County, to which rail service was extended in the mid-1980s (with another extension still planned), was unable to reach consensus on station-area development opportunities—in part because so much business development was taking place in areas not served by rail transit, including the Tyson's Corner megacenter.



Source: *Public Policy and Transit-Oriented Development: Six International Case Studies*

Figure 10. Portland metropolitan area: urban growth boundary.

Adopt Policies That Support Transit

Transit-oriented regional agencies and city governments use various policies to promote the development and use of transit services. These policies can influence transit use regardless of mode. Some of these policies are discussed in the following paragraphs.

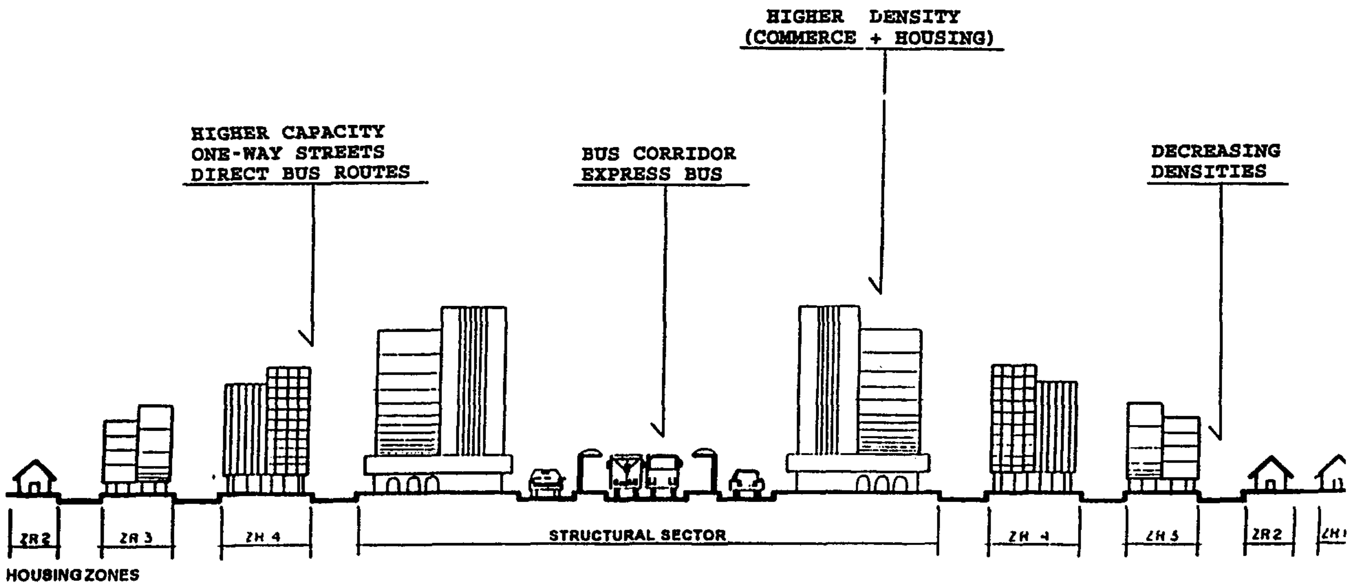
Transit-Supportive Housing Policies

In Curitiba, government-owned land near the transit corridors is used for community-assisted housing. Developers can also "buy" as many as two additional floors of housing by contributing to a low-income building fund. Residential densities of up to 202 per acre are allowed along four of the structural axes, a density conducive to high transit ridership.

In Portland, the Portland Development Commission put housing programs near stations. (Some public subsidy was necessary to ensure project feasibility.) Suburban infill projects along the Burnside Line also provide housing for transit commuters.

Transit-Supportive Shopping Center and Major Public Facility Siting Policies

In Curitiba, the municipal planning authority approves proposed shopping center locations and has rejected shopping centers outside transit corridors. Portland puts regional attractions (e.g., convention centers and sports arenas) at stations; this policy increases the number of off-peak riders. In Vancouver, the federal government is the largest single employer and landowner. Governmental agencies have cho-



Sources: IPPUC; Rabinovitch and Hoehn (1993)

Source: *Public Policy and Transit-Oriented Development: Six International Case Studies*

Figure 11. Hypothetical cross section of Curitiba's trinary road system.

sen to locate within station areas inside the Regional Town Centers and have incorporated this requirement in their requests for proposals (RFPs) for office space.

In Ottawa, one of OC Transpo's site design successes was securing the redesign of the Gloucester Centre shopping mall, directly north of the Blair station. Original plans called for the Gloucester Centre to face away from the Transitway station, which would have forced transit customers to cross the parking area to reach the mall's entrances. OC Transpo planners convinced the developers to orient Gloucester Centre toward the station.

Transit-Supportive Tax Policies

Brazilian employers are required to subsidize some workers' transportation costs. Any amount spent on transportation above 6 percent of income, up to a 20 percent maximum, is subsidized by employers. Employers purchase bus tokens and distribute them to eligible employees with their paychecks.

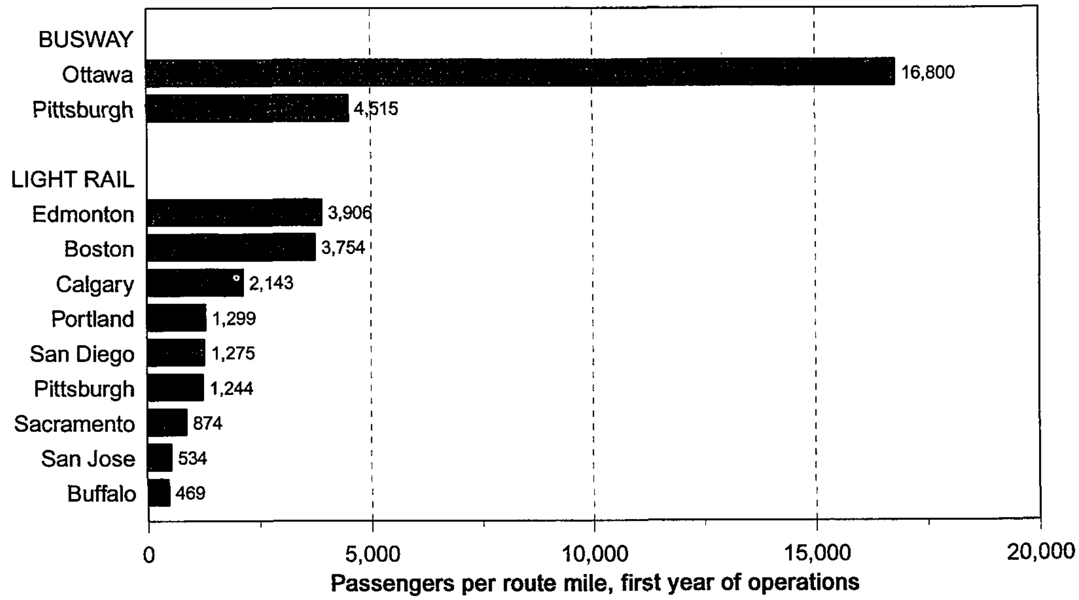
Integrate Transit-Land Use Planning and Implementation

Long-range integration of transit and land use depends on regional and local land use planning and transit agencies coordinating their efforts more closely than has been the case in most U.S. cities. This coordination involves establishing multidisciplinary functions within agencies (i.e., using transit planners as staff at regional land use planning agencies and having land use personnel or developers as staff at transit agencies) or creating agencies with a joint mission to plan and develop transit and associated development.

The case studies investigated for this research yielded several interesting approaches to planning and implementation; these are discussed in the following paragraphs.

Since its inception, Washington's Metropolitan Area Transit Authority (WMATA) has had a strong joint development-land use department, with a mission that includes station area development and land use planning. WMATA works with local jurisdictions to foster appropriate station area development. In some cases, WMATA issues RFPs to developers; in others, counties take the lead in developing station area planning and design guidelines and implementing station area master plans. Several local jurisdictions have adopted transit-oriented planning as a primary tenet of their planning for community development.

Regional government and oversight mechanisms have helped ensure coordinated planning in several case study cities. For example, in Canada, Vancouver's BC Transit is supported by a specially created "Crown Corporation" that can serve as a redevelopment agency and is isolated from public opposition to station locations and other development decisions. In addition, BC Transit has a Capital Projects Division, which oversees design and construction of all capital projects. The Division works with local government entities to preserve transit corridors for long-term development and to acquire land for station area development.



Source: *Public Policy and Transit-Oriented Development: Six International Case Studies*

Figure 12. Comparison of passengers per route mile among North American busway and light rail systems.

The Regional Municipality of Ottawa-Carleton (RMOC), modeled after Metro Toronto, was formed in 1969 to carry out regional planning, invest in major infrastructure, and provide regional services. Elected members serve on the Regional Council, whose responsibilities include overseeing regional transit services and planning development. All local land use plans and regulations must be consistent with the transit-oriented Official Plan for the region, which RMOC personnel developed

The Greater Vancouver Regional District provides planning and other services for the region. It also adopted the Livable Region Plan that set forth the town center-based regional vision. Although its formal land use and transit planning powers were removed in 1983, the district has sustained the regional vision through a 1990 update.

In the United States, Portland's Metro is the only example of an elected regional government agency. This agency is responsible for transportation and land use planning for the region. Tri-Met, the transit authority, has advocated transit-supportive development policies and has sought assistance from the Portland Development Commission, which has development expertise, urban renewal powers, and tax increment financing capability.

The Southern California Regional Transit District entered into cooperative agreements with the Los Angeles Community Redevelopment Authority and the City and County of Los Angeles for Metro station area planning and development implementation.

In Curitiba, development of the innovative transit system benefited because the head of the municipal transit organization had previously headed Curitiba's comprehensive planning organization. Having architect-planners run municipal transit operations has meant that service strategies have evolved with land use considerations in mind and design-oriented solutions to problems with daily operations.

Non-profit groups can advocate integrated planning. The 1000 Friends of Oregon, the Washington Regional Network for Livable Communities, and the Surface Transportation Policy Project (STPP) have raised public awareness of how land use management can reduce traffic congestion and how transit can shape urban form and reduce sprawl. The STPP has incorporated this awareness into guidelines for federal funding through ISTEA. Such groups also facilitate the public participation necessary to achieve agreement on plans and investment decisions.

Strong, long-term leadership is critical to achieving consensus on a regional vision. Efforts in Houston, Portland, and Curitiba were all led by charismatic individuals who gained sustained, widespread support for their transit-land use visions.

Experience in California and elsewhere has shown the importance of having a local politician support transit-oriented development, a transit agency that is willing to use features such as parking lots to allow station-linked development, risk-sharing by the public agencies (e.g., free land leases in return for a share of development profits or loan subordination) and the power of a redevelopment authority to condemn and assemble land and to use tax increment financing.

CHAPTER **4**

THE ROLE OF TRANSIT IN CORRIDOR PLANNING

If a travel mode is the means to an end, then successful transit service is the bundling of trips with similar ends in a way that is competitive with the automobile. Because the average household in the United States has two automobiles available for use on a well-connected (though often crowded) highway network, transit is most competitive when use of automobiles is hampered (e.g., by severe bottlenecks, high parking costs, and lack of parking). Most recent (i.e., post-World War II) experience shows that transit affects urban and suburban settings beyond the type of interline technology employed—be it bus, light rail, or heavy (commuter) rail. Success in attracting riders depends on more than the quality and frequency of interline service provided, regardless of modal type. Transit must be competitive with the automobile at the origin, along the line-haul, and at the destination; must attract riders; and must be cost-effective. Therefore, competitive transit is service that connects origins and destinations in an effective and cost-efficient manner—so that it is a feasible alternative to the automobile. During the research, project personnel learned that the following factors contribute to the ability of transit to be effective, to be efficient, or both:

- Origin
  - –Residential density
  - –Proximity to station
  - –Parking availability
  - –Feeder bus availability
- Destination
  - –Employment density
  - –Proximity to station
- Line-haul
  - –Length of line
  - –Balance of origins and destinations along the corridor.

See Volume 1, Part II, for a more specific discussion of this topic.

For communities to take full advantage of transit, they must determine the most important factors that affect transit's ability to attract riders and increase passenger miles per line mile and the factors that most affect transit's ability to operate cost-efficiently and decrease the annual cost per vehicle mile.

ORIGIN-RELATED FACTORS

Residential Density

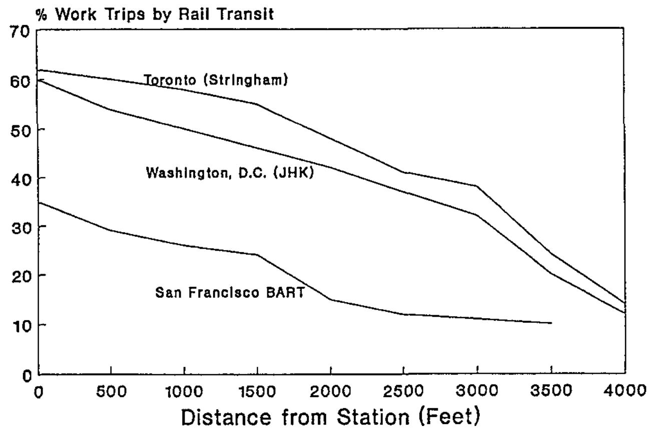
In the 1970s, Pushkarev and Zupan (*Public Transportation and Land Use Policy*) recommended minimum densities for various types of transit services, as follows:

- Bus
  - –Minimum service, 0.5 mi between routes, 20 buses/day, 4 dwelling units/residential acre
  - –Intermediate service, 0.5 mi between routes, 40 buses/day, 7 dwelling units/residential acre
  - –Frequent service, 0.5 mi between routes, 120 buses/day, 15 dwelling units/residential acre
- Light rail: 5-min peak headways, 9 dwelling units/residential acre, 25- to 100-square-mi corridor
- Rapid transit: 5-min peak headways, 12 dwelling units/residential acre, 100- to 150-square-mi corridor

Recent research indicates that a 10-percent change in density (persons per acre) is associated with roughly a 6-percent change in light rail ridership at a given station, and a 2.5-percent change in commuter rail ridership at a given station. Other research finds that in far denser settings, such as Chicago, a much higher elasticity exists: a 1-percent change in residential density is associated with a slightly more than 1-percent increase in both bus and rail riders. A review of this research suggests that precise minimum residential thresholds must be accompanied by assumptions regarding travel speeds, station spacing, and so forth, but that a strong relationship between transit use and density holds, nonetheless. (See Volume 1, Part I, Section 2.2, for a more complete discussion.)

Proximity to Rail Station

The proximity of residents to rail stations affects transit use significantly. On the basis of recent analyses, the rail mode share drops approximately 1 percent for each 100 ft from the station, up to a distance of about 1.5 mi. (Among San Francisco's BART stations, the drop off is slightly higher; for Chicago's Metra, it is somewhat less.)



Source: "An Evaluation of the Relationship Between Transit and Urban Form," *TCRP Research Results Digest, No. 7* (June 1995), p. 33.

Figure 13. Ridership and station access, selected U.S. cities.

Figure 13 summarizes research on the correlation of ridership and proximity to transit stations. All else being equal, rail ridership potential is affected by station proximity. In light of these and other findings, communities seeking to maximize transit use should encourage new development to cluster within 0.25 mi of rail stations—residents here are 5 to 7 times more likely to use rail than other area residents.

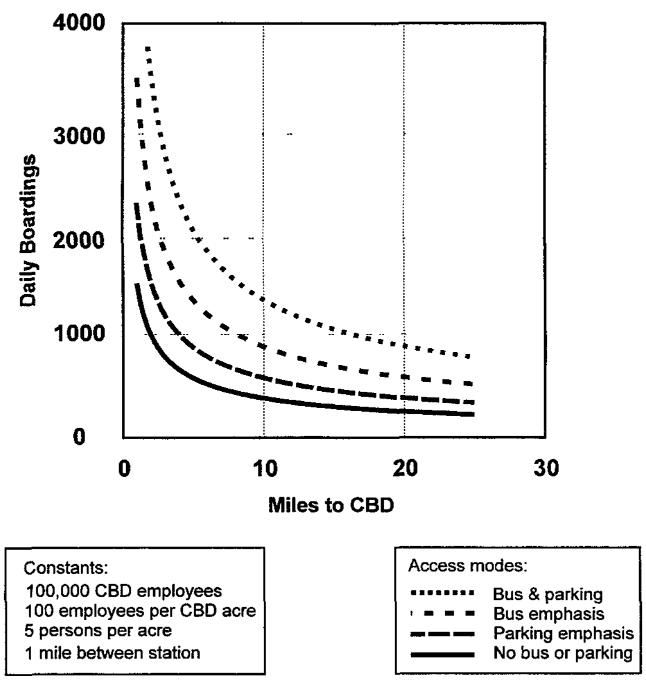


Figure 14. Light rail station boardings by distance to the CBD and access modes.

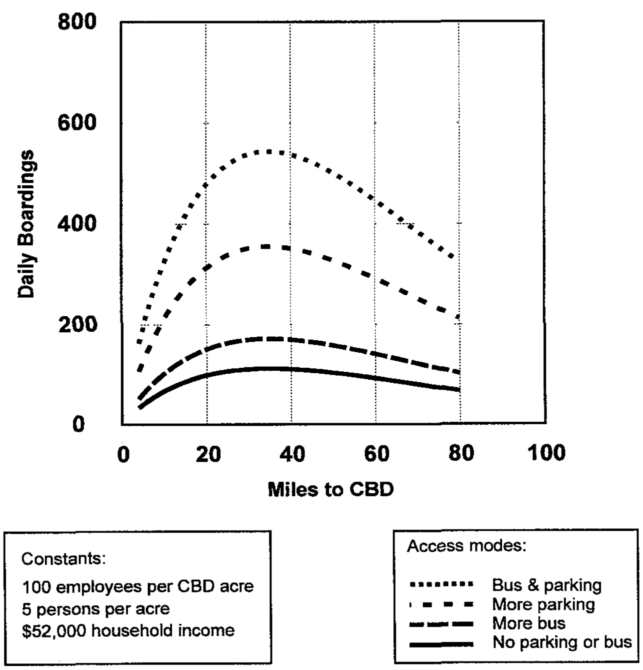
Parking and Feeder Bus Availability

Park-and-ride facilities and feeder bus services to transit stations expand transit's catchment area, thereby increasing patronage. Each form of access has its own costs and influences light rail and commuter rail differently. Park-and-ride facilities require land acquisition and affect traffic and air quality; feeder bus services involve route planning and operating cost issues. For light rail, whether a station has parking or not means a 50-percent difference in station ridership; but, as shown in Figure 14, the presence of a feeder bus system means a 130-percent difference in station ridership. For commuter rail, the situation is reversed. Parking produces a 200-percent increase in ridership over stations without parking, while feeder buses contribute only about 50 percent more riders than stations without such services. Research shows that the presence of both is significant for commuter rail (see Figure 15). Providing these access modes, among commuter rail lines ranging in length from a few mi to nearly 80 mi, is beneficial.

DESTINATION-RELATED FACTORS

Employment Density

The number and density of jobs correlate with rail ridership. Figures 16 and 17 show (on the basis of findings from



Source: *Commuter and Light Rail Transit Corridors: The Land Use Connection*, Section 3.3

Figure 15. Commuter rail station boardings by distance to the CBD and access modes.

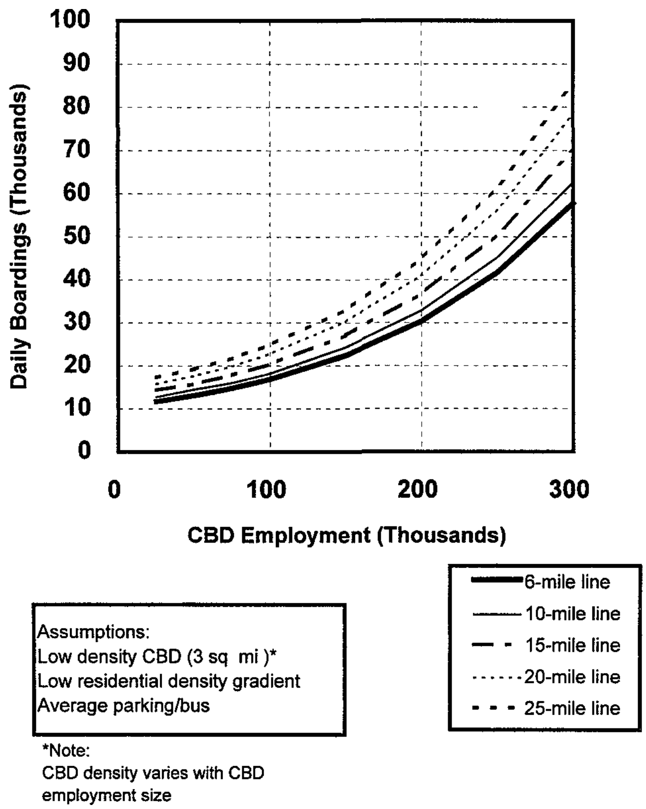


Figure 16. Light rail daily riders by CBD jobs and line length.

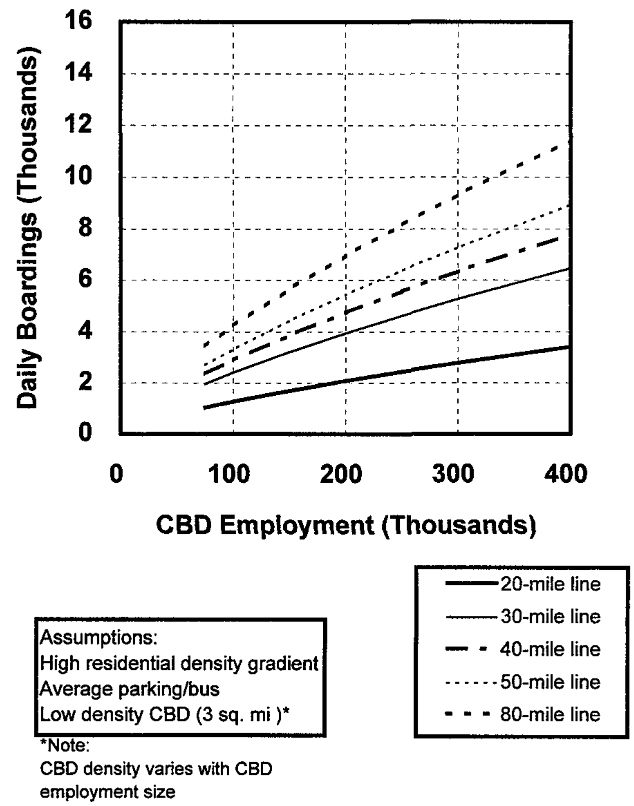


Figure 17. Commuter rail daily riders by CBD jobs and line length (3-square-mi CBD).

current transit properties) hypothetical results for light rail and commuter rail among typical urban settings (i.e., urban areas with CBDs that are 3 square mi [low density], have a low residential density gradient [representing newer cities that have low residential densities near the CBD and which decrease gradually away from the CBD], and an average amount of parking and feeder bus service at stations).

As jobs and job density increase, transit use increases by several orders of magnitude over a broad range of possible service lengths. For both light rail and commuter rail, longer lines experience the greatest growth and rate of growth of riders as job density increases—this relationship is particularly strong for light rail.

Proximity to Station

Table 6 summarizes data (about Chicago and San Francisco) on the distances people are willing to walk to and from

TABLE 6 Summary of influence of distance on modes of access for three rail systems

System	Home End		Work End	
	Distance up to which walking predominates	Mode of access beyond walking distance	Distance up to which walking predominates	Mode of access beyond walking distance
BART	0.625 mi	Transit for shorter trips, park-&-ride for trips longer than 1 mile	0.625 mi	Transit
Metra	0.500 mi	Drive, followed by being a passenger	1.500 mi	Very few trips
CTA	0.750 mi	Transit	0.750 mi	Transit

Source: *Mode of Access and Catchment Areas for Rail Transit,* Section 9.5.

home or work and a bus stop or rail station. Figures 18 and 19 relate distance and access mode at each end of the commuting trip for BART riders. Commuters are willing to walk farther on their transit-to-work trip than their home-to-transit trip. This is particularly true for commuter rail riders, because there are normally very few CBD stations, but less true for bus and light rail riders. The implication of these findings for light rail or bus transit to suburban activity centers is that the willingness to walk, while greater than for the home-to-transit trip, would be a limiting factor if the bus cannot approach work sites as conveniently as it typically would in a CBD setting.

LINE-HAUL-RELATED FACTORS

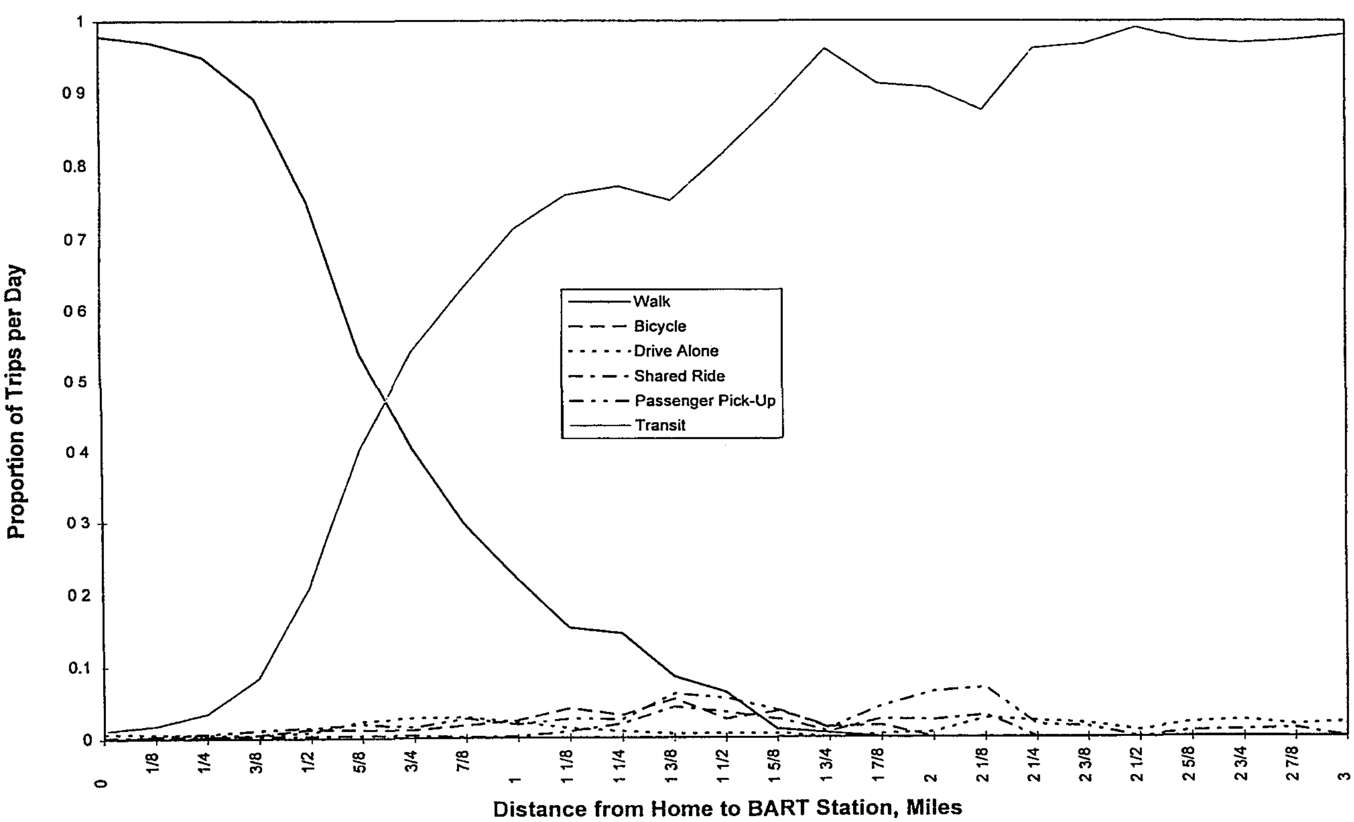
Length of Line

Research indicates that the longer a rail line, the greater the patronage; however, the law of diminishing returns seems to apply. For example, for light rail, a hypothetical increase in length from 6 to 10 mi—a 67-percent increase—only increases ridership by about 10 percent. For commuter rail, increasing line length from 20 to 30 mi (a 50-percent increase) increases ridership by nearly 90 percent; but from 30 to 40 mi (a 33-percent increase), however, ridership increases only 20 percent.

Balance of Origins and Destinations Along the Corridor

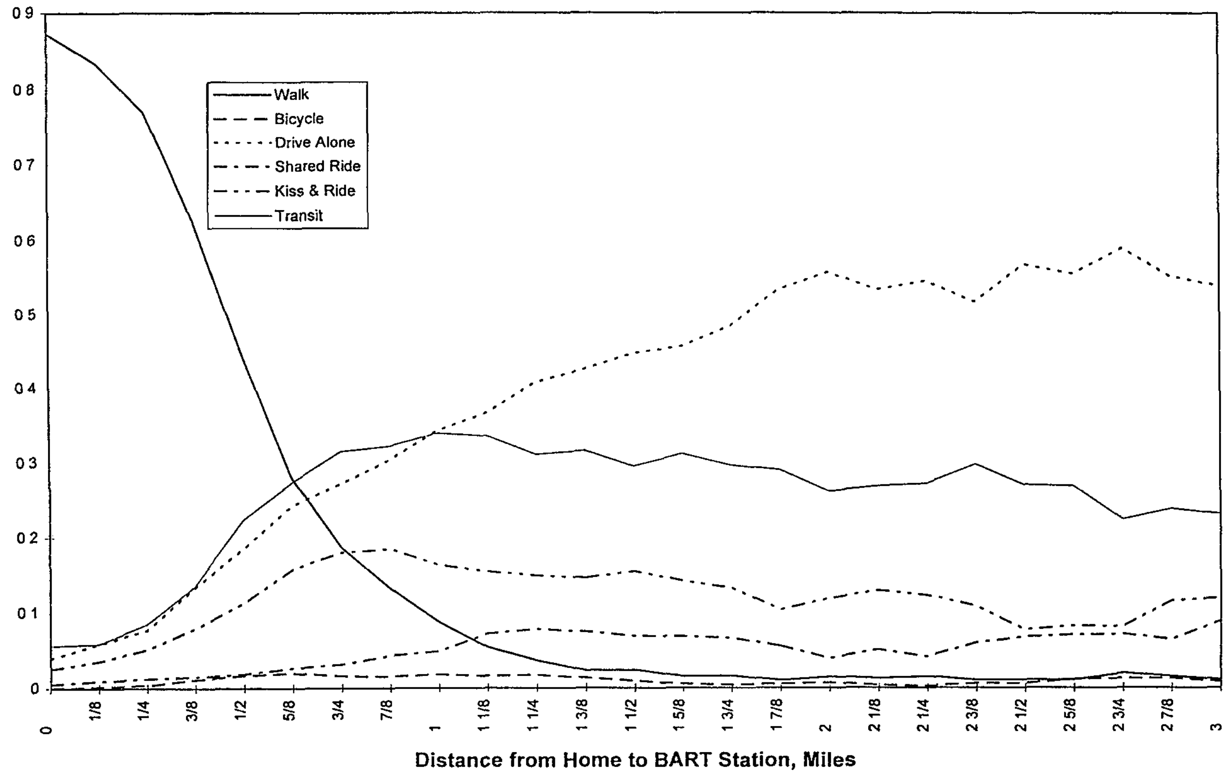
Typically, transit moves commuters into a major activity center in the morning and out in the evening. Some reverse commuting (i.e., from the major activity center to the suburbs) exists. Transit rarely serves the role of many modern highways: bidirectional flow during both commuting periods, and, to some extent, throughout the day. This situation results in skewed costs (geared to serve unidirectional peak flows) and limited revenues, requiring both fare increases and continual subsidies.

In Curitiba and Ottawa, CBD growth has been discouraged and linear growth (as supported by transit services) has been encouraged. Mixed-use development outside of downtown is encouraged as a way to balance the direction of ridership on the bus lines. This approach has led to a strong role for transit and a more financially stable and efficient system. U.S. cities with well-developed transit systems (e.g., Washington, D.C., and Boston) have mixed-use development outside of their CBDs, but there is considerable opportunity for improvement.



Source: *Mode of Access and Catchment Areas for Rail Transit,* Section 9.1.

Figure 18. Mode of access for commuting trips from home to all BART stations.



Source: *Mode of Access and Catchment Areas for Rail Transit,* Section 9.1.

Figure 19. Mode of egress for commuting trips from all BART stations to work.

WHAT ARE THE MOST IMPORTANT CORRIDOR CHARACTERISTICS THAT SHAPE TRANSIT'S EFFECTIVENESS?

Effectiveness can be measured as weekday passenger miles per line mile. Figure 20 shows effectiveness curves for a hypothetical 10-mi light rail line. Each pair of curves compares high, medium, and low residential densities with high and low CBD employment densities. The figure indicates that both residential and job density are important. Figure 21 shows the CBD job density of some U.S. cities. Portland, Boston, and Chicago have CBDs of about 2 square mi. Los Angeles and Washington, D.C., have CBDs of about 3 square mi. Philadelphia, Baltimore, San Francisco, and Buffalo have CBDs between these sizes. Each increase in residential density gradient is associated with a 40-percent increase in passenger miles per line mile (see Figure 22). Although the differences between employment densities within a 2 or 3 mi CBD are not large, the difference between 50,000 and 150,000 CBD jobs in either setting is substantial. For example, for a 10-mi light rail line, an increase in CBD employment from 50,000 to 100,000 jobs is associated with a 25- to 50-percent increase in transit effectiveness (passenger miles per line mile), while an increase from 100,000 to 200,000 jobs is associated with a 90-percent increase in effectiveness (Volume 1, Part II, Section 6.5). The role that station parking and feeder bus service would play, however, is strong enough that major increases in those factors would improve effectiveness more than increases in residential density or CBD job density.

For commuter rail, employment size and density correlate with effectiveness. As with light rail, ridership gains can be realized with more access services. For commuter rail, more parking at stations is more important than feeder buses in making lines perform better.

WHAT ARE THE MOST IMPORTANT CORRIDOR CHARACTERISTICS AFFECTING TRANSIT COST-EFFICIENCY?

Cost-efficiency is an important measure of total cost (annual operating cost and depreciation) divided by the annual vehicle-miles (see Volume 1, Part II, Executive Summary). Research indicates that light rail becomes more cost-efficient with higher CBD employment levels, higher CBD employment densities, and higher residential densities. The highest residential density is 3 to 5 percent more cost-efficient than the medium density, and the medium density is 5 to 7 percent more cost-efficient than the low density. Similarly, a CBD with 200,000 jobs (e.g., San Francisco) per-

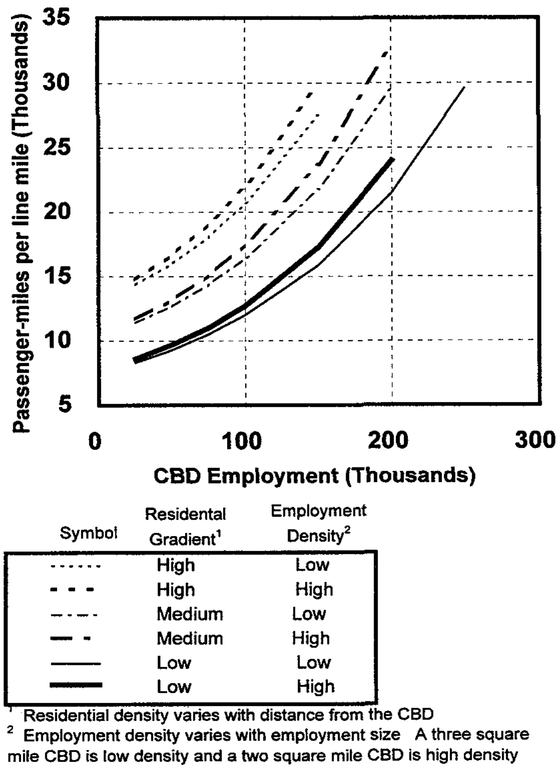
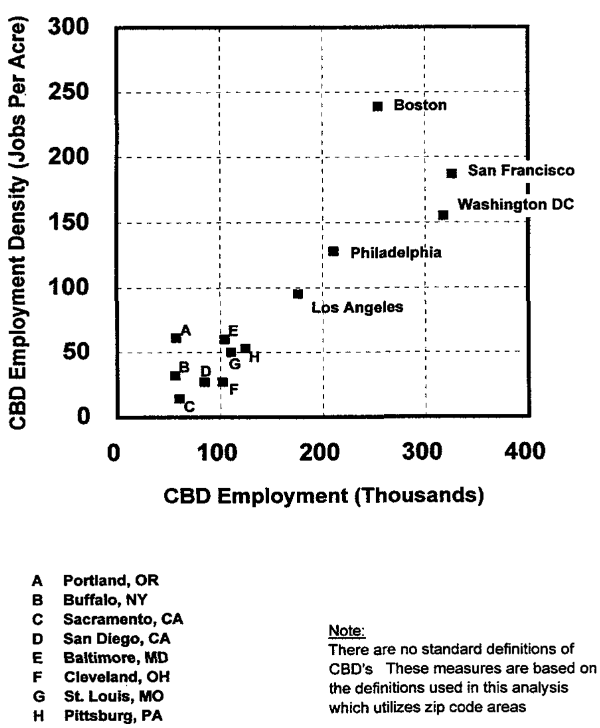
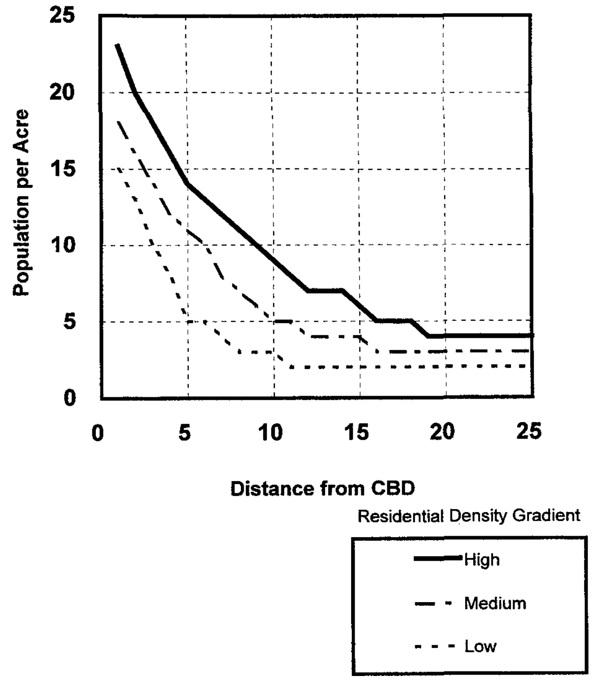


Figure 20. Light rail effectiveness by CBD jobs and various densities (10-mi line).



Source: *Commuter and Light Rail Transit Corridors: The Land Use Connection*

Figure 21. CBD employment numbers and density: 13 U.S. rail cities.



Source: *Commuter and Light Rail Transit Corridors: The Land Use Connection*, Section 4.1

Figure 22. Assumed residential density gradients: hypothetical light rail corridors.

forms 8 to 15 percent better than a CBD of 100,000 jobs (e.g., Los Angeles). CBD employment density, however, has less of an effect (see Figure 23). Although longer lines are more efficient, the benefits they offer diminish with each incremental change in line length and they cost more in absolute terms.

For commuter rail, residential density plays only a small role in the cost-efficiency calculation—line length, CBD employment, and CBD density are the most important. The most cost-efficient commuter lines are the longer ones (provided, of course, they serve areas where there are commuters). Larger, higher-density CBDs have somewhat higher cost and are slightly less efficient, as Figure 24 indicates. Depending on specific site characteristics and market factors, planners may want to emphasize development, parking, or buses to boost ridership.

Table 7 summarizes the findings on cost-efficiency and effectiveness for hypothetical light rail and commuter rail corridors. Light rail and commuter rail are both more cost-efficient and effective when the CBD is large (although beyond a certain level, light rail may not be feasible). The density of the CBD is more important for commuter rail effectiveness; light rail, with multiple stations, is more suited to lower density CBDs. Residential density matters more for light rail. Commuter rail lines become more effective with length, up to 50 mi; light rail ridership decreases with distance from the core.

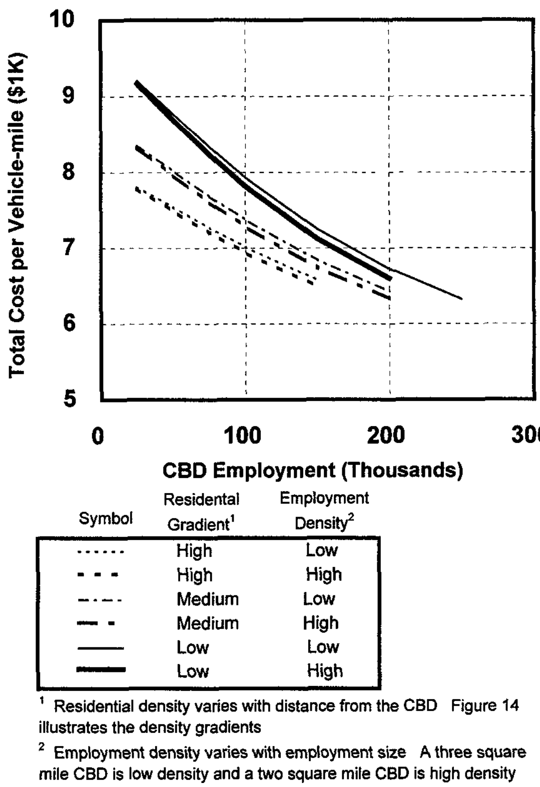


Figure 23. Light rail cost-efficiency by CBD jobs and various densities (10-mi. line).

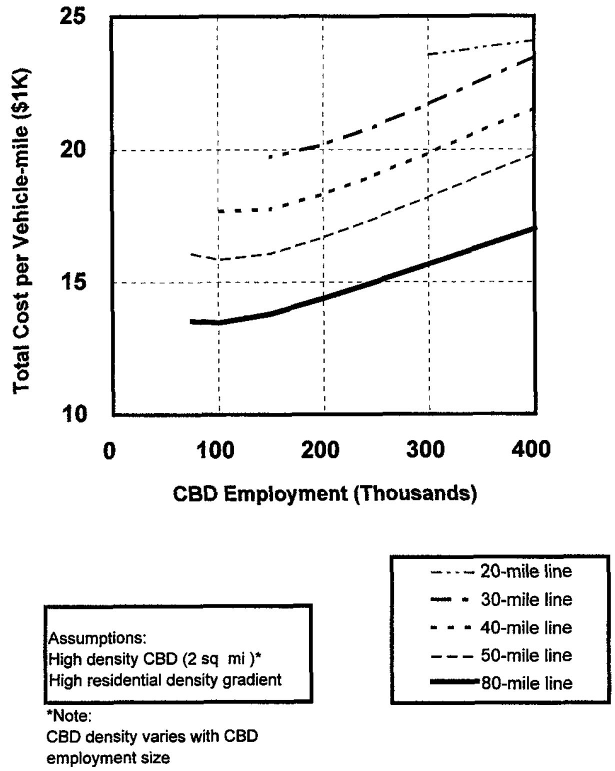


Figure 24. Commuter rail cost-efficiency by CBD employment and line length (high employment density).

TABLE 7 Summary of findings on cost-efficiency and effectiveness for hypothetical rail corridors

FACTOR	COST EFFICIENCY	EFFECTIVENESS
Light Rail		
Residential density gradient	Highly positive	Highly positive
CBD employment	Moderately negative (at high cbd job levels may not be possible)	Highly positive
CBD employment density	Slightly positive	Moderately positive Greater impact for larger cbds
Feeder bus	Unclear	Highly positive
Parking availability	Unclear (site-specific)	Moderately positive
Line length	Slightly positive	Slightly positive
Commuter Rail		
Residential density gradient	Not significant	Not significant
CBD employment	Slightly negative, for smaller cbds may have insufficient riders, especially for shorter line lengths	Highly positive
CBD employment density	Highly positive	Highly positive
Feeder bus	Unclear	Moderately positive
Parking availability	Unclear (site-specific)	Highly positive
Line length	Strongly positive, insufficient riders for shorter lengths	Varies, best at 50-mile length

Source: *Commuter and Light Rail Transit Corridors: The Land Use Connection,* Executive Summary.

CHAPTER 5

STATION AREA PLANNING AND DEVELOPMENT

For stations, maximum integration of land use planning and transit planning involves coordination among various agencies and levels of government. The planning and development process consists of several stages over many years. Initially, transit corridors are planned and located and station area development parameters are set forth in an overall regional vision. Next, the desired densities and types of land uses are determined at the regional level, then applied to each station area in local level planning, as codified in zoning ordinances and site planning guidelines. The guidelines include recommendations for transit system interfaces and transit-friendly design provisions. Finally, the plans are implemented for individual sites on a project-by-project basis, often over many years. Transit and development construction are coordinated to the extent possible.

Ideally, the transit agency is involved at each stage of this process. In practice, many transit agencies develop plans with little participation by land use agencies. Stations are brought to final design before land use agencies are permitted to review the plans. Land use regulations take little account of opportunities for joint development or other transit enhancements, and parking requirements are not altered to reflect the proximity of a site to transit. A few U.S. cities and some in Canada and abroad have achieved better coordination of transit planning. In these cities, the development community has made transit agencies aware of transit-oriented development opportunities.

The case studies and other research on cities that have integrated transit and land use planning illustrate that cooperation must continue over a long time to implement a transit-oriented vision. Regional administrative mechanisms, such as those already discussed, are one way to do this. Alternatively, key leaders can achieve similar results over time through existing organizations.

The guidance on land use density, design, and mix from the successful cities is clear. Many of the principles have been employed in downtowns and cities for years. Applying them successfully in subregional centers depends on how they are linked to high-quality transit services and the way in which these principles are applied to the outlying areas. Key principles and tools are summarized in the following sections.

(See Volume 2, Part IV, and *Influence of Land Use Mix and Neighborhood Design on Transit Demand* [unpublished] for a more specific discussion of this topic.)

PRINCIPLES

Encourage Employment and Residential Density Close to the Stations

Employment and residential density are the most important factors associated with transit ridership at either end of the trip. Indeed, proximity to transit service can produce an increase in property values that enhances the feasibility of higher-density development (see Volume 1, Part I, Section 3.1). Ideally, density should be highest closest to the stations, although any housing close to a station will boost ridership. Curitiba and Toronto have encouraged such a development pattern through their station area zoning. Other cities, however, such as Ottawa, have chosen not to encourage high-density nodes at all transit stations. In Ottawa, the integrated surface transit network allows low housing density (by Canadian standards) to be preserved in all but a few station areas. Buses fan into neighborhoods and either provide direct express services to destinations or feed into nearby Transitway stations on a timed-transfer basis.

The more buildings within walking distance of a transit station, the more people will use transit. Walking distances tend to be shorter on the home end of the trip—0.5 mi to 0.75 mi in urban areas. In downtowns, commuters will walk further to a commuter rail station than a bus or light rail station, and further from any rail station than a bus stop. In suburban areas, walking catchment areas are 8 to 10 times larger than those of downtown station areas and 3 to 4 times larger than those of urbanized areas.

In dense, mixed-use urban areas, walking is common. Between 0.5 and 1.5 mi, the proportion of transit riders who walk to or from transit steadily decreases. Rail's mode share drops about 1 percent for every 100-ft increase in distance between the residence and the rail station for a range of up to 1.5 mi. At the work end destination, the elasticity is about 1.5 percent per 100 ft for a range of up to 1 mi (Volume 1, Part I, Section 2.1).

For the densest and for most mixed-use settings, most access and egress trips are under 1.5 mi. As densities decrease, average access and egress distances increase. For the urban district stations, average access and egress distances are approximately 2 mi. For the low-density station areas, the average is approximately 3.2 mi; for suburban center stations, the average is approximately 4.2 mi. For downtown and dense urban stations, transit is the usual choice for trips beyond 1 mi. For suburban stations, park-and-ride is the usual choice for trips beyond 1,700 ft. For egress trips beyond 0.5 mi, transit is the preferred choice. (See *Mode of Access and Catchment Areas for Rail Transit*, Section 9.0 [unpublished] for a more detailed discussion of this topic.)

Within the Higher-Density Station Areas, Plan for a Mix of Land Uses

Neighborhoods with a mix of land uses also tend to be attractive and pedestrian-friendly, tend to have relatively high levels of employment and residential density, and tend to be nearer the region's CBD. These factors combine with good transit service to attract transit riders.

Mixed land use fosters transit use for work-related trips and mid-day trips in urban and suburban employment centers. To encourage commuting by transit, bicycling, and walking, housing must be included in the mix. To encourage mid-day trips by transit, bicycling, and walking, retail uses must be included in the mix. To encourage reverse commuting by transit, commercial uses must be in suburban activity centers near the station areas.

The appropriate level of development and the balance between land uses in each center in terms of increasing transit ridership are difficult to prescribe and should be the subject of local planning and market research studies.

Use Urban Design Features to Facilitate Pedestrian and Transit Travel

To encourage transit use, urban design in station areas should encourage high-density development and enhance the pedestrian environment. The following design principles (applied for years in downtowns) should be adapted to suburban activity centers that seek to encourage transit use:

- Parking should be in structures or underground to permit higher-density development. Large parking garages or surface lots should not hamper access to stations. In Vancouver, 90 percent of station-area parking is underground or in structures.
- Design of park-and-ride lot locations should not preclude development opportunities. In Ottawa, park-and-ride lots are only at terminal stations.
- Intermodal connections should be easy. Bus transfer facilities should be incorporated into busway and rail stations. Automobile traffic in station areas should be managed to facilitate station access.
- Buildings should be built out to the sidewalk, with active uses fronting the pedestrian way. Ground-level retail storefronts should be planned for access routes to the station. Personal service businesses (e.g., cleaners, delis, and barbers) gain business from the transit rider foot traffic; and, the convenience they offer in terms of doing errands fosters transit ridership.
- Streets and pedestrian paths should be continuous and connected.
- Topographical constraints should be overcome through steps, ramps, grading, and so forth, and shade trees and other weather protection features should be provided.
- Joint development should directly interface with the station wherever possible and the quality of the public (station) environment should match the quality of the private (development) environment.

TOOLS

Various factors influence the ability of transit and land use agencies to apply these principles to ensure optimal station area development and to encourage transit use. Several of these factors are discussed below. See Volume 2, Part IV, for detailed discussion of this topic.

Zoning

Zoning can be used to encourage higher-density, mixed-use development with transit-friendly design.

Curitiba employs "wedding cake" density patterns as distance from the structural transit axes increases. The density is encouraged through a bonus system. Floor Area Ratio (FAR) represents the ratio of the total building area to the lot area. FAR 6 was initially permitted along the structural axes; this was reduced to 5 for office towers and 4 for residential units. Higher densities are permitted for office use because offices generate more transit ridership per square ft than residences.

Curitiba also employs zoning to ensure a good mix of storefronts lining the transitways and to attract high-rise office and residential towers. Nearly all parcels within two blocks of the trinary road system have been zoned for mixed commercial-residential uses. Zoning requires that at least 50 percent of the ground and second floors be devoted to retail-commercial uses (e.g., shops, restaurants, and consumer services). This floor space does not count against permissible FARs. The result has been that most of the first two floors of buildings that front transitways are devoted to retail shops and eateries.

Transfer of development rights has been used in Curitiba to allow owners within the Historic Area to sell or transfer rights to developers elsewhere in the city. Vancouver's zoning code also permits density transfers. New York City has also made extensive use of transfer of development rights to permit higher densities around train stations.

In Montgomery County, Maryland, a special zoning district was established for the Friendship Heights Metro station to allow an optional doubling of density under special hearing and design review procedures. In Arlington County, Virginia, the area around the Ballston Metro station was zoned for coordinated mixed-use development that encouraged projects that are half commercial and half residential. The zoning allowed the permitted FAR of 3.5 for commercial uses to be increased to 6; even higher ratios could be achieved with more residential space. Street-level retail uses were required in all commercial buildings.

In Portland station areas, interim zoning preserves options while detailed plans are being developed. Interim zoning prohibits certain automobile-oriented uses within 1/2 mi of stations, sets minimum densities, limits parking, and requires that buildings be oriented to the light rail stations. Station areas have been zoned for higher-density, transit-friendly development. New zoning regulates building setbacks, parking lot locations, and pedestrian environment.

In Los Angeles, development was encouraged in Metro station areas by downzoning all areas outside the transit corridors while allowing higher-density development in station areas. In Vancouver, station area upzoning occurred selectively. Areas where higher density was not desired were allowed to keep lower densities, making the higher-density station areas more attractive to developers.

Strategic Timing of Station Area Development

Timing of development and service delivery can promote higher densities without undue community opposition. In Vancouver, BC Transit pursued a policy of locating Phase 1 SkyTrain stations in underdeveloped industrial areas, with the goal of creating "new towns in-town." Land purchase and development planning were handled by the "Crown Corporation." Until development took place, ridership was supported by rerouting feeder bus routes to these stations. "Not in my back yard" objections to higher density were avoided because the area was industrial. This model could be useful for urban areas seeking to develop vacant tracts in station areas.

In Ottawa, outlying segments of the busway were installed before the more expensive downtown segments, allowing more route miles to be constructed with available funds. This established momentum for the system and increased the accessibility of the transit line in rapidly growing outer areas first, enhancing its ability to channel growth.

How development planning and implementation fits in with the scheduled opening of new services is also critical. The transit agency must be credible in terms of construction and service delivery schedules. Although real estate values may respond positively to the planned introduction of new service, agency credibility and developer interest dissipate when important milestones are missed.

In Washington, D.C., regional agencies came to early agreement on the need to match rail system planning with strategic planning for regional development. Local jurisdictions were given a head start in preparing for transit-oriented development. In a strong economic environment, transit stations helped attract development.

Parking Management

How parking is managed in areas served by public transportation can encourage transit use in several ways. Long applied in downtown areas, parking management techniques are increasingly being employed in suburban activity centers to support denser development and to increase transit ridership.

Limiting the availability of parking encourages transit use and frees land for development. In Portland and Boston, downtown parking freezes, motivated by air quality concerns, have been in effect since the 1970s. These limits on commercial parking have helped each city maintain transit mode share to its downtown. In another approach, cities, such as Bellevue, Washington, are trying to eliminate or reduce parking in downtowns and suburban areas and imposing maximum parking ratios geared to the level of available transit service. In Curitiba, street parking is carefully regulated.

Pricing strategies can help deter automobile use and encourage parking in less dense fringe areas or park-and-ride lots. In Ottawa, when the transitway opened, the government began eliminating free parking for its employees and reduced downtown parking availability. In Ottawa, available parking was reduced by 15 percent from 1975 to 1984 (despite a near doubling of office space) with the bus system absorbing 70 percent of work-related trips to downtown. In Curitiba, off-street spaces are privately owned and relatively expensive. In Houston, a policy of parking fees in the downtown and in the Texas Medical Area activity center has increased the transit mode share to 28 percent in downtown and 13 percent in the Medical Area activity center—these shares are significantly higher than in the other activity centers in Houston where parking is free.

Design guidelines that require parking structures or underground parking permit higher development densities and free the street level for retail uses and other development that encourages pedestrian use. In Vancouver, surface parking is strongly discouraged. Where allowed, parking must be underground or in structures. Besides encouraging higher densities and pedestrian amenities, the higher cost of such parking discourages unnecessary use. At Metrotown station, 10,000 free parking spaces are provided to support the station area development; however, 90 percent of these are underground or in structures.

Strategic location of park-and-ride lots can help station area development and use of feeder buses for station access. In Ottawa, park-and-ride lots are limited to the eastern and western termini of the busway to encourage feeder bus use and to promote development at other stations. Similarly, in Vancouver, BC Transit provides no commuter parking at many of its rail stations—it uses its bus system to feed the high-capacity rail system instead.

Whether park-and-ride lots are appropriate depends on the mode, line length, and surrounding residential densities. For example, for light rail, with shorter distances to downtown, it is more important to encourage residential density and pedestrian or bus access than park-and-ride access. For commuter rail, with longer distances to downtown and lower residential densities, park-and-ride lots are more appropriate.

Reductions of parking requirements for developers in return for support of transit are used in many cities. In Ottawa, a reduction of 25 parking spaces is allowed at retail centers for every bus stop provided—either an on-site stop or a Transitway station physically integrated with the retail center. In Seattle, developers can reduce required parking by 15 percent in return for providing transit passes to employees for at least 5 years.

Auto-Free Zones

Auto-free zones (such as transit streets or pedestrian ways) free street space for pedestrians and transit vehicles. Curitiba was one of the first cities in the world to close its downtown streets to cars and return them to pedestrians. Many U.S. cities use transit malls and automobile-restricted zones. To ensure the strongest effect on transit ridership, however, such zones must be directly integrated either with surface routes (e.g., Denver and Minneapolis) or underground transit (e.g., Boston). Although suburban malls (even many "neo-traditional" centers) provide auto-free pedestrian spaces, the malls are surrounded by vast parking lots and such a configuration does not significantly encourage transit use.

Financial Arrangements

Transit agencies, in partnership with redevelopment authorities and economic development agencies, have used innovative financial arrangements to foster station area development. For example, in Portland, local improvement districts are being established to improve pedestrian and transit rider environment in business districts. Property owners pay a 20-year benefit-based assessment to pay off bonds for the local share of a project. The federal share was used as an incentive to gain merchant support. In Houston's Uptown area, a Transportation Improvement District, formed in 1987, makes benefit-based assessments on property owners to finance transit improvements. Using these funds, the Uptown District has provided landscaping, traffic signals, and pedestrian crossings; further improvements are planned.

Transit or local development agencies can use several arrangements to assist in project financing, including land assembly, lease and sale arrangements, and parking subsidies. (See Federal Transit Administration, *Transit-Based Residential Development in the United States: A Review of Recent Experiences,* March 1994.) Using FTA funding, transit agencies can reimburse land use agencies for station area planning efforts in some cases.

In Vancouver, BC Transit has used easements as an alternative to right-of-way acquisition, an arrangement facilitated by the aerial transitway design. The original landowners retain the rights to use the land under the guideway, the air rights, and the surrounding property for development. BC Transit is compensated only if a direct station connection is required.

Station Area Planning and Design Guidelines

To help developers meet zoning requirements, land use and transit agencies have joined forces in several cases to develop specific guidance on planning and design principles to be followed for station area development.

The Portland area exemplifies station area planning with its Transit Station Area Program for the eastside light rail line. Tri-Met, Metro, Portland, Gresham, and Multnomah County all cooperated to prepare development plans for each station area, conduct market studies, evaluate access modes, study urban design options, and change zoning ordinances. The planning, which was tailored for each station area, included active citizen participation. A similar effort is underway for the westside light rail line.

In Ottawa, planners from the RMOC and OC Transpo have prepared transit-supportive design guidelines to make development more transit friendly. Examples are as follows:

- Proposed collector roads must provide efficient on-site transit circulation—with turning radii to accommodate buses and continuous routings. Sidewalks must be provided on at least one side of the street. Collector roads are designed first to meet transit service requirements; residential subdivisions are served by transit on these collector roads rather than from adjacent arterials to reduce walking distances.
- The densest land uses, retail centers, and senior citizens' residences must be nearest the transit lines, with single-family homes and recreational parks farthest away.
- Transit stations are in the community core; the objective is to have virtually everyone within a 5-min walk (400 m) of a bus stop.
- Mixed-use development at secondary employment centers is encouraged.

Public Agency Buildings and Leases in Station Areas

Public agencies can be used as anchors for station-oriented development projects, either as building developers or as tenants of privately developed space. In Vancouver, many federal and provincial agencies have located along the SkyTrain and SeaBus Systems. A similar policy is followed in Portland.

CHAPTER 6

CONCLUSIONS

Transit can influence urban form, and the design of the urban environment can encourage transit use and reduce dependence on the automobile. Public policies can support more compact urban form, land use mix, and transit-friendly design. Communities seeking to increase transit use and transit-oriented development may want to adopt policies and practices that reflect the following premises:

- Density or compactness of employment and population is the most important factor associated with transit use. In this regard, local and regional land use and development policy should seek to preserve and strengthen development in CBDs and revitalize urban neighborhoods already served by transit. Channeling suburban development into higher density clusters of development will support transit rather than low-density sprawling patterns that require automobile access.
- Within areas served by transit, land use mix and urban design can encourage transit use, balance directional flows along transit lines, and reduce automobile use. Development can be integrated with transit service in various ways. Regulations, such as zoning and site planning guidelines, can require developers to provide higher densities and mixed land use, designed with pedestrians and transit riders in mind. Siting of government facilities can encourage development of transit station areas. Local and regional governments can serve as developers and landowners. Transit agencies can also incorporate land use planning and development functions into their staffs. Regardless of the approach used, cooperation among public sector organizations and between the public and private sectors is necessary to ensure the best results over time.
- The relationships of various land use characteristics to transit ridership are very different for commuter rail and light rail—the two modes most frequently considered as potential new transit systems. For light rail, effectiveness is linked to higher residential density, higher CBD employment levels, and feeder bus access at stations. For commuter rail, CBD size and density are far more important than residential density, and parking availability is more important than feeder bus access.
- Above all, those communities with a vision that includes good transit access should adopt regional and local transportation policies that put transit first in order to sustain the positive effects of transit on land use. This means providing services that respond to customer needs and providing transit that is perceived as convenient, clean, comfortable, fast, efficient, and competitive with the automobile. The transit mode is less important than the quality of service. Ottawa and Curitiba show how bus services can attract equal or greater ridership than light rail by providing excellent service and station design. Putting transit first also extends to highway building and parking policies. The most positive transit ridership results occur where highway construction is limited and parking options are controlled.

This research and many past efforts have shown that transit can play the strongest role in providing regional access and supporting development location if it is part of an overall regional vision, if it links compact activity centers, if supportive land use and design policies exist to strengthen and sustain station area development, and if commitments are made to high-quality transit service. Because of the current climate of residential and employment suburbanization, automobile dependence, and reduced funding for transit, such a program requires political leadership, innovative and cooperative agency relationships, a good public relations campaign, and the patience to wait for long-term results.

BIBLIOGRAPHY

Allen, W. R. et al. *The Impact of Rapid Transit on Suburban Residential Property Values and Land Development: An Analysis of the Philadelphia High-speed Line*. Philadelphia, University of Pennsylvania, Wharton School (1986).

Arrington, G. B., Jr. *Beyond the Field of Dreams: Light Rail and Growth Management in Portland*. Portland, Oregon, Tri-Met (1995).

Bernick, M., and R. Cervero. "Transit-Based Residential Development in the United States: A Review of Recent Experiences." Institute of Urban and Regional Development, University of California at Berkeley, Working Paper 611 (March 1994).

Bookout, L., and J. Wentling. "Density by Design," *Urban Land,* 47 (1988) pp. 10–15.

Boyce, D. E. *The Impact of Rapid Transit on Suburban Residential Property Values and Land Development*. Washington, D.C., U.S. Department of Commerce (1972).

Cambridge Systematics, Inc. *The Impacts of the UMTA Programs—Case Studies of Four Urban Areas*. Washington, D.C., UMTA (August 1988).

Cambridge Systematics, Inc. *The Effects of Land Use and Travel Demand Strategies on Commuting Behavior*. Washington, D.C., U.S. Department of Transportation, Federal Highway Administration (1994).

Cervero, R. *America's Suburban Activity Centers: The Land Use–Transportation Link*. Boston, Unwin-Hyman (1989).

Cervero, R. *BART@20: Land Use and Development Impacts*. Berkeley, Institute of Urban and Regional Development, University of California (July 1995).

Cervero, R. "Jobs-Housing Balance Revisited: Trends and Impacts in the San Francisco Bay Area." *Journal of the American Planning Association* (forthcoming, Fall 1996).

Cervero, R. "Rail Transit and Joint Development: Land Market Impacts in Washington, D.C., and Atlanta." *Journal of the American Planning Association,* 60, 1 (1993), pp. 83–94.

Cervero, R. *Ridership Impacts of Transit Focused Development*. Berkeley, University of California (1993).

Daniels, P. W. "Transport Changes Generated by Decentralized Offices: A Second Survey." *Regional Studies,* 15, 6 (1981), pp. 507–520.

Davis, E. et al. *Transit-Linked Development: A Case Study of Atlanta's MARTA System*. Washington, D.C., U.S. Department of Transportation (1985).

Ewing, R. *Best Development Practices: Doing the Right Thing and Making Money at the Same Time*. Chicago, American Planning Association (1995).

Frank, L. D. "The Impacts of Mixed Use and Density on the Utilization of Three Modes of Travel: The Single Occupant Vehicle, Transit, and Walking." Paper presented at the 73rd Annual Meeting of the Transportation Research Board, Washington, D.C. (January 9–13, 1994).

Frank, L. D. and G. Pivo. *Relationship Between Land Use and Travel Behavior in the Puget Sound Region*. Olympia, Washington State Department of Transportation, WA-RD 351.1 (1994).

Giuliano, G. "Is Jobs-Housing Balance a Transportation Issue?" *Transportation Research Record 1305*. Washington, D.C., Transportation Research Board (1991).

Green, R. D., and O. M. James. *Rail Transit Station Area Development: Small Area Modeling in Washington, D.C.* Armonk, New York, M.E. Sharpe (1993).

Handy, S. *How Land Use Patterns Affect Travel Patterns: A Bibliography*. Chicago, Council of Planning Librarians, No. 279 (1992).

Harris, C. "Bringing Land Use Ratios into the 90s." PAS Memo, Chicago, American Planning Association (1992).

Hooper, K. G., and JHK and Associates. "Travel Characteristics at Large-Scale Suburban Activity Centers." *NCHRP Report 323* Washington, D.C., Transportation Research Board (1989).

Kitamura, R et al. *Mobility and Livable Communities*. State of California Air Resources Board (1994).

Knight, R. and L. Trygg. "Evidence of Land Use Impacts of Rapid Transit Systems." *Transportation,* 6 (1977), pp. 231–47.

Leinberger, C. *Suburbia Land Use in Transition: Emerging Forces and Issues Shaping the Real Estate Environment*. Washington, D.C., The Urban Land Institute (1993).

Lowry, I. "Planning for Urban Sprawl." *TRB Special Report 221: Looking Ahead, the Year 2000*. Washington, D.C., Transportation Research Board (1988).

Maryland-National Capital Park and Planning Commission. *Transit and Pedestrian Oriented Neighborhoods*. Silver Spring, MD, MNCPPC (1992).

Mullins, J. A., et al. "Land Use Impacts of the Houston Transitway System." *Transportation Research Record 1237* (1989), pp. 29–38.

1000 Friends of Oregon. *LUTRAQ,* Vol. 6, Portland, Oregon (1995).

Parsons Brinckerhoff Quade & Douglas, Inc., Dr. Robert Cervero, Howard/Stein-Hudson Associates, Inc., and Jeffrey Zupan. *Commuter and Light Rail Transit Corridors: The Land Use Connection*. Washington, D.C., Transportation Research Board (1996).

Parsons Brinckerhoff Quade & Douglas, Inc., Dr. Robert Cervero, Howard/Stein-Hudson Associates, Inc., and Jeffrey Zupan. *Public Policy and Transit-Oriented Development: Six International Case Studies*. Washington, D.C., Transportation Research Board (1996).

Parsons Brinckerhoff Quade & Douglas, Inc., Dr. Robert Cervero, Howard/Stein-Hudson Associates, Inc., and Jeffrey Zupan. *Mode of Access and Catchment Areas for Rail Transit*. Washington, D.C., Transportation Research Board (1996).

Parsons Brinckerhoff Quade & Douglas, Inc., Dr. Robert Cervero, Howard/Stein-Hudson Associates, Inc., and Jeffrey Zupan. *Influence of Land Use Mix and Neighborhood Design on Transit Demand*. Washington, D.C., Transportation Research Board (1996).

Parsons Brinckerhoff Quade & Douglas, Inc., Dr. Robert Cervero, Howard/Stein-Hudson Associates, Inc., and Jeffrey Zupan. *Transit, Urban Form, and the Built Environment: A Summary of Knowledge*. Washington, D.C., Transportation Research Board (1996).

Pivo, G. "The Net of Beads: Suburban Office Development in Six Metropolitan Areas." *Journal of the American Planning Association*, 54, 3 (1988), pp. 509–20.

Pushkarev, B. S., and J. M. Zupan. "Where Transit Works: Urban Densities for Public Transportation." In *Urban Transportation: Perspectives and Prospects*, ed. by H. S. Levinson and R.A. Weant, Westport, Connecticut, Eno Foundation (1982).

Pushkarev, B. S. and J. M. Zupan. *Public Transportation and Land Use Policy*. Bloomington, Indiana University Press (1977).

Rice Center for Urban Mobility Research. Houston's Major Activity Centers and Worker Travel Behavior. Houston, Texas, Joint Center for Urban Mobility Research (1987).

Smith, W. "Mass Transit for High-Rise, High-Density Living." *Journal of Transportation Engineering*, 110, 6 (1984), pp. 521–35.

Stringham, M. "Travel Behavior Associated with Land Uses Adjacent to Rapid Transit Stations." *ITE Journal*, 52, 4 (1982), pp. 18–22.

Transit-Based Residential Development in the United States: A Review of Recent Experiences. Federal Transit Administration, Washington, D.C. (March 1994).

Transit Cooperative Research Program. "An Evaluation of the Relationships Between Transit and Urban Form." *TCRP Research Results Digest 7* (June 1995).

Vincent, M. J., M. A. Keyes, and M. Reed. *NPTS Urban Travel Patterns, 1990 Nationwide Personal Transportation Survey (NPTS)*. Washington, D.C.: Federal Highway Administration (June 1994).

Warner, S. B. *Streetcar Suburbs*. Cambridge, Harvard University Press (1962).