4

The Built Environment and the Demand for Transit

Three physical attributes of transit villages are thought to significantly increase transit ridership and thus distinguish them from other urban settings. These are the three dimensions, or 3-Ds, of what we believe make for successful transit villages: Density, Diversity, and Design. By density, we mean having enough residents and workers within a reasonable walking distance of transit stations to generate high ridership. By diversity, we mean a mixture of land uses, housing types, and ways of circulating within the village. And by design, we mean physical features and site layouts that are conducive to walking, biking, and transit riding. This chapter discusses these physical dimensions of transit villages and presents comparative findings from different studies on how these dimensions influence travel behavior. Chapter 5 extends these insights by presenting the results of some of our own work on the effects of transit-oriented development on transit riding, drawing largely from California experiences. Relative to other research in these areas, our work has focused centrally on the connection between transit villagelike development and travel behavior.

Demonstrating that transit-supportive designs and patterns of development do encourage people to ride trains and buses, and to walk and bike more often, is important from a public-sector perspective. If we are to build a sound and compelling rationale for governments and institutions to take transit-oriented planning and development seriously, it is essential that there be some evidence that society at large benefits as a result, especially in the form of more transit riding and, by extension, less automobile dependence. Thus, building a case for future transit village development partly hinges on demonstrating that the physical makeup of neighborhoods that surround transit stations matters. And for transit villages to produce the public benefits that are hoped for, they need to have the kinds of densities, diversity, and design that will draw significant numbers of people out of cars and into trains, buses, and other forms of travel.

4.1 DENSITY AND COMPACTNESS

Implicit in the creation of transit villages is an increase in residential densities above those typically found in American suburbs. It stands to reason that mass transit needs "mass," or density, if people are to ride trains and buses in appreciable numbers. If origins and destinations are thinly spread throughout a region, those with access to a car will drive rather than take mass transit. As noted in Chapter 3, fewer than 2 percent of all Americans making a work trip that began and ended in a suburb took mass transit in 1990. Nearly all of these suburb-to-suburb trips were by private car. Low-density settings are clearly not transit's natural habitat.

Many suburban developments across the United States are built at densities that are intrinsically dysfunctional from a transportation standpoint. Today, for example, most suburban office and commercial projects average floor-area ratios (i.e., building area divided by land area) of 0.2 to 0.3—densities that are too low to support frequent transit services, yet are sufficiently high to produce spot congestion. In the San Francisco Bay Area, a number of cities downzoned land near rail stations during the 1980s in fear of higher densities causing traffic snarls on connecting surface streets. Walnut Creek, an East Bay suburb served by BART, passed a moratorium in 1985 that banned new construction over 10,000 ft^2 on the very grounds that large-scale development would overwhelm streets connecting to BART. The problem with such actions is that they end up pushing growth farther out to the exurban fringes, often in the form of more auto-oriented shopping plazas and office parks, and thus, while perhaps temporarily holding the line on congestion locally, exacerbating transportation and environmental problems for the region as a whole. Banning growth near rail stations and displacing it to the metropolitan fringe only means more vehicle miles of travel and tailpipe emissions.

4.1.1 Effects of Density on Travel

The preponderance of evidence shows that higher densities and compact patterns of development lead to substantially higher rates of transit riding. Three lines of empirical work have been conducted on this question: intercity comparisons, international comparisons, and activity center and corridor studies. The following sections highlight some of the key findings from these studies.

4.1.2 Intercity Comparisons

These studies use comparisons between average density and built-environment characteristics of cities and transit usage, statistically controlling for such factors as differences in incomes and traffic congestion. In reality, however, these studies never do fully control for these other factors, so it is difficult to unambiguously infer exactly the importance of the built environment in shaping travel demand.

In a seminal 1977 study, *Public Transit and Land-Use Policy,* Boris Pushkarev and Jeffrey Zupan, both planners with New York's Regional Plan Association, developed a set of *land-use thresholds* that are necessary to financially justify different types of transit investments, based on intermodal comparisons of transit unit costs and intercity comparisons of transit trip generation rates.[1] They found the key determinants of transit demand to be the size of a downtown (defined by nonresidential floorspace), distance of a site to downtown, and residential densities. To justify the cost of a light rail transit investment, for instance, Pushkarev and Zupan concluded that minimum residential densities of nine dwelling units per acre were needed over a 75-mi^2 service area with the light rail line connected to a downtown that has at least 20 million ft^2 of nonresidential floorspace. Cities like Buffalo and Baltimore generally met these land-use thresholds and, in part because of the Pushkarev and Zupan study, opted to proceed with building light rail transit systems during the 1980s. Notwithstanding some of the limitations of Pushkarev and Zupan's analysis (e.g., data were predominantly from the New York metropolitan area, and the effects of suburban centers on mode of travel were ignored), the work is still frequently cited and has been used often as benchmarks in feasibility studies of proposed rail projects.

In another cross-city comparison of six U.S. metropolises (ranging in size from Springfield, Massachusetts, to the New York region), Wilbur Smith found that transit trips rose most sharply when residential densities increased from around 7 dwelling units to 16 units per acre.[2] In the case of greater New York, for instance, this residential density jump increased average weekday transit trips per person from 0.2 to 0.6. At residential densities of 100 dwelling units per acre, Smith found that each New Yorker was averaging around one mass transit trip per day.

4.1.2.1 Density Effects on LRT and Commute Rail Demand The classic work by Pushkarev and Zupan that has been cited was recently updated as part of a study on transit and urban form relationships sponsored by the National Research Council, under the Transit Cooperative Research Program (TCRP).[3] This 1995 study concentrated on how densities, downtown employment, and travel distance influence transit ridership for light rail and commuter rail systems, the types of systems that have been the focus of recent U.S. rail investments. Using data from 19 light rail lines (and 261 stations) across 11 U.S. cities, the study showed that ridership increases exponentially with both central business district (CBD) employment and employment density, controlling for a host of other variables, including income. Higher ridership levels also occurred with higher residential densities, especially for those making longer trips. The elasticity between ridership and population density was 0.592—that is, controlling for other factors, every 10 percent increase in population densities surrounding the 261 stations studied was associated with about a 6 percent increase in boardings at LRT stations. This relationship is further revealed by Figure 4.1. This figure, produced from the TCRP study, shows how daily boardings fall with both increases in population density and distance to CBD for a setting where the downtown has 100,000 workers at a density of 100 workers per acre, and the typical access distance to the light rail station is 1 mi. Assuming a station is 10 mi from the CBD, the experiences across these 19 light rail lines show that a neighborhood with an average of 20 persons per gross acre (e.g., small lots, some duplexes) could be expected to produce 2000 daily boardings, compared to just 900 daily boardings for a neighborhood averaging 5 persons per acre (e.g., ranch estates, quarter-acre lots).

The analysis of commuter rail services was conducted for six cities with 47 commute rail lines and 550 stations.[4] The TCRP study found rail ridership also increased with CBD size and employment density, though not in the same exponential fashion as for light rail.

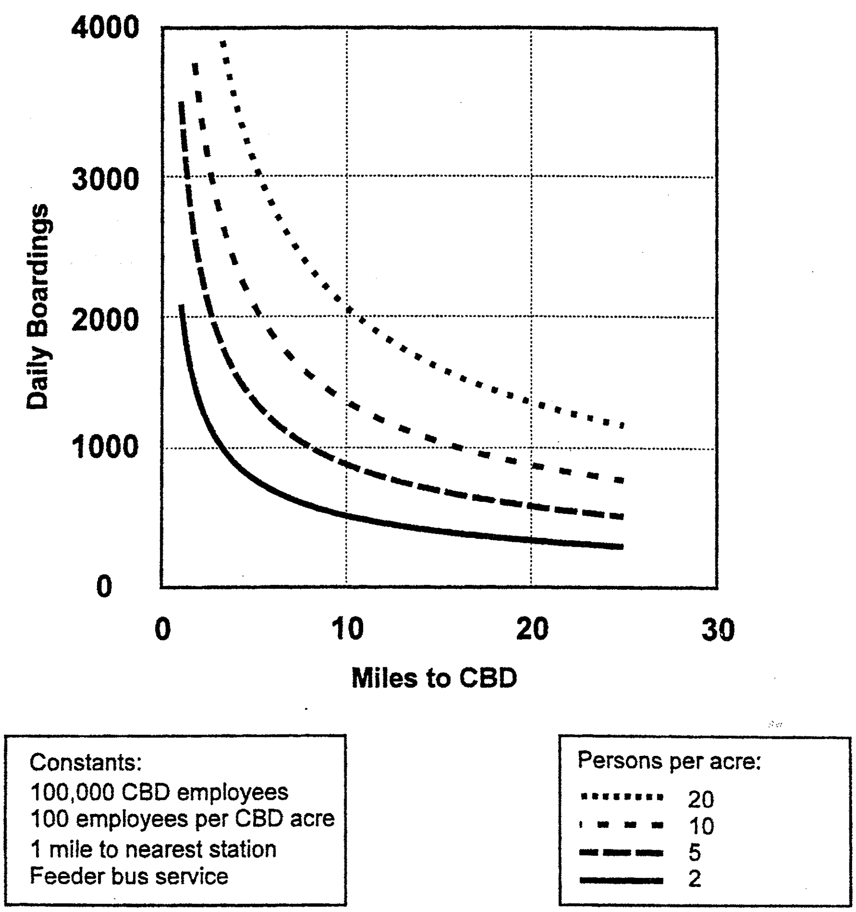


Figure 4.1 Light Rail Station Boardings by Distance to CBD and Residential Density. (Source: Parsons Brinckerhoff Quade & Douglas, Inc., Robert Cervero, Howard/Stein-Hudson Associates, Inc., and Jeffrey Zupan, *Topic 1 Report: Regional Transit Corridors: The Land Use Connection* [Washington, DC: Transportation Research Board, Transit Cooperative Research Program, 1995, p. 28].)

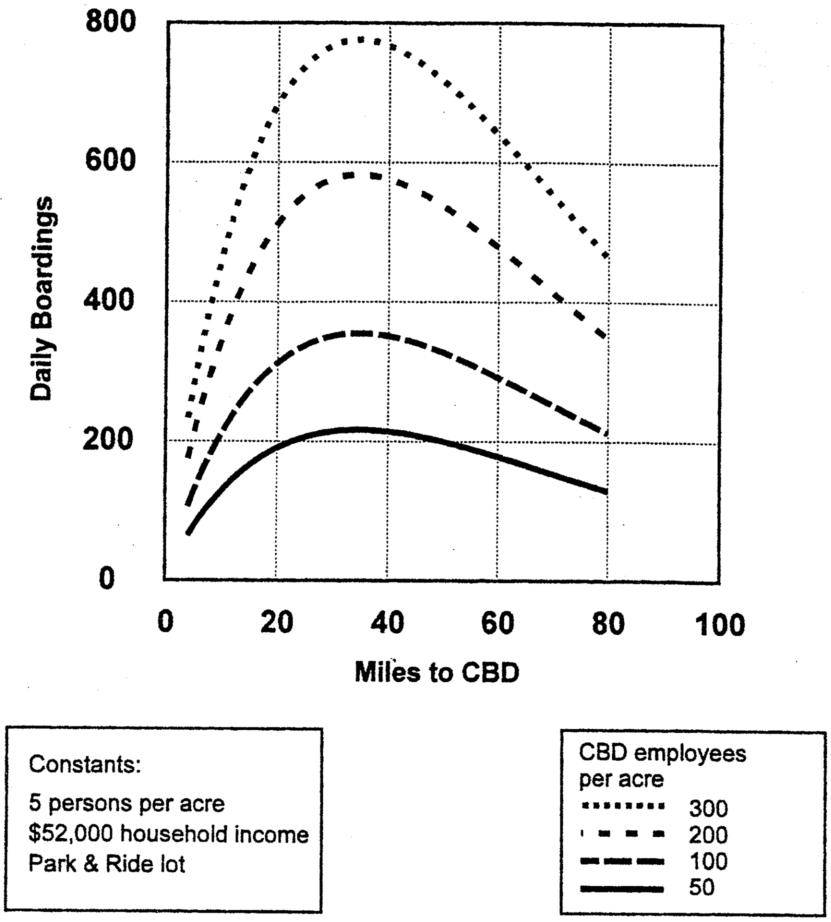


Figure 4.2 Commuter Rail Station Boardings by CBD Distance and Employment Density. (Source: Parsons Brinckerhoff Quade & Douglas, Inc., Robert Cervero, Howard/Stein-Hudson Associates, Inc., and Jeffrey Zupan, *Topic 1 Report: Regional Transit Corridors: The Land Use Connection* [Washington, DC: Transportation Research Board, Transit Cooperative Research Program, 1995, p. 30].)

Figure 4.2 shows that for a commuter rail station 40 mi from the CBD that has a park-and-ride lot and is surrounded by a neighborhood with average annual household incomes of $52,000 and five persons per acre, if the downtown destination has 300 workers per acre, nearly 800 boardings would be produced at this station. If, on the other hand, the downtown destination has just 50 workers per acre, the number falls to approximately 200 boardings.

Merging these demand-side results with cost models, the TCRP study was able to estimate relative cost efficiency, defined in terms of total annual costs divided by annual vehicle miles of service, for different land-use scenarios.[5] Figure 4.3 shows that for a 10-mi LRT line surrounded by denser housing (10 persons per acre), the cost per vehicle mile to a downtown with 100,000 workers (at 300 workers per acre) would be around $7. At the

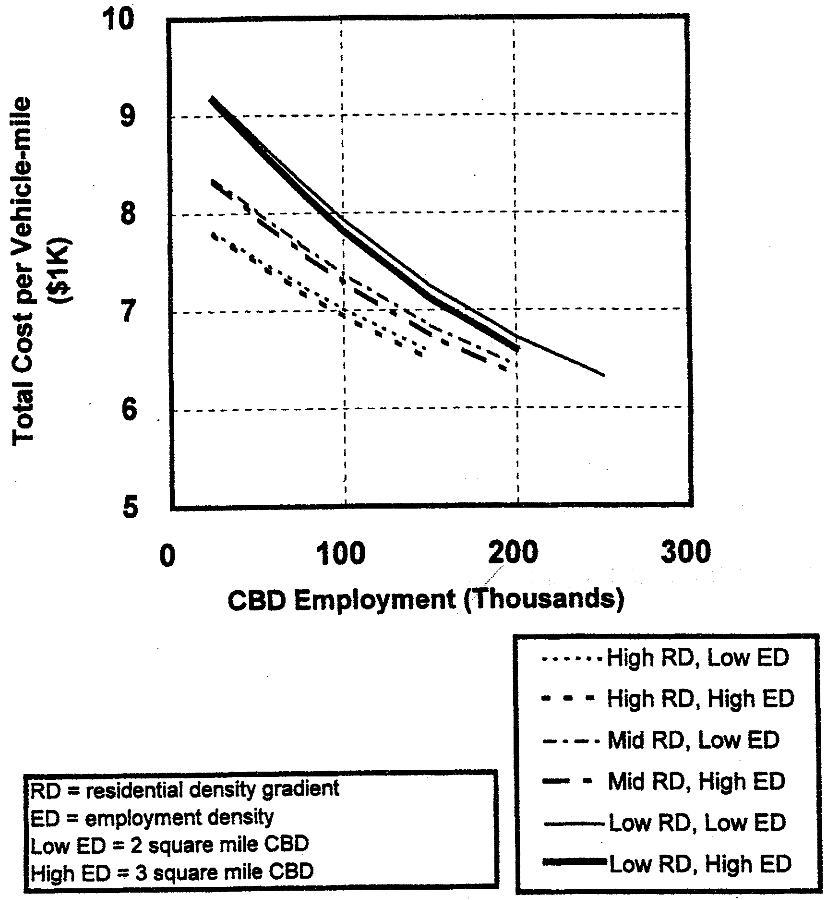
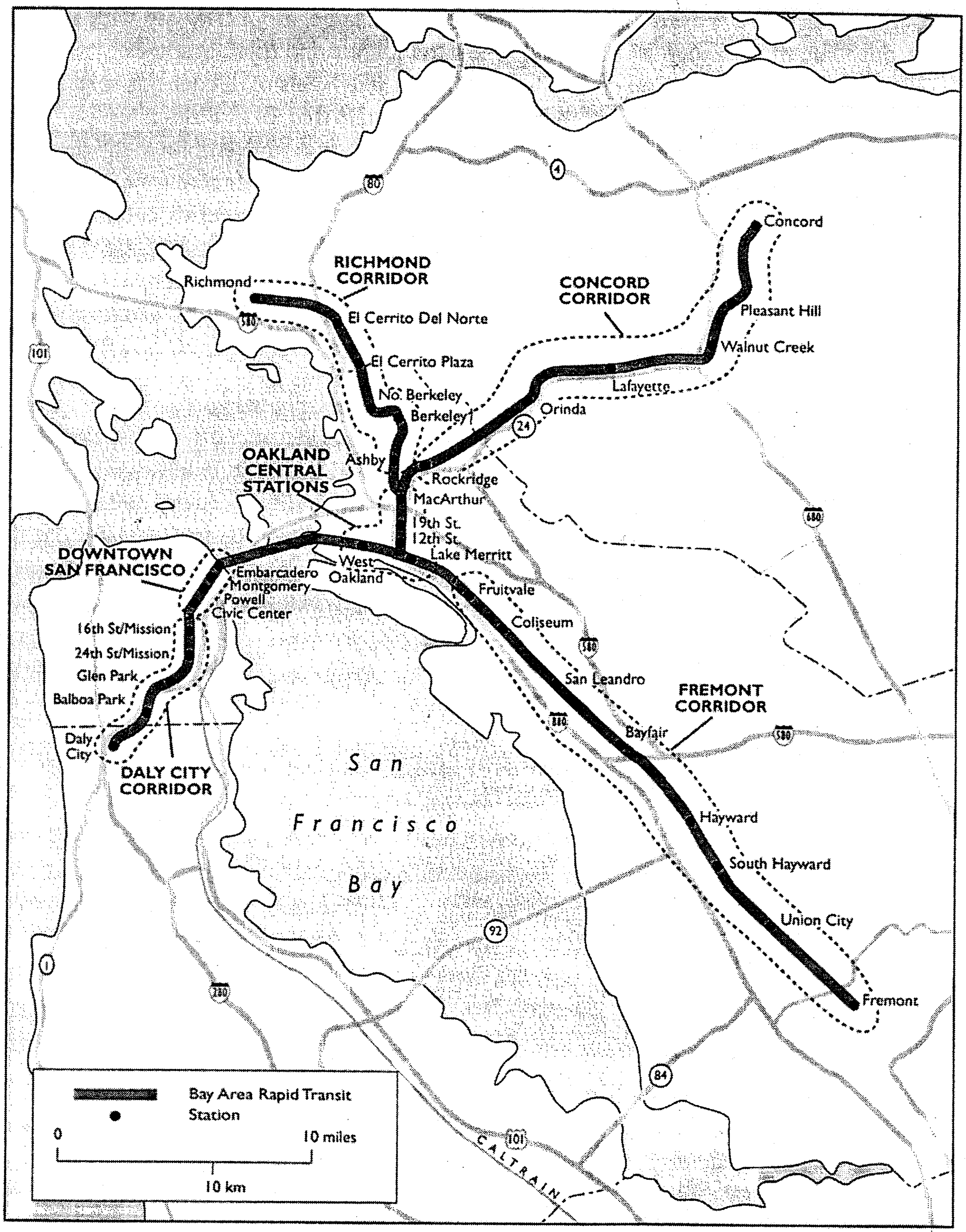


Figure 4.3 Light Rail Cost Efficiency by CBD Employment and Densities. (Source: Parsons Brinckerhoff Quade & Douglas, Inc., Robert Cervero, Howard/Stein-Hudson Associates, Inc., and Jeffrey Zupan, *Topic 1 Report: Regional Transit Corridors: The Land Use Connection* [Washington, DC: Transportation Research Board, Transit Cooperative Research Program, 1995, p. 78].)

other extreme, if the corridor densities were low (3 persons per acre), and employment size and densities were low also (20,000 workers at 100 workers per acre), then cost per vehicle mile would exceed $9. The lower cost efficiency reflects the fact that as ridership levels fall, service frequencies are usually scaled back, resulting in lower resource utilization (and thus higher costs per mile of service).

4.1.2.2 Density Effects on Heavy Rail: The Case of BART We recently developed similar demand models using 1990 ridership and land-use data for the 34 BART stations (shown in Map 4.1).[6] Land-use data were compiled for station-area catchments, defined as a contiguous area that captured 90 percent of all access trips to and egress trips from a



Map 4.1 Bay Area Rapid Transit System (BART), 1995.

BART station. BART's average catchment area is quite large, around 90 mi^2 with a radius of about 7 mi, though there was considerable variation around these averages.

Using statistical models that controlled for factors like levels of feeder bus service and household income in station catchment areas, we found that BART ridership per 1000 population (within the catchment) went up with population and employment densities (within 2 mi of stations).[7] On average, an increase of 10 workers per acre for a radius of 1 to 2 mi of a BART station increased the weekday turnstile counts entering and leaving the station by 6.5 per 1000 catchment population. Additionally, an increase of 1000 inhabitants per square mile added an average of 8 more rail trips per 1000 residents.

The effects of employment densities on ridership per square mile of catchment area were plotted for three different fare scenarios—$1, $2, and $3 fares to downtown San Francisco. BART has distance-based fares, so these scenarios also reflect length of trips and, indirectly, geographic setting (i.e., higher fares tend to be made by suburbanites). The plot in Figure 4.4 clearly reveals that ridership rates rise with employment densities and fall with price. At 150 employees per acre (e.g., downtown San Francisco's Embarcadero station) and a $2 average fare, there are nearly 250 daily turnstile entries and exits per square mile of catchment area; at 20 workers per acre, the rate is only about 150 turnstile counts.

Relationships were even stronger as a function of population densities, as suggested by the relatively steeper slopes for the sensitivity plots shown in Figure 4.5. Again assuming a fare of $2, Figure 4.5 shows that there would be nearly 200 trips per square mile for a station with a catchment zone that averages 4000 residents per square mile; this compares to

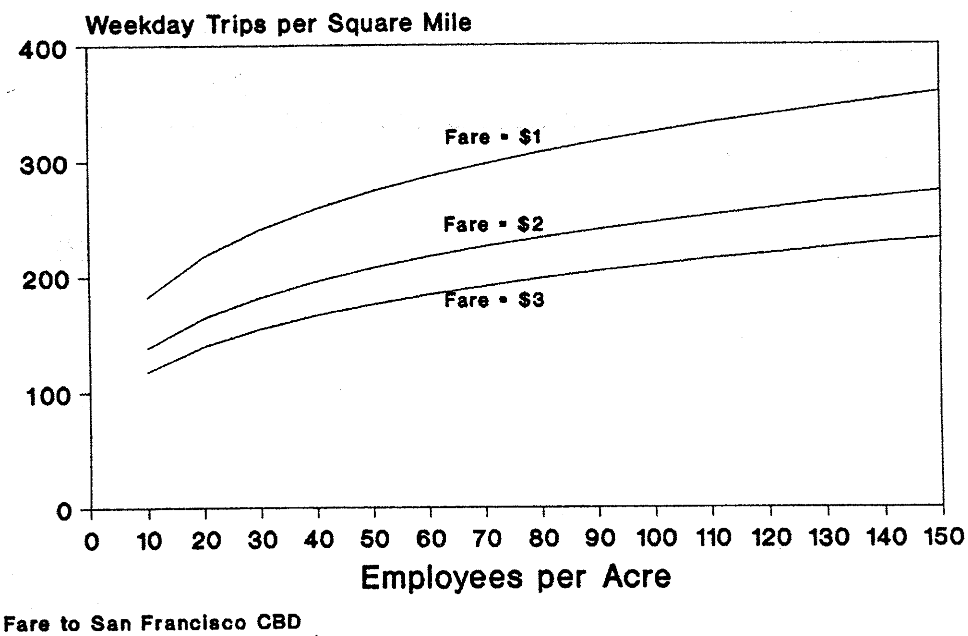


Figure 4.4 BART Weekday Rail Trips per Square Mile of Catchment Zone by Employment Density and Fare to San Francisco's CBD.

just 135 trips per square mile for a catchment zone with 2000 inhabitants per square mile. The most fortuitous scenario would be an average population density of 5000 residents per square mile (around 50 percent higher than the net residential density for the three BART-served counties) and an average fare to downtown San Francisco of $1. This combination could be expected to produce over 300 weekday trips per square mile of catchment area.

4.1.3 International Comparisons

Several notable studies with an international focus have examined the impacts of density on mode choice and such consequences of travel demand as gasoline consumption. The most influential, albeit controversial, is the work by Peter Newman and Jeff Kenworthy from Murdoch University in Perth, Australia.[8] Using international comparisons of U.S., European, and Asian cities, Newman and Kenworthy found that sprawling, auto-oriented U.S. cities like Phoenix and Houston averaged four to five times as much gasoline consumption per capita as comparably sized European cities (e.g., Copenhagen, Frankfurt). Differences in petroleum prices, incomes, and vehicle fuel efficiency explained only about half of these differences. The authors argued that the remaining difference was explained by urban structure: Cities with strong concentrations of central hubs, and accordingly a better developed public transport system, averaged much lower energy use than cities where jobs are scattered. Newman and Kenworthy also found a strong relationship

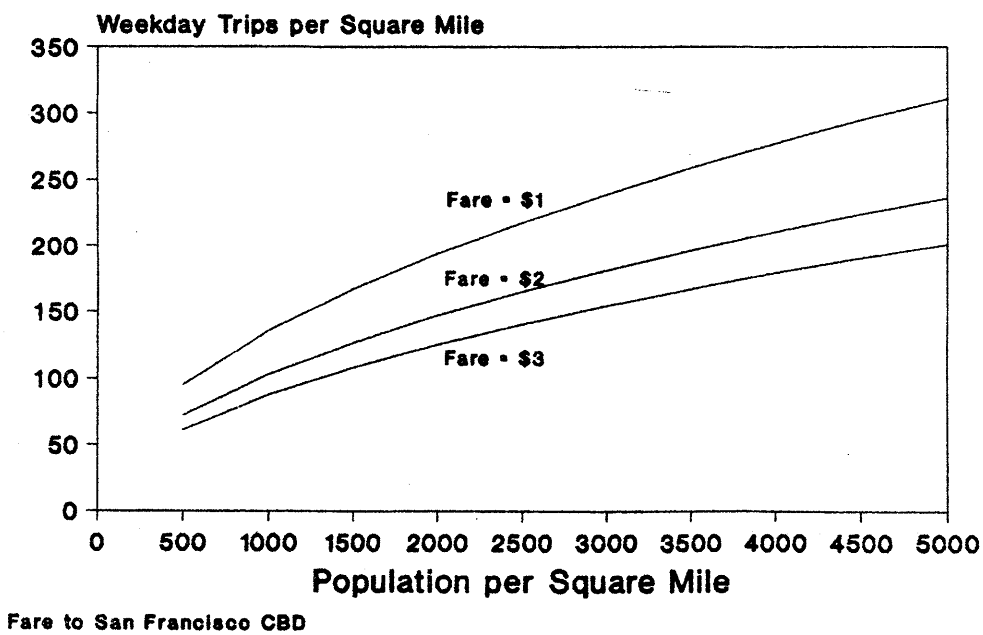


Figure 4.5 BART Weekday Rail Trips per Square Mile of Catchment Zone by Population Density and Fare to San Francisco's CBD.

between density and energy consumption within metropolitan areas. In the case of greater New York, for instance, Manhattanites averaged 90 gal of fuel consumption per capita annually compared to 454 gal per capita in the outer suburbs.[9]

In another study, John Pucher compared transit modal splits among 12 countries of Western Europe and North America (Canada and the United States). On average, European cities were found to be on the order of 50 percent denser with substantially more mixed-use neighborhoods than their American counterparts. Pucher found the percentage of all trips made by the automobile in U.S. cities to be more than double that of the majority of Western European countries, most of which have per capita incomes comparable to those of the United States. Pucher argued that transit's success in Europe can be explained by more supportive urban development patterns and automobile taxation policies rather than by factors like fare subsidies. Although impossible to measure, historical and cultural factors have also played a strong role in transit's relative success in Europe.

4.1.4 Intrametropolitan Comparisons

A final body of research has focused on how transit riding is influenced by densities at the neighborhood, activity center, or corridor level, typically within a single metropolitan area. These studies largely confirm the results of more macrolevel studies. Several studies have shown, for instance, that suburban employment centers and edge cities with above-norm densities typically average 3 to 5 percent more commute trips by mass transit among their work forces.[10] Bellevue, Washington, for instance, an edge city outside of Seattle, east of Lake Washington, has relatively high densities in its core, averaging 5 acres of building area for every acre of developed land. These densities are approximately one-third higher than in the nearby I-90/Eastside office-commercial strip and two-thirds higher than in Redmond, a community 5 mi east of Bellevue that has attracted a number of corporate tenants (e.g., Microsoft, Inc.) and campus-style office developments in recent times. In 1989, Bellevue averaged a 27 percent transit/ridesharing modal split for work trips headed to its center. This was two to three times higher than for the I-90/Riverside corridor and Redmond. Bellevue's success is not attributable to higher densities alone, however. Complementing the core's high-rise profile have been reductions in parking spaces, commercial-rate charges for parking, and good quality bus connections.

One common result from intrametropolitan studies of density's effects on travel demand is that the relationship is stronger at lower ranges of density and weaker at higher levels. Statistically, the relationship follows an exponential decay form—travel demand falls at a decreasing rate as density rises, whether travel is measured as trips per household, share of automobile trips, or gasoline consumption per capita. Using 1990 census data for the Bay Area, we found a strong inverse correlation between "percent commute trips by drive-alone auto" and "net residential densities" for 34 Bay Area subregions, as plotted in Figure 4.6; every doubling of mean residential densities was associated with roughly a 20 to 30 percent decline in the share of commute trips by drive-alone auto.[11] In a more recent study of 28 California communities, John Holtzclaw found that the number of automobiles and vehicle miles traveled (VMT) per household fell by one-quarter as densities doubled and by approximately 8 percent with a doubling of transit service levels.[12] Similar patterns have been found for the greater Seattle area.[13] Moreover, these relationships hold not only within metropolitan areas, but between them as well. For instance, Newman and Kenworthy's plot of gasoline consumption versus urban densities across 30 international cities also followed a decay function.

This remarkable consistency in the relationship between density and travel demand provides a useful policy lesson to the transit village movement: The biggest benefits come from going from very low to moderate densities, say from an average of 4 units per acre to 10 to 15 units per acre—that is, from a setting with quarter-acre estates to one with a mix of small-lot single-family homes and duplexes/triplexes. Increasing densities to mid- and high-rise apartments add relatively smaller benefits in terms of trip reduction. One doesn't need Hong Kong-like densities to sustain mass transit. If super-high densities were required, the term *transit village* itself would be a misnomer. Transit villages suggest places with more moderate residential densities, the kinds of settings sought by most middle-class households and that are in keeping with most Americans' lifestyle preferences.

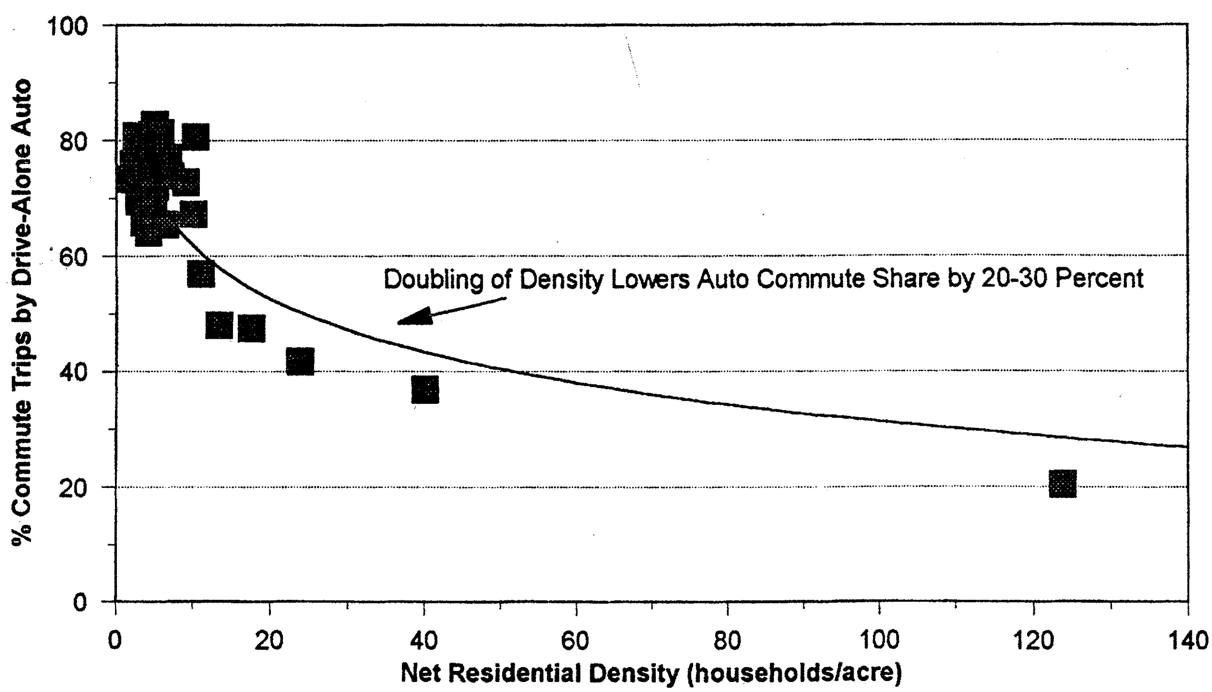


Figure 4.6 Higher Density Areas Average Lower Shares of Auto Commuting in the San Francisco Bay Area. Data are for 34 superdistricts in the nine-county Bay Area. Every doubling of residential density is associated with a 20 to 30 percent decline in drive-alone commuting shares.

4.1.5 Density, Design, and Perception

Today's typical suburban planned unit developments (PUDs) are designed at 5 to 6 dwelling units per residential acre (dua), well below the minimum of 12 dua necessary to support moderate levels of rail transit services.[14] Of course, communities are not designed singularly for the purpose of shaping travel behavior, much less to lure people to mass transit. More important, according to urbanologists Hans Blumenfeld and Jane Jacobs, is to design places at a proper human scale so as to impart a sense of identity and belonging to a place.[15] Hans Blumenfeld, with the assurance that comes from long practice, maintains the "right" residential densities are between 12 and 60 dua. Such a range, he contends, ensures people can easily reach places by foot and have frequent face-to-face contact without being overawed by a monumental scale. Jane Jacobs advocates even higher densities, more in the 50 to 150 dua range, to create a vibrant community and instill an attachment to place.

Many people wrongly equate density with high-rise buildings. The French architect Le Corbusier's Radiant City, the ultimate futuristic high-rise residential city, featured gross densities of only 120 to 150 dua. Since towers were separated by vast expanses of open space, the buildings in Radiant City covered only 12 percent of the ground. Four- to five-story residential buildings can produce average densities above those of Radiant City, in the 140 to 220 dua range.

Built environments are extremely malleable, able to accommodate a variety of spatial organizations and housing types. It is possible to build at 12 dua and still accommodate single-family detached units. Ebenezer Howard's garden cities, forerunners of today's transit village schemes, featured single-family homes built at 12 dua. Row houses (connected single-family homes with zero lot lines) can be developed as high as 6 dua. Mixing building types can nudge average densities up to the level where transit trips outnumber automobile trips. For instance, 50 dua can be achieved by designing a project where half of the units are single-family dwellings at 12 dua, 30 percent are row houses at 36 dua, and 20 percent are mid-rise apartments at 160 dua.

The reality is that most Americans prefer low-density areas with detached buildings not because they like spread-out development per se, but rather because they perceive such settings as safer and less hectic. Residential preference surveys consistently show that upward of 95 percent of Americans prefer single-family to multifamily dwellings.[16] Many associate density with noise, overcrowdedness, urban blight, and stress. Preference for single-family living also reflects the strong North American value placed on home ownership, secured tenancy, and privacy.[17]

Only recently have designers begun to recognize that actual and perceived densities can vary widely. Density is a perceived experience shaped by visual cues, some of which suggest crowdedness (e.g., busy sidewalks) and others that convey spaciousness (e.g., tree-lined streets).[18] James Bergdall and Rick Williams, in a study of three San Francisco streets with similar densities (39–47 dua) lined with buildings of identical height but different architectural details, concluded that facades with greater articulation (e.g., visible roofs, individual bay windows, and recesses) were perceived as lower in density than streets with facades of a uniform appearance.[19]

Architectural critics Lloyd Bookout and James Wentling contend that people will trade off higher densities in return for more amenities and better quality living environments.[20] Ways of making higher density projects acceptable include: extensive landscaping; adding parks, civic spaces, and small consumer services in neighborhoods; varying building heights and materials to break the monotony of structures; detailing rooflines; designing mid-rise buildings on podiums with tuck-under, below-grade parking; and replacing row apartments connected by exterior breezeways with eight-plex buildings (two-story stacked flats with four ground-level patios and second-level decks).

It is the prospect of reducing the perceived densities of transit villages by providing attractive amenities that motivated research on market acceptance of compact transit village development. The findings of this research are presented in Chapter 6, The Market for Transit Villages.

4.2 LAND-USE DIVERSITY

In addition to being compact, transit villages should be diverse in their land-use composition. The separation of land uses is a legacy of Euclidean zoning principles that, when applied in the 1920s, sought to protect residences from nuisances like smokestacks and foul odors. In today's cities where clean, nonpolluting businesses and shops are the norm, the logic of separating and excluding urban activities makes little sense. There are potential efficiencies in mixed land-use environments. By clustering eight neighborhoods around village centers and linking them with a community bus system and bike network, the developers of Columbia, Maryland, were able to achieve annual savings of $810,000 in 1975. From travel surveys, they estimated that households averaged 30 fewer miles driven per month.[21]

The transportation benefits of mixed land uses can be significant but are not always obvious. Settings with a mixture of land uses can encourage people to walk or ride to various destinations instead of driving. Having shops and restaurants connected to a nearby suburban job center with a nicely landscaped pathway likely means more people will walk to these destinations during, say, lunch time. It might also mean some who otherwise would have driven to work now ride transit instead because they don't need a car to be mobile in the midday.

Mixed land uses also promote resource efficiency. One example is shared parking. In a transit village, for instance, theatergoers might use the spaces vacated by office workers in the evenings. Shared parking can shrink the scale of suburban activity centers by as much as 25 percent, which might translate into a 25 percent more pedestrian-friendly environment. Also, less road capacity is necessary if a development is mixed instead of single use. At an executive park with only office space, for instance, most tenants will arrive in the morning and leave in the evening. This means sizing the road infrastructure to handle peak loads. If the same amount of floorspace was instead split between offices, shops, and residences, trips would be more evenly balanced throughout the day and week, reducing the amount of peak road capacity needed. Efficiencies can also be enjoyed by transit operators. Balanced mixed uses often translate into balanced, bidirectional travel flows. This means buses and trains will be more fully utilized along a route. When residences and workplaces are poles apart, the all too frequent spectacle of near-empty transit vehicles in certain directions is inevitable.

Mixed land uses are important beyond inducing people to ride transit or walk. Having shops, restaurants, newsstands, coffeehouses, and open-air markets near neighborhoods and work centers adds variety and vitality to an area. One only has to go to a suburban office park on a weekend to see how devoid of life these places can be. A mixed-use area, on the other hand, has people present throughout the day and week. Because of continuing activity and casual surveillance of many eyes, mixed-use environments feel safer. To seniors and others concerned with safety and alarmed about escalating crime, an attractive mixed-use transit village might be viewed as a safe haven and respite from the frenetic pace of a city. It is for such reasons that urban sociologist Jane Jacobs has argued that an essential feature of any healthy city is "an intricate and close-grained diversity of uses that give each other constant mutual support, both economically and socially."[22]

Some U.S. cities have been particularly active in targeting mixed-use development near transit stations. In Montgomery County, Maryland, a TS-M (Transit Station-Mixed) zoning classification has been established in the vicinity of some Metrorail stations, which allows for a wide range of commercial, service, and residential uses that serve transit users and residents in the area. The purpose of the TS-M zone is to:

> (a) promote the optimum use of transit facilities by assuring the orderly development of land in transit station development areas and enhancing access, both vehicular and pedestrian access;
>
> (b) provide for the needs of the workers and residents of transit station development areas;
>
> (c) provide for the incidental shopping needs of transit facility riders at Metrorail stations;
>
> (d) minimize the necessity for automobile transportation by providing, in largely residential transit station areas, the retail commercial uses and professional services that contribute to the self-sufficiency of the community.

Several west coast cities have been particularly active in zoning for mixed-use activities near transit in recent years. Hillsborough, Oregon, has created a mixed-use overlay zone for areas in close proximity to the planned Hillsborough Extension light rail line in the

Portland area. The city of San Diego provides density bonuses for developments that include child-care centers near light rail stops. And Lynwood, Washington, has created a special Mixed Use/Transit-Supportive zone that grants special use permits to any of the following activities that are sited near transit lines: banks, professional buses, retail stores, offices, and child-care centers.

Are there any special mixes of services that are compatible with a transit-oriented community? This partly depends on the parameters of a transit village. At blended densities of around 12 units per acre, a transit village with a one-quarter mile radius can accommodate a residential population of around 3800 (assuming an average of 2.5 persons per household). This range is generally large enough to support most neighborhood commercial uses, like a bakery or deli. Of course, to the degree that other neighborhoods abut a transit village, the retail market shed could easily expand outward. Among the "appropriate" uses proposed by the city of San Jose for a mixed-use infill neighborhood with a strong pedestrian orientation are:

bakeries	*galleries*	*post office*
banks	*grocery stores*	*professional offices*
bookstores	*gift shops*	*public/government uses*
camera stores	*hardware stores*	*radio, TV, video, music stores*
clothing stores	*health clubs*	*restaurants, bars*
collectible shops	*home furnishings*	*schools—private*
day-care centers	*ice cream parlor*	*shoe stores*
delis	*instruction studios*	*small appliance repairs*
drugstores	*laundromats*	*small theater*
dry cleaners	*office supplies*	*specialty foods*
florists	*personal service shops*	*sporting goods*
food vendors	*pet stores*	*tailor*

4.2.1 Mixed Use and Travel at Employment Centers

Two studies have examined how adding retail and other mixed uses at employment centers can shape travel behavior. A 1989 study of 59 large-scale suburban employment centers in the United States found that centers with on-site retail averaged about 8 percent higher rates of midday walk travel and lower rates of drive-alone commuting.[23] A more recent study by Cambridge Systematics explored the connection between the work environment and commute modes among 330 companies in the Los Angeles region that had introduced Transportation Demand Management (TDM) measures (e.g., ridesharing) in response to the Regulation XV trip reduction mandates aimed at improving air quality. The study found that transit captured 6.4 percent of commute trips in "diverse-mix" employment areas versus 2.9 percent of commute trips in "no-mix" areas (with both figures for companies that had introduced TDM measures and various incentives, such as free transit passes).

4.2.2 Mixed Use and Travel Within Neighborhoods

Empirical evidence on the transportation benefits of mixed-use environments outside of large-scale employment centers is only beginning to accumulate. In a comprehensive study of mixed-use sites in Colorado, average trip rates for individual shops in retail plazas and other mixed commercial settings were 2.5 percent below the mean rates published in the Institute of Transportation Engineers's *Trip Generation* manual.[24] The study recommended adjusting trip rates downward by this amount to reflect the higher likelihood of linked walk trips, instead of separate vehicle trips, between establishments in mixed-use settings.

More recent work has examined the implications of retail and other mixed uses in predominantly residential neighborhoods on nonwork travel specifically. In a comparison of shopping trips among residents from four neighborhoods in the San Francisco Bay Area, Susan Handy found those living in two traditional, mixed-use neighborhoods made two to four more walk/bicycle trips per week to neighborhood shops than did those living in nearby areas that were served mainly by automobile-oriented, strip retail development.[25] Residents of mixed-use neighborhoods, however, averaged similar rates of auto travel to regional shopping malls, suggesting that internal walk trips might not have replaced external auto trips but rather have been supplemental. In a recent comparison of work and nonwork travel among residents of six communities in Palm Beach County, Florida, Reid Ewing and his colleagues at Florida International University found that the presence of shopping, recreation, and school facilities within communities can significantly lower vehicle hours traveled (VHT) per capita.[26] A low-density planned suburban community, Wellington, whose residents commuted the farthest and drove the most, also averaged the shortest shopping and recreation trips because various retail shops and services were available within their community.

Another recent study addressed the influence of mixed uses on both work and shop trips in the Seattle-Tacoma region. That work, by Lawrence Frank and Gary Pivo, found that mixed-use neighborhoods were most strongly correlated with walk trips to work, but rather surprisingly they had little influence on mode choice for shop trips.[27] Our own recent study of work trips across 11 large U.S. metropolitan areas similarly found having retail shops near residences can be an inducement toward walking or riding transit to work.[28] Specifically, having retail shops and other nonresidential uses within 300 ft of one's residence lowered the probability of auto commuting in greater Boston, Dallas, Phoenix, Philadelphia, and seven other large metropolitan areas. Having stores between a transit stop and one's residence, for instance, allows transit riders to conveniently shop while en route home in the evening, thus linking work and shop trips in a single tour.[29] This research suggested, in fact, that the presence of retail uses can yield almost as many transportation benefits as higher densities in residential neighborhoods. Based on mode choice models estimated using 1985 travel data from these 11 metropolitan areas, Figure 4.7 plots the probability of walking or bicycling to work for commute distances of 0.125 to 1.5 mi. The graph shows that, for a commute distance of around 1 mi, one out of four work trips was by foot or bicycle if someone lived in a neighborhood with low densities and mixed uses or one with mid- to high-rise apartments but no nearby retail outlets. Of course, the highest transit ridership came from a combination of high densities and mixed land uses. At a 1.5-mi commute distance, there was a 25 percent chance that someone living in a mid- to high-rise neighborhood with surrounding stores walked or biked to work in these 11 metropolitan areas.[30]

4.2.3 Jobs-Housing Balance

Another form of mixed land uses that is engendered in the transit village concept is a balance of jobs and housing. Jobs-housing balance has been touted as a means of shortening commute trips, thus reducing vehicle miles of travel (VMT), freeway traffic, and tailpipe emissions.[31] California's two largest metropolitan areas—greater Los Angeles and the San Francisco Bay Area—sought to set subregional jobs-housing balance targets in the 1980s.

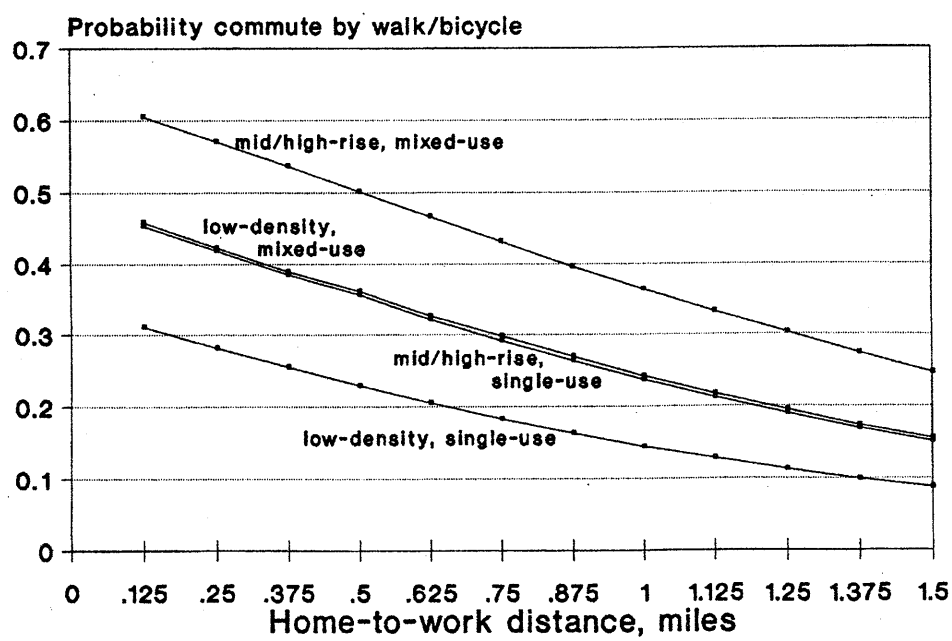


Figure 4.7 Probability of Commuting by Walking or Bicycling for Four Land-Use Scenarios as a Function of Commute Distance.

Genevieve Giuliano, Anthony Downs, and other observers have questioned whether jobs-housing balance will ever be an effective tool for producing transportation and air quality benefits for several reasons: workers in two-earner households usually work in different locations; exclusionary zoning policies limit residential mobility; and factors other than job access, such as quality of schools, exert strong influences on residential location choices.[32]

Peter Gordon and Harry Richardson further argue that jobs-housing balance will have little impact on the fastest growing travel segment, the nonwork trip, which already accounts for three-quarters of all trips in the United States and the majority of trips during the peak hour.[33] Others point out, moreover, that regional balance is a natural evolutionary process brought on by market conditions; over time, jobs and housing colocate so as to maintain an equilibrium in commuting time. For this reason, critics charge that planning initiatives that aim to balance growth (e.g., developing self-contained new towns or transit villages) are unnecessary. Martin Wachs and his colleagues at UCLA recently presented evidence that supports this colocation hypothesis: The average commute distances of 8000 hospital workers in southern California fell from 10.0 mi in 1984 to 9.7 mi in 1990. This and other research are consistent with the Law of Constant Travel Time that maintains transportation technologies and locational decisions adjust to maintain a fairly constant amount of time devoted to commuting, which according to Arnulf Grubler is in the 1 to 1.5 h per day range. He notes that this time budget has remained "close to an anthropological constant" since ancient Rome.

Other data paint a much different portrait of recent commuting trends, however. The National Personal Transportation Survey showed that the average commute length in the United States increased from 9.2 mi in 1983 to 10.6 mi in 1990. Moreover, census data reveal that the average work trip time increased from 1980 to 1990 in 35 of the 39 U.S. metropolitan areas with populations over 1 million. Three of the four areas experiencing the greatest increases in commute durations were California metropolises that have invested in rail transit over the past decade: metropolitan San Diego (19.5 to 22.2 min, +13.8 percent), Los Angeles-Long Beach (23.6 to 26.4 min, +11.9 percent), and Sacramento (19.5 to 21.8 min, +11.8 percent).

Recent research makes an even stronger case for public policies, like transit villages, that encourage balanced jobs and housing growth. In their study of travel in the Puget Sound area, Frank and Pivo found that commute distances and times tended to be shorter for those living in balanced areas. The average distance of work trips ending in balanced census tracts (with jobs-to-housing ratios of 0.8 to 1.2) was 28 percent shorter (6.9 versus 9.6 mi) than the distance of trips ending in unbalanced tracts. A recent study by Reid Ewing, titled "Before We Write off Jobs-Housing Balance . . . ," used 1990 census data to compute the proportion of work trips that remain within over 500 cities and towns in Florida. Ewing found that the share of internal, or within-community, commuting significantly increased with greater balance in the number of local jobs and working residents.

Our own recent work largely substantiates these findings from Seattle and Florida. Using 1990 census data for the 23 largest cities in the San Francisco Bay Area, the average one-way commutes of workers in cities with 50 percent more jobs than housing units were over 3 min longer than the regional average. Cities with high housing prices relative to the earnings of their workforce also tended to have very large shares of their workers living elsewhere. The city of Pleasanton, 35 mi east of San Francisco, experienced the fastest employment growth during the 1980s in the region (365 percent increase), changing from a predominantly bedroom community to a job-surplus city in 1990 (13 percent more jobs than housing units). Paralleling this trend have been rapid increases in commute distances among Pleasanton's work force, from approximately 13 mi in 1987 to 18.8 mi in 1993.

Creating mixed-use, balanced transit villages would clearly be consonant with the objective of reducing distances and drive-alone shares of commute trips. Notwithstanding the harsh criticism leveled at jobs-housing balance as an object of public policy, evidence shows that balanced growth matters.

4.3 TRANSIT-SUPPORTIVE DESIGN

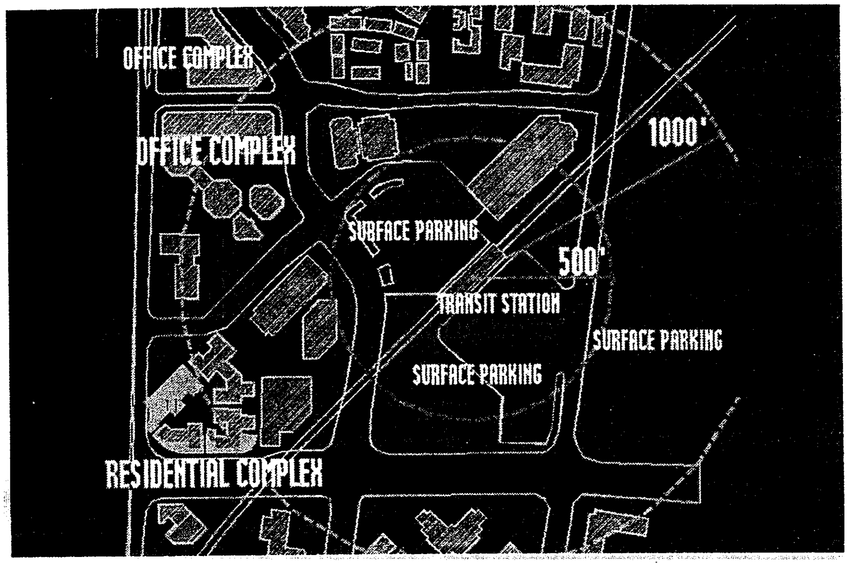
The final element in the triad of supportive physical characteristics of transit villages is urban design itself. Transit villages should encourage walking and transit riding. Since all transit trips involve some degree of walking, it follows that transit-friendly environments must also be pedestrian-friendly.

A common theme of transit-supportive design is to create places that, in addition to being more compact and diverse, have design features (e.g., landscaped sidewalks, parking in the rear, and retail streetwalls) that make walking and transit riding more enjoyable. The aim is to reorient community building away from the planned urban developments (PUDs) of the 1960s and 1970s toward patterns reminiscent of earlier streetcar suburbs and pre-World War II traditional communities.

A 1993 survey across the United States and Canada found 26 examples of completed design guidelines prepared by transit agencies that promoted transit-friendly development. The main purpose of these guidelines has been to influence the project design decisions of developers at the conceptualization as well as the plan review stages. Commonly accepted transit-supportive designs often include the following types of treatments:

- ☐ Continuous and direct physical linkages between major activity centers; siting of buildings and complementary uses to minimize distances to transit stops (Figure 4.8).
- ☐ Streetwalls of ground-floor retail and varied building heights, textures, and facades that enhance the walking experience; siting commercial buildings near the edge of sidewalks.

NO



YES

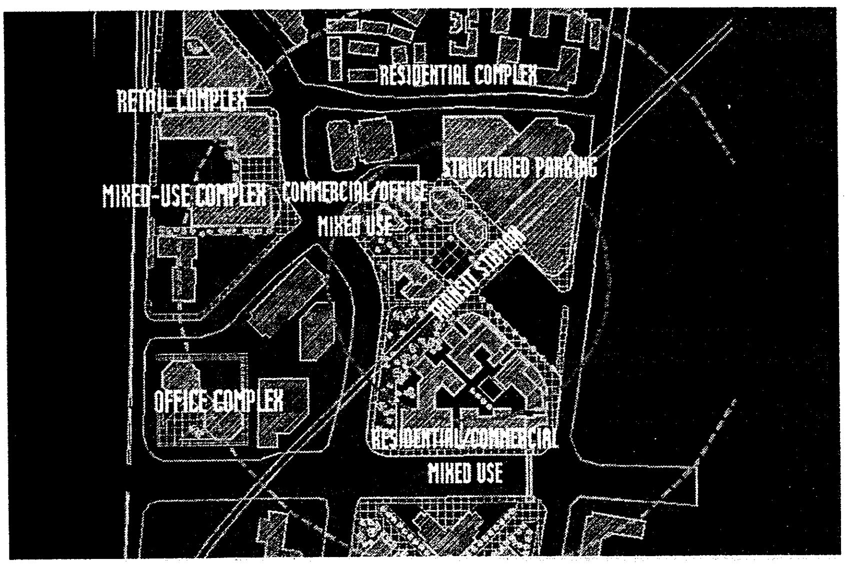


Figure 4.8 Are Land Uses Complementary and Within Walking Distance? Compact versus spread-out development around a transit station.

- ☐ Integration of major commercial centers with the transit facility, including air rights development (Figure 4.9).
- ☐ Gridlike street patterns that allow many origins and destinations to be connected by foot; avoiding cul-de-sacs, serpentine streets, and other curvilinear alignments that create circuitous walks and force buses to meander or retrace their paths; direct sight lines to transit stops (Figure 4.10).
- ☐ Minimizing off-street parking supplies; where land costs are high, tucking parking under buildings or placing it in peripheral structures; in other cases, siting parking at the rear of buildings instead of in front.

NO

Random disposition and orientation of the built forms;

No logical relations between transit infrastructure and buildings

YES

Disposition and orientation of the building according to a main axial system;

Direct link between transit infrastructure and building

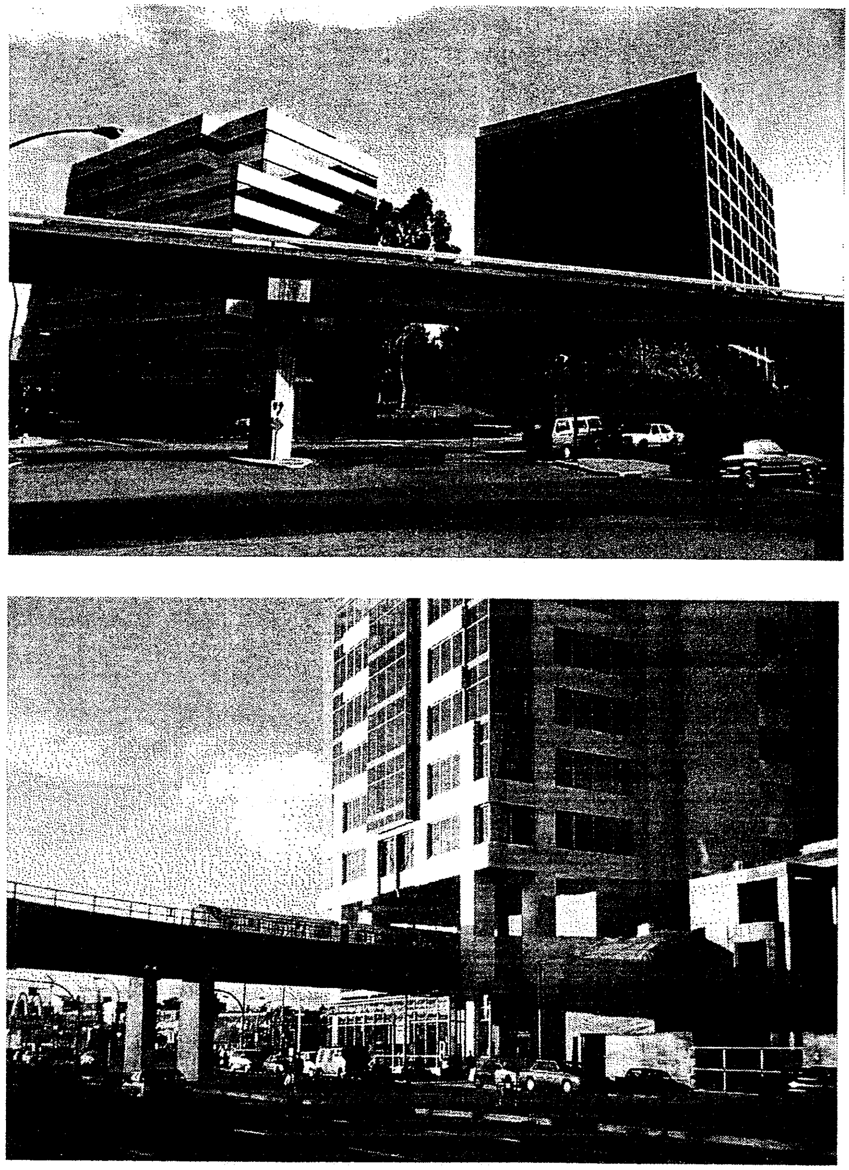
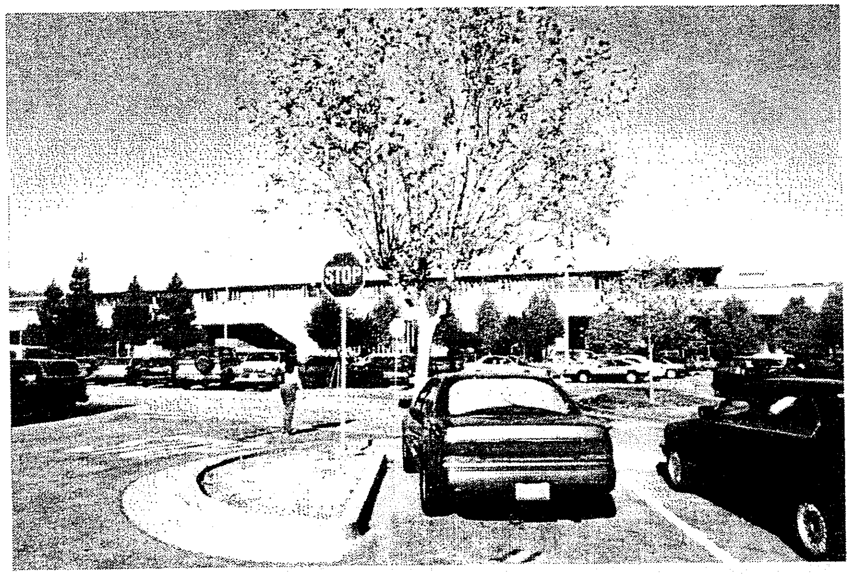


Figure 4.9 Do Buildings Fit with and Complement the Transit System? Building detachment versus building integration.

- ☐ Providing such pedestrian amenities as attractive landscaping, continuous and paved sidewalks, street furniture, urban art, screening of parking, building overhangs and weather protection, and safe street crossings.
- ☐ Convenient siting of transit shelters, benches, and route information.
- ☐ Creating public open spaces and pedestrian plazas that are convenient to transit.

The rationales for these design treatments are obvious. Any one treatment would unlikely be noticed. Collectively, however, they would create a fundamentally different suburban milieu than what the vast majority of Americans are used to. For the most part, these treat-



NO

YES

Figure 4.10 Are Walk Paths Direct and Separated from Parking? Direct versus disconnected sight lines to a transit station.

ments would not add terribly much to the cost of new planned developments. However, one only has to drive around most contemporary suburban subdivisions in the United States to know that these design approaches are more the exception than the rule.

Urban designers often stress the importance of public spaces in creating lively and interesting urban milieus. Having plazas, courtyards, gathering places, and greenery near transit stations, we believe, is vital to the transit village, a subject we address in more detail in Chapter 6. Among the activities taking place in public spaces, Jan Gehl, an urban

Transforming suburban neighborhoods into more pedestrian-friendly, transit-supportive environments might occur over a number of stages. Figure 4.11 shows a typical auto-oriented commercial district with a vast expanse of parking that separates buildings from the main street, numerous driveways and curbcuts, no internal or curbside sidewalks, exposed pathways, and minimal landscaping. Over time, this rather hostile environment for walking and transit riding could be redesigned, modified, and retrofitted so that it is more human in scale, compact, and attractive to pedestrians. In the early stages, less expensive things could be done: installing sidewalks and street lighting, improving pedestrian crossings, and consolidating driveways. The public improvements ideally would be enough to increase property values and spark a renewed interest in the area. This might lead to the intensification of uses, including the addition of housing. Figure 4.12 portrays how the setting might look after such measures as relocating parking, consolidating driveways, integrating walkways, improving the landscape, and filling in the main street with more neighborhood-oriented uses like restaurants and specialty retail shops are accomplished. The final stage of transformation is depicted by Figure 4.13. A light rail line penetrates the neighborhood. Flanking it is a public plaza that ties into a community complex. Courtyards, tree-canopied walkways, and further landscaping improvements enhance the setting. Additional housing densifies the neighborhood even more. The end result is the transformation of an auto-oriented commercial strip into a mixed-use neighborhood more conducive to walking and transit riding.

designer from Copenhagen, has identified three types: necessary activities, optional activities, and social activities.[34] Necessary activities are what you must do, such as walking to school, waiting for the bus, sitting because you are tired, etc. These activities take place at all times and more or less regardless of the quality of physical environment. There is no choice. Gehl maintains that a good neighborhood makes sure that all necessary activities take place in pleasant circumstances.

Optional activities are what you are tempted to do, given the right circumstances. They might include standing about looking at streetlife, sitting for a while to enjoy a place or scenery, having a latte at a sidewalk cafe, and so on. These are things you do when the situation is nice and inviting. Last, social activities involve meeting fellow citizens. This can involve major civic events such as festivals, parades, protests, and ceremonies. Another

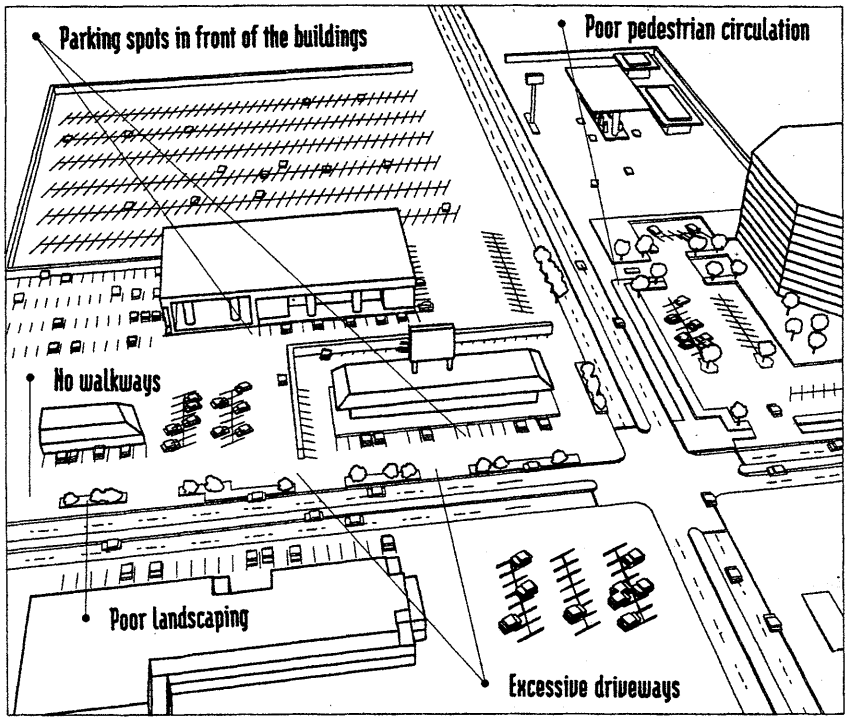


Figure 4.11 Auto-Oriented Commercial District Unfriendly to Pedestrians and Transit Users.

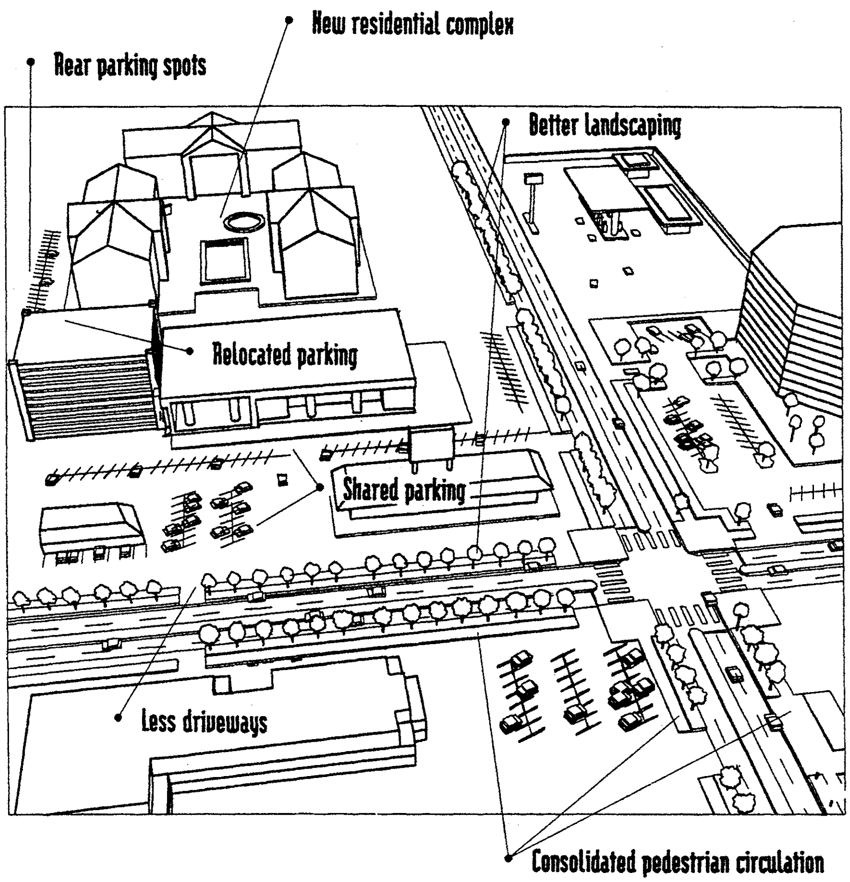


Figure 4.12 Initial Improvements Friendly to Pedestrians and Transit Users.

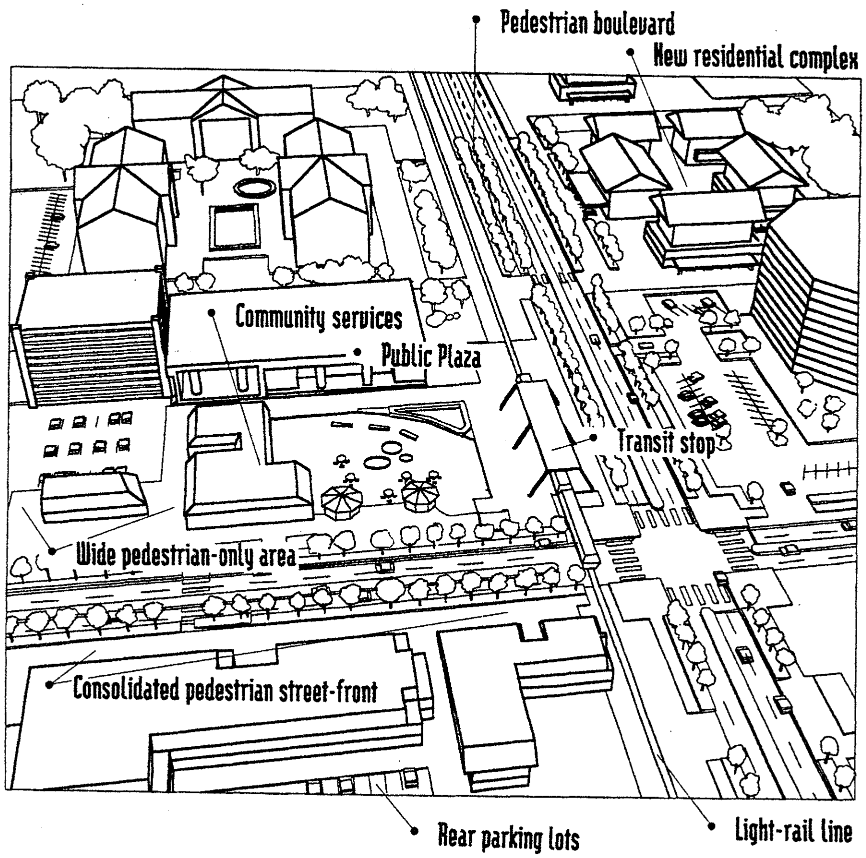


Figure 4.13 Transformation into a Transit-Oriented Neighborhood.

very important category of social activities is the multitude of humble everyday encounters, including passing others on sidewalks, seeing and overhearing people, and taking in the life and atmosphere of the city. Unplanned and unexpected meetings, and the sheer pleasure of serendipity, are what make social encounters so important. Great neighborhoods can accommodate both city celebrations and humble encounters.

Good neighborhoods make sure that this network of meetings of its people can prosper. Gehl has equated planning a neighborhood to planning a party along these simple lines: a feeling of welcome from the moment you arrive; enjoyable spaces and enough room for everyone; good catering—nice locations while eating and having refreshments; entertainment and music; and good places for standing about and sitting. Many of Gehl's prescriptions for neighborhood design have applicability to transit villages. Notably, transit villages must be places that are enjoyable for people to go and interact, whether en route to the train station or simply to take in village life. Having splendid public spaces, we believe, would perhaps do as much to draw people from different walks of life into the community as any single design element.

4.3.1 Transit-Supportive Design and Travel

Presently, our knowledge of how transit-supportive and pedestrian-friendly urban designs shape travel behavior is limited. After reviewing experiences with transit-supportive urban designs in greater Chicago, San Diego, San Francisco, Seattle, and Washington, DC-Baltimore, one study concluded that:

> the evidence on the impacts of transit-supportive site designs is admittedly thin. . . . With the exception of several sites in the Seattle and Washington, D.C. areas, employees at transit-supportive sites were generally as dependent on their cars to get to work as those working in more auto-oriented sites. Quite simply, the effects of micro-features tend to be too "micro" to exert any fundamental influence on travel choices. It is more likely that transit-friendly design elements influence midday travel, such as the incidence of walk trips during lunch hour, than peak-period commuting. Had data for other trips purposes as well as for internal trips within activity centers been available, a more positive light might have been cast on the transportation benefits of transit-supportive designs.[35]

In recent years, a number of studies have sought to gauge the importance of traditional neighborhood designs on travel choices in American cities. None of these studies has successfully isolated the unique effects of transit-supportive design features, as discussed in this section. However, these studies have measured differences in modal splits and rates of walk trips in traditional neighborhoods with transit- and pedestrian-friendly design features as well as land-use diversity and moderate levels of density.[36] Often, impacts are assessed by comparing travel statistics in these traditional neighborhoods with those from more typical auto-oriented subdivisions.

Quite a few of these neighborhood comparisons have been conducted for the San Francisco Bay Area. Using data from smog-check odometer readings, John Holtzclaw found that residents of dense, mixed-use, and pedestrian-friendly San Francisco neighborhoods drove, on average, only one-third as many miles each year as residents of Danville, a low-density, auto-oriented East Bay suburb with comparable incomes.[37] Another study found a dramatic difference in mode choice between auto-oriented suburbs and traditional pre-World War II neighborhoods with moderate to high densities.[38] In 1980, 23 percent of the trips in traditional Bay Area neighborhoods were on foot and 22 percent were by transit. By comparison, suburban residents made only 9 percent of their trips by foot and 3 percent by transit. Other studies have shown similar travel differences between auto-oriented and transit-oriented suburbs, both in the Bay Area and elsewhere.[39]

Many comparative studies to date can be faulted for not adequately controlling for confounding factors, most notably income, that might explain travel differences. Most comparisons have also failed to control for differences in transit service levels and geographic location. In the following chapter, we present our own recent research on this subject that introduces controls for removing the effects of these confounding factors. Chapter 5 aims to further strengthen the case, using our recent research findings, that transit villages can yield important social and public benefits.

NOTES

1. Boris Pushkarev and Jeffrey Zupan, *Public Transit and Land-Use Policy* (Bloomington: Indiana University Press, 1977).
2. Wilbur Smith, Mass Transit for High-Rise, High-Density Living, *Journal of Transportation Engineering,* Vol. 110, No. 6, pp. 521–535, 1984.
3. Parsons Brinckerhoff Quade & Douglas, Inc., Robert Cervero, Howard/Stein-Hudson Associates, and Jeffrey Zupan, *Regional Transit Corridors: The Land Use Connection* (Washington, DC: National Research Council, Transportation Research Board, Transit Cooperative Research Program H-1). Jeffrey Zupan and David Kerr were the principal analysts of the effects of the built environment on national transit ridership. Robert Cervero, Samuel Seskin, Jack Dean, Phil Smelley, Brent Baker, and Susan Serres assisted in the analysis.
4. The six cities were Boston, Chicago, Los Angeles, Philadelphia, San Francisco, and Washington, DC.
5. Cost components included annual operating and capital depreciation, including land acquisition. Many of these costs vary considerably according to operating settings. Average figures were relied upon. In the case of right of way, for instance, costs of $990,000 per track mile were assumed.
6. This analysis was carried out by Robert Cervero and is presented as Appendix B in the report titled *Regional Transit Corridors: The Land Use Connection,* cited in note 3.
7. Multiple regression models were estimated that, when expressing all variables in natural logarithm terms, took the following form:

   Estimated turnstile counts per 1000 population = 4.412 + 0.1351 (employees per acre) − 0.241 (land area) + 0.283 (feeder bus service per 1000 population) + 0.364 (household income).

   This model produced an R^2 of 0.833, with all variables statistically significant at the .01 probability level. Other model versions included variables measuring fares to downtown San Francisco, average household income, land-use mixture levels, and type of station (terminal or not).
8. Peter Newman and Jeffrey Kenworthy, Gasoline Consumption and Cities: A Comparison of U.S. Cities with a Global Survey, *Journal of the American Planning Association,* Vol. 65, No. 2, pp. 161–182, 1991.
9. This work sparked a firestorm of controversy about the methods used in drawing these inferences. Critics charged that Newman and Kenworthy failed to introduce

proper statistical controls that account for variations in fuel consumption, such as differences in the distribution of vehicle sizes across comparison cities. Amsterdam and Copenhagen, for instance, average much higher shares of subcompact and compact vehicles than cities like Houston and Phoenix, thus partly explaining lower fuel consumption per capita in European cities. For a critique of this work, see Peter Gordon and Harry Richardson, Gasoline Consumption and Cities: A Reply, *Journal of the American Planning Association,* Vol. 55, No. 2, pp. 342–345, 1989; José Gomez-Ibanez, A Global View of Automobile Dependence, *Journal of the American Planning Association,* Vol. 57, No. 3, pp. 376–379, 1991.

10. See Robert Cervero, *Suburban Gridlock* (New Brunswick, NJ: Center for Urban Policy Research, 1986); Robert Cervero, *America's Suburban Centers: The Land Use-Transportation Link* (Boston: Unwin Hyman, 1989); Kevin Hopper, *Travel Characteristics of Large-Scale Suburban Activity Centers* (Alexandria, VA: JHK & Associates, NCHRP Project Report 3-38[2], 1989); Cambridge Systematics, *The Effects of Land Use and Travel Demand Strategies on Commuting Behavior* (Washington, DC: U.S. Department of Transportation, Federal Highway Administration, 1994).
11. Data were obtained from the 1990 Census Transportation Planning Package, made available by the Metropolitan Transportation Commission in Oakland.
12. J. Holtzclaw, *Residential Patterns and Transit, Auto Dependence, and Costs* (San Francisco: Resources Defense Council, 1994).
13. Lawrence Frank and Gary Pivo found that higher population densities increased the share of shopping and work trips made by transit and on foot. Their research found that increasing population density from 20 to 40 persons per acre, holding factors like household income constant, would increase bus transit usage in the Puget Sound region from 1.7 percent to around 7 percent of all shopping trips. See L. Frank and G. Pivo, The Impacts of Mixed Use and Density on the Utilization of Three Modes of Travel: The Single Occupant Vehicle, Transit, and Walking, *Transportation Research Record,* Vol. 1466, pp. 44–52, 1994.
14. To support light rail services, Pushkarev and Zupan maintain that a minimum of 12 dua is necessary over a 50-mi^2 area in a region with a central business district with at least 25 million ft^2 of nonresidential floorspace.
15. See H. Blumenfeld, *The Modern Metropolis: Its Origins, Growth, Characteristics, and Planning* (Cambridge, MA: MIT Press, 1968); J. Jacobs, *The Death and Life of Great American Cities* (New York: Vintage Books, 1961).
16. W. Michelson, Most People Don't Want What Architects Want, *Transaction,* Vol. 5, No. 8, pp. 37–43, 1968; L. Bookout, The Future of Higher-Density Housing, *Urban Land,* Vol. 51, No. 9, pp. 14–18, 1992.
17. See N. Foote, J. Agu-Lughod, M. Foley, and L. Winnick, *Housing Choices and Housing Constraints* (New York: McGraw-Hill, 1960); W. Michelson, *Environmental Choice, Human Behavior, and Residential Satisfaction* (New York: Oxford University Press, 1977); C. Cooper-Marchus and W. Sarkissian, *Housing as if People Mattered* (Berkeley: Univer-

sity of California Press, 1986); J. Dillman and D. Dillman, Private Outside Space as a Factor in Housing Acceptability, *Housing and Society,* Vol. 14, No. 1, pp. 20–29, 1987.

18. See A. Rappaport, Toward a Redefinition of Density, *Environment and Behavior,* Vol. 7, No. 2, pp. 25–36, 1975.
19. J. Bergdall and R. Williams, Perception of Density, *Berkeley Planning Journal,* Vol. 5, pp. 15–38, 1990.
20. L. Bookout and J. Wentling, Density by Design. *Urban Land,* Vol. 47, pp. 10–15, 1988.
21. Comptroller General, *Report to Congress: Greater Energy Efficiency Can Be Achieved Through Land Use Management* (Washington, DC: EMD 82–1, December, 1981).
22. Jacobs, op. cit., p. 14.
23. Robert Cervero, *America's Suburban Centers: The Land Use-Transportation Link* (Boston: Unwin Hyman, 1989).
24. Colorado/Wyoming Section Technical Committee, Institute of Transportation Engineers, Trip Generation for Mixed Use Developments, *ITE Journal,* Vol. 57, No. 2, pp. 27–29, 1987.
25. Susan Handy, Regional Versus Local Accessibility: Neo-Traditional Development and Its Implications for Non-Work Travel. *Built Environment,* Vol. 18, No. 4, pp. 253–267, 1992.
26. Reid Ewing, P. Haliyur, and Gregory Page, Getting Around a Traditional City, a Suburban PUD and Everything In-Between, *Transportation Research Record,* Vol. 1466, pp. 53–61, 1994.
27. Frank and Pivo, op. cit.
28. Robert Cervero, Mixed Land Uses and Commuting: Evidence from the American Housing Survey. *Transportation Research* (forthcoming).
29. In transportation planning parlance, a tour is a complete circuit between one's residence and some other destination or destinations. As used in this example, the person is making a work-trip tour since the primary destination is the workplace. Other stops, such as to a cleaners or grocery outlet, are secondary to the purpose of going to work.
30. This analysis was conducted using 1985 commuting data from the American Housing Survey. For the probability plots shown in Figure 4.7, these relationships hold under the following conditions: public transit services are rated as "adequate" (by respondents to the American Housing Survey) and the person lives in a household with two automobiles available.
31. Robert Cervero, Jobs-Housing Balancing and Regional Mobility, *Journal of the American Planning Association,* Vol. 55, No. 2, pp. 136–150, 1989.
32. Genevieve Giuliano, Is Jobs-Housing Balance a Transportation Issue? *Transportation Research Record,* Vol. 1305, pp. 305–312, 1991; Anthony Downs, *Stuck in Traffic: Coping with Peak-Hour Traffic Congestion* (Washington, DC: The Brookings Institution, 1992).
33. Peter Gordon and Harry Richardson, The Commuting Paradox: Evidence from the Top Twenty, *Journal of the American Planning Association,* Vol. 57, No. 4, pp. 416–420, 1991.

34. Jan Gehl, *Giving the City a Human Face, A Challenge for the City* (Perth, Australia: Perth Beyond, 1992).
35. Robert Cervero, *Transit-Supportive Development in the United States: Experiences and Prospects* (Washington, DC: Federal Transit Administration, 1993), p. 122.
36. In some ways, it is more revealing to compare travel characteristics of traditional neighborhoods that are dense, mixed-use, and pedestrian friendly with travel from low-density, auto-oriented neighborhoods. In reality, there is a close correlation between density and the presence of mixed land uses and more pedestrian-oriented development.
37. John Holtzclaw, Manhattanization Versus Sprawl: How Density Impacts Auto Use Comparing Five Bay Area Communities, *Proceedings of the Eleventh International Pedestrian Conference* (Boulder, CO: City of Boulder, 1990), pp. 99–106. In a more recent study, Holtzclaw found similar results. This analysis of 28 California communities showed that the number of automobiles and VMT per household fell by 25 percent as densities doubled and by around 8 percent with a doubling of transit services, again controlling for factors like household income. See John Holtzclaw, *Residential Patterns and Transit, Auto Dependence, and Costs* (San Francisco: Resources Defense Council, 1994).
38. Fehrs and Peers Associates, *Metropolitan Transportation Commission Bay Area Trip Rate Survey Analysis* (Oakland: Metropolitan Transportation Commission, 1992).
39. See Ritachi Kitamura, Pat Mokhtarian, and Lynn Laidet, *A Micro-Analysis of Land Use and Travel in Five Neighborhoods in the San Francisco Bay Area* (Davis: University of California at Davis, California Air Resources Board, 1994); Maryland National Capital Park and Planning Commission, *Transit and Pedestrian Oriented Neighborhoods* (Silver Spring: Maryland National Capital Park and Planning Commission, 1992); White Mountain Survey Company, *City of Portsmouth Traffic/Trip Generation Study* (Ossippee, NH: White Mountain Survey Company, 1990).